ETHICAL RELATIONSHIPS BETWEEN SCIENCE AND SOCIETY: UNDERSTANDING THE SOCIAL RESPONSIBILITY OF SCIENTISTS

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Abstract

The wider social responsibility of scientists has received theoretical discussion but little previous empirical research. To elucidate the construct, this thesis investigated scientists' attitudes, values and beliefs about social responsibility, with a focus on Promethean gene technologies. The thesis articulates a framework for the construct domain and develops and validates a set of new measures related to scientific social responsibility.

Five technology fuelled, social and ecological, existential threats to Earth are identified, establishing the need for an increased ethic of social responsibility for the scientific endeavour and scientists in an age of Promethean technologies. The power of developing gene technologies and their social and moral implications are examined, followed by a discussion of relevant normative, meta-ethical and applied ethics theories. Next, Kohlberg's (1969) cognitive moral development theory, Rest's (1979) theory of moral behaviour, and Schwartz's (1992) theory of personal value orientation are discussed as a psychological context for scientific social responsibility. The few empirical studies addressing the issue are reviewed.

Original empirical contributions are presented in two studies. Study 1 is an explorative, qualitative research project using face-to-face, in-depth, unstructured interviews to investigate a purposive sample of scientists' (N = 22) beliefs about the social role of science, and scientists, in research and technology development. The participants all worked in the field of genetic engineering, or studied its social or ecological impacts. From a data-driven, manifest, thematic analysis, three themes emerged, each with several sub-themes: doing public good (sub-themes: benefit/harm, knowledge, technologies, and foresight); engagement (sub-themes: informing society, becoming informed, and integrity) and; compliance (sub-themes: scientific norms, business norms, laws and regulations, societal mores, and personal values). A theoretically-driven, latent, thematic analysis, examined the normative and meta-ethical reasoning underlying participants' manifest positions. Evidence was found for normative ethical reasoning (i.e., deontological, teleological and virtue ethics) and a range of meta-ethical approaches (i.e., ethical relativism, conventionalism, objectivism, moral absolutism, subjectivism, emotivism, and cultural relativism). From Study 1 items were proposed for two measures of social responsibility based on the first two stages of Rest's model of moral behaviour.

Study 2, a quantitative survey of scientists from six New Zealand Crown Research Institutes (*N* = 733, 40.9% female), used a nomological network of 39 hypothesised directional relationships (correlations) to help infer construct validity to five new instruments related to social responsibility: moral awareness, moral judgement regarding personal behaviour, technological optimism, attitude to the commercialisation of science, and attitude to the democratisation of science. Five existing instruments also comprised the nomological network: the four Schwartz higher-order value dimensions and a concurrent criterion, general attitude to genetic engineering. Exploratory factor analysis was used to select items for single factor instruments and confirmatory factor analysis to purify the instruments' dimensionality, followed by reliability analyses. Four new instruments demonstrated good psychometric properties. Twenty-seven of 39 hypothesised correlations were significant in the right direction (at the Bonferroni adjusted $p < .001$ level), providing initial support for the new instruments' construct validities and study results regarding participants' attitudes, beliefs and values towards conducting socially responsible Promethean science.

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Chapter 1 - Introduction

The purpose of the current work is to consider the social and moral responsibilities of science and scientists in an age of Promethean technology. Empirical research into scientists' wider social responsibilities is almost non-existent and the domain poorly defined (McCormick, Boyce, & Cho, 2009; Pimple, 2002; Prpic, 1998; Weil, 2002). In Study 1, the domain of scientific social responsibility is explored and a framework developed through qualitative interviews with scientists. Study 2 uses a quantitative survey to develop five new psychometric instruments to measure related aspects of scientists' attitudes to social responsibility. Both studies examine scientists' attitudes to social responsibility regarding their research. A secondary purpose is to examine scientists' moral attitudes to a relatively new and developing Promethean science of enormous potential power: gene science and technology. This is examined in both the qualitative and quantitative studies. This is a mixed method study in the interdisciplinary academic field known as science, technology and society studies or STS studies (Hackett, Amsterdamska, Lynch, & Wajcman, 2008; Spiegel-Rosing & de Solla Price, 1977).

Science, Technology and Society Studies

Science, Technology and Society' (STS) studies is a field of scholarship examining the social processes that underpin research, science and technology (Amsterdamska, 2008; Solomon, 2008), including their consequences for society (e.g., Barben, Fisher, Selin, & Guston, 2008; Hedgecoe & Martin, 2008). STS studies the sociology of scientific knowledge, science policy, science communication and dialogue, and public engagement in science (Hackett, 2008). STS studies recognise that science is a human activity influenced by human values. Society decides what research is to be done and what science gets funded (Hackett, et al., 2008). Social processes and values determine which science is supported and how it is used. The assessment of science is influenced by human values (Lowe, 2010).

Because the governance of science is value-laden, STS studies acknowledge that science itself is a value-laden endeavour (Wajcman, 2008). STS examines the relationship between science and society, including such issues as whose voices dominate and whose voices should be included (and why) in decision-making regarding science, as well as related important issues, such as the democratisation of science (Bucchi & Neresini, 2008; Hackett, 2008; Irwin, 2008), the commercialisation of science (Krimsky, 2004; Mirowski & Sent, 2008; Nowotny, Scott, & Gibbons, 2003), societal trust in science (Critchley, 2008; Irwin, 2008; Rampton & Stauber, 2001), and scientists' responsibilities to society (Johnson & Wetmore, 2008; Ziman, 1998). An important insight of STS studies is that much damage and confusion can result from the application of narrow disciplinary knowledge to part of a system without considering the other causally linked components of the local and global systems (Lowe, 2010). In researching scientists' attitudes towards their moral responsibility to society, it is importance to consider the current impacts of science and technology on society. This is necessary to convey the context, in which the science/society moral responsibility issue is currently set, and the importance and urgency of the issue.

The Impacts of Science and Technology on the Modern World

The development and practice of science and technology has been a major causal component of the exponential rise in human population, the rise of civilisations, and (in general) the betterment of conditions for human wellbeing and prosperity (Morgan, 1877; Nolan & Lenski, 2006; White, 1959). Indeed, some people believe that science is so important to society that the claim is made that "Science Made the Modern World, and it's science that shapes modern culture" (Shapin, 2008, p. 433). Agricultural technology enabled increased food production, which enabled corresponding increases in human population (Hopfenberg & Pimentel, 2001; Nolan & Lenski, 2006), and the development of civilisation (Toffler, 1980; White, 1959).

As Toffler (1980) describes it, the second great wave of civilisation, the industrial revolution, began in the 17th -18th century. Copernicus, Galileo, Descartes, Bacon, Newton, Hook, Boyle, Leibnitz and their contemporaries started to formalise the scientific method (Achinstein, 2004). A multitude of new technologies were discovered and dispersed on a wide scale. Perhaps, most importantly, first, with the development of the steam engine, and later, the development of the internal combustion engine, humanity discovered how to release and use the energy of fossil fuels, enabling animal and human labour to be replaced by machines (Pimentel & Pimentel, 1996; White, 1959). Fossil fuels enabled vastly increased intensification of food production, and thus enabled the continued exponential growth of human population (Hopfenberg & Pimentel, 2001).

Despite the obvious and acknowledged positive benefits of science and technology, humanity's current possession and use of technology, to provide the consumer products and comforts of the modern western lifestyle, now threatens the very existence of our own species, multitudes of other species of life, and the ecosystems of our planet, on which all biota depend (Flannery, 2009; Suzuki, 2010). The peer reviewed scientific evidence for this statement is prolific, growing exponentially, and rationally undeniable (e.g., Anderson & Bows, 2008; Bostrom, 2002; Caldeira & Wickett, 2003; Carpenter, et al., 2008; Carter, Deutch, & Zelikow, 1998; Commoner, 1966; Costanza, 1989; Dainton, 1971; Diamond, 2005; Dirzo & Raven, 2003; Food and Agriculture Organisation of the United Nations, 2009; Hall & Klitgaard, 2006; Hopfenberg & Pimentel, 2001; Huesemann, 2001; Intergovernmental Panel on Climate Change, 2007; Jackson, 2008; Joy, 2000; Katz, 2001; Kharecha & Hansen, 2008; Laurance, 2001; Leakey & Lewin, 1996; Lovelock, 2006; Lubchenco, 1998; Meadows, Meadows, Randers, & Behrens III, 1972; Meadows, Randers, & Meadows, 2004; Meier, et al., 2007; Met Office Hadley Centre, 2009; Nobel Laureates, 2001, 2007; Pimentel & Pimentel, 2006, 1996; Rapp, 1995; Raven, 2002; Rees, 2003; Rockström, et al., 2009; Schellnhuber, 2009; Serageldin, 2002; Sherwood & Huber, 2010; Small & Jollands, 2006; Smil, 2008; Tainter, 1988; Union of Concerned Scientists, 1992; United Nations Environment Programme, 2002a; Vermeer & Rahmstorf, 2009; Vitousek, Ehrlich, Ehrlich, & Matson, 1986; Wackernagel & Rees, 1996; Werth & Avissar, 2002; Willis & Bhagwat, 2009; Worm, et al., 2006; Youngquist, 1999).

Five technology fuelled crises threatening Gaia

Human use of technology gives rise to at least five potentially catastrophic crises that are currently threatening humanity and the stability of earth’s ecosystem services. These threats are over-population, resource depletion, pollution, social inequity, and human malevolence. In the current work the term Gaia is used as Lovelock (1979/2000, p. ix) defined it “the entire surface of the Earth including life is a self-regulating entity.” This definition includes humans. For the purpose of this thesis, the human social and moral crises enabled by development of technology (i.e., the exacerbation of social inequity and human malevolence), fall under the general rubric of consequences for Gaia.

Over-population

Over-population is both a contributory cause of the other crises and a crisis in itself. World population is still expanding and estimated to hit a peak of about 9.2 billion around 2050, after which it is projected to start declining (UN Population Division/DESA, 2008). Although the earth might be capable of carrying this many people, it cannot do so at the current consumption rates of the western world, it cannot do so without more efficient use of fresh water and soil resources, and it cannot do so without oil, or a suitable energy substitute, to fuel food production and distribution (Brown, 2008; Cohen, 2003; Hopfenberg & Pimentel, 2001; Meadows, et al., 1972; Meadows, et al., 2004; Pimentel & Pimentel, 2006; Raven, 2002; Rockström, et al., 2009; Serageldin, 2002; Smil, 1997; Wackernagel & Rees, 1996). In the year 2000, 3% of the known remaining oil reserves were consumed (Chow, Kopp, & Portney, 2003). Oil discovery is a fraction of current use (Brown, 2008). At current rates of consumption, practically obtainable oil will be depleted in 30-40 years. Without oil, and assuming a healthy western diet for all, according to some of the world's foremost experts, the Earth can feed 2-3 billion people, much less if everyone were to have an American lifestyle (Cohen, 1995, 2003; Erhlich & Ehrlich, 1990; McCluney, 2004; Meadows, Meadows, & Randers, 1992; Pimentel & Pimentel, 2006, 1996; Pimentel, Pimentel, & Karpenstein-Machan, 1999; Smil, 2008). The inevitable Malthusian crunch is fast approaching.

Resource depletion

Resource depletion is a function of the number of people on the planet and our technological power to extract and consume the earth's resources. Potentially catastrophic resource depletion threats currently include: *energy, water, land and soil, forests, species diversity and food.* Again, the scientific evidence is prolific, growing and indisputable.

Energy. Oil provides 95% of all energy humans use; renewable resources currently provide about 2.6% (Chow, et al., 2003). The easy to obtain half of all known oil reserves have already been used. However, the rate of use continues to escalate. Without cheap oil, energy poverty will beset humanity (Bentley, 2002; Chow, et al., 2003; Gotton, 2001; Hall, 2004; Hall & Klitgaard, 2006; Howden, 2007; Meadows, et al., 2004; Peet, 1992; Raven, 2002; Smil, 2008; Wackernagel & Rees, 1996; Youngquist, 1999).

Water. Humans already capture and use over half of the planets fresh water supplies. Water shortages are predicted to be a global problem in the 21st century (Avissar & Werth, 2005; Brown, 2008; Gleick, 2003; Raven, 2002; Rockström, et al., 2009; United Nations Environment Programme, 2002b, 2009; Vorosmarty, et al., 2004).

Land and soil. Soil erosion is occurring at up to 300 times the rate of natural renewal. This represents an immense problem for future food production (Fedoroff, et al., 2010; Lal, 2007; Meier, et al., 2007; Pimentel & Sparks, 2000;

Raven, 2002; Steinfeld, Wassenaar, Castel, Rosales, & Haan, 2006; Stocking, 2003; Wackernagel & Rees, 1996).

Forests. Forest are the lungs of the Gaia; breathing in carbon dioxide and releasing oxygen. They are an important mechanism of climate regulation. They are being decimated at unprecedented rates (Avissar & Werth, 2005; Butler, 2006; Cox, et al., 2004; Food and Agriculture Organisation of the United Nations, 2009; Maslin, Malhi, Phillips, & Cowling, 2005; Nepstead, 2007; Rockström, et al., 2009; Soares-Filho, et al., 2006; Werth & Avissar, 2002).

Species diversity. Life, on land, in the oceans, and in the air is becoming extinct at 1000 to 10,000 times the background rates of the past 60 million years. Biologists are referring to this phenomenon as the sixth great mass extinction event. Previous extinction events had natural causes; the current event is caused by humans (Carpenter, et al., 2008; Dirzo & Raven, 2003; IUCN, 2009; Jackson, 2008; Leakey & Lewin, 1996; May, Lawton, & Stork, 1991; Pimm, Russell, Gittleman, & Brooks, 1995; Willis & Bhagwat, 2009; Worm, et al., 2006).

Food. Over-population, depletion of oil, water, land and soil, and climate change, present significant new problems for the production of adequate supplies of food (Basset-Mens, Small, Paragahawewa, Langevin, & Blackett, 2009; Borlaug, 1997; Brown, 2008; Fedoroff, et al., 2010; Hopfenberg & Pimentel, 2001; Lal, 2007; Lappe, Collins, & Rosset, 1998; Meadows, et al., 2004; Pimentel & Pimentel, 2006, 1996; Real Time Statistics Project, 2009; Serageldin, 2002; Smil, 1997, 2008; Steinfeld, et al., 2006; Stocking, 2003; West, 2010)

Under current patterns of consumption, and exacerbated by population and economic growth, these resources are all critically threatened and expected by eminent authorities to reach critical biological tipping points within the next 20-100 years (Brown, 2008; Flannery, 2009; Meadows, et al., 1992; Raven, 2002; Serageldin, 2002).

Pollution

Planetary pollution is a function of global population, consumption rates and disposal practices (Williams, 2005). Pollution occurs on land, in the atmosphere and in the oceans (Bell & Davis, 2001; Griffith, Duncan, Riggan, & Pellom, 1989; Hamer, 2003; Herat, 2009; Huesemann, 2001; Schwartz, 1994; Steinfeld, et al., 2006; Thompson, Swan, Moore, & vom Saal, 2009; Wong, et al., 2007). Although there is a wide range of different types of serious pollution, carbon pollution of the atmosphere and the oceans, primarily caused by fossil fuel use, is perhaps the most dangerous pollution threat to the majority of life on earth. Carbon pollution of the atmosphere, leads to *global warming, climate change, sea level rise, polar* *ice melt, and ocean acidification* (Cox, Betts, Jones, Spall, & Totterdell, 2000; Kharecha & Hansen, 2008; Matthews, Gillett, Stott, & Zickfeld, 2009).

If the remaining fossil fuels are burned, under a business as usual scenario, climate models predict that *global warming* could make more than half of the planet uninhabitable for mammals due to heat stress within 300 years (Sherwood & Huber, 2010). In the shorter term, *climate change* is predicted to have negative consequences for food production and the spread of disease vectors (e.g., Anderson & Bows, 2008; Carpenter, et al., 2008; Fedoroff, et al., 2010; Gleick, et al., 2010; Hamilton, 2010; Hansen, et al., 2008; Hasselmann, et al., 2003; Intergovernmental Panel on Climate Change, 2007; Oreskes, 2004; Rajan, 2006; United Nations Environment Programme, 2009).

S*ea level rise* is predicted to remove valuable agricultural land from production and make many major coastal cities uninhabitable. It is estimated that sea level rise, due in part to heat expansion of the oceans, but mostly due to *polar ice melt* (caused by rising global temperature), will make hundreds of millions of people climate refugees during the current century (Chen & Li, 2007; Goodstein, Huntington, & Euskirchen, 2010; Hansen, 2007; Hasselmann, et al., 2003; Pritchard, Arthern, Vaughan, & Edwards, 2009; Schuur, et al., 2009; Vermeer & Rahmstorf, 2009).

Social Inequity

The fourth looming crisis, an issue of human morality, is social inequity. One to two billion people are undernourished; Serageldin (2002) claimed 40,000 people die of hunger related causes each day. In contrast, 1.1 billion people are overweight and 340 million are obese. According to Serageldin (2002, p. 55) “20% of the world’s population consumes 85% of the world’s income, the remaining 80% live on 15%, with the bottom 20% living on 1.3% of the world’s income”. Thirty years ago the wealthiest 20% were 30 times richer than the poorest 20% (Serageldin, 2002). Recently, Meadows et al. (2004) estimated this ratio is now 82:1. Social inequity is rapidly increasing in scope and severity.

Poverty and ill-health go hand in hand. Great disparity exists between health indicators for the developed and developing worlds including: quality of life, disability, life expectancy and infant mortality (Mascie-Taylor & Karim, 2003). Current medical research practice continues to exacerbate this disparity (Resnik, 2004). According to Resnik (2004, p. 43) “less than 10% of the world’s biomedical R&D funds are dedicated to addressing problems that are responsible for 90% of the world’s burden of disease”. Climate change will have its most profound negative health impacts on the poor (Costello, et al., 2009; Jay & Marmot, 2009; McMichael, Friel, Nyong, & Corvalan, 2008).

Small and Jollands (2006) claimed social inequity will provide a breeding ground for justifiable, malevolent, retaliatory action using new and emerging technologies – future wars and terrorism. Similar sentiments were expressed in a statement called "The Next Hundred Years" issued in December 2001 on the 100th Anniversary of the Nobel prizes. The statement was signed by 110 Nobel Laureates.

> The most profound danger to world peace in the coming years will stem not from the irrational acts of states or individuals but from the legitimate demands of the world's dispossessed. Of these poor and disenfranchised the majority live a marginal existence in equatorial climates. Global warming, not of their making but originating with the wealthy few, will affect their fragile ecologies most. Their situation will be desperate, and manifestly unjust. It cannot be expected, therefore, that in all cases they will be content to await the beneficence of the rich. If, then, we permit the devastating power of modern weaponry to spread through this combustible human landscape, we invite a conflagration that can engulf both rich and poor. The only hope for the future lies in co-operative international action, legitimized by democracy. It is time to turn our backs on the unilateral search for security, in which we seek to shelter behind walls. Instead we must persist in the quest for united action to counter both global warming and a weaponised world. These twin goals will constitute vital components of stability as we move toward the wider degree of social justice that alone gives hope of peace….As concerned citizens we urge all governments to commit to these goals which constitute steps on the way to the replacement of war by law. To survive in the world we have transformed we must learn to think in a new way. As never before, the future of each depends on the good of all. (Nobel Laureates, 2001 para. 1)

Human malevolence

Nearly fifty years ago, the psychologist Carl Jung, made the following insightfully statement about the human condition:

> Our intellect has created a new world that dominates nature and has populated the world with monstrous machines. . . .His (*sic*) genius shows the uncanny tendency to invent things that become more and more dangerous, because they represent better and better means of wholesale suicide. . . .In spite of our proud domination of nature, we are still her

victims, for we have not even learned to control our own nature. Slowly but, it appears, inevitably, we are courting disaster. (Jung, 1964, p. 18)

The fifth crisis facing humanity is human malevolence: oppression, violence, terror and war. In the first half of the 20th century, 187 million people perished in the two world wars and their aftermath. According to Rees (2003) the 20th century was possibly the first in which more human lives were lost due to war and human atrocity than through natural disasters. In the 1980s, the world's nuclear stockpile was equivalent to 10 tonnes of TNT for every person in America, Russia and Europe.

In a technologically advanced world, state condoned and mandated evil has competition from a far more diverse and intangible set of perpetrators – terrorists. While nuclear technology is still beyond terrorists' capacity, it may not always be so. However, the September 11 event demonstrated the potential of non-military technologies to be used for malevolent purposes. Technologies which have equal potential to be used for good or be weaponised in some manner are referred to as 'dual-use technologies' (Carter, 1989). Many of the powerful new and emerging technologies have this dual-use capacity. In the future, perhaps the most probable, and possibly the most fearsome, weapons of choice for terrorists will be chemical or biologically engineered agents (Preston, 2010; Rees, 2003). The biggest threat is seen from biological weapons which will become more readily available technically, and impossible to control using traditional policies. Preston (2010, pp. 3, slide 4) claimed that "For terrorists, bioweapons provide the ultimate in stealthy, asymmetrical warfare, and are well-suited to both clandestine development and employment."

The knowledge and technology to develop and produce biological and chemical weapons can be found in medical and hospital laboratories, chemical factories, and agricultural research facilities (Preston, 2010; Rees, 2003). The development and use of such weapons is not confined to nation states; thousands of much smaller, less wealthy groups and organisations, even single individuals could conceivably deploy such weapons (Preston, 2010; Rees, 2003). The possibility of their use will continue to increase with the passage of time as the number of groups and individuals who have access to the necessary technological knowledge and resources continue to grow. Technological progress and convergence increases the ease of development, access, use, and the efficiency and effectiveness of these types of weapons (Rees, 2003; Small & Jollands, 2006).

Small and Jollands (2006) argued that, given the above conditions, and combined with the evident range of human moral behaviour, over time, the probability of this kind of malevolent event approaches certainty. As Sir Martin Rees, President of the British Royal Society, stated:

> We are entering an era when a single person can, by one clandestine act, cause millions of deaths or render a city uninhabitable for years, and when a malfunction in cyberspace can cause havoc worldwide to a significant segment of the economy: air transport, power generation, or the financial system. (Rees, 2003, p. 61)

Categories of threat, values, and the perception of moral issues

The evidence accumulated by ecological and environmental scholars indicates society's current technological trajectory is on a collision course with the planet's ecosystems limits (e.g., Brown, 2008; Flannery, 2009; Meadows, et al., 1992; Meadows, et al., 2004; Pimentel & Pimentel, 2006, 1996; Raven, 2002; Suzuki, 2010; Wackernagel & Rees, 1996). The current biophysical and social crises are a direct result of how humans have chosen to use technology in the past, up until the present day. Some of these threats could potentially see the demise of humanity and the rest of the mammals (Sherwood & Huber, 2010). Such global terminal risks, with the potential to imperil human civilisation for all time to come, are characterised by Bostrom (2002) as existential risks. Most existential risks facing Gaia today result from human use/misuse of technology (Bostrom, 2002).

These five identified potential crises fall under two general categories of threats to Gaia: environmental threats and social threats. Without human possession of science and technology these threats could not exist in their present form. Therefore, an essential part of the social and moral responsibilities of the science community and scientists involves being aware of, and sensitive to, environmental and social issues and using scientific knowledge to address these known threats. The social issues associated with the potential crises are largely ones of equity, justice, fairness and human evil, all of which relate strongly to morality and human values.

Research has found that values are related to attitudes to the environment and perception of environmental issues (Beckmann & Kilbourne, 1997; Beckmann, Kilbourne, Van Dam, & Pardo, 1997; Schultz & Zelezny, 1999; Stern & Dietz, 1994; Stern, Dietz, Kalof, & Guagnano, 1995). Values are also related to concern about social issues (Schwartz, 2006; Stern, Dietz, Abel, Guagnano, & Kalof, 1999), moral reasoning (Abdolmohammadi & Baker, 2006; Crilly, Schneider, & Zollo, 2008; Fritzsche & Oz, 2007; Helkama, et al., 2003; Lan, Gowing, McMahon, Rieger, & King, 2008; Lan, Gowing, Rieger, McMahon, &

King, 2010) and moral behaviour (Bardi & Schwartz, 2003; Hitlin, 2003; Schwartz, 2006). Therefore, it is proposed that personal values will be related to scientists' attitudes to social and moral responsibility in research and development. The nature of this relationship will be explored further and specific hypotheses proposed in a latter chapter.

Promethean technologies

If we wish to avert or ameliorate the looming crises and develop and maintain socially and ecologically sustainable systems, then society must take a new approach to the governance and use of science and technology (Bunge, 1977; Jonas, 1985; Luppicini, 2008). This is especially so because, despite the "extreme power which we possess today" (Jonas, 1985, p. 23), a new crop of technologies, currently in development, will further, vastly increase human power over nature (de Grey, 2004, 2007; Drexler, 1986; Gibson, et al., 2010; Good, 1965; Henderson, 2010; Joy, 2000; Kurzweil, 2001, 2005; Lavine, Voss, & Coontz, 2007; Parliamentary Office of Science and Technology, 2008; Small & Jollands, 2006). If we continue to use these new technologies with the same lack of forethought in regard to the wellbeing of Gaia, as we have used the technologies we already possess, the crises currently threatening will likely be greatly exacerbated and new ones introduced (Jonas, 1985; Luppicini, 2008; Moor, 2005).

In the current work, these new, powerful technologies will be referred to as Promethean technologies (Prometheus means forethought), in recognition of the god-like power, over both the social and physical worlds, with which they endow us, and the necessity for forethought in their application (Henderson, 2010; Jonas, 1985; Joy, 2000; Slaughter, 2007; Small, 2003; Small & Jollands, 2006). Promethean technologies include: nuclear and quantum technologies, gene and biotechnologies, information and communication technologies, artificial intelligence, virtual reality technologies, nanotechnologies, robotics, human machine interfaces and prosthetic devices, cyborg technologies, cognitive and neuro-technologies, and of course, weapons of mass destruction. Small and Jollands (2006) claimed that these technologies, particularly in convergence, will give humanity unprecedented god-like power over six primary dimensions of nature: time, space, energy, matter, life and consciousness.

Depending upon how we use these technologies, they have the potential to accelerate, ameliorate, halt, or, in the most optimistic scenarios, even reverse the looming ecological and social crises (Jonas, 1985). Thus, technology, while opening up a range of new possible futures, does not itself necessitate any particular future, but rather, it is what society, and the various groups and individuals that compose society, chose to do with the coming Promethean technologies that will determine the realised future from a wide range of possibilities. Along with technological governance, an understanding of human nature, individual and social behaviour and morality, is a necessary component to understanding the probable impacts of new technologies on both humans and the rest of Gaia (Bradshaw & Bekoff, 2001; Small & Jollands, 2006). This suggests that scientists' awareness of their social and moral responsibilities to society will be enhanced by knowledge of human nature and an awareness of the range of human behaviour at the individual, social and political levels.

Three ways humans cause harm using technology

Not all the problems or possible harms associated with humanity's use of Promethean technology qualify as existential threats, or are as dire as the five identified crises – these are existential threats that, by virtue of the magnitude of the potential harm, demand deep and immediate consideration (Jonas, 1985). Many lesser harms to individuals, groups, or society as a whole, or other issues of moral import may also arise from the use and misuse of technology. Small and Jollands (2006) identified three main ways in which humans cause harm via the use of technology. These are: *accidental, incidental and malevolent*.

Small and Jolland (2006) defined *accidental causes* as "the harmful effects of technology on the environment, humans, and other species of life that are unforeseen and arise unexpectedly from the complex and intricately interconnected causal network that we call nature" (p. 348). While these are by definition unknown at the time, with hindsight problems such as global warming, ozone depletion, and species extinction were in this category in the past. However, the fact that unexpected, harmful social and moral consequences may arise from the application of new technologies, suggests that, an important social and moral responsibilities of scientists, and the science community, is to *foresight* possible harmful consequences of new knowledge and technologies under development.

Social responsibility would suggest a *precautionary approach* where harmful possibilities are indicated, and also engagement with the public to inform them of the potentials and to participate in dialogue with them regarding the appropriate action to take, including legal and regulatory procedures. Thus, we could say that scientists have a *duty of public care* or an obligation to seriously consider what the possible negative consequences of new knowledge and technology could be. Because foresight lacks the certainty of hindsight, it is inevitable that some harmful consequences will only be discovered in hindsight.

This fact suggests that *ongoing monitoring* of the consequences of Promethean technologies is also an important social responsibility of science and scientists.

Incidental causes of technological harm were defined as “those technologies whose detrimental effects were known or foreseeable when the technology was developed or which were once accidental and of which we have since become aware…. we may nonetheless choose to use the technology for various reasons anyway” (Small & Jollands, 2006, p. 349). Leaded petrol was used for many years despite the known detrimental effects to human health (Green, 2001). Global warming is currently in this category – although we have been aware of it for three decades, we have, as yet, made no meaningful response. Social and moral responsibility in such cases should involve *engagement* with the public regarding the cost/benefits of the beneficial and harmful effects for the impacted groups in society, to enable society to make informed decisions, rather than merely leaving it to the vagaries and inequities of market forces.

Malevolent causes were defined as “the case where we are not only aware that the outcomes of a particular use of a technology will be harmful to humans, animals or the environment, but we use the technology precisely for this reason” (Small & Jollands, 2006, p. 350). Examples include conventional, atomic, chemical, and biological weapons. Morally appropriate behaviour on the part of scientists would be to *refrain from participation* in the development of technologies whose principle purpose is malevolent and to warn the rest of humanity when others are working on such projects.

These deliberations on the way in which human use of technology can lead to harm suggest possible elements of an ethic of social and moral responsibility for scientists. These are: a duty of public care, foresighting possible harmful consequences, engaging in dialogue and deliberation with the public regarding the certainties and uncertainties and potential uses and abuses of Promethean technologies, taking a precautionary approach in cases where uncertainty is present, maintaining long-term monitoring of Promethean technologies for unexpected and unintended consequences, and refraining from participation in research which has dubious moral intent (e.g., weapons of mass destruction). An important related question is: what do the public think about science, scientists and their social and moral role in society? Public attitudes provide us with an understanding of the social and moral expectations placed on science and scientists. This question is addressed in the next section.

Societal concerns regarding science and technology

The public are also concerned about the impacts of science and technology and about scientists' moral responsibilities to society. The UK House of Lords Select Committee on Science and Technology, in the 2000 report on Science and Society, identified a public crisis of confidence in science and technology – particularly in areas making rapid advances such as biotechnology and information technology (Irwin, 2001). The report emphasised the importance of public confidence and trust in science and identified a new mood for dialogue suggesting that direct engagement with the public over science-based policy should be a normal and integral part of the process rather than merely an optional add-on (Irwin, 2001). Calls for public engagement in dialogue about the direction of science policy reflect a democratic ideology which is sometimes referred to as 'democratisation of science'.

Confirming the House of Lords assertions, a Guardian/ICM poll indicated that scientists had lost the trust of the public, with only one in three believing what scientists say. With regard to cutting edge technologies, belief in the assertions of scientists was even lower, with only 16% believing scientists regarding the safety of GM food and 13% accepting their word regarding cloning (Freedland, 1999). Similar public distrust towards the biotech industry itself has also been noted (Hill, 1999). The credibility and social authority of science and scientists are questioned by the public. Wynne (1980, p. 190) claimed the question that the public asks in relation to risk in science and technology is: "Who controls the scale, distribution and reversibility of the risk - is it an agent I understand, and trust? What is the meaning of the proposed risk and the nature of the alternative courses of action?" In a similar vein, Hagendijk (2001), claimed

> Qualitative studies also suggest that the public is not so much risk averse but distrustful of scientists and regulators who do not seem to take the concerns of citizens seriously and deny uncertainty with respect to new biotechnological options that emerge. (Hagendijk, 2001, p. 26)

Wildavski and Dake (1990) claimed that trust (or lack of it) and the perceived credibility (or lack thereof) of institutions was an important factor underlying public perceptions of risk and acceptance of new technologies. Trust is strongly dependent upon past experience (Lodorfos, Mulvana, & Temperley, 2006). There have been a number of well-known and spectacular instances of the unintended or unforeseen negative effects of science and technology (Tenner, 1996), irresponsible social actions by corporations (Bowie & Duska, 1990; Cavanagh & McGovern, 1988; Donaldson, 1992; Hurt & Robertson, 1998;

Michalos, 1995; Tenner, 1996), and unwarranted scientific optimism regarding technological developments (Green, 2001; Krier & Gillette, 1985; Tenner, 1996; Ticky, 2004).

For example, in a recent article in the Journal of the American Medical Association (JAMA), it was claimed that the US Food and Drug Administration (FDA), which is noted for its strict controls on the release of new drugs, frequently makes mistakes about the safety of new medications. The authors of the article found that, between 1975 and 1999, of the 548 new medications approved, fully 20% were later found to have serious or life threatening effects and had to be withdrawn from the market. The authors concluded that the safety of new products cannot be known with certainty until a drug has been on the market for many years (Lasser, et al., 2002). Again, this suggests the need for, and value of, ongoing monitoring of the effects of Promethean technologies.

Thus, caution (if not distrust) on the part of the public regarding new and powerful technologies, primarily being developed by multinational corporations, may well be the public's most rational approach. Nonetheless, because of the technological nature of modern risks (Cutter, 1993), Beck (1992) claimed that science was the principal social institution trusted as competent to make knowledge claims about risk. While trust, or the lack of it, is increasingly being seen as an important issue by policy makers, the generally proposed response of improved communication strategies misses the main point (Marris, Wynne, Simmons, & Weldon, 2002).

According to Marris et al. (2002), building and maintaining trust requires not just public relations strategies, but behavioural changes on the part of regulators, scientists and industry. To be trusted they must demonstrate, over prolonged periods of time, ethical and social responsibility. This requires demonstrating adequate risk management, admitting past errors, admitting uncertainty and factoring it into decision-making, being transparent about how decisions are made, and punishing irresponsible behaviour by members of their ranks (this list from Marris et al. suggests important aspects of the public engagement component of scientists' social and moral responsibilities). Most importantly, it requires demonstrating that the views of the public are understood, valued, and are truly taken into account in decision-making, rather than being ridiculed, marginalised, or merely paid lip service (Marris, et al., 2002).

According to a study of the Spanish public, values play an important role in policy making and technology policy should be guided by precaution, that is, "While the consequences of a new technology are not well known, action has to be guided by caution and the technology's use should be controlled in order to protect health and the environment" (Lujan & Todt, 2007, p. 106). Three-quarters of the sample supported this statement of the precautionary principle while only 6% rejected it. The study also showed that the Spanish public considered that scientists' conclusions can be influenced by economic pressures, in particular, the interests of research sponsors. The researchers concluded "for future technology development and regulation, policy has to respond clearly and unambiguously to social demands for precaution…. Current and future European policy initiatives will have to respond to such public demands in order to find acceptance and create trust" (p. 108).

Trust in institutions and experts plays an important role in the perception of risk and responses to risk communication (Lang, O'Neill, & Hallman, 2003; Poortinga & Pidgeon, 2003; Poortinga & Pidgeon, 2005). Belief in information from institutions, regulators and scientists is dependent upon the credibility of, and trust in, the source (Drottz-Sjoberg, 2000; Hunt & Frewer, 2001; Lidskog, 2001; Slovic, 1993). Trust in university and public funded scientists, has been found to be higher than trust in industry or privately funded scientists, in some studies (e.g., Critchley, 2008). Thus, the increasing commercialisation of science (Cohen, Duberley, & McAuley, 1999; Krimsky, 2004; Nowotny, et al., 2003) is likely to adversely affect public trust in science. It is claimed that commercialisation, and the resulting focus on intellectual property, challenges the idea of science as a public good and the open publication of research (Nowotny, et al., 2003). Krimsky (2004) claimed that commercialisation of science will result in reduced academic freedom, erosion of ethical standards, and that scientists will lose their independent status.

Research indicated that the New Zealand public are reasonably trusting of scientists in the abstract (i.e., not in connection with a particular issue). Hipkins, Stockwell, Bolstad, and Baker (2002) found that the NZ public expressed greater trust in public-sector scientists than in industry scientists (72% and 62% respectively rated as quite or very trustworthy). However, by contrast, in a random sample of the New Zealand public (N = 1684), Small, Parminter and Fisher (2005) found that, regarding information about a particular controversial area of science, genetic engineering, 41% either disagreed or strongly disagreed that scientists could be trusted. Only 24% agreed or strongly agreed that scientists could be trusted on this issue, while a further 34% were either neutral or did not know. The disparity between the levels of trust in scientists by the New Zealand public in these two studies suggests that the context or trust issue may affect the public's willingness to trust experts.

A survey (N = 1839) of UK public attitudes to science, conducted on behalf of The Office of Science and Technology and the Wellcome Trust in 2000, also confirmed the public's concern about science and technological developments (The Office of Science and Technology and The Wellcome Trust, 2000). On the positive side, 75% agreed they were 'amazed by the achievements of science', 68% agreed that 'science and technology are making our lives healthier, easier and more comfortable', while 84% agreed 'scientists and engineers make a valuable contribution to society'.

However, only 43% agreed that 'the benefits of science are greater than the harmful effects', 17% disagreed with the remainder being undecided. Forty-one percent considered that 'the speed of development in science and technology means that it cannot be properly controlled by Government', 36% believed that 'science is out of control and there is nothing we can do to stop it' and 61% believed 'science is driven by business – at the end of the day it's all about money.' Fifty-six per cent agreed that 'scientists seem to be trying new things without stopping to think about the risks' and 70% of the British public agreed that 'rules will not stop researchers doing what they want behind closed doors.' Sixty-nine percent considered that 'scientists should listen more to what ordinary people think.'

Another survey (N = 1001), conducted in 2002 and commissioned by the British Royal Society, about public attitudes to science, investigated the science issues of most concern to the public (The Royal Society, 2002). Seventy-four percent of respondents worried about bioweapons, 70% worried about global warming, 60% worried about genetic engineering of food and animals, 53% worried about nuclear power, 46% worried about xenotransplantation, 40% worried about gene therapy and 28% worried about stem cell research. In this study 53% of respondents agreed with the assertion, 'the funding of scientific research is becoming too commercialised' (27% disagreed), and 53% agreed that, 'I want more influence over the type of scientific research that is done' (32% disagreed). In response to this MORI survey, Paul Nurse, Nobel laureate and chair of the Royal Society's Science in Society initiative, is quoted as saying: "Clearly there is a need for scientists to explain more clearly to the public how science is funded and regulated and for a greater dialogue between scientists and the public" (O'Neill, 2002).

In March 2002, a National Forum for Science was held at the Royal Society in London for the purpose of understanding the decline in public confidence of science and to find ways of improving it. The delegates included: scientists, politicians, special interest groups, and the general public. Four general themes were identified:

- applied science is uncontrolled and guided by vested interests, 'new frontier' science is inadequately regulated, and the public feel powerless to influence science on ethical grounds;
- the public wants more transparency about scientific information, they believe that information is limited to power groups such as scientists, corporates and government – none of which they can trust;
- the media, the chief source of public information, seems to play a confused role – oscillating between hype and scaremongering or acting as advocates for scientists
- science education needs to change – both to increase public knowledge and to attract more researchers.

The forum concluded that scientists should be trained in communicating with the public, that citizen juries should be set up to give the public more influence on government decisions regarding science policy, and that organisations such as the Royal Society should provide information about science and make the public aware of scientific discoveries (Starling, 2002).

To sum, although, in general, the public strongly supported science and scientists, they had a number of concerns regarding the practice and consequences of science. These included concerns about scientists' moral behaviour in the laboratory and scientists' willingness (or lack of) to engage with the public and listen to their opinions. The public were concerned about potential harms created by science, the directions and governance of science, and the current lack of transparency. They were uneasy about the influence of commercialisation on science, considering that when science is for profit rather than for public good, issues of social and moral responsibility may be neglected.

The public were keen to have increased engagement with science and increased participation in setting the scientific research agenda. The issues that concerned the public were issues regarding the wider social and moral responsibilities of science and scientists. Social responsibility in research behoves scientists to address these public concerns. As yet, there has only been piecemeal response from the scientific community and the notion of the social responsibilities of science and scientists remains unclearly defined and has not been operationalised (Hackett, 2002; Pimple, 2002; Weil, 2002). As previously noted, one response to some of these public concerns is that governments and scientific bodies are suggesting the increased democratisation of science (Irwin, 2001; Irwin & Wynne, 1996).

A New Ethical Relationship Between Science and Society

In the past two decades a number of authors have called for a new ethical relationship between science and society with an increased science-society interface and greater public participation in science and science governance (Cournand, 1977; Funtowicz & Ravetz, 1993; House of Lords Select Committee on Science and Technology, 2000; Irwin & Wynne, 1996; Lenk, 1983; Nicholas, 1999b; Petrinovich, 1999; Ravetz, 2006; Walter & Richards, 1998; Ziman, 1998, 2001). Prominent scientists have been warning of the dangers of powerful new technologies since the 1950s, and urging a precautionary approach to technological development and use (Abelson, 1970; Allhoff, 2009; Bradshaw & Bekoff, 2001; Commoner, 1966; Costanza, 1989; Dainton, 1971; Joy, 2000; Rotblat, 1999; Russell & Einstein, 1955; Sakharov, 1981; Ziman, 2001).

Science is the pursuit of knowledge about the natural world and the social world. Technology is the application of scientific knowledge for the purpose of manipulating and controlling the natural and social worlds. Science and technology are socially embedded practices. Ethics is the analysis of human actions and practices in order to determine their rightness or wrongness, particularly in relation to moral principles, duties, obligations, and rights. Technology extends the range of possible human actions and practices (Heidegger, 1977; Jonas, 1985; Luppicini, 2008). Therefore, the practice of science and technology by scientists and technologists, and their use and application by society are open to ethical analysis and evaluation.

As science penetrates deeper into the mysteries of nature, and the power of technology to manipulate and control physical and social reality increases, the social and moral consequences of technology become more ubiquitous and far reaching throughout space, time and society (Cournand, 1977; Lenk, 1983; Luppicini, 2008; Moor, 2005; Small & Jollands, 2006; Ziman, 1998). As a consequence, many scholars have argued that the resulting technological extension of the scope of the effects of human action warrants an extended ethic concerned with the future of humankind, other creatures dependent on human power, and the dignity of nature (Bunge, 1977; Jonas, 1985; Lenk, 1983; Petrinovich, 1999; Potter, 1971; Small & Jollands, 2006).

Scientists, as the discoverers of scientific knowledge and the inventors of technology are an essential component of the science society interface. Scholars have proposed that as science and technology increase in power, scientists have correspondingly increased social responsibility to society, including foresighting the possible implications for society and engaging with the public about the governance of science and the acceptable applications of scientific knowledge and technology (Bradshaw & Bekoff, 2001; Cournand, 1977; Cournand & Meyer, 1976; Jonas, 1985; Lenk, 1983; Lubchenco, 1998; Rotblat, 1999; Russell & Einstein, 1955; Sakharov, 1981; Small & Mallon, 2006; Ziman, 1998). As Petronovich (1999, p. 6) states: "Proactive discussions of the moral implications of developing technologies must take place before political, commercial, and legal imperatives force society to seek quick moral fixes."

Kenneth Pimple (2002) in an effort to provide a comprehensive organising scheme for the responsible conduct of research (RCR) claimed that three important questions need to be asked regarding the ethics of a research project or product: "(A) Is it true? (B) Is it fair? (C) Is it wise? To answer these questions he identifies six domains of research ethics: scientific integrity (is it true); collegiality, protection of human subjects, animal welfare, and institutional integrity (is it fair?) and social responsibility (is it wise?). Pimple notes that the Core Instructional Areas identified by the U.S. Public Health Service do not address the question of scientists' responsibilities to the larger society (i.e., is it wise?). Along with others (e.g., Cournand, 1977; Hackett, 2002; Prpic, 1998; Weil, 2002; Ziman, 1998), he noted that this issue has received far less attention than ethical issues internal to the practice of science.

Pimple (2002), considering the reasons for this "disturbing gap" (p. 198) claimed: "there is no consensus on the social responsibility of science or scientists (aside from those considerations covered by the other five domains, such as basic competence and truthfulness)" (p. 198). He observed that addressing social responsibility is complicated by the fact that while the other five domains "focus on what an individual scientist can do….no scientist is responsible for setting the research agenda for the nation or the world" (p. 198). Nonetheless, he pointed out that while "no one scientist can bear the burden alone, it is true that each scientist has an obligation to carry some part of the burden…. clearly science as an institution and scientists as a group do have such a moral obligation" (p. 198).

The aim of the current work is to shed some light on this under researched area and address Pimple's "disturbing gap." This is done by examining scientists' attitudes, values and beliefs about the nature of the science community's social and moral responsibilities to society, and scientists' personal social and moral responsibilities regarding technological development and application by society. Additionally, the related STS studies constructs of scientists' attitudes to the commercialisation of science, their attitudes to the democratisation of science and their belief in technological optimism are examined in the current work.

Empirical Ethics and Post-Normal Science

The original empirical work reported in this thesis is a mixed method study (Tashakkori & Creswell, 2007), that is, it involves both qualitative and quantitative research methods (i.e., Qual-Quant – data from the qualitative research, conducted first, while independently meaningful, also provides an input into the quantitative research). The current work also borders an area of ethics research known as empirical ethics (Borry, Schotsmans, & Dierickx, 2005). Empirical ethics is a recent development in ethics arising primarily from the medical and bioethics fields. The aim of empirical ethics is to use both descriptive and normative approaches to analyse ethical issues, thus adding context sensitivity to the analysis of ethical issues (Musschenga, 2005; van der Scheer & Widdershoven, 2004).

In order to do empirical ethics, methodologies from the social sciences such as qualitative and quantitative research techniques are used to provide scientifically robust descriptive knowledge of the ethical beliefs of a range of interested stakeholders, which, in combination with analytical moral theory, contributes to a normative ethical analysis (Molewijk, Stiggelbout, Otten, Dupuis, & Kievit, 2004; Small, 2007b; van der Scheer & Widdershoven, 2004).

Empirical ethics is one tool that may be used to understand and enhance the science-technology/society interface. It may also be regarded as a science based technique (i.e., an appropriate technology) that may assist with the implementation of Post-Normal Science through the scientific exploration of public attitudes, beliefs and values regarding issues of contention. Post-Normal Science refers to a methodology that involves the inclusion of an extended peer community to engage in dialogue regarding decisions to be made on science issues in which the facts are uncertain, values are in dispute, the stakes are high and decisions urgent (Funtowicz & Ravetz, 1993; Gallopín, Funtowicz, O'Connor, & Ravetz, 2001; Ravetz, 2006). The five identified crises facing Gaia belong to this category.

Research Objectives and Studies Conducted

In the current work two original studies were conducted. The first is a qualitative exploration of the attitudes, values and beliefs of 22 New Zealand scientists regarding their social responsibility in research and the moral role of science in society. While the primary focus was on the construct of social responsibility in research, because two thirds of participants were genetic engineers, and the the other had conducted research examining the impacts of genetic engineering through their own disciplinary lens, the issue of social responsibility regarding gene technology was a secondary, specific technological focus. The objectives of Study 1 were:

Objective 1a) *To ascertain what scientists understand as being their wider social and moral responsibilities to society in research and technological development (i.e., to map the domain of scientific social responsibility from the perspective of the scientist) and to explicate the moral reasoning processes scientists use to determine and navigate these responsibilities. Gene technologies provided a focus for examples and discussion.*

Objective 1b) *To obtain information to propose items for the development of new instruments to measure scientists' attitudes to social responsibility in research (the instruments will be refined and further developed in Study 2). The first social responsibility instrument measures scientists' awareness of the moral role and responsibilities of the institution of science to society (moral awareness). The second social responsibility instrument measures scientists' attitudes to their personal social responsibilities to society when conducting scientific research (moral judgment). Additionally, information for items for the development of two other new instruments, to measure the related constructs of attitudes to the democratisation and commercialisation of science, was also sought. These instruments formed part of a nomological network designed to help infer their construct validity.*

Objective 1a is intended to address the nature (domain) of scientists' social responsibilities, about which Pimple (2002) claimed there was no consensus. Some data from Study 1 have been previously published at academic conferences (Small, 2008, 2009; Small & Mallon, 2004), and in a peer reviewed journal (Small & Mallon, 2006). The focus of Small and Mallon's (2004, 2006) work was on commercialisation of science, democratisation of science and public trust in science. The focus of Small's (2008, 2009) work was on the responsibility of science to society and scientists' social responsibility.

The second original study is a quantitative survey of New Zealand scientists' (N = 733) attitudes, values and beliefs regarding personal moral responsibility and the ethical responsibilities of the science community with particular reference to the Promethean technology of gene science. Study 2 examined the scale items proposed in Study 1 and tested the psychometric properties of the two new instrument developed to measure scientists' attitudes to social responsibility in research, and the new instruments to measure the related constructs of scientists' attitudes to the democratisation of science, and the commercialisation of science. A fifth new instrument, designed to measure scientists' degree of technological optimism and also be part of the nomological network, and was developed in Study 2 with items derived from academic literature. Study 2 included testing hypothesised relationships between these five related constructs, Schwartz's (1992) four higher-order value dimensions, and general attitudes to genetic engineering (Small, et al., 2005). These ten constructs formed a nomological network and a partial theory of scientific social responsibility.

The primary objectives of Study 2 were:

Objective 2a) *To refine and develop the proposed items into psychometrically robust research instruments and use them to measure: scientists' attitudes to social responsibility in the practice of scientific research and technological development, and scientists' attitudes to constructs that are hypothesised to be related to these attitudes as antecedent variables (i.e., personal value orientation and technological optimism) and as consequent variables (attitude to the democratisation of science, and attitude to the commercialisation of science).*

Objective 2b) *To test the construct validity of the new instruments by embedding them in a nomological network of hypothesised relationships between the various constructs and testing these hypotheses.*

The survey also measured scientists' general moral attitude towards a particular set of Promethean technologies, genetic engineering (GE) - a subset of gene technologies. An instrument developed by Small et al. (2005) was used for this purpose. This instrument is used as a concurrent criterion in the nomological network. At the same time as the scientists' survey was conducted, a survey of the New Zealand public measured their general moral attitude to GE using the same instrument (Small, 2005a). Thus, the second study also briefly compares New Zealand scientists' moral attitudes to GE with those of the New Zealand public. The secondary objectives of Study 2 were:

Objective 2c) *To measure and explicate New Zealand scientists' moral attitude to GE and its relationship to their attitude to social responsibility.*

Objective 2d) *To compare moral attitudes to GE between the New Zealand public and New Zealand scientists.*

The following schematic, Figure 1.1, gives an overview of the primary research constructs and their hypothesised antecedent and consequent relationships. Specific hypotheses comprising the nomological network, along with their rationales are proposed in later chapters. Some data from the Study 2 survey have been previously published at academic conferences (Small, 2005b, 2006, 2007a; Small & Botha, 2006).

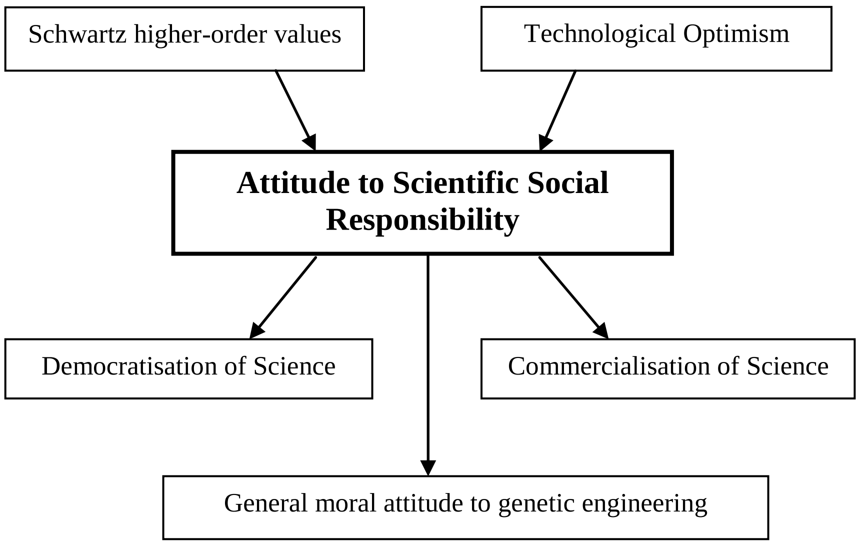

Figure 1.1. Social responsibility in scientific research: antecedent and consequent variables studied in this thesis.

Thesis Overview

This is a thesis conducted in the interdisciplinary field of Science, Technology and Society Studies (STS). It has philosophical, psychological and empirical ethics components. Chapter 1, through a discussion of some potential social and ecological crises arising from human use of technology, has argued a need for an extended ethic regarding the development of Promethean technologies. Evidence of public concern regarding the moral consequences of science and technology has also been presented. Environmental impacts and social justice were identified as primary areas of social and moral concern for responsible science. The original empirical research to be presented in the current work has been briefly outlined above. Below is a chapter-by-chapter overview of the thesis.

Chapter 2 provides an overview of the potential of one Promethean science: gene technology. This chapter considers some of the technologies and applications that are currently emerging from modern gene science, touching on some of the ethical issues that are raised, and indicating the vast potential gene technology has for social and moral impacts on society. This reinforces the need, established in Chapter 1, for an extended ethic of social and moral responsibility for scientists, and provides background knowledge for Studies 1 and 2, which include investigation of scientists' attitudes to gene science and genetic engineering.

Chapter 3 presents a literature overview of philosophical theories relevant to the examination of social responsibility including normative moral theories, meta-ethical theories, and relevant applied ethics fields, such as environmental ethics, bioethics and technoethics. Next, some concepts necessary to the understanding of social responsibility in an age of Promethean technologies are explicated. These are: existential risk, the precautionary principle and, technological optimism. Then, psychological theories of ethical behaviour, with a particular focus on cognitive moral development and personal value orientation are discussed. In particular, Kohlberg (1969) and Rest's (1979, 1986) theories of moral development and behaviour, and Schwartz's (1992) theory of the structure of human values, are reviewed and the relationship of the four higher-order value dimensions to scientists' attitudes to social responsibility in research is examined. Fifteen experimental hypotheses forming part of the nomological network are proposed in Chapter 3.

Chapter 4 reviews the theoretical and empirical literature regarding scientists' social responsibilities in research and technological development. First, the perspectives of some eminent physicists, physicians and ecologists regarding the need for an extended ethic of social responsibility for scientists are surveyed, and the historical 'code of scientists' reviewed. Then, the few empirical studies investigating scientists' attitudes to their wider social responsibilities are reviewed. A further fifteen experimental hypotheses forming part of the nomological network are proposed in Chapter 4.

Chapter 5 considers some methodological issues regarding the development of the new instruments, the concept of nomological networks and their use in the construct validation of psychometric instruments and related theory is explicated. Next, an additional nine hypotheses which describe the relationships between the five new research instruments, the four higher-order Schwartz value dimensions, and the concurrent criterion, general attitude to genetic engineering, are proposed.

This gives a total of 39 hypotheses which comprise and complete the relationships in the nomological network. Then, the research model is visually explicated through a series of diagrams showing the relationships between the various research constructs. Finally, some philosophical, methodological and reporting issues relevant to mixed methods research are discussed, with a primary focus on qualitative research.

Chapter 6 is Study 1, the qualitative investigation of scientists' beliefs about the social and moral role of science and scientists in scientific research and technological development. This study involved in-depth interviews with 22 New Zealand scientists and provides rich descriptions of their beliefs, their concerns and conflicting insights about social responsibility and some aspects of gene technology. Thematic analysis is used to develop a framework for the domain of scientific social responsibility. Study 1 also examines the participating scientists' moral reasoning processes about social responsibility and aspects of gene technology. Extensive quotes are employed to tell the story in their own words and, where applicable, due to the high functioning intellect of the participants, to analyse their own perceptions and some of their conflicting attitudes, values and beliefs.

Chapter 7 is Study 2, the quantitative study of scientists' attitudes to social responsibility in research and the related constructs of personal values, technological optimism, commercialisation of science, democratisation of science, and attitudes to genetic engineering. In this chapter five new instruments are developed and their psychometric properties analysed: first exploratory factor analysis was used to select instrument items and then confirmatory factor analysis was used to refine item selection and test scale dimensionality. In the final stage of instrument development, reliability analyses were conducted. Next, the attitudes, beliefs and values of scientists regarding social responsibility, technological optimism, commercialisation of science, and democratisation of science, as measured by the new instruments, are briefly explicated. Additionally, their attitude to GE was examined and compared with the attitude of the New Zealand public.

Chapter 8 draws conclusions, notes study strengths and limitations, and suggests areas for further research. To conclude the Introduction, an extensive passage from Jane Lubchenco's 1997 Presidential Address to the American Association for the Advancement of Science (AAAS), is quoted. This passage from Lubchenco eloquently and authoritatively summarises the rationale for the current research.

I see the need for a different perspective on how the sciences can and should advance and also return benefit to society. This different perspective is firmly embedded in the knowledge of specific, identifiable changes occurring in the natural and social worlds around us. These changes are so vast, so pervasive, and so important that they require our immediate attention….

[W]e now live on a human-dominated planet. The growth of the human population and the growth in amount of resources used are altering Earth in unprecedented ways….The resulting changes [to the natural world] are relatively well documented but not generally appreciated in their totality, magnitude, or implications….

We are modifying physical, chemical, and biological systems in new ways, at faster rates, and over larger spatial scales than ever recorded on Earth. Humans have unwittingly embarked upon a grand experiment with our planet. The outcome of this experiment is unknown, but has profound implications for all of life on Earth….

The challenges for society are formidable and will require substantial information, knowledge, wisdom, and energy from the scientific community. Business as usual will not suffice…. Although these services [ecosystem services] are essential to human societies, their continued existence has been taken for granted. Never before have human actions so threatened their provision….

Science is the pursuit of knowledge about how the world works, a pursuit with an established process for inquiry, logic, and validation. Scientists engage in science because we are curious about why things are the way they are, we relish the fun and challenges of problem-solving, and we wish to contribute something useful to current and future generations. Society supports science because doing so in the past has brought benefits and doing so now is expected to provide more. Traditional roles of science have been to discover, communicate, apply knowledge, and to train the next generation of scientists….

A different application of scientific knowledge is emerging as equally important in today's world: knowledge to inform policy and management decisions…. Many of the choices facing society are moral and ethical ones, and scientific information can inform them. Science does not provide the solutions, but it can help understand the consequences of different choices….

It is time for the scientific community to take responsibility for the contributions required to address the environmental and social problems before us, problems that, with the best intentions in the world, we have nonetheless helped to create. It is time for a re-examination of the agendas and definitions of the "grand problems" in various scientific disciplines.

We can no longer afford to have the environment be accorded marginal status on our agendas. The environment is not a marginal issue, it is **the** issue of the future, and the future is here now. On behalf of the Board of AAAS, I invite you to participate vigorously in exploring the relationship between science and society and in considering a new Social Contract for Science as we enter the Century of the Environment. (Lubchenco, 1998, pp. 491-497)

Chapter 2 – Gene Science: A Promethean Technology

Our knowledge and ability to control biological processes, of our own and other species, has increased dramatically in the past 100 years. Knowledge and technologies from physics and chemistry provided the tools to investigate biological processes at a molecular and atomic level. Evolutionary theory, Mendel's laws of inheritance, the discovery of DNA, the mapping of the human genome, genetic engineering, gene therapy, genetic enhancement, cloning, stem cell therapies, epigenetics, synthetic biology and life extension research, offer powerful new insights into the nature of life, and the development of technologies to manipulate living organisms.

Although genetic technologies are here considered as the prime example of a Promethean technology, it is only one of a set of similarly powerful technologies with potential for significant physical, ecological, social and moral impacts on Gaia. Some of these technologies will enable us to change not only the world but also our own nature; they are heralded as issuing in the age of transhumanism and the rise of the posthuman (Kurzweil, 1999; Vinge, 1993; Warwick, n.d.). Bostrom (2003, What is Transhumanism? Para. 1) defined transhumanism as "The intellectual and cultural movement that affirms the possibility and desirability of fundamentally improving the human condition through applied reason, especially by developing and making widely available technologies to eliminate aging and to greatly enhance human intellectual, physical, and psychological capacities."

The Human Genome Project

The first draft of the human genome (90% complete) was published in 2001 and the full sequence completed and published in 2003. The Human Genome Project (HGP) achieved three major goals. First, it sequenced the order of all the 2.9 billion base pairs in the genome. Second, it developed maps locating genes for major sections of all our chromosomes. Third, it produced 'linkage maps' enabling inherited traits to be tracked over generations. Francis Collins, the director of the HGP described the results and meaning of the project:

> It's a history book - a narrative of the journey of our species through time. It's a shop manual, with an incredibly detailed blueprint for building every human cell. And it's a transformative textbook of medicine, with insights that will give health care providers immense new powers to treat, prevent and cure disease. (Cited by National Human Genome Research Institute, 2009, para. 6)

It took ten years and cost more than $US1 billion to sequence the first human genome. The project was expected to take much longer. However, the development of new technologies enabled its early completion. Since the project first began in 1993 the science and technology to sequence genomes has undergone exponential development (Margulies, et al., 2005). Recently, a Californian company, Complete Genomics, sequenced another human genome for $US1,700 in less than a week (Fox, 2009). Sequencing the genome only marks a beginning – it will take many decades (and massive computer power) to understand how the approximately 20,500 genes in the human genome (National Human Genome Research Institute, 2009) interact with one another to produce over two hundred thousand different proteins (Gribbin, 2002).

It is important to note that a great deal is still not understood about how the genome actually works. For example, contrary to the last hundred years of scientific belief, it has recently been shown that Mendel's Laws, while fundamentally correct, are not absolute and exceptions occur (Lolle, Victor, Young, & Pruitt, 2005). The concept of inherited acquired characteristics was, for a long time, considered biological and scientific heresy, but the new science of epigenetics provides evidence of a Lamarkian mechanism for the inheritance of phenotypic characteristics (Jablonka & Raz, 2009). A dozen years ago molecular biologists designated long stretches of organisms' genomes as 'junk DNA' claiming that these non-coding segments served no purpose. Recent research has shown important roles for 'junk DNA' (Nowacki, et al., 2009), demonstrating the hubris of this assumption. It now appears that 'junk DNA' plays a vital role in evolution (in particular enabling the fast genetic adaptation to changing environmental circumstances) and it will be crucial for the refining of GE techniques and for gene therapy (Feng, Naiman, & Cooper, 2009; Vinces, Legendre, Caldara, Hagihara, & Verstrepen, 2009). New evidence also suggests that the recombinant DNA repeats (rDNA), previously thought of as 'junk DNA' are essential for repairing the damage caused by factors such as UV light (Ide, Miyazaki, Maki, & Kobayashi, 2010).

Individual genomic sequencing could soon become a routine part of medical care as the technology becomes faster and cheaper. Genomic sequencing will eventually be a useful tool for medical diagnosis, prognosis and pharmacological prescription. Pharmacogenomics is a new science at the intersection of pharmaceuticals and genomics which studies the interaction between individual genetics and the body's reaction to drugs. In the future, drugs could be tailored to individual needs based upon a person's own genetic makeup (Human Genome Project Information, 2008).

Ethical issues around individual genomic sequencing include privacy of the sequenced individual's data, adequacy of consent, stereotyping and stigmatisation, inclusion and differential benefits, and cultural and community-specific concerns (Foster & Sharp, 2006). Concerns exist regarding ownership of the genome and the question of who may have access to the information and what use they may make of it. For example, if potential employers or insurance companies have access to the data, employment opportunities may be denied and insurance cover rejected, if the genomic information indicates a predisposition to debilitating or deadly conditions such as cancer, Parkinson's disease etc. (Robertson, 2003).

Another important issue with implications for the practice of science, the dissemination of scientific knowledge, and for medical practice, is the question of patenting genes and gene sequences (Schacht, 2006). Many companies that have discovered the function of a particular gene have lodged patent applications over the genes (Ho, 2000). In the year 2000, over 6000 gene patents had been granted with over 1000 of these specifically related to human genes and more than 20,000 gene patents were pending at that time (Grisham, 2000).

While commercial biotech companies are strongly in favour of being able to patent genes, claiming that it is necessary in order to fund research and innovation (Schacht, 2006), many scientists and scientific bodies are opposed. Some in the research community claims that patenting slows the progress of science by restricting open access and use of the genes in further research (Andrews, 2002; Small & Mallon, 2006). Physicians and patients also claim that patenting of genes restricts patients' access to medical care (Leonard, 2002; Wadman, 2010). Others are strongly opposed to patenting genes on the principle that 'no one should be able to patent life' and that genes are products of nature and are merely discovered by humans and, therefore, should not be patentable (Ho, 2000; Wadman, 2010). Some object that the 'patenting of life' "turns organisms, including human parts, into saleable commodities" (Ho, 2000, p. 30). The topic of gene patenting remains controversial and undecided from a legal perspective (Wadman, 2010). The patenting of genes will continue to pose legal, social, moral and economic issues for some time to come.

Fertility

Technology is helping us control the fertility of our own and other species. On one hand, 20th Century contraceptive technologies enabled infertility when desired, on the other, technologies such as in vitro fertilisation (IVF) help the infertile reproduce. Artificial insemination is common practice in agriculture as are other technologies for the manipulation of reproduction. Amongst humans, egg harvesting and womb rental for surrogacy are becoming more common and generating a host of social and ethical questions (Waldby, 2009). Perhaps one day it will be possible for an embryo to be conceived and grown to full term entirely outside of a female body.

Opening up further new reproductive vistas, researchers have shown that it is possible to produce viable and fertile bi-maternal mice – that is, mice which share the genes of two mothers – with no paternal input (Kawahara, et al., 2007). Bi-maternal mice are smaller, lighter in weight, have a stronger immune system and live up to a third longer than male/female mice offspring (Kawahara & Kono, 2009). In the future, this technology applied to humans could make males redundant, and the resulting humans may be genetically superior.

Gene Technologies

Genetic engineering

The breeding of promising individuals over generations in order to create desirable phenotypic characteristics in plants and animals has long been practiced in horticulture and animal husbandry. This is a relatively slow process with progressive changes made over many generations, not by nature or natural selection, but by human intervention in the evolutionary progress of the species. Racehorses, dogs and the staple grains are prime examples of centuries and even millennia of breeding to slowly bend nature to the aesthetic tastes and teleological desires of humans (Silver, 1998).

With the discovery of recombinant DNA technology, humans have gained the power to make changes to an organism’s genome in a single generation. Genetic engineering (GE) involves the chemical addition or deletion of a specific gene from an organism’s genome in order to bring about a desired change in the organism’s phenotype. With this process, organisms can have current characteristics enhanced or removed and even entirely new characteristics, not naturally evident in the organism’s species, added. Thus, a gene from one species (or a synthetic analogue of the gene) may be spliced into the genome of the same or a different species, or even an organism from a different biological kingdom, giving the new GE organism phenotypic characteristics from the donor species (Silver, 1998; Small, 2004a, 2004b).

In this way GE can create organisms with desired attributes much more quickly than through traditional breeding (i.e. in a single generation). This amounts to a speeding up of evolution in a direction decided by humans. This also differs from normal evolution, and animal and plant husbandry, in that the new organism does not co-evolve over time with the other organisms in its environment. Another difference between GE and selective breeding is that organisms can be created that could not possibly have come about naturally, as organisms generally cannot breed with others from different species or kingdoms.

Proponents see great hope for the common good of humanity in GE technology, and often claim that the technology will be needed to produce enough food to feed the future world population (Borlaug, 1997; Fedoroff, et al., 2010; Ortiz, 1998). A recent report by the British Royal Society claimed that the world needs genetically engineered crops to minimise environmental impacts and increase food yields to meet the challenge of feeding another 2.3 billion people by 2050 (The Royal Society, 2009). Another recent article in the journal *Science*, makes similar claims (Fedoroff, et al., 2010). Noting that many important crops have sharp declines in production (20-30%) once the temperature exceeds 30 degrees Celsius, they claimed global warming will drastically reduce production in tropical and sub-tropical zones by the mid-21st Century causing food scarcity.

Both groups of scientists believed a radical rethink of agriculture is required to develop crops that are heat, salt and drought tolerant and that do not need the current high levels of chemicals and fertilisers. Genetic engineering is their preferred radical strategy. They claimed GE will be necessary in order to produce crops at current production levels, let alone the production levels required for an increasing population by 2050 (Fedoroff, et al., 2010; The Royal Society, 2009). Given the likelihood of significant future temperature increases, water shortages, salinity and degraded soil conditions in many of the world's major growing regions (Brown, 2008), genetic engineering appeals to these advocates as an appropriate research strategy to enable continued production of major crops in changing environments.

Advocates of GE claim that the technology is safe. In 2008, GE crops were grown on 300 million acres worldwide. It is claimed that GE crops have been consumed for over 13 years without any incident (Fedoroff, et al., 2010). Furthermore, production has increased and so have farmers' profits, while pesticide and herbicide use has been reduced and the use of no-till method of agriculture (helpful for reducing soil erosion) increased (Fedoroff, et al., 2010).

GE may also be able to increase the effectiveness of plants to extract necessary minerals for growth (such as nitrogen and phosphorus) enabling them to be grown on poorer quality soils using less fertiliser (West, 2010). One concern associated with these types of changes is that these alterations improve the fitness of plants, and if these new super-fit traits were to spread to weedy relatives, through horizontal gene transfer, super-weeds could also result.

Another beneficial potential of GE is the enhancement of nutritional qualities of crops. For example, the much heralded golden rice is engineered to contain extra beta-carotene which converts to vitamin A when consumed by humans; many people in developing countries, where rice is the primary staple, suffer from vitamin A deficiency (Tang, Qin, Dolnikowski, Russell, & Grusak, 2009). Foods with genetically enhanced health qualities or with healthy additives are referred to as functional foods and the science of developing them and studying the relationship between food plant genes, health and the individual human genome is called nutrigenomics.

Currently GE is being used to engineer micro-organisms and bacteria (particularly for the production of medicines such as insulin, factor 9 clotting agent, human growth hormone, etc.), plants and animals for both food production and the production of medicines (Small, 2004b). An example of a potential GE food animal is the 'eco-friendly' GE pig, engineered to contain bacteria which help pigs remove phosphate from their food, thus stopping it from passing through into the environment where it causes harm to life in streams and rivers (Golovan, et al., 2001). Pigs have also been genetically engineered, for medical purposes, to contain human genes so that their organs will not provoke such a strong immune system rejection when used for xenotransplantation - the replacement of failing human organs with those from animals (White, Langford, Cozzi, & Young, 1995).

Genetic engineering for medical purposes is considerably more acceptable to the general public than GE of food crops (Frewer & Shepherd, 1995; Hamstra & Smink, 1996; Small, et al., 2005). 'Farmaceuticals' is the term given to medicines produced by GE plants or animals. It is hoped that numerous medicines will be able to be grown in plants and/or animals and refined more cheaply than through current techniques (Giddings, Allison, Brooks, & Carter, 2000). A biotech company, SemBioSys, has submitted an Investigational New Drug application for safflower-produced recombinant human insulin to the U.S. FDA (SemBioSys, 2008). Phase I and II clinical were initiated in December 2008. Edible vaccines (e.g., potatoes, tomatoes, bananas etc) are being developed for a range of diseases (e.g., cholera, measles, malaria, hepatitis B, type 1 diabetes etc) and are proposed as a logistically simpler resolution of the problem of getting vaccines to those in need in developing countries (Chowdhury & Bagasra, 2007; Levi, 2000).

In New Zealand, AgResearch Ltd has created GE cows containing a synthetic copy of the human myelin basic protein gene (hMBP). The aim of this research was the production of hMBP in the cows' milk in order to produce a reagent for research into the treatment of multiple sclerosis (Fisher, Small, Roth, Mallon, & Jerebine, 2005; Small & Fisher, 2005). Silk worms have also been genetically engineered so that they produce a form of the human protein collagen which scientists hope to harvest for applications such as artificial skin and wound dressings (Tomita, et al., 2003).

The industrial sector also contains many potential applications for GE technology in terms of new methods of producing currently available materials, new materials with desirable qualities, and the production of chemicals and biofuels. For example, spider silk is stronger than steel and as resilient as kevlar, but it is very expensive to produce. Scientist have placed artificial versions of silk genes in various plants (potatoes, tobacco) and animals (goats) and, using this technology, hope to be able to mass produce silk protein for the development of new biodegradable 'super-materials' (Scheller, Guhrs, Grosse, & Conrad, 2001). Gene-engineered viruses have even been used to help manufacture a 'green' battery which the authors claim is capable of powering an iPod for three times as long as current iPod batteries (Lee, et al., 2009).

While GE technology offers the potential to alleviate some current threats to humanity, critical commentators express ethical concerns about potential negative consequences of the practice of GE: the potential to develop dangerous organisms, the impossibility of reversibility once such organisms are lose in the environment, and the potential for negative impacts on humans, other animals and the environment (Antoniou, 1996; Fox, 1999; Ho, 2000; Rifkin, 1998; Straughan, 1995b). Others criticise the technology from a deontological moral perspective; creating life is the province of 'God' or nature – human attempts to usurp the role of God or nature are seen as committing acts of hubris – against God or nature (Appleby, 1999; Straughan, 1995a).

Of particular concern to some is the possibility of human-animal chimeras (Robert & Baylis, 2003). They imagined a fusion between a chimp and a human. Robert and Baylis suggested that there might be confusion over the status of such a creature and that it might lead to social disorder. Savulescu (2003), on the other hand, argued that there might be good reasons to create human chimeras. He suggested medical reasons (e.g., to confer resistance to specific diseases such as AIDS), to delay aging, or to enhance human capabilities (e.g., he suggests, elephant genes to improve memory, owl genes to enhance night vision or bat genes for the sense of sonar). Clearly, a range of ethical questions are opened by the creation of chimeras and, undoubtedly, there will be a range of different responses to these questions.

Gene therapy

It may be possible to treat human genetic disorders through GE and a related technology, gene therapy. GE is conducted on eggs or embryos whereas gene therapy is a technique that may be used to change the genome (germ-line cells i.e., eggs or sperm) or the somatic cells of particular organs (in vitro or in vivo) of a developing or already developed organism. Changes made to somatic cells using gene therapy are not inherited by the organism's descendants (Gene Therapy Net, 2010). Gene therapy modifications, when conducted on germ-line cells, are inherited by the organism's descendants. Gene therapy uses a vector (most usually a disabled virus) to 'infect' target cells with the desired gene. Genetic engineering has successfully produced germ-line changes in marmoset monkeys – that is, the genetic change was inherited by the organism's descendants (Sasaki, et al., 2009). Using such techniques hereditary diseases could be cured and eliminated from the germ-line and the disease potentially eliminated from a species (Gene Therapy Net, 2010).

Gene therapy was successfully used to give colour vision to naturally colour-blind monkeys (Mancuso, et al., 2009), thus suggesting similar correction or enhancements to human senses using gene therapy may be possible. Gene therapy succeeded in curing, amongst other things, cases of 'bubble boy syndrome', a progressive degenerative disease of vision called Leber congenital amaurosis, and a cancer of the blood called EBV lymphoma (Neimark, 2009). The gene therapy drug ProSavin has been found effective for treating a monkey analogue of Parkinson's disease and is currently being trialled with human subjects (Jarraya, et al., 2009).

Some advocates believe gene therapy or GE might help cure a number of deadly hereditary diseases including cystic fibrosis, haemophilia, Tay-Sachs, muscular dystrophy, multiple sclerosis and diabetes. Gene therapy may also be used to activate the immune system against infectious diseases and cancers and to trick the body into growing new tissue to heal wounds, repair injured hearts and rejuvenate arthritic joints (Neimark, 2009).

Genetic enhancement

Beside therapeutic GE there is also the possibility of using GE to enhance humans. Naturally occurring doubled muscled cattle (e.g., Belgium Blue) have 20% extra muscle mass. This is known to be caused by a mutation on bovine MSTN, the myostatin coding gene (Grobet, et al., 1997). Scientists have been able to create double muscled GE myostatin knockout mice (McPherron, Lawler, & Lee, 1997). These mice have muscles 2-3 times heavier than normal mice. While extremely rare in humans, at least two children are known to have this mutation naturally, exhibiting exceptional strength and speed (Associated Press, 2007; Schuelke, et al., 2004). This suggests a gene target for super-athletes and perhaps super-soldiers.

Several genes have been discovered in mice which, when manipulated by GE, improve brain performance by stimulating nerve fibre growth, enhancing problem solving and memory (Routtenberg, Cantallops, Zaffuto, Serrano, & Namgung, 2000). Between 40-80% of variation in human intelligence is believed attributable to genetic factors. A genome-wide scan, involving 634 sibling pairs, identified two chromosomal regions (on chromosomes 2 and 6) that explain variation in IQ (Posthuma, et al., 2005). These genes, and the proteins they code for, offer clues to increasing the intellectual potential of humans or ameliorating the effects of diseases such as Parkinson’s, Alzheimer’s, autism and dyslexia.

While considerable moral debate is associated with therapeutic GE (i.e., curing disease), enhancement gene technologies create even greater moral concern for most people. Approximately 80% of New Zealand public and a similar percentage of New Zealand scientists either disagreed or strongly disagreed that it is acceptable to genetically engineer humans in order to enhance human capabilities (Small, 2006). However, some ethicists argue that, if we can enhance humans in ways that promote human wellbeing, then we have a moral obligation to do so (Savulescu, 2005). Savulescu (2005) cites gene therapy experiments that turned lazy monkeys into workaholics and promiscuous rodents into monogamous ones.

Clearly there may be debate about what counts as an enhancement, and the line between therapy and enhancement is easy to blur. Another concern regarding enhancement is: who gets it? Those who can afford it? If so, does this mean the wealthy will become a new and different type of human from the poor, thus enhancing human inequality at the genetic level? Will we evolve (under human direction) into multiple separate species, unable to breed with each other? Given the tensions that exist between races, what kind of tensions might exist between separate species descended from Homo sapiens? Clearly, a range of legal, ethical and social issues confront genetic enhancement.

Given the historical disregard of molecular biologists for "junk DNA" and our current lack of understanding of how genes interact with one another to form a multitude of proteins, expert assessments of the nature of genetic enhancement might also be deluded. Human efforts to 'improve humanity' may well do more damage to our species than good. Of course, future knowledge may palliate or even eliminate the threat of lack of knowledge. However, completely understanding the human genome may take some time yet – with approximately 2.9 billion 'letters' the possible combinations and interactions within the genome are astronomical. It will be beyond human intellectual capacity – but perhaps not beyond the capacity of super-intelligent machines.

Conscious evolution or eugenics?

One issue arising from gene therapy, genetic enhancement and behavioural genetics is the historically sinister shadow of eugenics. Eugenics "requires that natural selection be replaced by intentional human control" (Hansen, Janz, & Sobsey, 2008, p. S105). It is clear that human command of medicine and gene technology now gives us the power to consciously (or unconsciously) manipulate the evolution of our species. The question is: should we do it, or is it too much of an ethical and perhaps epistemological and ontological minefield? Some specific issues which would require prior resolution include:

- What might be the unintentional effects of such tinkering with human nature?
- If we do it, on what medical, social, legal, financial, bases should it be done?
- Should individuals be free to design their own offspring and, if so, what degree of freedom should be allowed? (e.g., should blind or deaf parents be allowed to genetically engineer their children to be blind or deaf?)
- What are the rights of genetically engineered children?
- Who is allowed to make decisions for them and by what authority?

Behavioural genetics

DeCamp and Sugarman (2004) discussed ethical concerns regarding behavioural genetics. This research field attempts to explain the role of genes in causing human behaviour as diverse as personality, intelligence, memory, fear and addiction. Behavioural genetics techniques are being used to research psychiatric illness with significant genetic discoveries published in regard to autism, schizophrenia, dementia and depression (DeCamp & Sugarman, 2004). DeCamp and Sugarman identified two major areas of ethical issues in regard to behavioural genetics: “the conduct of behavioural genetics research; and the applications of its research findings” (p. 27).

These might, respectively, be considered to be the internal research integrity and the wider, societal issues regarding ethical and socially responsible application of research results and technologies. DeCamp and Sugarman posed the following question regarding the socially responsible application of behavioural genetics “how might a genetic basis for behaviour change societal notions of responsibility and accountability?” (DeCamp & Sugarman, 2004, p. 28).

DeCamp and Sugarman (2004, p. 29) attribute the need to raise such questions to “the power of post-HGP techniques to yield insight into the complexities of human behaviour and disease”. They point out that Institutional Review Boards (IRBs – U.S. ethical research committees) are specifically prohibited from considering the long-range effects of applying knowledge gained from research. Summarising their conclusion, DeCamp and Sugarman claimed:

> While some of the ethical concerns in the latter category [ethical and social responsibility regarding research applications] are likely to be of substantial importance and animate considerable popular concern, they currently fall outside the realm of traditional research review. *Determining how to deal with these concerns should be a focus of future scholarly work* (emphasis added). (2004, p. 27)

Cloning and stem cells

Reproductive and therapeutic cloning is a process that asexually makes a genetically (nearly) identical twin or copy of an organism. In the process of somatic cell nuclear transfer (SCNT) the DNA nucleus from a female egg (oocyte) is removed and replaced with the DNA nucleus taken from a somatic cell of a donor. If the process works (failure rates are currently very high) the cell starts dividing and forms a blastocyst (i.e., early stage embryo where all cells are still pluripotent stem cells) (Human Genome Project Information, 2009).

In the case of reproductive cloning the blastocyst is transferred into the uterus of a surrogate mother and born in the standard way, similar to the in vitro fertilisation (IVF) process. In the case of therapeutic cloning the pluripotent stem cells are extracted from the blastocyst (thus destroying it) and the stem cells cultured and multiplied in vitro. Pluripotent stem cells are immortal and capable of turning into any of the different types of cells from which the body is made (Human Genome Project Information, 2009).

The medical potential of stem cells is significant - they may be used to repair damaged organs or, perhaps even, be used to grow replacement organs (e.g., heart, kidney, liver, bladder, skin, cartilage, etc.) for the donor, thereby ensuring there will be no immune system rejection (Mooney & Mikos, 1999). Tissue engineering, as this branch of science is called, has already had some successes. New bladders have been grown on collagen scaffolds from patients' own bladder cells and implanted in the patient with successful function (Atala, Bauer, Soker, Yoo, & Retik, 2006).

On a non-medical tangent, biologists are experimenting with similar techniques to culture muscle cells, in vitro, into processed meat for human consumption; effectively meat without animals (Datar & Betti, 2010). Factories producing meat in this manner could have environmental benefits reclaiming land from agricultural production as well as health benefits by increasing the omega 3 content of cultured meat. For some vegetarians it may resolve their moral prohibition against meat.

It is believed that pluripotent stem cells are a potential cure for many currently incurable diseases or offer better prospects than current treatments. Animal and/or human clinical trials are now underway for a number of conditions including Huntington's disease, Parkinson's disease, Type 1 diabetes mellitus, Celiac disease, cancer, muscle damage, cardiac failure, spinal injury and neurological disorders (Singec, Jandial, Crain, Nikkhah, & Snyder, 2007).

Amongst other things, stem cell therapy has been used in humans to cure some forms of blindness (Graham-Rowe, 2004), treat spinal cord injuries (Kang, et al., 2005), and heart disease (Strauer, Schannwell, & Brehm, 2009). In guinea pigs, deafness has been cured by using stem cells to grow new hair cells in the Organ of Corti in the cochlear (Coghlan, 2005; Izumikawa, et al., 2005) and new teeth have been grown in mice (Yen & Sharpe, 2008), suggesting similar age reversal treatments for humans might be possible.

There is considerable moral resistance to therapeutic cloning and to embryonic stem cells because in order to harvest the stem cell a potential life is destroyed. From a Kantian ethical perspective, an issue that arises regarding embryonic stem cells and therapeutic cloning, even if the blastocyst was not destroyed, is that of using human beings as means rather than treating them as ends in themselves (American Medical Association, 1999; Kant, 1998). Adult stem cells, which are not a potential new life, and may be turned into a restricted range of body cells, are not regarded as raising the same moral issues, but unfortunately do not exhibit pluripotency.

More recently scientists have been learning how to induce somatic cells to revert to pluripotent stem cells (Yu, et al., 2007; Zhou, et al., 2009). Induced pluripotent stem cells (iPS for short) are not considered to be the start of a new organism (i.e., a clone). They are, therefore, not considered to pose the same ethical problems as therapeutic cloning or embryonic stem cells (stem cells harvested from blastocysts created by IVF, or normal sexual reproduction, and hence potentially living organisms). Proof-of-principle experiments in mice have demonstrated the potential of iPS to repair acute myocardial infarction (Nelson, et al., 2009). It is probable that most stem cell therapies will eventually be carried out using adult stem cells or iPS in order to avert the immediate ethical issue of stem cell source.

Reproductive cloning is cloning for the purposes of reproduction or creating a new organism. Currently, many countries, on moral grounds, outlaw human reproductive cloning. Many people feel that it is just wrong (deontologically) to create a 'carbon copy' of an existing human. Some express concern, regarding the possession or lack of a "soul" of a chemically created human clone. The Catholic Church is strongly opposed to cloning. Pope Benedict XVI is cited as claiming "Human cloning is more dangerous than Weapons of Mass Destruction" (Anon, 2004).

Concerns regarding the moral status and potential treatment of human clones - as 'lab rats' or the psychological impacts on the clone of knowing that s/he was created as a 'duplicate' of some other person, give rise to psychological and philosophical issues of identity. The issue of commodification of humans also arises (Ho, 2000). For teleological moralists, questions include: under what circumstances (if any) would reproductive cloning of humans be acceptable?

A major ethical issue regarding human reproductive cloning is the fact that it is not yet safe. While some healthy mammal clones have been born, the vast majority suffer from developmental problems, often resulting in spontaneous abortion, deformity or disability. The successful birth rate of clones implanted in animal surrogates is only between 1-3%. Clones who live to be born often have compromised immune systems, higher rates of infection, increased rates of tumour growth, large offspring syndrome and other debilitating disorders (Human Genome Project Information, 2009).

Given the concerns with safety, and the high probability of developmental problems currently associated with cloning, most scientists consider it immoral to attempt human reproductive cloning at present (Committee On Science Engineering and Public Policy, 2002). In 2001, France and Germany proposed a worldwide ban on reproductive cloning at the UN which has been effective since September 2006 (Arsanjani, 2006). However, the ethicist Strong (2005, p. 45) argued that, if safety issues were resolved, reproductive cloning: "is a form of procreative freedom and, as such, deserves respect." He analysed the arguments against reproductive cloning finding them problematic and concluded that it could be: "ethically justifiable in at least some cases involving infertile couples" (p. 45).

Nonetheless, a number of 'renegade scientists' have stated their ambitions to produce the first human clones – including some involved with the Raelian 'religion' (Rael, 2005). In 2009 Doctor Panayiotis Zavos claimed to have created 14 cloned embryos and transplanted 11 of them into four women. No live births resulted but Zavos stated his intention to continue his efforts (Connor, 2009).

Epigenetics

Normal identical twins have identical genes but may have a different life history. Different environmental experiences can create epigenetic differences between identical twins. A study of identical twins found that 35% of twin pairs had significant differences in DNA methylation and histone acetylation profiles with the differences increasing as the twins aged. Increased differences in DNA methylation and histone acetylation were associated with increased differentially expressed genes and increased phenotypic differences in identical twins (Fraga, et al., 2005).

Epigenetics is a relatively new and, as yet, poorly understood field which studies the impacts of environmental conditions on an individual's genome in regard to the up or down regulation of genes resulting in different phenotypic expression. Epigenetics also studies the heritability of such acquired phenotypic characteristics. Environmental conditions may switch certain genes on (up regulate) or off (down regulate) through a process known as DNA methylation, or by creating changes to chromatin structures or histone proteins (Jablonka & Raz, 2009). Contrary to past scientific belief, it has been shown, (at least in flies), that epigenetic phenotypic effects caused by environmental conditions can be inherited by up to 13 generations of descendants. Note that it is only the methylation of the DNA that is changed and inherited; the actual sequence of the inherited genome remains unchanged. Transgenerational epigenetic effects have been shown to occur in both plants and animals. A recent review of the epigenetic literature documented over 100 cases of epigenetic transgenerational phenotype changes

(Jablonka & Raz, 2009). It has recently become clear that environmental factors, by 'up'- or 'down- regulating' specific genes (i.e., switching the genes off or on), can bring about phenotypic changes in an organism.

Synthetic biology

"Synthetic biology aims to design and build new biological parts and systems or to modify existing ones to carry out novel tasks" (Parliamentary Office of Science and Technology, 2008, p. 1). Proponents of synthetic biology claim the technology offers prospects for novel methods to produce food, drugs, chemicals or energy, environmental biosensors, bioremedial agents to clean up pollution, and new therapeutic techniques. Engineering principles are used to build standardised interchangeable segments of DNA that can be used as biological building blocks to make new, or to alter existing, organisms. DNA sequences (potentially even whole genomes) can now be designed on computers and produced in chemical laboratories. It is conceivable, that in the future, entirely new forms of life might be created in the laboratory using the techniques of synthetic biology (Chopra & Kamma, 2006).

The potential for the *malevolent* use of synthetic biology is clear. It is now possible to construct the genome of a medium-size virus in about three weeks (Parliamentary Office of Science and Technology, 2008). In 2002, researchers from the University of New York constructed the poliovirus by following a recipe downloaded from the Internet and using synthetic gene sequences sourced from a mail-order supply firm. They tested the virus by injecting it into mice, which then became paralysed and died. Their purpose was to show how easily terrorists could create deadly biological weapons (Cello, Paul, & Wimmer, 2002).

As is the case with GE, synthetic biology attracts the 'do it yourself' brigade, including groups with such exciting names as: OpenWetWare (OpenWetWare, 2009), DIYbio (DIYbio, 2010), Biopunk (Biopunk.org, n.d.), and Biohack (Bishop, 2008). Synthetic biologists in California are about to launch an open source biological production facility called BIOFAB (International Open Facility Advancing Biotechnology). BIOFAB "aims to boost the ease of bioengineering with "biological parts" that are shared resources, standardized and reliable enough that they can be switched in and out of a genome like electronic parts in a radio" (Katsnelson, 2010).

J. Craig Venter, who led the private research project to decipher the human genome, in competition with the publically funded project, had the goal of creating the world's first synthetic organism. He envisaged creating organisms which have the ability to manufacture biofuels and other useful compounds. He considered that a "new design phase of biology" is about to begin (Grant, 2008). On May 21, 2010 Venter's team published details of the successful creation of a synthetic genome that began replicating and producing proteins (Gibson, et al., 2010). This achievement is considered proof-in-principle of human created life forms. Although many useful organisms may be created, the possibility of dangerous ones being created either accidentally or deliberately is also very real. The Oxford University ethicist Professor Julian Savulescu, reflecting on the achievement of Venter's team said:

> Venter is creaking open the most profound door in humanity's history, potentially peeking into its destiny. He is going towards the role of a god: creating artificial life that could never have existed naturally. The potential is in the far future, but real and significant: dealing with pollution, new energy sources, new forms of communication. But the risks are unparalleled (quoted in Henderson, 2010).

Savulescu continued:

> We need new standards of safety evaluation for this kind of radical research and protections from military or terrorist misuse and abuse. These could be used in the future to make the most powerful bioweapons imaginable. The challenge is to eat the fruit without the worm. (quoted in BBC News, 2010)

Among the serious issues concerning synthetic biology are biosecurity risk, biosafety, intellectual property, stakeholder engagement and involvement, unforeseen harmful consequences, human malevolent use of the technology, and technological governance.

Life extension

Historically, mortality has separated humans from gods; except perhaps, until the 21st century. The quest for immortality has been a recurring theme for humanity throughout recorded history– in myth, religion, literature, alchemy, and science. Impressive work is currently being conducted in the area of life extension (de Grey, 2005; Finkel, 2003). The average life span in developed countries has steadily increased and current projections are that someone born today could potentially live very much longer than the current maximum natural full term of around 120 years. It has long been known that calorie restriction (CR) diets can improve the health (in particular reduction of cancers and increased immunity), and extend the life of most mammals by up to 40% (Weindruch, Walford, Fligiel, & Guthrie, 1986). Recently a molecular level epigenetic mechanism for the effects of CR has been proposed (Li, Liu, & Tollefsbol, 2009); glucose restriction produced increased expression of hTERT (human telomerase reverse transcriptase). This provides targets for drugs for life extension.

Telomerase is an enzyme that is responsible for the formation of the telomere DNA sequence. This sequence forms a cap on the ends of chromosomes. Telomeres are responsible for maintaining genomic stability and regulating cellular division. As somatic cells divide the telomere sequences get shorter and shorter, limiting cells to a fixed number of divisions (Greider & Blackburn, 1989; Harley, Futcher, & Greider, 1990). Cellular senescence and eventually death occur when telomeres reach a critical value. Heritability of telomeres is strong with studies estimating it at 40-80% (Codd, et al., 2010). This is thought to be an important component of aging at a cellular level. Cancer cells preserve their telomeres no matter how many times they divide (i.e., they are immortal). Cancer cells have increased telomerase activity, thus suggesting a possible mechanism for increasing the longevity of normal cells.

The compound resveratrol, which is found in red wine, has been shown to extend the life of yeast cells by about 70%. Resveratrol increases production of a class of enzymes called sirtuins (produced in yeast by the gene sir2). Production of these enzymes is also increased in yeast during calorie restriction (Howitz, et al., 2003). Resveratrol offers research potential for life extension drugs. Both calorie restriction and resveratrol appear to work through epigenetics i.e., by up- or down-regulating health and age related genes.

By manipulating specific genes in various organisms scientist have been able to greatly increase their lifespan and their resistance to illness. Knocking out one copy of the insulin-like growth factor (IGF-1) gene in mice led to a 26% increase in lifespan (Holzenberger, et al., 2003). Adding an additional sir-2.1 gene (the nearest equivalent of the sir2 gene in yeast) to the genome of *C. elegans* (a nematode worm) led to a 50% increase in lifespan (Tissenbaum & Guarente, 2001), while decreasing the activity of the daf-2 gene led to a doubling of the lifespan of *C. elegans* (Kenyon, Chang, Gensch, Rudner, & Tabtiang, 1993).

Single genes which have significant lifespan effects in fruit flies have also been discovered. Mutants fruit flies with reduced activity (down-regulation) of the mth gene (the Methuselah gene) have a 35% increase in average lifespan and increased resistance to stressors such as starvation and heat (Lin, Seroude, & Benzer, 1998), while reduced expression of the Indy (I'm not dead yet) gene doubles the fly's lifespan with no noticeable negative side effects (Rogina, Reenan, Nilsen, & Helfand, 2000).

Helfand & Inouye (2003, p. 276) claimed that "There is great conservation between different organisms suggesting that what is learned in one model system will be true for others." Research with healthy centenarians (and their very old - 91+ siblings), using genetic linkage analysis, found a region on chromosome 4, that contains between 100 and 500 genes, associated with extra long healthy lives (Puca, et al., 2001). In the past few years a handful of these genes have been identified as important to the aging process (Rucz, 2008). Stem cell therapies and gene therapies are also expected to play a significant role in life extension in terms of rejuvenation of aging or diseased cells and organs, elimination of genetic disorders, and up or down regulation of 'aging' genes.

The Cambridge University biogerontologist, Aubrey de Grey (2007) is a champion of radical life extension i.e., not just extension by a few years but by hundreds, even thousands, of years (of eternal youth, not the Tithonus error, as he referred to life extension without maintenance of youth). His approach is different from calorie restriction and its genetic equivalents - which are essentially a means of retarding aging. He proposed instead, a continuous engineering process of repairing damage caused to the organism by aging. He identified seven types of such damage and concluded that, when we can repair these types of damage, we will be able to give living organisms arbitrarily long life spans (de Grey, 2005).

De Grey believed that there are people alive now who will live for 1000 years or more. He proposed the concept of "longevity escape velocity" by which he means that if the first wave of rejuvenation therapies add an extra 30 years, during this extra 30 years, a second wave of therapies will likely be developed which add still more years, and so forth, until dying is essentially conquered (de Grey, 2004, 2005). Given the accelerating pace of biological knowledge his "longevity escape velocity" is a plausible (though by no means certain) hypothesis, though whether, or when, society will chose to allow the coming of the 'new immortals', is another question.

Gene Technologies and the Potential for Harm

Despite having a large range of intentionally positive applications, it is also clear that GE, gene therapy, synthetic biology and the other technologies emerging from genetic science could create harm in the world through *unforeseen* and unintended side effects, through *incidental* effects – known side effects associated with positive intentional effects, or through *malevolent* intent (see Chapter 1 for a summary of the three ways in which humans cause harm through technology). For example, scientists experimenting with the mouse pox virus (a mouse analogue of smallpox in humans) accidentally succeeded in making the virus much more virulent and deadly, even to mice vaccinated against the disease (Jackson, et al., 2001) - an unintended and *unforeseen* effect.

The potential to alter human smallpox or to combine genes from different diseases to create super diseases for the purpose of warfare or terror is clear and very real (*malevolent* intent). It is reported that the former Soviet Union succeeded in using recombinant DNA techniques to combine features of smallpox and Ebola (Katz, 2001). As Sir Martin Rees noted, regarding biological and chemical weapons, “A few adherents of a death-seeking cult, or even a single embittered individual, could unleash an attack” (Rees, 2003, pp. 48-49). The possibility of creating lethal pathogens that target specific groups in society based on gene markers specific to that group also exists (Katz, 2001).

Another worrying trend is DIY bioengineering. Reportedly, home hobbyists (often without training in the field) are conducting GE experiments from information and products found on the Internet and equipment constructed in home labs. Synthetic biology will further exacerbate this trend. Such experiments are conducted without regulation or control. These biohackers, as they call themselves, claim that the future Bill Gates of biotech could be developing a vaccine for cancer in their garage (Wohlsen, 2008). An equally plausible scenario is that synthetic organisms escaping from uncontrolled home GE labs could cause outbreaks of dangerous diseases and serious environmental damage.

The issue of posthumanism poses serious ethical issues for humanity. What will the new humans be like? How wise will human directed evolution be? What will the consequences be? Vastly extended human life spans seem technologically imminent. A range of *incidentally* harmful effects of human ‘immortality’ seem obvious and easy to predict. What might the *unforeseen* harmful consequences be? How can humanity balance the potential harms and potential benefits of Promethean gene technologies?

Summary

Gene technologies have the potential for enormous social and moral impact on humans, animals and the environment. Gene technology could potentially change humans and other species and even the nature of evolution itself. With these technologies mastered, humans will be able to control life, change nature to our own ends, change ourselves and our genomes in ways that we desire, eliminate many diseases, perhaps even eliminate death, design and make new forms of life that never existed before, and develop a whole new range of biological-based industries.

Gene technologies hold fantastic potential for public good and the benefit of humanity. However, they also hold fantastic potential for harm. In a worst case scenario, through accidental, incidental or malevolent causes, the result could be the demise of life on Gaia (Bostrom, 2002; Joy, 2000; Rees, 2003). Much depends upon what humans choose to use the technologies for. As Promethean technologies spread to all echelons of society, what humans choose to use these technologies for will be determined by the full range and extent of human nature and human behaviour, from the altruistic to the malevolent. A problem that will have to be solved, sooner rather than later, is how to stop the malevolent application of these technologies. This chapter has been confined to gene technologies, primarily because participants in Study 1 have expertise in this technology and, therefore, gene science is a theme running throughout this thesis. However, other, equally powerful technologies are currently emerging (e.g., nanotechnology, super-intelligent machines, neurotechnologies etc.) with similar potential for disruptive social and moral consequences. To avoid existential disaster it is imperative these Promethean technologies are responsibly developed and controlled.

Chapter 3 - Review of Theory

This chapter reviews theoretical considerations relevant to social and moral responsibility in research. It consists of two parts. The first part is composed of three sections. The first section considers the history of the philosophical discussion of ethical theories and moral reasoning. The second section reviews some branches of applied ethics of particular relevance to science and technology. The purpose of these two sections is to explicate philosophical moral theories and practices that are useful for analysing and thinking about the issue of social and moral responsibility, particularly with regard to the practice and application of science and technology. The third section considers existential risk, the precautionary principle and technological optimism, issues relevant to social responsibility in science. Part two of the chapter considers psychological theories of ethical behaviour, focussing on cognitive moral development, moral behaviour, and personal value orientation.

Philosophical Background

Normative ethics is the development and study of ethical theories to help guide human moral behaviour. Normative ethics is usually distinguished from descriptive ethics, which is the empirical study of what people believe their moral responsibilities and rights are and what they actually do when faced with moral issues. There are three main types of normative theories, each with a different focus. The focus of *teleological* ethical theories is on whether the consequences of an action or practice are good or bad. The focus of *deontological* theories is whether actions and practices are right or wrong for their own sake. The focus of *virtue ethics* is on what it means to be a virtuous person and how a virtuous person would act (Pojman, 1998c).

Normative ethics attempts to identify or formulate rules and principles, duties and obligations that guide how people ‘ought’ to act (and what their motives or intentions should be) in particular situations, and sometimes, across all situations. A related field of study, meta-ethics, analyses the concepts of good and evil, rights and responsibilities. In the qualitative research in the current work (Study 1) participants’ attitudes and values were examined for evidence of normative ethical reasoning and meta-ethical reasoning or assumptions. The instrument used to measure scientists’ general attitude to genetic engineering (Study 2) includes measures to assess teleological ethical concern and deontological ethical concern.

Applied ethics is the application of normative theories as a basis for analysing real world ethical problems. In the past 30-40 years a number of fields of applied ethical studies related to science, technology, humans and society, and global ecosystems have emerged (Hackett, et al., 2008; Pojman, 2001b). Three of these applied ethical fields are briefly discussed - environmental ethics, bioethics /deep bioethics, and technoethics. From these fields of study, philosophers' arguments for the need for an increased ethic of social and moral responsibility on the part of scientists are presented.

In addition, two concepts related to the social and moral implications of science and technology will be briefly introduced and discussed - technological optimism and the precautionary principle (Krier & Gillette, 1985). Technological optimism is one of the constructs in the nomological network related to social responsibility in science. Relationships amongst the constructs in this nomological network will be tested to help establish the construct validity of the new measures (Cronbach & Meehl, 1955) developed in Chapters 7 of the current work. A number of other ethical concepts are touched upon in this chapter including the issue of moral perception and sensitivity (Blum, 1991; Sherwin, 2001). This particular philosophical issue is strongly related to psychological theories of moral judgment and behaviour (Rest, 1979, 1986). These discussions lead to the proposal of a number of experimental hypotheses to be tested in the quantitative study (Chapter 7).

Normative Ethical Theories

Teleological ethics

Teleological theories are consequentialist in nature, holding that the moral value of an action, practice or rule is a function of the consequences of that action (Hursthouse, 2009). That is, is the effect of the act or rule (i.e., the consequent states of affairs of the world) good in itself? As Pojman (1998d, p. 738) stated: "teleological theories see only instrumental value in the acts but intrinsic value in the consequences." Regarding the consequence of an act, one can ask: how does it compare with the 'goodness' of the effect of possible alternative actions, practices or rules in the particular situation? This implies that different states of the world are of different importance, or have different degrees of intrinsic value (Zimmerman, 2008). That is, they may either be ordered on a scale that goes from very evil to very good or that, at a minimum, multiple alternative end states of affairs, in a particular situation, may be ranked in terms of their values. Thus, for teleological ethical theories one needs a method for ranking the value of different effects of action or practices, or states of affairs or states of the world.

The legal system recognises gradations of illegal unethical behaviour and, as the crime increases in degree of evil (disvalue), punishment correspondingly increases in severity (Jones, 1991). To the extent that society can reach such generally agreed classifications of the consequences of actions or practices (i.e., the resulting states of the world) suggests that consequences or states of affairs of the world have *objective* value, the degree or intensity of which is intrinsic to the outcome itself. This suggests the meta-ethical theory of *objectivism* or *moral realism* (Sayre-McCord, 2009).

However, it is contingently true that across individuals, groups, cultures, and time, people may hold different moral beliefs, and on occasion, rank different consequent states of the world differently in terms of their magnitude of value. This is a descriptive thesis known as *cultural relativism* (Pojman, 1998d). For example, while modern society considers slavery evil, two centuries ago, for many people and nations, slavery was considered to have valued economic and societal consequences, and therefore, according to teleological ethics, was a morally acceptable practice, at least to people with these particular value priorities. That moral judgments and the value attributed to consequences are dependent upon the cultural milieu implies *moral conventionalism*, while the fact that different moral judgements can be made by different individuals, even within the same milieu, implies *moral subjectivism* (Pojman, 1998d).

Teleological ethics is relevant to the current work in that the practice and application of science and technology has consequences for individuals, groups, society as a whole, for states of affairs and for the state of the world, as argued in Chapter 1. These consequences may be good or bad for Gaia, and have value or disvalue for society, groups and individuals. Evaluating potential consequences is a necessary component of foresight. Therefore, teleological ethical reasoning is one mechanism the science community and individual scientists can use to practice social and moral responsibility regarding future implications of their research.

Deontological ethics

Deontological theories deny the teleological principle. Rights, obligations, duties, rules and ethical principles form the basis of deontological reasoning (Pojman, 1998c). That is, an act or practice is right or wrong, or is an obligation on principle, without consideration of the real or expected consequences of the act. Deontological theory holds that certain features of the act or practice itself have intrinsic value (Pojman, 1998d). Deontological theory has a strong and a weak version (Pojman, 1998b). The strong version holds that moral rules have universal objective validity, that there should be no exception to rules or principles, and that an adequate moral system will have a consistent set of principles which are never in conflict. This version of deontology is sometimes referred to as moral absolutism. The most well known proponent of this view is Kant, who believed that we could rationally determine such a consistent set of principles (Kant, 1998).

A more moderate deontological position, championed by Ross (1998) is *moral objectivism* which "holds that moral principles have universal objective validity but admits that many (if not all) of its principles may be overridden by other principles at different times and occasions" (Pojman, 1998a, p. 18). A somewhat similar position is known as *moral pluralism or value pluralism* (Mason, 2008). This position holds that there are a plurality of different values but is not committed to either the belief of universal objective validity (i.e., *moral realism*), as Ross is, or *moral subjectivism* (i.e., morality is in the eye of the beholder), a position sometimes attributed to Nietzsche (1998). In either case the moral task is to discern which of the conflicting principles takes precedence in a particular situation. In such cases, one may, as Ross (1998) and Moore (1966) do, resort to *moral intuitionism* (the theory that the good or the right thing to do can be known directly via intuition) in order to determine which rule is the appropriate one.

Just as we are able to discern gradations of value regarding consequential states of the world, we may also discern gradations of value among moral rules and principles, either in particular situations or in abstract consideration. Thus, in the abstract, most people would agree that the practice of *protecting innocent people from harm* is a rule of greater moral importance or intrinsic value than *telling the truth*. However, for a deontologist such as Ross (1998) it might be possible, indeed, morally good, in a particular case, to give precedence to telling the truth over protecting innocent people from harm.

Deontological ethics are relevant to the current work in that science and technology are practices which can be evaluated against deontological moral principles (e.g., humans should not play God). Thus, the science community and individual scientists in their evaluation of their moral responsibilities to society should be cognizant of the deontological principles important to themselves, other individuals, groups, cultures and societies, regarding particular scientific and technological practices.

Virtue ethics

Virtue ethics is usually traced back to Aristotle (Pojman, 1998d). It differs from teleological and deontological ethics in that its focus is on the agent rather than an action or its consequences, that is, it is agent-focussed rather than act-focussed (Hursthouse, 2009). Rather than considering the sort of *actions or practices* that are *right or wrong* (as is the case in deontological theories) or the *actions or practices* that will bring about *the most beneficial ends* (as is the case in teleological theories), virtue ethics considers the sort of *people* we ought to *be*. Rather than asking: “What is the right thing to do (given these particular circumstances)?” the virtue ethicist asks: “What would the virtuous person do (given these particular circumstances)?” Or: “What is the best way for me to live given the particular circumstance?” (Pojman, 1998d).

Thus, the virtuous person demonstrates characteristics or virtues (we might also call them values, traits, dispositions, or even habits) such that he/she consistently acts in a manner that leads to what Aristotle (1996) called *eudaimonia* (the ultimate practical good - personal happiness, flourishing or wellbeing) and consistently avoids actions that diminish eudaimonia. Aristotle also invoked the concept of *phronesis* (practical or moral wisdom - derived from experience and learned knowledge) in order to explain how an agent understands what dispositions, and actions grounded therein, lead to eudaimonia. Thus, according to Aristotle, life experience helps individuals to internalise the virtues (and thus become of virtuous character) while recognising and avoiding the vices.

Aristotle considered virtues to be a *golden mean* between two extremes. For example, courage is the virtue of having the right amount of fear, with too little fear the agent is foolhardy rather than courageous and with too much fear the agent is cowardly. The polar opposites of cowardice and foolhardiness are considered vices while the golden mean between these two, courage, is considered a virtue. Thus, the morally virtuous person is guided by moderation and lives according to Aristotle’s golden mean (Aristotle, 1996).

Virtues, just like rules or principles, may come in conflict with one another and it is the task of the moral agent to use their practical wisdom and experience to act on the virtue that will enable them to live well and achieve excellence in their life. Virtue ethics is relevant to the current work in that, personal values, which ground important elements of an individual’s self-identity (Feather, 1988;

Hitlin, 2003), including the virtues they hold important for themselves as human beings and as scientists, may influence the attitudes and beliefs that they hold regarding their responsibilities to society in research and development, and particular technological practices, such as genetic engineering.

Intrinsic and extrinsic value

Aristotle stated: "Clearly then the term 'goods' would have two meanings, (1) things good in themselves and (2) things good as a means to these" (Aristotle, 1996, pp. 9, Book I, ch. VI,). Similarly, referring to the notion of good, Moore (1966) stated:

> They may either assert that this unique property does always attach to the thing in question, or else they may assert only that the thing in question is *a cause or necessary condition* for the existence of other things to which this unique property does attach. (p. 21 emphasis in original)

Moore (1966, p. 21) noted the ordinary language expression for the first concept is "good in itself" which he calls *intrinsic value.* The concept of intrinsic value has a relationship to both deontological and teleological moral reasoning. Thus, in deontological ethics certain features of the moral act itself or principle guiding the act are said to have intrinsic value (Pojman, 1998d).

Moore (1966) referred to the second concept as "value as means" (p. 21). This concept is commonly referred to as *extrinsic value*. In teleological moral reasoning, the action or practice, in itself, has only extrinsic value, that is, its value rests in the fact that it brings about certain consequences, and the ultimate criterion of teleological morality regarding the action or practice is the intrinsic value of the consequences (Pojman, 1998d).

There is considerable variation of belief amongst philosophers as to what type of entity or thing can have intrinsic value. Aristotle (1996, pp. 10-11) talked about objects, things and goods, naming happiness (eudaimonia) as the "final end". Moore (1966) used the term in regard to a number of different *objects* both *concrete* and *abstract*, *qualities of objects* and also *states of objects*. Frankena (1973) gave a long list of entities with intrinsic value: life, consciousness, health and strength, pleasures, truth, knowledge, beauty, wisdom, virtues, peace, freedom, and so on. Butchvarov (1989) considered that *properties* have intrinsic value, Ross (1930) believed it was *facts*, while Chisholm (1975) thought it was *states of affairs*.

Beside the question of whether something is good or bad there is also the question of how good or bad a thing is, and how to compare the degree of value of two different things. There is diversity of opinion regarding how intrinsic value is to be measured, and whether the intrinsic value of some goods or objects is incommensurable (Zimmerman, 2008).

The concept of intrinsic value and the ability to determine preference or rank the intrinsic value of different states of affairs is necessary for teleological ethical evaluation of the consequences of an action or a practice such as a technology like genetic engineering. Thus, for genetic engineering, a teleological ethical evaluation might require determining preference of the consequences of using genetic engineering as opposed to the consequences of not using it, or using some alternative technology or practice. The concept of intrinsic value is also necessary for deontological evaluation of actions or technological practices because the rules or principles themselves are said to have intrinsic value. Where deontological principles or rules are in conflict it is necessary to be able to rate or determine preference between the principles.

Fields of Applied Ethical Studies Relevant to Technology

Environmental ethics

Because human possession and use of science and technology are currently threatening dire consequences for ecosystems and the environment (as illustrated in Chapter 1), environmental ethics is a field of applied ethics particularly relevant to the social implications of science and technology. Traditional ethics were primarily anthropocentric, attributing intrinsic value only to humans. Thus, Kant considered that only rational beings were ends in themselves (Pojman, 2001a). In contrast, Rolston (2001) argued for the thesis that nature has intrinsic and objective value (i.e., value independent of human valuation – *value objectivism*). Schweitzer (2001) argued for a *Reverence for Life*, an extension of intrinsic value and moral concern to all of life. This point of view is called *biocentric ethics*.

Ecocentric ethical theorists, such as Leopold (2001), viewed the biosphere holistically, believing that the environment, rather than being merely a resource for humans, is at the centre of value. A central concept of Leopold's *Land Ethic* is that "A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it does otherwise" (2001, p. 125). The most radical version of environmental ethics is deep ecology – a term coined by Arne Naess (1973). Deep ecology holds that nature and natural diversity are intrinsically valuable (thus implying value objectivism) and "that everyone and everything is equally valuable as part of the whole" (Pojman p. 76), or as Naess (1973) termed it *biospherical egalitarianism*.

Deep ecology proposes a transpersonal gestalt psychology. That is, Naess argued that as humans mature, how they identify themselves widens. He advocates the extension of the concept of the (narrow) self to the comprehensive Self (with a capital S). The comprehensive Self blurs the distinction between man and environment and sees all things as interconnected and interdependent. A reduction in human population and greater protection for biodiversity are central tenets of deep ecology (Naess, 2001).

Bioethics and deep bioethics

The term *bioethics* was originally coined by Potter (1971, p. 1), who defined it as “the knowledge of how to use knowledge for the social good.” Potter envisaged bioethics as a multidisciplinary field, combining biology, ethics, humanities and social sciences with a particular orientation to the science of survival, choosing the moral future that we want for the world within the bounds of biological constraints (Potter & Whitehouse, 1998).

Bioethics, as it has come to be practised, now subsumes the long established field of medical ethics. Potter’s focus on the wider global biological survival issues has received little attention from bioethicists in comparison to medical ethics (Gaines & Juengst, 2008). More recently, Potter and Whitehouse (1998) have used the term ‘deep bioethics’ to refer to Potter’s original concept, linking the concept historically and philosophically to Arne Naess and the Deep Ecology movement (Naess, 1973) and Leopold’s (1949) ‘Land Ethic’ concept.

Currently, the dominant approach to bioethics is the *Four Principles* approach developed by Beauchamp and Childress (1994). The principles are beneficence (doing good), non-maleficence (not doing harm), autonomy (personal freedom) and justice (fairness). Beauchamp and Childress claimed that these four principles roughly accord with our ‘common morality’ and it is generally considered that they are sufficient to analyse and resolve most bioethical problems, although this assumption is disputed by some, in particular feminist writers, who claimed that the four principles are predominantly Western and masculine values (e.g., Gilligan, 1982; Noddings, 1984; Sherwin, 1992).

The four principles approach allows for both deontological and teleological reasoning to be combined in the analysis of an ethical issue. The principles are used to analyse the consequences of an act, or of alternative acts. Thus, a four principles analysis of an act will consider the potential benefits and the harms of the act, the fairness or justice of the distribution of benefits and harms across affected individuals and groups (stakeholders) as well as the degree of autonomy that the stakeholders had to access or avoid the benefits and harms. Beauchamp and Childress (1994) recognised that, in particular situations, there may be conflicts between these four principles. No one principle is invariably given precedence over any other. Rather, when there is a conflict between the principles, the decision maker(s) must evaluate the priority given to the principles in terms of the facts (or beliefs) associated with the particular situation.

The approach is, therefore, teleological ethics combined with a 'weak' version of deontological ethics. Moral reason, moral intuition or moral sentiment is necessary in order to determine which moral principle takes precedence under a particular set of circumstances. Mepham (1996, 2000) used the four principles and stakeholder theory to devise a qualitative tool called the 'Ethical Matrix' for analysing ethical issues. The Ethical Matrix has all identified stakeholders in the issue on one axis and the four principles on the other axis. Specifying the benefits, harms, the degree of stakeholder autonomy in the situation, and the fairness or justice of the consequences for all the stakeholder groups, enables moral decision-makers to clarify deontological and teleological factors relevant to their decision. Mepham (1996, 2000) used the Ethical Matrix to analyse the morality of food biotechnologies.

Taking the Ethical Matrix as a base, Small and Fisher (2004; 2005) developed a quantitative tool which they named the 'Ethical Valence Matrix'. The concept is similar to Mepham's, except that rather than using descriptive qualitative analyses as in each of the cells of the Ethical Matrix, the Ethical Valence Matrix has a numerical rating of the degree of benefit, harm, autonomy or fairness that the issue holds for each of the stakeholder groups. By summing the four principle scores for a stakeholder group, a four principles ethical valence score regarding the issue can be derived for that stakeholder group. A quantitative comparison can then be made between the ethical valence scores of the stakeholder groups. Small and Fisher (2004; 2005) used the Ethical Valence Matrix to analyse scientists' moral attitudes and beliefs to a research project involving the genetic engineering of cows.

Technoethics and the responsibilities of scientists

Over the past 30 years, technoethics has emerged as a field of applied ethics that specialises in examining the ethical dimensions of technology and its impacts on society (Bunge, 1977; Luppicini, 2008). Luppicini (p. 5) considered "that it is of vital importance to encourage dialogue aimed at the ethical use of technology, guarding against the misuses of technology, and formulating common principles to help guide new advances in technological development and application to benefit society." Accepting Heiddegger's (1977) argument that new technologies enable new relationships, previously not possible, into the world, technoethics recognises that technology is a part of societal development creating change and raising new opportunities for action and ethical issues that did not previously exist.

Technoethics is an interdisciplinary field which subsumes or overlaps a range of areas of ethical research including: computer ethics, Internet ethics, cyberethics, information ethics, media ethics, medical ethics, bioethics, engineering ethics, neuroethics, roboethics, nanoethics, professional technoethics, educational technoethics, environmental technoethics, and military technoethics (Luppicini, 2008). Its genesis was in the 1970s when Mario Bunge (1977) first coined the term. Although Bunge held that pure science "is intrinsically valuable, technology can be valuable, worthless, or evil, according to the ends it is made to serve. Consequently technology must be subjected to moral and social controls" (Bunge, 1977, p. 106).

Bunge (1977) considered that, as professionals intimately involved with the development of new technology, scientists and engineers have extra social and moral responsibilities regarding technological innovations and their applications and technological progress in general. He claimed:

> The technologist must be held not only technically but also morally responsible for whatever he designs and executes: not only should his artifacts be optimally efficient but, far from being harmful, they should be beneficial, and not just in the short run but also in the long term. (Bunge, 1977, p. 100)

Bunge (1977) concluded that, like other people, technologists are personally responsible for what they do, subject to both praise and blame. Thus "the technologist is responsible not only to his employer and his profession but also to all those likely to be affected by his work. And his primary concern should be the public good" (p. 107).

Another key figure in the development of technoethics was Hans Jonas. His work focuses on ethics regarding the development of new technologies and the way in which technology alters the power of individuals (Jonas, 1985). Thus, he began the preface to the English version of his 1985 book *The Imperative of Responsibility: In Search of an Ethics for the Technological Age* by summarising its premise:

> Modern technology, informed by an ever-deeper penetration of nature and propelled by the forces of market and politics, has enhanced human power beyond anything known or even dreamed of before. It is a power over matter, over life on earth, and over man [sic] himself; and it keeps growing at an accelerating pace. Its unfettered exercise for about two centuries now has raised the material estate of its wielders and main beneficiaries, the industrial "West," to heights equally unknown in the history of mankind…. But lately, the other side of the triumphal advances has begun to show its face, disturbing the euphoria of success with threats that are as novel as its welcome fruits. Not counting the insanity of a sudden, suicidal atomic holocaust, which sane fear can avoid with relative ease, it is the slow, long-term, cumulative – the peaceful and constructive use of worldwide technological power, a use in which all of us collaborate as captive beneficiaries through rising production, consumption and sheer population growth – that poses threats much harder to counter. The net total of these threats is the overtaxing of nature, environmental and (perhaps) human as well. Thresholds may be reached in one direction or another, points of no return, where processes initiated by us will run away from us on their own momentum – and towards disaster. (Jonas, 1985, p. ix)

Jonas (1985) responded to the techno-crisis threatening nature and humans by developing a theory of responsibility, which he claimed had previously been lacking from ethics. The axiom of this theory of responsibility is: "responsibility is a correlate of power and must be commensurate with the latter's scope and that of its exercise" (Jonas, 1985, p. x). He went on to claim that to discharge this responsibility we must lengthen our *foresight* with *a scientific futurology*, by which he meant using scientific knowledge about cause and effect relationships to extrapolate and attempt to predict future states associated with technological development. Bradshaw and Bekoff (2001) and Small and Jollands (2006) claimed that any such endeavour must take account of the psychology of human nature, as technological impacts on Gaia arise from the application of technology by humans.

However, Jonas noted that such foresight will always be uncertain and incomplete and proposed that:

> Consequently, an imaginative "heuristics of fear," replacing the former projections of hope, must tell us what is *possibly* at stake and what we must beware of. The magnitude of those stakes, taken together with the

> insufficiency of our predictive knowledge, leads to the pragmatic rule to give the prophesy of doom priority over the prophesy of bliss. (Jonas, p. x)

He claimed that a philosophy of nature regarding "man's duties towards himself, his distant posterity, and the plenitude of terrestrial life under his dominion" was required to "bridge the alleged chasm between scientifically ascertainable 'is' and morally binding 'ought'" (p. x).

Jonas' (1985) insight, and a contention of the present thesis, is that modern technology changes the landscape of ethics. In the past, without Promethean technologies, the effects of human actions were proximally located in time and space and limited by their degree of control of energy and matter, as were their consequent impacts on human life and other conscious beings. Under such circumstances our moral responsibility needs to extend only as far as the effects of our actions. Now that humans possess sufficient power over nature as to affect the global conditions for human and non-human life, the far-off future and even the physical destiny of the planet, the framework of former ethics is no longer valid.

Therefore, according to Jonas (1985), Promethean technology warrants a new extended ethic of responsibility, particularly with respect to the development, use and application of technology; such that responsibility corresponds to the potential reach of the effects of our use of a particular technology. In order to address the failure of past ethics to deal with the reality of today's world, Jonas proposed a new *categorical imperative* or supreme principle of morality: "'Act so that the effects of your action are compatible with the permanence of genuine human life'; or expressed negatively: 'act so that the effects of your action are not destructive of the future possibility of such life'" (p. 11).

Another technoethicist, Moor (2005, p. 117), proposed Moor's Law: "as the social impact of technological revolutions grows, ethical problems increase." As an adjunct to Moor's Law, Luppicini (2008, p. 16) proposed the Law of Technoethics "ethical rights and responsibilities assigned to technology and its creators increase as technological innovations increase their social impact." Luppicini claimed:

> Because ethical considerations within technoethics are embedded within rapidly changing domains of technology, discerning ethical issues requires considerable effort…. research on ethics and technology focuses the identification of controversial practices as moral problems, followed by an analysis and synthesis of factual data associated with these problems. (Luppicini, 2008, p. 14)

Common to the three fields of applied ethics discussed above is the perception of a need for an extended ethic of value and an extended ethic of responsibility of science and scientists to society. Environmental ethics and deep bioethics make this claim due to the need to protect and preserve the environment and other species of life from human desecration. Technoethics also sees this same need, but in addition, it sees the problem facing the environment and life on earth as being due to human possession and use of technology, and makes the further claim that science, scientists, and technologists have a particular responsibility in this respect.

The arguments proposed by these three fields of applied ethics form the underlying assumptions and the rationale for conducting the current work. The technoethicists claim that the nature of the extended ethic for science and scientists is a social responsibility to society. The question arises: What are the elements that comprise scientists' social responsibility to society? Clearly, the attitudes, beliefs and behaviour of scientists are crucial for the implementation of an extended ethic on their part. As little empirical research has previously been conducted in this area, an aim of the present thesis is to elucidate scientists' beliefs about the nature of their social and moral responsibilities to society (Study 1 – Chapter 6) and their attitudes towards these responsibilities (Studies 1 and 2 – Chapters 6 and 7). In addition, the relationship of attitudes to social responsibility and a particular Promethean technology, genetic engineering, is examined (Study 2 – Chapter 7).

Moral Sensitivity and Perception

The issue of moral epistemology, the problem of recognising or perceiving what one's moral responsibilities are, has been raised in philosophical literature in regard to moral behaviour of an agent. Blum argued:

> An agent may reason well in moral situations, uphold the strictest standards of impartiality for testing her moral maxims and moral principles, and be adept at deliberation. Yet unless she perceives their moral character accurately, her moral principles and skill at deliberation will be for nought and may even lead her astray. (Blum, 1991, p. 701)

Blum claimed that moral sensitivity and perception are essential, though under-theorised, dimensions of moral agency. Building on Blum's argument, Sherwin (2001) made the further claim that "moral perception, like aesthetic perception, involves a type of skill that can be trained and honed" (p. 177). She believed that because moral perception is necessary for morally responsible action, we each have a moral responsibility to develop our skills in moral sensitivity and perception. Noting that a number of philosophers contend that our ability to perceive moral elements of a situation is dependent upon having "emotional sensitivity to the concerns of others," (p. 178) she sets out to provide insight into how moral sensitivity might be developed and enhanced.

First, she suggested that learning and using different moral theories (i.e. teleological, deontological and virtue ethics), each of which can illuminate different moral aspects of a situation, while not being sufficient for responsible moral perception, can raise ethical consciousness. Second, she suggested that literature, by engaging our emotional and cognitive processes in fictional situations, can enhance moral perception and sensitivity. Third, she proposed that imaginative techniques such as prototypes, metaphor and narrative may enhance moral perception. Lastly, drawing on feminist epistemology and feminist philosophy of science she contended that "*feminist* consideration of different cultural practices and values is an essential tool for developing one's capacity at moral perception in a multicultural world" (p. 179). She claimed that we need to be able to ensure that our moral perception is cognizant of the perspectives of others in very different situations to ourselves.

Sherwin's suggestions presuppose and advocate the value of moral education for sensitivity and recognition of moral issues. Other theorists have also suggested that education about ethical theories and relevant fields of applied ethics may help scientists' perception of the nature of their social and moral responsibility to society (e.g., Bebeau, Pimple, Muskavitch, Borden, & Smith, 1995; Beckwith & Huang, 2005; Sherwin, 2001). However, Beckwith and Huang claimed:

> Many of us were trained to think of ourselves as working in the 'ivory tower' mode – seekers of truth uncontaminated by the outside world. Few students of science receive as an integral part of their scientific education an analysis of the social impact of science and rarely is there a mention of social responsibility. (2005, pp. 1479-1480)

Beckwith and Huang (2005, p. 1480) proposed that "education at the graduate level should include the study of the social implications of science and the historical instances where scientists have spoken out."

A number of meta-ethical theories, postulated by various philosophers have tried to explain the basis of moral perception. These include *moral rationality* (e.g., Kant, 1998), *moral intuition* (e.g., Moore, 1966, Ross, 1998), and *emotivism* (e.g., Hume, 1957, Stevenson, 1998). The value of rationality in regard to ethical decision-making is clearly shown in teleological ethical arguments. The value of moral intuition (the idea that we *just know* what is good, or how to rank different goods) is also apparent though somewhat more difficult to justify or explain. Rawls (1971) claimed that "any ethical theory is bound to depend on intuition to some degree at many points" (p. 40). Moore (1966) justified moral intuition with the theory that 'the Good' is a non-natural property, somewhat like a Platonic form that we intuitively recognise.

Some authors propose that moral intuition is determined by a combination of cultural (i.e., from learned behaviour, particularly in childhood) and evolutionary derived instincts (Greene & Haidt, 2002; Ridley, 2003). Empirical evidence, from functional Magnetic Resonance Imaging (fMRI) experiments, has suggested a relationship between the emotions and moral decision-making (emotivism) and behaviour (Greene & Haidt, 2002; Greene, Nystrom, Engell, Darley, & Cohen, 2004; Greene, Sommerville, Nystrom, Darley, & Cohen, 2001; Haidt, 2001; Haidt, Koller, & Dias, 1993; Moll, et al., 2007). Humans appear to have two different 'operating systems', one rational and one emotional, that compete sometimes and cooperate at other times (Greene & Haidt, 2002; Greene, et al., 2004; Haidt, 2001; Moll, et al., 2007; Small, 2004a, 2004b).

Empirically, if moral intuition has both an evolutionary genetic component and a learned component, it should demonstrate a degree of *cultural relativity* (learned) and a degree of *cultural universality* (inherited). To the extent that morality is learned, it will be subject to cultural relativism (implying *moral conventionalism* – moral principles are dependent on social or interpersonal agreement). To the extent that morality is inherited, it will be subject to a degree of cultural universality implying *moral objectivism* - the belief that at least some moral principles have universal objective validity.

Schwartz (1992) proposed a theory of human values that is consistent with both cultural universality and cultural relativism. The values and their structural relationship appear to be universal and relatively invariant across cultures, whereas the level of importance placed on any particular value or set of values is influenced by cultural factors and varies across cultures (Schwartz, 1990; Schwartz & Bilsky, 1990). It has already been proposed that personal values will be an antecedent influence on scientists' attitudes to social and moral responsibility. Specific hypotheses are proposed later in this chapter in the section on Schwartz Value Types.

Risk, Precaution, Optimism and Costanza's Payoff Matrix

Bostrom (2002) proposed a new class of technological risks, which he called existential risks. The nature of existential risks is briefly explained and a proposed response to existential risk, the precautionary principle, is described. Next, Costanza's pay-off matrix, a decision tool for technological policy choice, appropriate for existential risks, for which the probably of occurrence is highly uncertain, is described. The payoff matrix incorporates the concept of technological optimism (and technological pessimism). Technological optimism is discussed in regard to scientists, its effects on their perception of their social responsibility, and its relationship to the precautionary principle. Finally, in this section, two hypotheses are proposed about the relationship between technological optimism, the precautionary principle, and social responsibility in scientific research.

Existential risks

Bostrom (2002) categorised risk according to scope (the size of the at-risk population: global, local and personal) and intensity (how badly each individual in the group will be affected: endurable or terminal). Naming the category of global, terminal risk, existential risk, he defined it as: "one where humankind as a whole is imperilled. Existential disasters have major adverse consequences for the course of human civilisation for all time to come" (p. 3). Bostrom claimed that existential risk is a new category of risk for humans (with the exception of extremely rare events such as a species-destroying comet strike), first emergent in the mid-twentieth century with the advent of nuclear weapons.

He pointed out that these types of risk were not part of our evolutionary or cultural history and that we cannot rely on institutions, moral norms, social attitudes or previous experience with managing normal risk, to guide us in respect to existential risk. The reactive approach – trial and error, is unworkable in this situation – there is no chance to learn from error – for existential risk error is fatal. Existential risk requires proactive action. This requires foresight and willingness to take preventative action, that is, it requires a precautionary approach applied with forethought. Bostrom (2002) claimed that existential risk dilution is a global public good and, therefore, likely to be undersupplied by the market, and one might add, subject to the tragedy of the commons (Hardin, 1968).

The precautionary principle

The precautionary principle is one proposed response to the risks and potential negative impacts of technology on society and Gaia. It may be the only possible effective response to existential risk (Bostrom, 2002). The precautionary principle states: "when an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically" (Raffensperger and Tickner, 1999, cited in Kriebal, et al., 2001, p. 872). The precautionary principle is proposed as a guideline for decision-making. It has four main components: "taking preventative action in the face of uncertainty; shifting the burden of proof to the proponents of an activity; exploring a wide range of alternatives to possible harmful actions; and increasing public participation in decision making" (Kriebal, et al., 2001, p. 872).

The term 'precautionary principle' is an English translation of the German word *Vorsorgeprinzip* which might also be translated as 'foresight principle', a translation which focuses on anticipatory action rather than the slightly more negative reactive focus of the English word 'precaution'. As previously argued, foresight is a necessary component of scientific social and moral responsibility (Jonas, 1985). Foresight is a prerequisite for teleological ethical reasoning. The precautionary principle is, therefore, a teleological ethical principle.

Technological optimism and Costanza's payoff matrix

Costanza (1989) designed the *payoff matrix* as a method for calculating the most appropriate policy options for society when faced with risks of very high or terminal intensity at the national or global level. He identified two common opposing attitudes regarding the *real state of the world*. The first was *technological optimism* and the second *technological pessimism*, or *prudent pessimism*, as Costanza preferred to call it. Technological optimism is the belief that technology can provide a solution to all the problems facing humanity and the global environment – that there is a 'technological fix' for all problems. According to Krier and Gillette (1985), technological optimism arose as a response to the *Limits of Growth* (Meadows, et al., 1972). Optimists believe "that *exponential technological growth* will allow us to expand resources ahead of exponentially increasing demands" (Krier & Gillette, 1985, pp. 407, emphasis in original).

The optimists argue that, in order for an optimistic future to come to pass, we must believe that it is possible and act accordingly. However, as Costanza noted:

> This assumption allows problems of intergenerational, intragenerational, and interspecies equity and sustainability to be ignored (or at least

postponed), since they are seen to be most easily solved by additional growth….Energy and resource limits to growth, according to these paradigms, will be eliminated as they arise by clever development and deployment of new technology. (Costanza, 1989, p. 2)

Since there are currently no known technological solutions for the most serious environmental issues facing humanity and Gaia, technological optimism is essentially a faith-based belief in human ingenuity to develop technologies to address these issues before they become overwhelming (Krier & Gillette, 1985).

Technological pessimism, on the other hand, questions faith in the technological fix. Technological pessimism "assumes that technology will *not* be able to circumvent fundamental energy and resource constraints and that eventually economic growth will stop" (Costanza, 1989, pp. 2, emphasis in original). The pessimists argue that the optimists, by continuing on the current growth and consumption path, will hasten resource depletion, ecosystem destruction and social collapse. The pessimists claim that we need to immediately start conserving resources and protecting the environment for the wellbeing of future humans. Although Costanza (1989, 2000), Daly (1996), Daly and Cobb (1994) and Huesemann (2001) provide robust arguments demonstrating the inadequacy of technological optimism, nonetheless, the dominant view of society, politicians and economists is still firmly wedded to technological optimism and the pursuit of economic growth and consumerism (e.g., World Business Council for Sustainable Development, 2000).

Costanza, taking the conservative position that at best it is highly uncertain as to what the real state of the world is (that is, whether the optimists are right or the pessimists are right), made the case for a precautionary approach to policy making. He does this through a game theory argument based on his payoff matrix, which considered the payoff resulting from basing policy on the technological optimist's position versus the payoff resulting from the technological pessimist's position, when either of these two positions is the real state of the world. Costanza's payoff matrix is presented in Table 3.1 below.

If the optimists are right, then a technological optimism policy results in the highest payoff for society. However, if the pessimists are right then the technological optimism policy will result in disaster (i.e., the collapse of ecological and social systems). Thus the technological optimism policy is a high stakes gamble between a high payoff and a disastrous payoff.

Table 3.1

Payoff Matrix for Technological Optimism vs. Pessimism

Current policy	Real State of the World	
	Optimists right	Pessimists right
Technological optimist policy	High	Disaster
Technological pessimist policy	Moderate	Tolerable

Costanza, 1989

In contrast, Costanza argued that the technological pessimist policy offers moderate payoffs if the optimists are right about the real state of the world and tolerable payoffs if the pessimists are right. Accepting the technological pessimist policy, the gamble is between a moderate payoff and a tolerable payoff. While the pessimist policy does not offer the potential high payoff of the optimist policy, neither of its potential payoffs is as damaging as the optimists' potential disaster.

The payoff matrix implies that if we do not know the real state of the world then the optimal game theoretic strategy is to choose the technological pessimists' policy. Precaution is, therefore, the most sensible policy in the current world situation. As Costanza stated, "One does not run blindly through a dark landscape that *may contain crevasses. One assumes they are there* and goes gingerly and with eyes wide open, at least until one can see a little better" (Costanza, 1989, pp. 5, emphasis in original).

The argument is convincing and has become a common theme in ecological economics literature. However, the optimist policy holds a powerful sway over human nature, because, according to Costanza's matrix, if technological optimism is the real state of the world then the payoff for adopting a technological optimist policy is high: we are safe to, not only maintain the status quo, but to strive for ever greater levels of economic growth. According to Gaskell, Eyk, Jackson and Veltri (2004), there is a culture of technological optimism in the U.S., and this helps explain the more positive attitude the American public have regarding the Promethean technologies of genetic engineering and nanotechnology, than their European counterparts. These authors noted that technological optimists are "more interested in science, more enthusiastic about progress, more confident in nature's ability to withstand human intervention, and more trusting of those involved in innovation and regulation of technology" (p. 496).

Small and Jollands (2006) presented an argument claiming that, even if the real state of the world is such that the optimists are right, the payoff of policy based on technological optimism is not necessarily *high* as proposed by Costanza, but rather, it is *indeterminate*. They argued that while the payoff could be high, it could also be disastrous. This is because, increasing technological development places increasing power over nature in the hands of a greater range of people and groups (i.e., over time, technological power over nature is progressively diffused across all echelons of society). As the number of people and groups with access to technologies capable of causing create harm increases, so too does the probability that aberrant groups or individuals will use knowledge and technology for ends disastrous to society and Gaia, perhaps accidentally, but equally as likely, malevolently. It is now recognised that in the near future, due to increasing technological development, even a single aberrant individual may be able to use technology to cause cataclysmic consequences for the rest of humanity and Gaia (Rees, 2003).

It is proposed that a scientist's degree of technological optimism will be related to his/her perception of the degree of need for social responsibility in research: the more technologically optimistic, the less the perception of risky social impacts, consequently, the less importance placed on social responsibility. Therefore, technological optimism is one of the constructs in the nomological network describing social responsibility in research. As part of this work, an instrument will be developed to measure scientists' technological optimism.

Scientists and technological optimism

A report from the National Science Board (1977, p. 78) suggested that technological optimism was common amongst scientists: "a kind of naiveté among many scientists that leads them to believe that their science really can solve any problem, given enough time, money and effort." Similarly, a study of the 1993 German and 1998 Austrian Technology Delphis (technological foresight exercises) found that self-rated top-experts in a field tended to suffer from an optimism bias, and the degree of optimism was positively correlated with the degree of self-rated knowledge (Ticky, 2004). Less specialised experts were found to be less optimistic than top-experts. Reinforcing the concept of technological optimism amongst scientists, Rollin (1996) claimed that scientists often underestimated the risk associated with their field of work. Ticky found that over-optimism was due to the experts' involvement, and their underestimation of realisation and diffusion problems. While both sets of experts were over-optimistic, business research and development experts were more optimistic than academic experts.

We might rationally expect that a scientist's level of technological optimism might bear some relationship to the degree of precaution that the scientist would consider necessary or advisable in the development of a new technology. If it is believed that technology can solve all problems and everything is going to turn out great, then there is no motivation or need for precaution. If a precautionary approach is an essential component of the practice of social responsibility in research, technological optimism may obscure perception of social risks and diminish the perceived need for social responsibility associated with science and technology development. Kilbourne, Beckmann, Lewis and Van Dam (2001) found small to medium negative relationships between belief in the technofix and perception of general environmental problems (r = -.22), and perception of specific environmental problems (r = -.20), and perception of the need for change to protect the environment (r = -.30) Two specific hypotheses follow this argument and evidence:

H1 There will be a small to medium negative correlation between technological optimism and scientists' awareness of the need for social responsibility in scientific research and development.

H2 There will be a small to medium negative correlation between technological optimism and scientists' judgments of the importance of specific personal behaviours to enhance social responsibility in scientific research and development.

An instrument for measuring the construct of technological optimism was developed for the quantitative study in order to test its relationships with the other constructs in the nomological network.

So far, this chapter has considered philosophical theories of ethics (normative and meta-ethical), and applied ethics sub-fields relevant to human moral behaviour, technology, and technology use. Two variables thought to be antecedent to scientists' attitude to social responsibility in research have been identified: personal value orientation and technological optimism. Two hypotheses have been proposed for testing regarding technological optimism, and perceptions of social issues arising from research, and judgment of importance of behaviours to enhance morally responsible research.

Nearly all of the philosophical ethical concepts that have been discussed above are closely aligned to various psychological theories of moral behaviour. These connections will be evident in the section immediately below in the discussion of psychological explanations of moral perception, moral judgment, and moral behaviour.

Psychological Theories of Moral Judgment and Responsibility

There is a considerable range of human activities that come under the scrutiny of moral and psychological analysis, from criminal or anti-social behaviour through compliance with moral rights, moral principles and moral obligations, to pro-social behaviours such as altruism and supererogation. As well as acts of commission, acts of omission are also open to moral analysis. Sometimes moral problems (dilemmas) hinge not on whether a particular act is ethical or unethical, but which is the best moral action of several possible alternatives.

An understanding of the causes and contingencies of ethical reasoning and moral judgment may contribute to an understanding of how and why scientists adopt a particular moral stance towards a new technological practice, such as genetic engineering, and, more generally, to social responsibility regarding science and technology. Psychological theories of moral reasoning and behaviour generally postulate one or more of three main classes of factors or variables: individual factors, factors associated with the situation or context in which the moral issue arises, and more recently, factors which are related to the issue, action or practice itself. These latter are called issue-contingent factors and are theorised to give the issue moral intensity (Jones, 1991). Regarding antecedents to scientists' attitudes to social responsibility in research and development (a component of Study 2), the current work focussed on two psychological theories – cognitive moral development and behaviour and personal value orientation. Both of these theories are concerned with individual variables.

This section first considers cognitive moral development and behaviour as explicated in the theories of Kolberg (1969) and Rest (1979, 1986). Cognitive moral development is discussed because it is an integral part of all three types of psychological moral theories (i.e., individual, situational and issue-contingent models) and its focus is the explanation of moral judgement – an essential component of social responsibility. Next, a theory of personal value orientation developed by Schwartz (1992) will be discussed. Previously, it has been suggested that personal value orientations are an antecedent variable to scientists' attitudes to social responsibility. The relationship between personal values and scientists' attitude to social responsibility in research will be further explicated and specific hypotheses proposed.

Cognitive moral development and moral behaviour

Much research has been conducted in the cognitive-developmental approach to moral behaviour. Building upon earlier work by Piaget (1932), Kohlberg (1969) developed a model of the stages of individual cognitive moral development from middle childhood to adulthood. His model posited three broad levels, each composed of two stages. Moral development, according to Kohlberg, consists of the individual's invariant and irreversible sequential passage from the lower to higher stages.

At the pre-conventional level (stages 1 and 2) the individual's moral reasoning is dominated by personal interest and concrete consequences (i.e., external rewards or punishments). At the conventional level (stages 3 and 4) moral reasoning is dominated by conformity to the mores of society, family or peers. Stage 3 reasoning relates to conformity to the mores of significant others while stage 4 relates to conformity to the mores of the broader society (e.g., laws). At the principled level (stages 5 and 6), the individual sees beyond norms and laws, and the authority of groups or individuals, basing moral reasoning on universal values or ethical principles. Individuals at this stage of moral development apply teleological, deontological and virtue ethics reasoning to moral issues.

Rest (1979), while accepting the basic definition of stages and sequence of Kohlberg's model, criticised its simplicity – in particular the notion that individuals use only the stage of moral reasoning that they have currently reached. He proposed that individuals use various stages of moral reasoning, in varying degrees, depending on their overall level of moral development and the issue at hand. In answer to the question, "When a person is behaving morally, what must we suppose has happened psychologically to produce that behaviour?" Rest (1986) developed a very general theory of the psychological antecedents to moral behaviour. Rest proposed that, logically, the person must have used at least four basic psychological processes.

1. ***Moral sensitivity or recognition of an ethical issue.*** The individual must have been able to make an interpretation of the situation with regard to: what actions were possible, who would be affected by each course of action (i.e., stakeholders), and how the stakeholders would regard the effects on their welfare. This is similar to the proposals of the philosophers Blum (1991) and Sherwin (2001) who considered that without moral sensitivity or perception regarding an issue, moral reasoning will either not occur or be deficient. The

instrument developed in the current work (Studies 1 and 2) to measure scientists' awareness of the social responsibility of science to society is focussed on this stage of Rest's psychological theory of moral behaviour. It does this by asking questions about the moral responsibility of science to society.

2. ***Moral reasoning or ethical judgment.*** The individual must have been able to make a judgment about which course of action is morally right (fair, just or good), thus deciding which line of action ought (morally) to be taken. The instrument developed in the current work to measure scientists' judgments about the importance of personal behaviours believed to enhance social responsibility in the context of scientific research and technological development (Studies 1 and 2) is focussed on this stage of Rest's psychological theory of moral behaviour. It assumes that it in order to judge the importance of the action in their own scientific practice they have made a judgment about the moral status of the action.
3. ***Moral commitment or ethical intention.*** The individual must give priority to ethical values above other personal values and decide to intend to do what is morally right. This stage of Rest's psychological theory of moral behaviour is not specifically addressed in the current work. While scientists' judgment of the importance of particular behaviours associated with social responsibility in research was canvassed, intentions to actually perform these behaviours in specific situation were not. The relationship between this psychological stage and the normative theory of virtue ethics is clear. The agent must not only be able to perceive the ethical issue and make an ethical judgment about the right thing to do, but the agent must also want to, and intend to, be a moral person and do the right thing.
4. ***Moral implementation or ethical behaviour.*** The individual must have sufficient perseverance and implementation skills to follow through with their intention to behave ethically and to overcome any obstacles. This stage of Rest's psychological theory of moral behaviour is not addressed in the current work.

Rest's model is visually depicted in Figure 3.1.

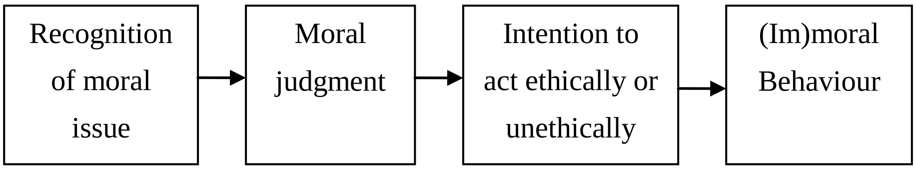

Figure 3.1. Rest's necessary psychological processes for moral behaviour.

Rest (1986) claimed that each of these stages is conceptually distinct and that success at one stage does not necessarily imply success at any other stage. Nonetheless, his model implies that before a moral judgment can be made there has to be recognition of the moral issue. Because both of these constructs are about attitudes towards social responsibility in research they are expected to be strongly related. Therefore, the following hypothesis is proposed:

H3 There will be a large positive correlation between awareness of the need for social responsibility in scientific research and development and judgments of the importance of specific behaviours to enhance social responsibility in scientific research and development.

The relationship between these two instruments (or the related constructs that they measure) forms part of the nomological network used to help infer their construct validity.

Rest defined moral judgment as “the process by which a person arrives at a judgment of what is the moral thing to do in a moral dilemma” (cited in Lan, et al., 2010, p. 185). He claimed that empirical studies linked moral judgment to moral behaviour (Rest, 1986). The focus of the current work about scientists’ social responsibility is on the first two stages of Rest’s theory: moral sensitivity and moral judgment. Rest’s theory of the psychological processes involved in moral judgment and behaviour is consistent with Ajzen and Fishbein’s (1980) theory of reasoned action, and Ajzen’s (1991) later version, the theory of planned behaviour. While the theory of reasoned action is not specifically a theory of moral behaviour, it is commonly used in the explanation of volitional behaviour. Moral action is usually considered to be an instance of volitional behaviour (although, c.f. Hume, 1957, and the meta-ethical theory of emotivism) Therefore, it is theoretically congruent that a theory of moral behaviour is consistent with the theory of reasoned action.

Personal values and social responsibility in research

Previous empirical research has shown that personal values (as measured, for instance, by the Schwartz Value Survey) are related to environmental concerns (Beckmann & Kilbourne, 1997; Beckmann, et al., 1997; Schultz & Zelezny, 1999;

Stern & Dietz, 1994; Stern, et al., 1995), to social concerns (Pichado, 1997; Schwartz, 2006; Stern, et al., 1999), to moral perception and reasoning (Abdolmohammadi & Baker, 2006; Crilly, et al., 2008; Fritzsche & Oz, 2007; Helkama, et al., 2003; Lan, et al., 2008; Lan, et al., 2010), and to moral behaviour (Bardi & Schwartz, 2003; Hitlin, 2003; Schwartz, 2006). Perceptions of the morality of an action and intentions to rectify an unethical situation are influenced by personal values (Finegan, 1993; Glover, Bumpus, Logan, & Ciesla, 1997).

It was argued in Chapter 1 that social and environmental impacts are important consequences of science and technology and, therefore, social and environmental awareness are important aspects of social responsibility in science and technological development. In this chapter, it was argued that moral perception is important in order to realise and understand ethical issues including the social and moral implications of technology. Kolberg (1969) and Rest's (1986) psychological theories of moral behaviour postulate that moral perception and moral judgment are important for determining the appropriate moral action or behaviour in a particular set of circumstances. Schwartz's value types have been empirically demonstrated to influence moral perception and moral judgement, the first two stages of Rest's model, which are the focus of the current work. Therefore, it is postulated that a scientists' personal values will be an antecedent influence on their attitudes to social responsibility regarding science and technology.

Schwartz value types. Schwartz and Bilsky (1990) proposed that values represent motivational concerns regarding three crucial evolutionary, universal requirements of human existence: the needs of individuals as biological organisms, requisites of coordinated social interaction, and survival and welfare needs of groups. Values are enduring, stable entities that are highly resistant to change (Rokeach, 1973). Schwartz (1992) identified five formal features of values that recur in the literature. These are: 1) values are concepts or beliefs, 2) values pertain to desired end states or behaviours, 3) values transcend specific situations, 4) values guide selection or evaluation of behaviour and events, and 5) values are ordered by relative importance.

Similarity between the qualities of personal values, deontological, teleological and virtue ethics, and intrinsic and extrinsic value can be immediately recognised. Values, like deontological, teleological and virtue ethics, guide selection or moral evaluation of behaviour or events. Values are beliefs or concepts which pertain to desired end states (i.e., states with intrinsic value) which may be ordered by relative importance – teleological ethics involves beliefs about, and evaluation of (an assessment of the value or importance ranking), the likely end states associated with particular behaviours in a particular situation (extrinsic value of the act). Deontological ethics involves the evaluation of behaviour or alternative behaviours (action or practice) against a set of conceptual principles (beliefs or values) which may also be ordered by relative importance. Just as values are considered to transcend specific situations, moral principles are often considered to have universal application (e.g., the meta-ethical theories of moral absolutism or subjective universalism). Values, like virtues, are strongly associated with a person's sense of self-identity. The concept of virtue helps define an individual's personal identity or self concept (as a virtuous person who seeks to do the right thing). Similarly Hitlin (2003) and Feather (1988) argued that values are at the core of personal identity.

Because values are relatively stable and central to a person's cognitive structure they are important in focussing attention on salient issues when confronted with a new attitude object – such as gene technology or nanotechnology. However, values are usually considered relatively distal determinants of behaviour, working through more proximal determinants such as beliefs, attitudes and norms (Beckmann, et al., 1997; Hitlin, 2003; Schultz & Zelezny, 1999; Stern, et al., 1999). Values form a point of intersection between the individual and society in that they are both self-centred and socially-centred, serving both individualistic and collectivist interests (Beckmann & Kilbourne, 1997).

To the extent that evolutionary selection pressures play a causal role in human values we would expect universals in the content and structure of values. The Schwartz Value Survey has received considerable cross-cultural support over more than 70 countries for the universality of its dimensions and structure (Bardi & Schwartz, 2003; Schultz & Zelezny, 1999; Schwartz, 1992, 2006; Stern, Dietz, & Guagnano, 1998). Schwartz's value theory postulates ten motivational types of values:

- **Self-direction** (individualistic): value goal is independent thought and action – comprised of creativity, freedom, choosing own goals, curiosity, and independence.
- **Stimulation** (individualistic): value goal is need for variety and stimulation to maintain optimal level of activation – comprised of excitement, novelty, and challenge.
- **Hedonism** (individualistic): value goal is pleasure or sensuous gratification for oneself – comprised of pleasure, and enjoying life.

- **Achievement** (individualistic): value goal is personal success through demonstrating competence according to social standards and thereby obtaining social approval – comprised of ambition, influence, capability, success, and self-respect.
- **Power** (individualistic): value goal is attainment of social status and prestige, control or dominance over people and resources – comprised of authority, wealth, social power, preserving one's public image, and social recognition.
- **Security** (individualistic and collectivist): value goal is safety, harmony, stability of society, of relationships, and of self – comprised of social order, family security, national security, reciprocation of favours, cleanliness, sense of belonging, and healthy.
- **Conformity** (collectivist): value goal is restraint of actions, inclinations and impulses likely to upset or harm others and violate social expectations or norms – comprised of obedience, self-discipline, politeness, honouring parents and elders.
- **Tradition** (collectivist): value goal is respect, commitment and acceptance of the customs and ideas that one's culture or religion imposes on the individual - comprised of respect for tradition, humility, devoutness, accepting one's place and role in life, and moderation.
- **Benevolence** (collectivist): value goal is preservation and enhancement of welfare of people with whom one is in frequent personal contact – comprised of helpfulness, loyalty, forgivingness, honesty, responsibility, true friendship, and mature love.
- **Universalism** (individualistic and collectivist): value goal is understanding, appreciation, tolerance, and protection for the welfare of all people and for nature – comprised of broad-mindedness, social justice, equality, world at peace, world of beauty, unity with nature, wisdom, and protecting the environment.

It is claimed that Schwartz's value types exhibit temporal stability, internal reliability, and external validity (Bardi & Schwartz, 2003). The Schwartz Value Survey is an internationally used and valid instrument for measuring value types and personal values. Empirical investigation has confirmed theoretical predictions about the relationships between the motivational types of values (Schultz & Zelezny, 1998, 1999; Schwartz, 1990, 1992; Schwartz & Bilsky, 1990; Spini, 2003). Value types that serve individual interests (power, achievement, hedonism, stimulation, and self-direction) emerged as an adjacent set of regions while value types that serve collectivist interests (benevolence, tradition, conformity) emerged as a second set of adjacent regions opposed to the first set. The relationships between the motivational types of values are visually depicted in Figure 3.2.

In the figure, adjacent value types are most compatible, whereas increasing distance around the circular order indicates decreasing compatibility and increasing value conflict. Value types opposite each other are in greatest conflict. Schwartz (1992, p. 43) claimed "the total value structure can be viewed as composed of four higher order value types that form two basic, bipolar, conceptual dimensions."

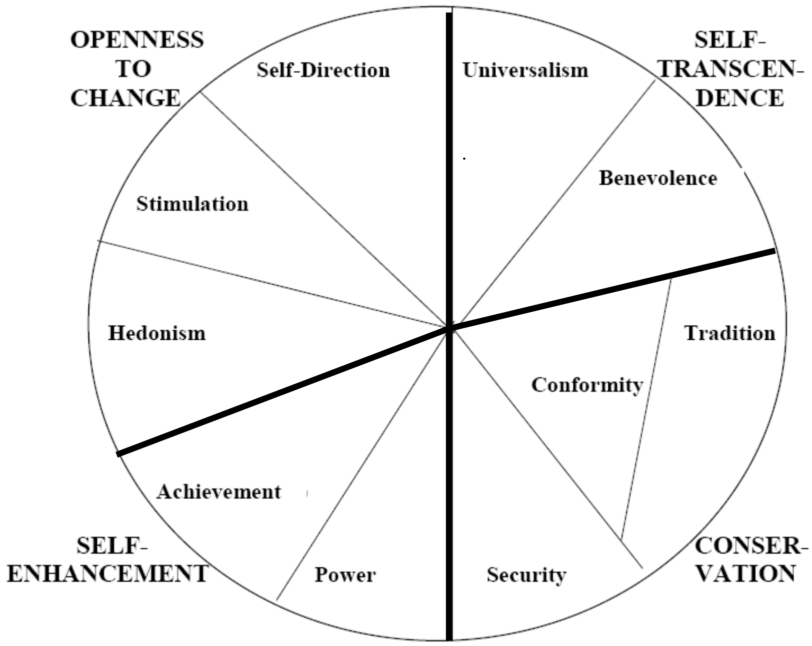

Figure 3.2. Relationships between motivational types of values, higher order value types and bipolar dimensions. (Source: Schwartz, 1992, p.45)

The first two bipolar higher order dimensions are *openness to change* versus *conservation*. At the openness to change end of this dimension are the value types of *self-direction*, *stimulation* and *hedonism*, while at the opposite end are the value types of *security*, *conformity* and *tradition*. The second bipolar dimension is *self-enhancement* versus *self-transcendence*. The self-enhancement pole includes the value types of power and *achievement*, while the self-transcendence pole includes the *universalism* and *benevolence* value types.

Openness to change. The value types of self–direction, stimulation and hedonism, which comprise the openness to change higher order dimension, are individualistic values concerned with the self, personal motivation, and personal gratification. Self direction is concerned with personal freedom, curiosity and creativity. Stimulation is concerned with excitement, novelty and challenge. Hedonism is defined as "pleasure or sensuous gratification for oneself" (Schwartz, 1992, p. 8). For the scientist, this set of values is likely to be associated with a desire to experiment with new, challenging areas of science for personal curiosity, gratification and the excitement of discovery with a dislike of restrictions being placed upon one's activities.

It is proposed that scientists strong on these values will place greater emphasis on academic freedom and their own interest in conducting scientific research than considering the social implication of the research on the wider society. This focus will be associated with a lower awareness of the need for social responsibility in research and a lower personal judgment of the importance of activities designed to enhance social responsibility. However, a reservation needs to be made based on previous empirical research. Based on similar reasoning to the above, Fritzsche and Oz (2007) also hypothesised a negative relationship between openness to change and ethical decision-making in a series of vignettes. They found a small negative (r = -.03, N = 100), non-significant correlation. Beckmann et al. (1997), while making no directional hypothesis, found a small, negative, non-significant (r = -.14, N = 264) correlation between openness to change and environmental concern. Both studies lacked adequate statistical power (at conventional levels i.e., .80) to detect a conventionally small but true population correlation (see Chapter 7, pp. 261-262 for a fuller discussion of statistical power). Myyry and Helkama (2002) found a medium size negative correlation (r = -.29, p < .05) between openness to change and moral sensitivity. Thus, although I have chosen to propose the relationships in H4 and H5 on the basis of conceptual reasoning, the few related empirical studies, although having an effect in the conceptualised direction, are unclear as to the truth or size of the effect. The available evidence suggested the relationship between openness to change and scientific social responsibility is small and negative. The following hypotheses are proposed regarding the higher order value dimension of openness to change:

H4 There will be a small negative correlation between the higher order value dimension, openness to change, and scientists' awareness of the need for social responsibility in scientific research and development.

H5 There will be a small negative correlation between the higher order value dimension, openness to change, and scientists' judgments of the importance of specific behaviours to enhance social responsibility in scientific research and development.

The individualistic value types of self-direction, stimulation and hedonism comprising openness to change are oriented towards freedom and independence, an interest in novelty and creativity, and personal gratification - values consistent with academic freedom. Technological optimism is a belief that focuses on the benefits of new technologies and minimises the risk associated with them. Perceptions of benefit and low risk may be considered as acceptable conditions for embracing academic freedom in research. Thus, although no previous empirical research was found relating these constructs, the next hypothesis is:

H6 There will be a positive correlation between the higher order value dimension, openness to change, and the construct of technological optimism.

Conservation. The value types of tradition, conformity and security which comprise the higher order dimension of conservation are primarily collectivist values (security is both individualistic and collective) concerned with the wellbeing of others and the stability and harmony of society. Security is concerned with the safety, harmony and stability of society, the preservation of social order and the security of family and nation. Conformity is concerned with the non-violation of social norms and restraint of actions that might cause harm to others. Tradition is concerned with respect for traditions and the customs of one's culture. This set of values is likely to be associated with reservations about new and disruptive technologies that will have profound effects upon society, particularly any which may have harmful social impacts. However, while conformity was found to be positively correlated to the New Environmental Paradigm and ecocentrism, tradition was negatively correlated with these measures of environmental attitudes (Schultz & Zelezny, 1999), suggesting mixed forces operating within the higher order value dimension of conservation with respect to environmental attitudes (and perhaps attitudes to social responsibility).

Fritzche and Oz (2007) found a small (r = -.15) non-significant negative relationship between conservation and ethical behaviour (although, as discussed above this study has low statistical power). Myyry and Helkama (2002) found a small non-significant positive correlation (.07) between conservation and moral sensitivity (with a sample size of 50, statistical power of this study was also poor). The conceptual reasoning and empirical evidence relating conservation to social responsibility is mixed. Nonetheless, it is tentatively proposed that scientists strong on these values will be sensitive to the social impacts on society of emerging Promethean technologies and place greater emphasis on the greater good of society than their personal research ambitions. This focus will be associated with a higher awareness of the need for social responsibility in research and a higher personal judgment of the importance of activities designed to enhance social responsibility. However, because of the mixed theoretical and empirical evidence, it is expected that the relationships depicted by H7 and H8, if correct, will be small. Therefore, the following hypotheses are tentatively proposed regarding the higher order dimension of conservation:

H7 There will be a small positive correlation between the higher order value dimension, conservation, and scientists' awareness of the need for social responsibility in scientific research and development.

H8 There will be a small positive correlation between the higher order value dimension, conservation, and scientists' judgments of the importance of specific behaviours to enhance social responsibility in scientific research and development.

The reasoning used above to propose a positive relationship between conservation and social responsibility suggests that individuals rated highly on conservation, with its focus on security, conformity and tradition, might be hesitant about new and novel technologies that create great change and hence negatively related to technological optimism. On the other hand, empirical research suggests that scientists tend to be highly optimistic about the technologies they are developing (National Science Board, 1977; Rollin, 1996; Ticky, 2004). Since the enlightenment, technology has been considered a driving force behind the grand narrative of progress of western civilisation (Lyotard, 1984). The traditional, and currently still dominant, social paradigm of both western culture and the culture of science is one of optimism about technology and belief in the technological fix (Costanza, 1989; Gaskell, et al., 2004; Milbrath, 1984; Pirages & Ehrlich, 1974; Postman, 1993; Winner, 1986). These considerations might suggest that conservation, with its orientation towards stability and the preservation of one's culture will be positively associated with a belief in technological optimism. Due to these conflicting conceptual arguments any relationship is likely to be small. Therefore, the following hypothesis is tentatively proposed:

H9 There will be a small positive correlation between the higher order value dimension, conservation, and the construct of technological optimism.

Self-transcendence. Benevolence is a collectivist value type while universalism is individualistic and collectivist. These value types comprise the higher order dimension of self-transcendence. Benevolence is concerned with the "preservation and enhancement of the welfare of people with whom one is in frequent personal contact" (Schwartz, 1992, p. 11). Universalism is concerned with the "understanding, appreciation, tolerance, and protection for the welfare of *all* people and for nature" (Schwartz, 1992, p. 12, emphasis in original). Schwartz claimed that people high on this value "realise that failure to accept others who are different and treat them justly will lead to life-threatening strife, and failure to protect the natural environment will lead to the destruction of the resources on which life depends" (Schwartz, 1992, p. 12).

As documented in Chapter 1, the primary risks associated with Promethean technologies are social and environmental and hence it is proposed that scientists strong on self-transcendence values will be sensitive to the social impacts of Promethean technologies on society and nature. They will also be likely to have a higher personal judgment of the importance of activities designed to enhance the social and moral responsibility of science. Empirical evidence has found positive relationships with medium effect sizes between self-transcendence (and universalism and benevolence) and environmental concern (Beckmann, et al., 1997; Schultz & Zelezny, 1998, 1999; Stern, et al., 1995) and self-transcendence (and universalism and benevolence) and moral judgment and behaviour (Crilly, et al., 2008; Fritzsche & Oz, 2007; Helkama, et al., 2003; Lan, et al., 2008), and self-transcendence and moral sensitivity (Myyry & Helkama, 2002). As all these reported empirical relationships were medium size positive effects, a medium size positive relationship between self-transcendence and social responsibility in science is predicted. Therefore, the following hypotheses are proposed about the higher order dimension of self-transcendence:

H10 There will be a medium-size positive correlation between the higher order value dimension, self-transcendence, and scientists' awareness of the need for social responsibility in scientific research and development.

H11 There will be a medium-size positive correlation between the higher order value dimension, self-transcendence, and scientists' judgments of the importance of specific behaviours to enhance social responsibility in scientific research and development.

From a conceptual perspective, high concern for the welfare of nature and all humans may lead to caution regarding, or even rejection of, the concept of a technological fix for all environmental and social problems. This reasoning would suggest a negative relationship between self-transcendence and technological optimism. Kilbourne et al (2001, p. 212) argued similarly that for individuals who believed in *technofix,* cause for concern regarding environmental problems "is minimized, engendering an attitude suggesting that change in individual or social behaviour ought to be unnecessary." They proposed two hypotheses regarding individuals' increasing belief in the technofix: "(a) their perception of the existence of environmental problems will decrease, and (b) their perception of the amount of change necessary to protect the environment will decrease" (p. 213). For hypothesis (a) they found a correlation of -.22 for perception of general (environmental) problems and -.20 for perception of specific (environmental) problems, and -.30 for hypothesis (b). Therefore, a small- to medium-size negative relationship is proposed between self-transcendence and technological optimism.

H12 There will be a small-to medium-size negative correlation between the higher order value dimension, self-transcendence, and scientists' belief in technological optimism.

Self-enhancement. The value types of power and achievement, which compose the higher order dimension of self-enhancement, are individualistic values concerned with personal power, wealth and ambition. Power is concerned with the "attainment of social status and prestige, and control and dominance over people and resources" (Schwartz, 1992, p. 8). Promethean technologies offer increased personal power and control over both 'the other' and nature. Achievement values "emphasize demonstrating competence in terms of prevailing cultural standards, thereby attaining social approval" (Schwartz, 1992, p. 8). These values are strongly concerned with self as opposed to other life and nature.

Concern with personal interests may obscure awareness of social and moral impacts of Promethean technologies and lower judgment of the importance of activities designed to enhance the social responsibility of science. Empirical research supports this reasoning with self-enhancement (in particular, the comprising value type of *power*) found to be negatively correlated (r = -.20, p <.01) with perceptions of ecological problems (Beckmann, et al., 1997), negatively correlated (r = -.22, p <.05) with ethical behaviour (Fritzsche & Oz, 2007), and negatively correlated (r = -.38, p < .01) with moral sensitivity (Myyry & Helkama, 2002). Therefore, hypotheses 13 and 14 are proposed.

H13 There will be a small- to medium-size negative correlation between the higher order value dimension, self-enhancement, and scientists' awareness of the need for social responsibility in scientific research and development.

H14 There will be a small- to medium-size negative correlation between the higher order value type, self-enhancement, and scientists' judgments of the importance of specific behaviours to enhance social responsibility in scientific research and development.

Achievement and power, the value types comprising self-enhancement, are oriented towards personal wealth, ambition, success, and control and dominance over people and resources. While Promethean technologies offer increased power to control people and resources, technological optimists perceive benefit rather than risk associated with such technologies. Some empirical studies have suggested a positive relationship between self-enhancement and optimism (e.g., Regan, Snyder, & Kassin, 1995) and between self-enhancement and lowered perceptions of environmental risk (e.g., Stern & Dietz, 1994; Stern, et al., 1995). It is proposed that self-enhancement will be positively related to a belief in technological optimism. The empirical evidence is too slight to meaningfully predict the size of the relationship. Therefore, the next hypothesis is:

H15 There will be a positive correlation between the higher order value dimension, self-enhancement, and the construct of technological optimism.

Summary

This chapter outlined the traditional normative ethical and meta-ethical theories relevant to understanding the social responsibility of science and scientists to society. It then discussed three areas of applied ethics of particular relevance to the topic (environmental ethics, bioethics and technoethics), highlighting calls from scholars about the need for an extended ethic of scientific social responsibility. Emphasis was placed on the responsibility of the science community, and individual science practitioners, to society and Gaia, and the critical role they play. Philosophers' claims about the importance of moral perception and sensitivity to ethical judgment and behaviour were then discussed.

The concept of existential risk and its relationship to the precautionary principle was introduced. Costanza's Payoff Matrix, which analyses consequent effects of approaches to handling existential risks, introduced the notion of technological optimism. Evidence for over-optimism amongst scientists regarding their own field of technology was presented and a relationship between technological optimism and scientists' attitude to their social responsibility to society was postulated. A specific directional hypothesis was proposed regarding technological optimism and each of the two new instruments being developed to measure scientists' attitudes to social responsibility in research.

Next, three well established psychological theories relevant to moral perception and moral judgment were explicated: Kolberg's theory of cognitive moral development, Rest's theory of the stages of moral behaviour, and Schwartz's theory of personal values. Relationship between four higher order value dimensions and scientists' attitude to their moral responsibility to society was postulated: eight analytically derived directional hypotheses were proposed between the well established Schwartz higher order value dimensions and the two new instruments designed to measure scientists' attitudes to social responsibility. Four directional hypotheses were also proposed regarding the relationship between the Schwartz higher order value dimensions and attitude to technological optimism. These relationships form part of the nomological network of constructs designed to help infer construct validity to the new instruments developed in this thesis. In addition, a large positive relationship between the two new instruments to measure scientists' attitudes to social responsibility was hypothesised.

The next chapter reviews scientists' concern with social responsibility. Several hypotheses are proposed regarding the relationship between scientists' attitudes to social responsibility and to consequent variables (i.e. commercialisation of science and democratisation of science).

Chapter 4 - Scientists' Concern with Social Responsibility

This chapter reviews scientists' concern with social and moral responsibility. In the first section the writings of scientists (in particular, physicists, physicians and ecologists) are reviewed. In the second section, the meagre research literature regarding scientists' attitudes to social and moral responsibility in science and technological development is reviewed.

Promethean Technology and Scientists' Responsibility to Society

This section reviews literature regarding scientists' writings about ethical and social responsibility in scientific research and technological development. Although socially and morally irresponsible behaviour includes misconduct and unethical behaviour, this is not the focus of the current work. For scientists, being socially responsible implies more than just not being unethical (Bunge, 1977; Jonas, 1985; Luppicini, 2008; Pigman & Carmichael, 1950; Reiser & Bulger, 1997; Ziman, 1998).

Pimple (2002) noted that unethical behaviour by scientists and research misconduct has received considerable previous attention from scholars, with guidelines for in/appropriate practices being well established. In contrast, he claimed that social responsibility – the relationship between research and the common good - had received very little attention, and guidelines were non-existent. On a similar note, Prpic (1998), in her study of eminent Croatian scientists' values, also observed a lack of empirical research regarding scientists' attitudes to social responsibility. Therefore, one goal of the current work is to help fill this void in the empirical literature and to further develop the construct of social responsibility in research. Because of the dearth of empirical research into scientists' attitudes, and because a small group of scientists have been at the forefront of advocating an increased role of social responsibility for scientists and technologists, a sample of these scientists' thoughts regarding the issue are reviewed.

Because of their role as the producers of knowledge and inventors of technology, scientists have a higher degree of insight into how such discoveries and inventions might affect the world (Reiser & Bulger, 1997). Scientists are the *human cause* behind science and technology and, in general, they have greater understanding than the public or politicians about the implications, the probabilities and uncertainties, and the risks and benefits associated with their science and technology (although, as previously discussed, research indicates that top experts are inclined to be overly optimistic in their evaluation of a new technology). Promethean technologies affect "an increasing number of people [and they] provide novel opportunities for action about which well thought out ethical policies have not yet been developed" (Luppicini, 2008, p. 1). Therefore, scientists have an extra responsibility to society to ensure the products of their research are used for the good of society rather than for harm. Reiser and Bulger (1997), noting that standards have been set to protect human and animal participants in scientific experiments from harm and abuse, claimed that this sets a precedent for the scientific community's responsibility, not only to individual subjects, but also to society.

After the Second World War and the development of nuclear technology, the social and moral role of the scientist came under increased public scrutiny and debate. Questions raised concerned the role of science as: the disinterested pursuit of knowledge; the pursuit of economic and commercial interests; and a practical response to human suffering. The role of social responsibility in setting research agendas became a matter of public debate too (Nicholas, 1999b). Scientists themselves, especially physicists, physicians and ecologists, were amongst the first to raise the issue of their extra responsibility due to the increased power of Promethean technologies to affect the social and physical worlds.

Physicists

Largely because of the Manhattan Project and the unleashing of nuclear energy at Hiroshima and Nagasaki, physicists were in the vanguard of those realising the need for an increased ethic of social responsibility in science (Nicholas, 1999b). The physicist, J. Robert Oppenheimer, who led the Manhattan Project to develop the atomic bomb, in a speech to workers at Los Alamos on November 2, 1945 made the following statement:

> It is not possible to be a scientist unless you believe that the knowledge of the world, and the power which this gives, is a thing which is of intrinsic value to humanity, that you are using it to help in the spread of knowledge, and are willing to take the consequences (cited in Masters, 2007, p. 0399014).

Philip Abelson, a physicist whose work made a major contribution to the Manhattan Project, suggested in a 1970 editorial of *Science* that "a few decades ago, most scientists held the view that their principal duty was to advance the frontiers of knowledge" (Abelson, 1970, p. 241). He claimed that this was changing, with public policy aspects of science and technology gaining an increasing role in scientists' activities. Thus, he suggested that "scientists will have continuing and important roles in determining how science is applied. One important function is that of watchdog." (p.241). He believed that scientific communities could play an important role helping to create judicious public opinion and that "scientists can make imaginative contributions to planning, and they can help ensure that the factual bases for decisions are as sound as possible" (Abelson, 1970, p. 241).

Nobel Peace Laureate and physicist Sir Joseph Rotblat also worked on the Manhattan Project, resigning before completion of the bomb when it became clear that Germany had abandoned its efforts to construct one. He argued that although science has enormously improved the quality of life, it has also "created great perils, threatening the very existence of the human species" (Rotblat, 1999, p. 1475). He believed that scientists must be accountable for their research, and professional organisations of scientists "should work out ethical codes of conduct for their members, including the monitoring of research projects for possible harm to society" (p. 1475).

The Russian physicist and Nobel Peace Laureate, Andrei Sakharov, while in isolated detention in Gorky, wrote an essay on the responsibility of scientists, published in *Nature* (Sakharov, 1981). While holding similar views as those expressed above regarding the social responsibility of scientists, probably because of his (and of some of his Russian colleagues') particular situation, his views have a somewhat more political and activist stance. He considered that: "Scientists and scholars cannot fail to think about the dangers stemming from uncontrolled progress, from unregulated industrial development, and especially from military applications of scientific achievement". Therefore, he claimed experts are "under an obligation to subject these problems to unbiased and searching examination, making all socially significant information available to the public in direct, first-hand form, and not just in filtered versions" (p.184).

Describing the abuses of human rights that he and other Soviet scientist had been subjected to, Sakharov stated: "in order to protect innocent persons it is permissible and, in many cases, necessary to adopt extraordinary measures such as an interruption of scientific contacts or other types of boycott" (1981, p. 185). He argued that it was time for scientists to demonstrate their sense of responsibility in a socially significant way and to take a public stand. He concluded his essay by saying "the defence of justice, the international defence of individual victims of violence, the defence of mankind's lasting interests are the responsibility of every scientist" (p.185).

Albert Einstein, perhaps the most renowned scientist and physicist of the 20th century, made several memorable statements that demonstrated his attitude to the issue of social responsibility in scientific research and application:

- "Technological progress is like an axe in the hands of a pathological criminal" (Einstein, n.d. -a).
- "It has become appallingly obvious that our technology has exceeded our humanity" (Einstein, n.d. -b).
- "Concern for man and his fate must always form the chief interest of all technical endeavours. Never forget this in the midst of your diagrams and equations" (Einstein, n.d. -c).

The first two statements emphasised the danger of powerful modern technologies in the hands of a very fallible humanity. Einstein was suggesting that humanity's spiritual and moral development is insufficient to wisely handle our current technological power. The third statement makes it clear that he believed that social responsibility should be every scientist's *primary* concern.

Physicians

Physicians are responsible for the wellbeing of people. This responsibility has led them to be amongst the leaders in recognising the potential harms of technology for humanity and in advocating increased social responsibility in science (Physicians for Social Responsibility, n.d.). However, Lewis Wolpert (1989), (a distinguished professor of medicine) claimed science is not responsible for the misapplication of knowledge. Nonetheless, he suggested a major obligation for scientists: the necessity to inform the public on science and its social implications. As Wolpert saw it, scientists' obligations were to examine the social implications of their work, to make these known to the public and to make it clear how reliable their conclusion were. He did not consider it to be the responsibility of scientists' to decide how it should be used – rather, he saw this as a political decision. He claimed:

> Whatever new technology is introduced, it is not for scientists to make moral or ethical decisions about its use, as they have no special rights or skills in this regard. There is grave danger in asking scientists to be more socially responsible if they would also be given the right and authority to make such decisions on their own. (Wolpert, 1999, p. 281)

This statement by Wolpert may be criticised on several points. First, it is not clear that scientists "have no special rights or skills in this regard", as some of the arguments discussed above show (e.g., Bunge, 1977; Cournand, 1977; Jonas, 1985; Luppicini, 2008). As the discovers of new knowledge and inventors of new technologies they may have marginal extra benefits and rights compared to the rest of society; indeed this is traditionally recognised by the granting of patents and the bestowing of honours for scientific achievements. If researchers are to be credited as being responsible for positive outcomes from their discoveries and inventions should they not, as Reiser and Bulger (1997) and Bunge (1977) argued, also being held responsible for harm?

Second, as scientists and specialists in their particular disciplines they may possess knowledge and skills which allow them to better understand and predict the potential applications of new technologies than those unversed in the relevant science (Luppicini, 2008; Reiser & Bulger, 1997). Certainly, scientists may better understand the causal processes involved – an important aspect of foresight and teleological ethics as proposed by Moore (1966) and Bunge (1977). Third, asking scientists to be more socially responsible does not necessarily mean giving them "the right and authority to make such decisions on their own" (Wolpert, 1999, p. 281). Rather, it involves scientists' greater participation in societal decision-making processes regarding science. This can occur through transparent science processes, technological foresighting and evaluation, advocacy for the objects of intrinsic value studied or impacted by their scientific discipline, and information dissemination to, and dialogue and deliberation with, the public and other relevant stakeholder groups regarding moral issues related to science, technology and their uses and application within society.

Wolpert (1999, p. 282), cautioning against bioethics, claimed pejoratively that it is a "growth industry" and that "bioethicists have a vested interest in finding difficulties" (p. 282). He argued for a "distinction between knowledge of the world and how it is to be used" (p. 282). However, other authors argue that while this distinction may have been valid in the past, because techno-science, big science, or as termed in the current work, Promethean science and technology, are so intertwined in the production of knowledge and its use, this distinction has broken down and is no longer valid (Haraway, 1997; Nicholas, 1999a).

Wolpert (1999) further claimed: "One should not abandon the possibility of using a scientific idea to do good because one could use the same idea to do bad. There is no knowledge that is not susceptible to manipulation for evil purposes" (p. 282). Even agreeing with Wolpert on these two propositions, one could still take the position that some technologies are almost purely evil (as did, for example, Bunge, [1977]), having no, or almost no, foreseeable good applications, and hence ought to be banned. Candidate technologies for pure evil might include nuclear weapons, biological weapons and other weapons of mass destruction as highlighted by the Russell-Einstein Manifesto. However, it should be noted that the people responsible for developing the *Mutual Assured Destruction* (M.A.D.) rationale for the development and proliferation of nuclear weapons may not share this view (Sokolski, 2004).

In Wolpert's (1989, 1999) view, the extra social and moral responsibility of scientists lies in transparency of knowledge and information through engagement with the public about scientific discoveries, their potential implications for society, and the degree of certitude associated with the science. He did, however, note that for scientists there may be conflicts between "responsibilities as researchers and their responsibility to those for whom they work" (1999, p. 281). Although not defining what he meant by "responsibilities as researchers" he went on to point out that "Scientists, just like everyone else, have to try not to become the unquestioning tools of their employers" (1999, p. 282), implying that in certain circumstances scientists have a responsibility to question and even act against the instructions of their employers. Considering the question of whether there are some areas of knowledge that are too dangerous to research (as was argued by Commoner, 1966; Dainton, 1971; Joy, 2000), Wolpert (1999) claimed that, provided the above responsibilities were fulfilled, then there were no areas which ought not to be subject to research.

Another physician, Kenneth Shine, in his Presidential address to the Institute of Medicine, National Academy of Sciences (USA), also argued for a higher degree of accountability of scientists and physicians for science and its products (Shine, 1989). He considered that scientists must identify the importance of what they do in relation to improvements in health and biotechnology. He also saw the need for a larger social ethic – one that addresses the question about the right and proper way for society to use its resources and set its priorities. Unlike Wolpert, Shine believed that scientists have a responsibility for how knowledge is used and to whom it is made available. He claimed that recognising and acting on the need for accountability is ethically and socially essential, and that doing so will increase society's confidence in science.

Ecologists

Ecologists, like physicists and physicians, are another group of scientists whose research prompts a focus on social responsibility. According to Bradshaw and Bekoff (2001), ecologists are caught between two competing models of science: "a science apart from society and a science directly engaged with society" (p.460), with some ecologists arguing for a new social contract of active engagement while others argue that such engagement amounts to advocacy undermining scientific neutrality and credibility. Ecologists work at the intersection of humans, nature, science and society. They consider such topics as sustainability, ecosystems services, animal ethics and restoration ecology. These issues explicitly involve studying the relationship between humans and nature and implicitly require examining the boundaries between science and society (Bradshaw & Bekoff, 2001).

Claiming that "most environmental problems stimulating current research are products of science and the culture in which they were developed" (p.460), Bradshaw and Bekoff (2001) considered that the question of how separate science is, or should be, from society should be a concern for all scientists. They stated their case for scientific social responsibility:

> There is growing recognition of the social and ecological costs that have accompanied science and its supporting worldview. The majority of reported marine dead zones, extinctions and land transformations of nearly half of the surface of the Earth have been created directly or indirectly by Euro-American cultures at the expense of the indigenous peoples. In the 21st century, science is challenged to be relevant to multiple worldviews, many of which are beginning to appear in ecological literature and concepts." (Bradshaw & Bekoff, 2001, p. 462)

In their opinion, excluding consideration of science-society interactions and its intrinsic subjectivity diminishes the power of science, and makes it more vulnerable to political manipulation. Therefore, they sought a broader view of scientific knowledge – one that included in its practice and theory, scientists and science itself (Bradshaw & Bekoff, 2001). The current work also shares this perspective. Bradshaw and Bekoff stated:

> Many ecologists argue that the biosphere should be viewed as an integrated complex system. The incorporation of the human dimension necessitates that ecologists go one step further and view the knowledge, practice and practitioners of this dimension as part of the biosphere. (Bradshaw & Bekoff, 2001, p. 464)

The thesis of their paper is that this kind of understanding requires shifting from a model of science as separate from society to one of integration. Somewhat similarly to Ziman (2001), Bradshaw and Bekoff argued that integrative approaches to science and interdisciplinary collaboration need to be part of a science education that supports socially responsible science.

The Russell-Einstein Manifesto

On 9 July, 1955 the Russell-Einstein Manifesto was issued in London by an eminent group of scientists including Albert Einstein, Bertram Russell, Max Born, Linus Pauling and Joseph Rotblat. The Manifesto, noting the "tragic situation which confronts humanity…as a result of the development of weapons of mass destruction", called for an end to war and invited scientists and the general public to subscribe to the following resolution:

> In view of the fact that in any future world war nuclear weapons will certainly be employed, and that such weapons threaten the continued existence of mankind, we urge the governments of the world to realise, and to acknowledge publicly, that their purpose cannot be furthered by a world war, and we urge them, consequently, to find peaceful means for the settlement of all matters of dispute between them. (Russell & Einstein, 1955)

The Russell-Einstein Manifesto instigated the 'Pugwash Meetings' which, according to Khan (1988, p. 258), became a force of moderation in international relations and emphasised "the new role of the scientist as the conscience of humanity, and the moral duty of the scientist to be concerned with the ethical consequences of his (sic) discoveries."

The epistemic code of scientists

Over time, scientists have developed general rules of procedure to guide the conduct of individual scientists towards each other and to help produce certified knowledge. Merton (1942b) examined the general norms of scientific activity, defining these rules as: 1) *universalism*: scientific work should be judged on the basis of its scientific merits or significance alone, 2) *principle of organised scepticism*: scientific works should be judged provisionally on the relevant evidence at hand – however, an open mind should be kept regarding what might be found in future, 3) *principle of disinterestedness*: the advancement of scientific knowledge should take primacy over scientists' personal motives, 4) *the principle of communism*: scientists should share the knowledge acquired through research with the scientific community, which has a right to that knowledge. This last principle is often in conflict with the commercialisation of science and the patenting of intellectual property that became a prominent feature of late 20th century science (Krimsky, 2004).

Twenty-five years after Merton first formulated the scientist's code, Cournand (a Nobel Laureate for medicine) and Meyer (1976) reformulated the norms for scientists as: *honesty, objectivity, tolerance, doubt of certitude, unselfish engagement and communal spirit*. Honesty and objectivity were defined as: avoiding the undisciplined introduction of subjective elements into their perceptions, preventing their desires and aversions from penetrating their observations of the phenomena that they study and their analyses of these observations. Cournand and Meyer argued this could affect selection of problems and hypotheses and the presentation of data (Cournand, 1977; Cournand & Meyer, 1976).

Tolerance was defined as "the recognition that respect for the creative potentialities of other scientists is closely related to respect for their good faith" (Cournand, 1977, p. 700). Doubt of certitude was defined as: "an attitude of readiness to question what is accepted as certain by established authorities in science is one of the *primum movens* in the generation of new knowledge" (p.700). Recognition of error is relevant because: "the recognition, acknowledgment, and admission of error favors progress in understanding" (p.700). Unselfish engagement was defined as: "the scientist's purpose should be to extend our knowledge and understanding of the universe, and not to secure personal gain or promote the supremacy of a particular philosophy or ideology" (p.700). Communal spirit was defined as:

> It is incumbent on scientists to appreciate and respect their dependence on the community of scientists. Scientists must recognise that their own work is part of the larger scientific enterprise and that they themselves are linked to their colleagues through submission to its traditions and participation in its ethos. (Cournand, 1977, p. 700)

Ziman (2001) called the values underlying the scientists' code *epistemic values* because they are principally invoked as a process for acquiring certified scientific knowledge, a necessary aspect of scientists' social and moral responsibility. However, in Ziman's view, it is not a sufficient condition, given the power of modern technology to ubiquitously affect society. In contrast, he referred to the values that relate to how scientific knowledge is put to use in society as *moral values*. In the current work, these moral values have been referred to as *social and moral responsibilities*. For convenience, henceforth, the term "the *social responsibilities* of science and scientists" will be used.

The code of scientists as explicated by Merton and reformulated by Cournand and colleagues contains epistemic values, but it does not contain prescriptions about how scientists should act in regard to the use to which their discoveries are put (Cournand, 1977; Ziman, 1998). That is, it does not prescribe an ethic of social responsibility for scientists. Cournand (1977) noted that industrialised countries were experiencing the fruits of science in terms of unparalleled technological development, but that the benefits of these new technologies were distributed in a grossly unbalanced manner, both within industrialised countries and among the nations of the world. He claimed that the traditional code of scientists is no longer sufficient as a guide for scientists' responsibilities, that it "does not give adequate guidance in such matters as the value of scientific knowledge versus other aspects of life or the application of the knowledge gained by scientific research" (1977, p. 702).

Ziman (1998) observed an historic distinction between academic scientists and industrial scientists, claiming that Merton's code of scientists was mainly applicable to academic scientists while industrial scientists were committed to a different (unstated) code. Whereas academic scientists could claim disinterest, objectivity and academic freedom, industrial scientists were required to loyally serve their employers, they were not free to choose their own topics or publish at will, and they did not own the results of their research. Despite the fact that the products of industrial science are intimately interwoven into society and industrial scientists are more likely than academic scientists to encounter ethical dilemmas of social responsibility, they do not usually have a direct say in how these dilemmas are resolved. Rather, the legal responsibility rests with their corporate employers, who frequently are not scientists themselves.

Ziman (1998) claimed that, like academic scientists, industrial scientists have shied away from the ethics of social responsibility, albeit for somewhat different reasons. He pointed out that industrial scientists are not completely powerless, or exempt from blame, in the face of unethical or socially irresponsible behaviour by their employers. They can choose not to take jobs with organisations whose policies and practices they find ethically unacceptable or they can resign or whistle-blow if required to do unethical or socially irresponsible work. And, like other subordinates, they cannot escape personal blame for crimes committed on the orders of higher authorities (Ziman, 1998).

A moral code for scientists

Cournand argued for the extension of his reformulated scientist's code beyond the domain of science, that is, scientists should apply their traditional code in their transactions with the extra-scientific realm of society. He proposed that the code should recognise that scientists are individuals who live in a society which has ends other than those of scientists and suggested that the code should be a basis for dialogue and pragmatic reconciliation of conflicting views (Cournand, 1977).

Cournand characterised science and technology as following a path of blind emergence, analogous with biological evolution, which has led to the current broadening disparities between those who have and those who have not, while technology remains unchecked. He believed that we need to find ways of controlling the processes of emergence to favour humankind's survival – this he termed *humanised emergence*. Like Ziman (2001), Cournand wanted an ethic for science that fosters the values of egalitarianism, political pluralism, and fraternalism in socio-political development.

Ziman (2001, p. 165) claimed that "research scientists are trained to produce specialised bricks of knowledge, but not to look at the whole building." Similar to Bradshaw and Bekoff's (2001) argument, Ziman stated the case for what he called 'metascience', an educational discipline extending "beyond conventional philosophy and ethics to include the social and humanistic aspects of the scientific enterprise" (p. 165). He wanted to see metascience become an integral part of scientific training in order to help equip scientists of the future with the skills necessary to tackle ethical dilemmas as they arise.

Research on Scientists' Attitude to Social Responsibility

As documented above, a number of eminent scientists have published their views regarding the necessity for increased social responsibility in science and technological development and philosophers of science and technology have likewise made a considerable contribution to the discussion of this issue. However, according to a number of authors (e.g., McCormick, et al., 2009; Pimple, 2002; Prpic, 1998; Weil, 2002), published empirical research into scientists' attitudes to social responsibility is almost non-existent. Many studies have examined the ethical attitudes of various professional groups, including scientists and engineers. However, usually the focus of such studies was on participants' attitudes regarding misconduct or unethical behaviour in research or practice, or the epistemic values of science, rather than attitudes to social responsibility regarding the wider community.

The premise underlying the present thesis is that the Promethean power of modern science and technology warrants an extended ethic of social responsibility on the part of the scientists and technologists (Bunge, 1977; Cournand, 1977; Jonas, 1985; Lenk, 1983; Luppicini, 2008; Moor, 2005; Ziman, 2001). The purpose of the empirical research presented here is to examine scientists' and technologists' attitudes to social responsibility in science and technology. While this question has surfaced as a small part of a larger issue in some other studies, no other study for which this question is the primary focus has been identified during the literature search for this paper.

One study, which looked at the professional values of eminent scientists in Croatia (Prpic, 1998), identified six areas of social relations of scientists 1) colleagues, 2) students, 3) respondents and/or patients, 4) work organisations, 5) clients or research sponsors, and 6) the wider social community. It is this latter component, scientists' values regarding their relationship with the wider social community, which is relevant to the present discussion. Another study, which asked a limited number of questions on social responsibility, amongst a range of other issues, is the 2008 survey of New Zealand scientists and technologists by Sommer (2010). A couple of studies also examine scientists' attitudes to public engagement (Market & Opinion Research International, 2000; Small & Mallon, 2006). Small and Mallon (2006) also examined scientists' attitudes to the commercialisation of science, another factor which, as previously discussed, the public and some scholars believe restricts scientists' ability and predilection to act socially responsibly.

A study by Krasner and Houts (1984) examined the differences in value structure and epistemological beliefs about science amongst two groups of psychologists, behaviourists and non-behaviourists. Over the past 60 years a small body of empirical literature has examined the psychology of scientists, sometimes including their values. However, generally they address epistemic values rather than the issue of scientists' social responsibilities to society. As these were the only related empirical studies that the author could find they are discussed in greater detail in the remainder of this chapter.

The epistemic values of scientists

Mahoney (1979) reviewed the empirical literature about the psychology of scientists and examined evidence for the generally accepted Mertonian (epistemic) social norms in actual scientific behaviour. He cited ample evidence to show that these idealised norms are frequently violated by scientists in practice. He cited a number of well known examples demonstrating that scientists frequently are not objective but are strongly influenced by particular theories, which as Kuhn (1962) has shown, they are very reluctant to give up, even in the face of new evidence (which also contradicts the Mertonian values of organised scepticism and the disinterested pursuit of truth). Some scientists even refused to examine evidence (e.g., Skinner refused to examine Chomsky's criticisms of behaviourism) which claimed to contradict their pet theories (Mahoney, 1979).

Scientists' objectivity is also often compromised by intense emotions regarding their work. Thus, Mahoney (1979, p. 353) cited Mitroff (1974, pp. 70-71) regarding the "inner and often extreme emotions that are connected with the doing of science" and noted that Mitroff challenged the idea that it is desirable for scientists to be unemotional in their work. Rather, he claimed, it is this passion that motivates them. Mahoney also documented evidence that the principle of communality (open sharing of information and cooperation with scientific colleagues) is often neglected in the competitive endeavour to be first to publish, a very important career factor for many scientists, which Mahoney described as "perhaps the most generously documented phenomenon in the literatures of science" (p. 362). For industrial scientists, the imperative of patenting new discoveries obstructs and clashes with the principle of communality (Grisham, 2000; Leonard, 2002; Schacht, 2006; Wadman, 2010).

Mahoney (1979) also attacked the idea that scientists are particularly rational and logical in their work. He claimed scientists suffer from *confirmation bias*. This is a tendency to actively seek out and give more weight to evidence that confirms one's hypotheses, and ignore or underweight evidence that disconfirms those hypotheses. He pointed out that confirmation bias is also common in the practice of scientific publication, with editors preferring to publish positive results rather than negative results. He claimed that "popular over-emphasis on null hypothesis testing exacerbates this irrationality" (p. 355).

Croatian scientists' values

In her study of eminent Croatian scientists, Prpic (1998) used the responses of 320 scientists to ratings of the importance of a range of value statements, garnered from philosophy, sociology and psychology, regarding the practice of science, to analyse their values. Her sample included 64 natural scientists, 61 technical scientists, 111 life-scientists (bio-medical and bio-technical) and 84 social scientists. Overall, the scientists rated all the values as important, although there were considerable differences in the degree of importance attributed to social values and norms. In particular, the traditional epistemic values were rated highly important: conceptual accuracy, objectivity, and commitment to searching for the truth. Interestingly, responsibility for the effects of one's research results, a value implying a degree of social responsibility, was considered very important (the third most important value) by Prpic's sample.

The next most important group of values was related to supporting colleagues and sharing knowledge, knowledge for the benefit of society (a value implying social responsibility), openness to data and originality. The lowest ranked values (though still above the scale midpoint) were the rights of respondents and patients – anonymity and voluntary participation, the accessibility of research and data to scientific public scrutiny, and value-neutrality: "consistent ethical neutrality or avoidance of evaluating human and social un/desirability of scientific results" (p. 278).

Because of the lack of any previous empirical data regarding scientists' attitudes towards social responsibility, on a philosophical basis, Prpic hypothesised that value-neutrality (the idea that science is the value free discovery of true knowledge) would define scientists' attitudes to social responsibility. That is, she hypothesised that those who view science as value-neutral will be less inclined to consider the social and moral implications of their research. Value-neutrality was rated the least important of the rated values. Nonetheless, it still received considerable support, 46% rating it as important and 16% as very important. Prpic noted that this contradicts the ranking the scientists gave to "knowledge for the benefit of man [sic] and society and responsibility for the effects of one's research results". Prpic (1998, p. 279) asked: "how can a scientist be responsible for the effects of his or her research without evaluating its humane and social value?" She concluded that only a small proportion of scientists in her study held a consistent attitude towards social responsibility.

Prpic's (1998) analyses showed that there were significant differences between scientists from different disciplines in regard to the factor of broader social responsibility. Technical and life scientists showed the greatest concern with social responsibility, while natural scientists and social scientist showed less such concern. However, the technical and life scientists also displayed greater value-neutrality than the natural and social scientists, thus demonstrating greater inconsistency between value-neutrality and social responsibility.

New Zealand scientists' values

Sommer (2010), in collaboration with the New Zealand Association of Scientists (NZAS), conducted a survey of New Zealand scientists (previous surveys had been conducted in 1994, 1996 and 2000). The latest survey contained several questions relevant to scientists' attitude to social responsibility. Of a survey population estimated to be approximately 6,000, a random sample of 930 scientists was sent an Internet survey. Of this number, 361 (38.6%) usable surveys were returned, 28.8% (*n*=104) of respondents were female and 71.2% (*n*=257) were male. Scientists self-identified as belonging to one of the nine following broad fields of science: agriculture and soil science; biological sciences; engineering sciences and applied sciences and technologies; earth and environmental sciences, and natural resources; medical and health sciences, mathematics and computer sciences; physical sciences; social and behavioural sciences; and other.

Respondents were required to assess their own affinity with a range of statements. The first statement relevant to the current work was: "In my professional capacity, I feel responsible first to science and the creation of new knowledge or products, and then to the concerns of citizens" (Sommer, 2010, p. 21). Only 2.8% agreed emphatically, 25.2% agreed in substance, 8.6% neither agreed nor disagreed, 48.2% disagreed in substance, while 11.9% disagreed emphatically. Women (67.3%) disagreed more than men (57.2%). Differences were also found in regard to scientific fields of study. Medical and health scientists, and engineers and applied scientists (71.4% and 71.1% respectively) disagreed more than other disciplines. Social and behavioural scientists (46.5%) were the only group in which less than 50% disagreed with the statement. Sommer (2010, p. 21) concluded that scientists' sense of social responsibility "already strong, strengthened over the past decade."

The next statement of interest focussed on scientific governance: "It is the proper role for government with regard to funding of science to define broadly what should be investigated, thereby providing scientists with a 'research agenda'" (Sommer, 2010, p. 22). Disagreement was stronger (55.7%) than agreement (33.6%). Women disagreed more than men (65.4% and 51.7% respectively) and men agreed more than women (38.5% and 21.2% respectively). These results suggest that there is considerable dissatisfaction amongst scientists with the role that the New Zealand government currently takes in setting the research agenda. As no questions were asked regarding academic freedom or the public's right to participate in the setting of the science agenda, it is difficult to know whether scientists believed that they, or the public (or someone else), should have this responsibility (although see the question below regarding scientists decision-making role regarding dangerous technologies).

The next statement of interest addresses the precautionary principle: "The New Zealand government's Sustainable Development Programme of action establishes a set of principles that require government to address risk and uncertainty when making choices, taking a precautionary approach to funding science and technology. I think that these constraints are more detrimental than they are helpful" (Sommer, 2010, p. 23). Only 3.6% agreed emphatically with this statement, 36.6% agreed in substance, 37.7% neither agreed nor disagreed, 13.6% disagreed in substance, and 1.4% disagreed emphatically. Although a rather large group declined to respond either way, clearly, on balance, New Zealand scientists were not very supportive of the precautionary principle. Note the contrast between these New Zealand scientists' attitudes to the precautionary principle and the attitudes of the Spanish public (Lujan & Todt, 2007, reported in Chapter 1), who overwhelmingly supported the application of the precautionary principle to technological development (75% support, 6% opposed).

The final proposition of interest concerned the development of dangerous technology and the decision role of scientists: "I think that the development of potentially dangerous technology should be decided, primarily, within the scientific and engineering community" (Sommer, 2010, p. 24). Although 26.1% of respondents agreed with this assertion, the majority, 54.5% disagreed. Sommer (2010, p. 24) concluded: "these data, once again, represent a strong inclination towards societal responsibility and citizen involvement over strict expertise."

British scientists' attitude to public engagement

Market and Opinion Research International (2000) conducted a study in Britain about the role of scientists in public debate. The research was sponsored by the Wellcome Trust and the Office of Science and Technology (UK). Noting that public understanding of science was well researched they observed "little effort has been made to understand how scientists themselves perceive increasing calls for them to become more involved in communicating their research to the public, and to increase dialogue on the social and ethical implications of research" (P. 3). The quantitative survey was conducted with a randomly selected sample of 1652 British scientists using face-to-face interviews.

Regarding their image, only 9% of scientists thought that the public considered scientists *responsible*, whereas 44% of scientists perceived scientists as being responsible. Only 4% of scientists thought the public considered them *socially responsible*, whereas 29% of scientists perceived scientists as being socially responsible (Market & Opinion Research International, 2000). These results are interesting not only for the discrepancy in how scientists think the public views them and how scientists perceive their own profession, but also the relatively low perceptions scientists have of their profession regarding responsibility and, in particular, social responsibility.

Over 70% of scientists considered their field of research had social and ethical implications for the public. Biomedical scientists (79%) were more likely to agree than non-biomedical scientists (60%), while scientists who work with patients (94%) were the most likely to agree with the statement. Overall, 93% of scientists agreed (56% strongly agreed) "that the non-specialist public needs to know about the social and ethical implications of scientific research" (Market & Opinion Research International, 2000, p. 9).

The vast majority of British scientists agreed that communication of social and ethical implications of research to both the public (84%) and policy makers (91%) was their responsibility because their scientific knowledge and skills gave them insight into these issues (Market & Opinion Research International, 2000). Sixty percent claimed they would like to spend more time communicating their results to the public. Although 75% felt adequately equipped to communicate the scientific facts of their research, only 20% felt well equipped to do so. This confidence declined regarding the communication of social and ethical issues associated with their work (62% felt adequately equipped, and only 10% well equipped). Lack of public knowledge and education (53%), and lack of public interest in science and technology (22%), were perceived as barriers to communication with the public, by the scientists surveyed. The media were perceived as a barrier to communication with the public by 35% of scientists.

Ethical and societal concern in biomedical science

A recent study of biomedical scientists (N = 856) in the U.S. reported somewhat lower levels of concern about ethical and social consequences of their research (McCormick, et al., 2009). They noted that, while there was "an increasing literature on scientists' views of scientific misconduct and behaviour, very few studies have been published on scientists' perceptions of the ethical, societal, and policy *implications* of their research" (p. 2, emphasis in original).

McCormick et al. (2009) surveyed biomedical scientists to find out what percentage perceived ethical and societal implications associated with their research, and whether biomedical scientists perceived a need for research ethics consultation or would find such a consultation useful. While 41% reported that they had not previously experienced ethical and societal issues arising from their research, 59% reported they had. Although 53% did not expect their current research to generate such issues, 31% thought that it might, while a further 17% thought that it definitely would. Half (51%) reported that they would find a research ethics consultation service at their institution moderately, very, or extremely useful. Thirty-six percent claimed that such a service would be useful to them personally. Respondents conducting research with human participants were more likely to consider an ethics consultation service useful to them personally than those not conducting research with humans.

Democratisation and commercialisation of science

Democratisation of science

Noting the increasing literature suggesting public mistrust in science and the calls for increased engagement between science and society as a remedial response, Small and Mallon (2006), in unstructured interviews with 21 New Zealand scientists, examined their attitudes to commercialisation and democratisation of science[1]. Some authors have suggested that the increasing commercialisation of science and its control by big business creates conflict for scientists, compromising the public good role of science (Nowotny, et al., 2003), compromising scientists' ethical and social responsibility (Hurt & Robertson, 1998; Krimsky, 2004; Olivieri, 2003) and reducing public trust in science (Eichelbaum, Allan, Fleming, & Randerson, 2001; Polkinghorne, 2000). That commercialisation of science would likely increase public distrust in science is also suggested by the results of Small et al. (2005). They found that trust in companies was much lower than (the already relatively low) trust in scientists regarding genetic engineering. Only 7% of the public agreed or strongly agreed that they would trust what companies say about genetic engineering (cf. 24% trust scientists), whereas 68% either disagreed or strongly disagreed that companies could be trusted (cf. 41% distrusted scientists). A further 24% were either neutral or unsure about the trustworthiness of companies (cf. 34% were neutral or unsure regarding scientists).

The democratisation of science, that is, the engagement of the public in dialogue about science and technology, its social and moral implications for society, and participation in setting the research agenda, is one approach suggested for combating the erosion of public trust in science (House of Lords Select Committee on Science and Technology, 2000). Advocates suggested that increased openness and transparency in science and increased public participation in scientific decision-making may help ensure the social responsibility of science and hence help restore public trust and confidence in science (Irwin, 2001).

Small and Mallon (2006), in their qualitative study, found that the scientists in their sample generally considered that the public have a right to have a say in setting the research agenda and that the science community has a responsibility to engage and dialogue with the public in this regard. The main reasons scientists

[1] This study was conducted as part of Study 1 in the current research. However, results are reported here for two reasons. First, the data presented have been published in the peer reviewed literature, and second, it was not the sole work of the current author. Professor Mary Mallon conducted three of the interviews, assisted in the analysis of the data, and co-authored the journal article.

gave for this attitude were that the public had a right to participate when science issues were contentious and had important social and ethical implications for society. They argued that, because considerable funding for science came from the public purse, the public had a right to say how that money should be spent, that science should conform to the mores of society as revealed by engagement with the public, and that in order to do public good science, science needed to engage with the public to determine what the public considers public good science to be.

However, more than half of the interviewees spontaneously expressed the belief that there should be limitations to the public's role in setting the science agenda. A range of reasons were given for this position. The most common was the belief that science is complex and many of the public are not scientifically literate enough to meaningfully participate (in the public understanding of science literature this position is known as the *deficit theory*). Thus, some scientists suggested that it needs to be an informed public who participate (Small & Mallon, 2006).

Related to the deficit theory concern, some scientists thought that it was not for the public to tell scientists about science (some expressed their frustration at being given lectures by members of the public who clearly did not understand the science they were advising the scientists about). Hence, some suggested the public's role should be restricted to applications of the technology (rather than having a say in basic science), or to the spiritual, ethical and cultural issues that surround the science and technological applications.

Some scientists expressed concern about the logistical processes of democratisation, the time consuming nature of dialogue, the logistical difficulty of getting fair representation, the diverse range and contradictory nature of public opinion, and the impossibility of reaching consensus (Small & Mallon, 2006). These process issues related to the democratisation of science led to a concern that allowing the public too great a role would result in paralysis of scientific progress. Another concern of scientists, regarding democratisation, was that the public could be used as pawns in the agendas of vocal pressure groups and be influenced by media misrepresentation of science. Finally, the validity of the democratic process as a decision-making tool to provide optimal solutions was questioned by some scientists.

Generally, scientists expressed uncertainty about how best to engage with the public. They noted a range of different options, and while some thought these options were adequate, most did not (Small & Mallon, 2006). Data taken from this study and statements made by the participants were used in the construction of the attitude to democratisation scale developed for the quantitative study in this thesis. Democratisation of science is one of the component constructs forming the nomological network designed to infer construct validity to the new instruments being developed in the current work.

Democratisation and social responsibility. A conceptual argument may be made that concern for social responsibility in science will be related to attitudes to democratisation of science. Those who favour democratisation are more concerned with engaging with the public and finding out what their opinions and concerns are. They are also more in favour of sharing the decision-making regarding the science agenda. These attitudes are consistent with recognition of the social responsibilities of science and a willingness to seek inclusive ways of addressing these issues. However, no empirical literature was found that would indicate a likely effect size for the relationship. Therefore, the next two hypotheses are:

H16 There will be a positive correlation between scientists' favourable attitude to the democratisation of science and their awareness of the need for social responsibility in scientific research and development.

H17 There will be a positive correlation between scientists' favourable attitude to the democratisation of science and their judgments of the importance of specific behaviours to enhance social responsibility in scientific research and development.

Democratisation and technological optimism. As part of the nomological network of study constructs, further hypotheses are proposed regarding the democratisation of science, the construct of technological optimism, and the four higher order Schwartz value dimensions. Scientists who have a strong belief in technological optimism may perceive lower levels of risk attached to new technologies and believe in a *technology fix* for any emerging problems. Their perception of the need to dialogue with the public about the social consequences of technology, about its acceptability, and about the science agenda, will be diminished. If scientists who are technological optimists also believe that the democratisation of science is likely to impede scientific progress (as a majority of scientists in Small and Mallon's (2006) qualitative study believed) then they will be less likely to support the democratisation of science (i.e., it is both unnecessary and impedes scientific progress). However, no empirical literature was found that would indicate a likely effect size for the relationship. Therefore, the next hypothesis is:

H18 There will be a negative correlation between scientists' favourable attitude to the democratisation of science and their belief in technological optimism.

Democratisation and openness to change. The individualistic value types, 'hedonism', 'self-direction' and 'stimulation', constituting 'openness to change', are oriented towards personal satisfaction and fulfilment, freedom, independence, and self direction. Such values are consistent with the traditional scientific value of academic freedom, whereas the democratisation of science is likely to place limits on scientists' degree of freedom to choose and conduct research following their own interest and intellectual stimulation. This suggests a negative association between democratisation and openness to change. On the other hand, the openness to novelty and challenge aspects of this dimension might suggest greater tolerance of change towards more democratic processes in science, perhaps suggesting a positive relationship. No empirical evidence was found that suggested the size of any relationship between the two variables. On balance, it is predicted the relationship will be negative but, because of the two contradictory forces, it is likely to be weak. Therefore, the next hypothesis is:

H19 There will be a small negative correlation between scientists' favourable attitude to the democratisation of science and the higher order value dimension openness to change.

Democratisation and conservation. The higher order value dimension 'conservation' is predominantly collectivist oriented; the comprising value types of 'tradition', 'conformity' and 'security' are about the maintenance and security of the collective's culture and status quo. Traditionally, the public have had little say in the direction and agenda of science and academic freedom has been highly valued by the science community. It is proposed that scientists strong on the higher order value dimension of conservation will tend to want to maintain current practices and will value the concept of academic freedom. It is also likely that they will be accepting of scientists' traditional perspective of the deficit theory of public understanding of science and hence be opposed to the democratisation of science. However, on the other hand, the scientists in the sample work and live in western culture which has a strong tradition of democracy and may believe that democratic principles should also apply to the world of science. Some support is found for this idea in Small and Mallon (2006) in their qualitative study where most of the scientists they interviewed were supportive, in principle, of the democratisation of science even if they questioned the capability of the public and were concerned about the practical implications in terms of the detrimental effects on scientific progress. No previous empirical data was found about the relationship between these two constructs. On balance it is predicted that the relationship will be negative but, because of the two contradictory forces argued above, it is likely to be weak. Therefore, the next hypothesis is:

H20 There will be a small negative correlation between scientists' favourable attitude to the democratisation of science and the higher order value dimension of conservation.

Democratisation and self-transcendence. The higher order value dimension, 'self-transcendence', is comprised of the value types 'universalism' and 'benevolence'. These values are associated with justice and equity, concern for friends, concern for all people and concern for nature. It is proposed that scientists strong on self-transcendence will consider it the public's right to participate in setting the research agenda, particularly in an age of Promethean technologies with significant social and moral implications for society. No empirical literature was found relating democratisation of science to self-transcendence. Hence, while a positive relationship is proposed for conceptual reasons, no prediction is made regarding the size of the relationship. Therefore, the next hypothesis is:

H21 There will be a positive correlation between scientists' favourable attitude to democratisation of science and the higher order value dimension self-transcendence.

Democratisation and self-enhancement. The higher order value dimension, 'self-enhancement' is comprised of the value types 'hedonism', 'power' and 'achievement'. These are individualistic values concerned with personal gratification, success, ambition, and control over people and resources. It is proposed that the logistics of democratisation will slow decision-making and hence scientific progress as well as diminishing scientists' control over the science agenda. No empirical literature was found relating democratisation of science to self-enhancement. Hence, while a negative relationship is proposed for conceptual reasons, no prediction is made regarding the size of the relationship. Therefore, the next hypothesis is:

H22 There will be a negative correlation between scientists' favourable attitude to democratisation of science and the higher order value dimension of self-enhancement.

Commercialisation of science

In the Small and Mallon (2006) study most interviewees had a negative attitude to the commercialisation of science, but were resigned to it being politically and economically ordained. Generally, they considered it an ideological imperative of governments to turn science and technology into economic growth and wealth creation. However, most viewed it as an unsuitable model for science – of more detriment than value. A range of serious concerns was expressed by scientists regarding the negative effects of commercialisation on science.

First, commercialisation was viewed as inhibiting scientific progress by most of the interview participants (e.g., by restricting scientific result sharing in order to protect commercial advantage). Second, science quality was considered to be negatively affected, commercialisation was perceived as focussing on applied rather than basic research, with commercial imperatives setting research agendas rather than good science. Third, public good science was considered to be negatively affected; concern was expressed about profit seeking at the expense of public good. Fourth, science transparency and scientific communality were considered to be compromised by commercialisation with secrecy about science results until after patents were obtained in order to gain commercial advantage (Small & Mallon, 2006).

Fifth, public trust in science and scientists was thought to be damaged (because of the association of science with big business – perceived negatively by both the public and scientists). Sixth, concerns were expressed regarding the impact of commercialisation on scientists' ethical conduct. Scientists were concerned about personal wealth-seeking taking precedence over public good, and about the competitive funding process, which a number of scientists claimed encouraged exaggeration of the potential benefits of research in order to secure funding. Seventh, scientists' viewed it as damaging to their careers and working conditions. They saw commercialisation as contributing to a loss of their independent status, coercing scientists to be pawns of big business and politicians, with the consequent effect of a drop in status, authority, and trust in the eyes of the public (Small & Mallon, 2006).

Eighth, scientists thought that commercialisation eroded their traditional academic freedom (concerns included loss of autonomy, increasing managerialism and bureaucratic compliance). Finally, scientists considered their ability to participate in public dialogue to be restricted by the commercialisation of science (commercial sensitivity restricting companies' willingness to allow science employees to discuss science issues in public). This resulted in a reduction of science transparency and increased secrecy in the eyes of the public. As one scientist lamented "the focus and the science is to make money – it's not for the public good anymore" (Small & Mallon, 2006, p. 112). Several scientists considered that, because of the power of the technologies currently being developed, a precautionary approach was necessary in the interest of the public good and for social responsibility. These scientists were concerned that the imperative of profit would compromise precaution.

Amongst Small and Mallon's (2006) interviewees, commercialisation was frequently seen as conflicting with the aims of democratisation (i.e., openness and transparency, increased engagement and dialogue with the public and increased public participation in the scientific research agenda). A few scientists expressed mixed feelings about commercialisation, although finding it undesirable for the reasons cited previously, they nonetheless thought that it was necessary in some cases, particularly where the development of new products was a lengthy and expensive process (e.g., the pharmaceutical industry). Against the general grain of opinion, two scientists held positive views of commercialisation. One claimed that money was the root of all progress and hence commercialisation would enhance scientific innovation (Small & Mallon, 2006). Data and statements taken from Small and Mallon's participants were used to construct a scale of attitudes to the commercialisation of science for use in Study 2 of the current work.

Commercialisation and social responsibility. Commercialisation of science is one of the construct components forming the nomological network designed to infer construct validity to the new instruments related to scientists' attitudes to social responsibility being developed in the current research. The commercialisation of science has been identified as a possible threat to ethical behaviour in science and to scientific social responsibility by the public (O'Neill, 2002; The Office of Science and Technology and The Wellcome Trust, 2000; The Royal Society, 2002), by theorists and science commentators (Hurt & Robertson, 1998; Krimsky, 2004; Nowotny, et al., 2003; Olivieri, 2003; Polkinghorne, 2000), and in empirical research (Small & Mallon, 2006). However, no empirical evidence was found which suggested the likely strength of the relationship. Therefore, the next two hypotheses are:

H23 There will be a negative correlation between scientists' favourable attitude to the commercialisation of science and their awareness of the need for social responsibility in scientific research and development.

H24 There will be a negative correlation between scientists' favourable attitude to the commercialisation of science and their judgments of the importance of specific behaviours to enhance social responsibility in scientific research and development.

Commercialisation and democratisation. Small and Mallon (2006) found, in their qualitative study, that scientists felt conflict between the goals of democratisation of science and the increasing commercialisation of science. They perceived a rational conflict between the aims of democratisation (e.g., trust, transparency, participation) and the perceived consequences of commercialisation. However, no empirical evidence was found which suggested the likely strength of the relationship. Therefore, the next hypothesis is:

H25 There will be a negative correlation between scientists' favourable attitude to the commercialisation of science and a favourable attitude to the democratisation of science.

Commercialisation and technological optimism. As part of the nomological network of study constructs further hypotheses were proposed regarding the constructs of commercialisation of science and technological optimism, and the four Schwartz higher order value dimensions. Scientists who have a strong belief in technological optimism will be less concerned about potential negative social and moral consequences of Promethean technologies. They believe in a *technology fix* for any emerging problems. Their perception of the need for strong governance of science and technology will be diminished. They will be less likely to believe that market driven Promethean science will lead to negative social consequences for society and thus more likely to support the commercialisation of science. Kilbourne, Beckman, Lewis and Van Dam (Kilbourne, et al., 2001) found a medium size positive correlation (r = .33, p <.01) between economic liberalism (a laissez-faire approach to economics) and belief in the technofix. Therefore, the next hypothesis is:

H26 There will be a medium size positive correlation between scientists' favourable attitude to the commercialisation of science and their belief in technological optimism.

Commercialisation and openness to change. The individualistic value types, 'hedonism', 'self direction' and 'stimulation', which comprise the higher order value dimension, 'openness to change', are oriented towards freedom, independence, self-direction, novelty and creativity consistent with academic freedom, free market theory and with opening science up to commercialisation. This suggests a positive correlation between commercialisation and openness to change. On the other hand, as some scientists considered that commercialisation of science will restrict academic freedom and independence this suggested a negative relationship between commercialisation and openness to change. No empirical evidence was found regarding this relationship. On balance, it is predicted that openness to change will be positively related to a favourable attitude commercialisation but, because of these contradictory forces, the relationship is likely to be weak. Therefore, the next hypothesis is:

H27 There will be a small positive correlation between scientists' favourable attitude to the commercialisation of science and the higher order value dimension of openness to change.

Commercialisation and conservation. The higher order value dimension conservation is predominantly collectivist oriented; the comprising value types of tradition, conformity and security are about the maintenance and security of the collective's culture and status quo. The increasing commercialisation of science is a relatively recent phenomenon in the history of science. The science culture of the twentieth century was mainly oriented towards public good science funded by the state through university and government controlled science bodies with a significant amount of academic freedom for individual scientists, particularly in the university system (Nowotny, et al., 2003; Ziman, 1994). This could suggest a negative relationship between commercialisation and conservation. However, the cultural tradition of Western society, the source of the scientist participants in the current work, is strongly orientated towards laissez-faire governance structures, capitalism and private ownership. Because this is a highly dominant tradition of Western culture it is proposed that an orientation towards tradition, preservation of culture, conformity and security will be positively related to the construct of commercialisation of science. However, because of these contradictory conceptual forces, the relationship is expected to be weak. No previous empirical research was found regarding this relationship. Therefore, the next hypothesis is:

H28 There will be a small positive correlation between scientists' favourable attitude to the commercialisation of science and the higher order value dimension of conservation.

Commercialisation and self-transcendence. The higher order value dimension, 'self-transcendence', is comprised of the value types 'benevolence' and 'universalism'. Its value focus is towards the collective and concern for all people, justice, equity, nature, and with preservation of the environment. Self-transcendence is concerned with the public good rather than private good. It is proposed that self-transcendence will be negatively associated with a favourable attitude to the commercialisation of science. In an age of Promethean technologies, where the potential social and environmental impacts are immense, self-transcendence is consistent with a preference for public benefit over the privatised benefits of commercialised science. No previous empirical research, which might indicate the likely effect size, was found regarding this relationship. Therefore the next hypothesis is:

H29 There will be a negative correlation between scientists' favourable attitude to the commercialisation of science and the higher order value dimension self-transcendence.

Commercialisation and self-enhancement. The higher order value dimension 'self-enhancement' is comprised of the individualistic value types 'achievement' and 'power'. These values are orientated towards ambition, success, wealth, authority, and control over people and resources. These values are consistent with free market concepts, privatised goods and hence the commercialisation of science. Additionally, Promethean science offers enormous potential for power and control over society and nature. Therefore, a positive relationship is predicted between self-enhancement and the commercialisation of science. However, no previous empirical research, which might indicate the likely effect size, was found regarding this relationship. Therefore, the next hypothesis is:

H30 There will be a positive correlation between scientists' favourable attitude to the commercialisation of science and the higher order value dimension self-enhancement.

Questioning scientific objectivity

Krasner and Houts (1984) claimed that the traditional value-free conceptualisation of science is based on the "epistemology and ethics developed in the logical positivist philosophy of science" and that "the history of science was construed as a story of progress towards unbiased, objective knowledge" (p. 804) derived from the analysis of objective raw data. They noted that this conception has been challenged both by scientists and philosophers. They cited Heisenberg pointing out the implausibility of objective observation, Toulmin showing that theory and assumptions precede observation, Hanson's argument that there can be no neutral observation language, MacIntyre's claim that the "epistemological status of scientific claims may be no less relativistic than the comparable status of value claims in philosophical ethics" (p. 841) and Kuhn's challenge to the notion of gradual progress towards objective truth. Rejecting objectivism they asserted the value-laden nature of science claiming that scientists must be understood in the social context of the common assumptions of their discipline, including its norms and values. They claimed that scientists begin with assumptions that cannot be justified by appeals to facts or logic and that some of these assumptions vary with disciplinary perspective.

Krasner and Houts (1984) studied the value systems of two groups of psychologists, the first group self-identified as behaviour modification psychologists while the second group did not self-identify with behaviour modification. Significant differences were found between the two groups of psychologists theoretical orientations. Behavioural psychologists were more oriented toward the factual (rather than the theoretical), to impersonal causality (rather than personal will), to behavioural content (rather than experimental), towards environmental determinism, toward physicalism, and were more quantitative in orientation than the non-behavioural psychologists. The non-behavioural psychologists were more oriented towards biological determinism than behaviourists. Behaviourists also showed greater objectivism (rather than subjectivism) than the non-behaviourists.

Behaviourists showed significantly less metaphorism, rationalism and anti-empiricism and more reductionism than the non-behaviourist. Multiple regression analysis showed that participants who viewed science as value-neutral favoured physiological reductionism and quantitative methods in psychology, whereas those who viewed science as value-laden “favored an intuitionist-subjectivist epistemology” (p. 848). Krasner and Houts (1984) concluded: “It will be especially important to relate [discipline-specific assumptions] to broader sociocultural and personal values in order to understand how the latter impact on the goals of research as well as on the influence of science on social planning and social policy” (p. 848).

Summary

To summarise this chapter, the social and moral consequences of technology are becoming increasingly important as science and technology become more powerful in their social ramifications (e.g., Jonas, 1985; Luppicini, 2008; Small & Jollands, 2006). Considerable theorising and discussion about this issue has occurred both by scientists themselves (Abelson, 1970; Commoner, 1966; Cournand, 1977; Dainton, 1971; Lovelock, 2006; Polkinghorne, 2000; Rotblat, 1999; Russell & Einstein, 1955; Sakharov, 1981; Union of Concerned Scientists, 1992; Wackernagel & Rees, 1996; Walter & Richards, 1998; Wilson, 2002; Wolpert, 1999; Ziman, 1998) and by bioethicists and philosophers of technology (Bulger, Heitman, & Reiser, 2002; Bunge, 1977; Jonas, 1985; Lenk, 1983; Lujan & Todt, 2007; Luppicini, 2008; Moor, 2005; Nicholas, 1999b; Petrinovich, 1999; Van Potter & Whitehouse, 1998).

However, few empirical studies have been conducted regarding scientists’ attitudes to this issue (Market & Opinion Research International, 2000;

McCormick, et al., 2009; Pimple, 2002; Prpic, 1998; Weil, 2002). The mostly qualitative anthropological work that has been conducted with scientists has usually focussed on what Ziman (2001) calls the epistemic values of scientists, rather than what he calls the moral values, that are the primary focus of this work.

In this chapter, 15 directional hypotheses have been proposed regarding the relationships between the various research constructs and their relationships to the higher order Schwartz value dimensions. These hypothesised relationships form part of the nomological network being developed to help assert the validity of the research instruments designed to measure the constructs under study. In Chapter 5, nine further hypotheses regarding relationships between the previously discussed research constructs and a concurrent criterion (general attitude to genetic engineering) are proposed along with a discussion of the rationale for development of a nomological network and its relationship to the construct validity of the research instruments under development.

Chapter 5 - Nomological Networks and Mixed Methods Research

This chapter consists of two sections. The first section is about the quantitative research (Study 2). So far 30 hypotheses have been proposed as part of the nomological network of relationships between the research constructs. In addition, a further nine hypotheses are proposed in this chapter, which describe relationships between the study constructs and a concurrent criterion: general attitude to genetic engineering. Next, six conceptual diagrams, one for each of the five construct for which a new measurement instrument was developed, and a further one to include the existing instruments, are presented to illustrate the relationships between the research constructs. The second section primarily relates to the qualitative research (Study 1). Some philosophical issues associated with mixed method approaches to research with a particular focus on qualitative methodologies are discussed.

Nomological Network and Quantitative Research Hypotheses

Nomological networks

The literature reviewed in previous chapters suggested the need for an extended ethic of scientific social responsibility in an age of Promethean technologies. Very little empirical research has been conducted into scientists' attitudes to social responsibility (and related constructs), and the domain of the construct remains to be properly described and defined (McCormick, et al., 2009; Pimple, 2002; Prpic, 1998; Weil, 2002). The author knows of no existing instruments to measure scientists' attitude to social responsibility. Therefore, two aims of the current work are to explicate the construct domain through in-depth interviews with scientists (Study 1) and to use the qualitative exploration of the content domain to start exploratory development of instruments to measure scientists' attitudes to social responsibility in research (Study 2).

According to the philosophers Blum (1991) and Sherwin (2001), and the psychologist, Rest (1986), before an agent can make moral judgments about the right action in a particular situation the agent needs to perceive or be aware of a moral issue. Therefore, it is proposed to develop two instruments to measure scientists' attitudes to social responsibility: one instrument to measure scientists' awareness of the issue of the social responsibility of science to society and one instrument to measure scientists' judgments of the importance they place on a range of personal actions believed to enhance their social responsibility in research. Also consistent with the decision to develop two instruments which measure slightly different aspects of scientists' attitudes to social responsibility is the observation by Pimple (2002) that "no scientist is responsible for setting the science agenda…. No one scientist can bear the burden [of social responsibility] alone, it is still true that each scientist has an obligation to carry some part of the burden" (p. 198). The first instrument addresses scientists' awareness of the social burden of science to society (the burden that no single individual carries). The second instrument addresses the social burdens (judgments about specific practices to enhance social responsibility) that each scientist bears.

The literature reviewed has suggested a range of constructs related to the concept of social responsibility in research. These constructs include personal values, technological optimism, democratisation of science, and commercialisation of science. Previous research, theory and analytical arguments are used to propose 30 directional hypotheses about relationships amongst these constructs. In the next few pages another nine directional hypotheses will be proposed about the relationship between the research constructs and a concurrent criterion (i.e., global attitudes to genetic engineering). These 39 hypotheses describe relationships amongst the study constructs which constitute a nomological network.

A construct is defined as "some postulated attribute of people, assumed to be reflected in test performance" (Cronbach & Meehl, 1955, p. 283).According to Cronbach and Meehl (pp. 299-300), "A construct is defined implicitly by a network of associations or propositions in which it occurs. Constructs employed at different stages of research vary in definiteness." By the last sentence Cronbach and Meehl meant that, in the early stages of development a construct is usually ill defined, but as more propositions that capture relations between the new construct and other constructs in the network are developed, both theoretically and empirically, the construct becomes more definite. They stated "At least in the early history of a construct the network will be limited, and the construct will as yet have few connections" (p. 290). Since the current work is aimed at establishing the domain of a new construct (and developing potential measures for it), the construct is in the early stage, and is not yet clearly defined, as are some of the other constructs that are proposed as being related (i.e., democratisation of science, commercialisation of science, and technological optimism, with new measures being developed for these constructs in the current work).

The construct validity of a measure is the degree to which the measure reflects the construct under consideration. Thus, a construct validity coefficient would represent “the proportion of the test score variance that is attributable to the construct variable” (Cronbach & Meehl, 1955, p. 298). Unfortunately, no such generally accepted statistic is available (Although, recently Westen and Rosenthal [2003] proposed two measures of construct validity based on nomological network analysis. These measures will be discussed briefly in Chapter 7). Therefore, other means of inferring construct valid must be pursued. As argued by Cronbach and Meehl:

> Construct validation takes place when an investigator believes his instrument reflects a particular construct, to which are attached certain meanings. The proposed interpretation generates specific testable hypotheses, which are a means of confirming or disconfirming the claim. (Cronbach & Meehl, 1955, p. 290)

Cronbach and Meehl proposed that nomological networks may be used to help infer the construct validity of a measure. If instruments do not measure the constructs of interest, then proposed theoretical relationships between the constructs will not be found between the instruments used to measure them. Cronbach and Meehl defined nomological networks as “Scientifically speaking, to ‘make clear what something is’ means to set forth the laws in which it occurs. We shall refer to the interlocking system of laws which constitute a theory as a nomological network” (p. 290). They further defined the concept “The laws in a nomological network may relate (a) observable properties or quantities to each other; or (b) theoretical constructs to observables; or (c) different theoretical constructs to one another. These “laws” may be statistical or deterministic” (p. 290). In order to help infer construct validity, the goal is to embed the construct into a network of other constructs and test the hypothesised relationships in terms of their direction (positive or negative) and the strength or effect size of the relationship (Cronbach & Meehl, 1955; Meehl, 1978, 1990; Smith, 2005a).

In the literature review (Chapters 3 and 4), interpretations of the proposed constructs were presented which led to the proposal of 30 directional hypotheses which described relationships between the theoretical constructs. In addition, a further nine hypotheses (giving a total of 39 hypotheses in the nomological network) are proposed below between the study constructs and a concurrent criterion measure of ‘general attitude to genetic engineering’ (Small, Parminter and Fisher, 2005). As well as specifying the direction of the relationship, where there was sufficient prior empirical evidence or good theoretical reasons an attempt was made to estimate the strength of the correlation in terms of Cohen’s (1988) effect size conventions (i.e., small, medium, large). This follows Meehl’s

(1978, 1990) advice that hypotheses that predict the size of the relationship are much more informative than hypotheses that only predict the direction of the relationship. As Smith noted "If the outcome is close to prediction, one has demonstrated much stronger support for one's theory than if one had merely confirmed a positive relationship between two variables" (Smith, 2005a, p. 399). These relationships will be tested in the quantitative component of this work, Study 2 in Chapter 7. These constructs and relationships complete the nomological network designed to infer construct validity to the new research instruments.

Further hypotheses

Study 2 will quantitatively assess NZ scientists' general attitudes to genetic engineering (this construct will be further explicated in Study 2) using an instrument developed by Small, et al., (2005). This data was collected concurrently in the scientists' survey and also forms part of the nomological network of theoretical constructs. Thus, further hypotheses are proposed about the relationship between this construct and other constructs in the nomological network. These further hypotheses regarding the concurrent criterion will be tested in Study 2.

Because genetic engineering is a Promethean technology with enormous potential social and moral implications for society (as described in Chapter 2), but about which considerable scientific uncertainty still remains, it is proposed that scientists with a stronger awareness of the need for social responsibility in scientific research and development will have a more precautionary and consultative approach to the technology resulting in a less positive general moral attitude to GE. No previous empirical research was found which might indicate the strength of the effect size. Therefore, the following two hypotheses are proposed.

H31 There will be a negative correlation between scientists' awareness of the need for social responsibility in scientific research and development and their favourable general moral attitude to genetic engineering.

H32 There will be a negative correlation between scientists' judgments of the importance of specific personal behaviours to enhance social responsibility in scientific research and development and their favourable general moral attitude to genetic engineering.

It is also proposed that belief in technological optimism is consistent with a positive general attitude to genetic engineering. No previous empirical research was found which might indicate the strength of the effect size. Therefore, the next hypothesis is:

H33 There will be a positive correlation between scientists' belief in technological optimism and their favourable general moral attitude to genetic engineering.

It is proposed that because of the enormous commercial potential of genetic engineering that a favourable attitude to the commercialisation of science will be associated with positive general attitude to genetic engineering. No previous empirical research was found which might indicate the strength of the effect size. Therefore, the next hypothesis is:

H34 There will be a positive correlation between scientists' favourable attitude to the commercialisation of science and favourable general moral attitude to genetic engineering.

It is proposed that scientists who are in favour of the democratisation of science, who favour power sharing and public inclusion in the development and application of contentious new Promethean technologies, will be more aware of and concerned about the potential social impacts of Promethean sciences such as genetic engineering. Their concern about the power of the technology and uncertainty of applications and impacts will lead to a more precautionary approach towards genetic engineering. Thus, favourable attitudes to the democratisation of science will be negatively related to a positive general attitude to genetic engineering. No previous empirical research was found which might indicate the strength of the effect size. Therefore, the next hypothesis is:

H35 There will be a negative correlation between scientists' favourable attitude to the democratisation of science and favourable general moral attitude to genetic engineering.

It is also proposed that personal values will be related to general moral attitude to genetic engineering. The higher order value dimension of 'openness to change' is comprised of the value types 'hedonism', 'stimulation' and 'self-direction', having an individualistic orientation towards personal pleasure seeking, personal freedom (and for scientists, academic freedom), creativity and novelty. Thus, it is proposed that openness to change will be associated with a positive general attitude to genetic engineering, a novel technology with enormous potential, but as yet unclearly defined applications, that remain to be creatively explored. No previous empirical research was found which might indicate the strength of the effect size. Therefore, the next hypothesis is:

H36 There will be a positive correlation between scientists' scores on the higher order value dimension of openness to change and favourable general moral attitude to genetic engineering.

The opposing higher order value dimension of 'conservation' is comprised of the value types 'tradition', 'conformity' and 'security', and has a collectivist orientation towards the current culture, security, and restraint from actions that might harm others. It is proposed that a favourable general attitude to genetic engineering will be negatively associated with conservation, a technology which has the potential for great benefit, but more importantly, in connection to the value dimension of conservation, also has potential for great harm and is currently associated with considerable uncertainty regarding applications and impacts. No previous empirical research was found which might indicate the strength of the effect size. Therefore, the next hypothesis is:

H37 There will be a negative correlation between scientists' scores on the higher order value dimension of conservation and a favourable general moral attitude to genetic engineering.

The higher order value dimension of 'self-enhancement' is comprised of the individualistic value types, 'power' and 'achievement', with an orientation towards ambition, success, wealth and control and dominance of people and resources. It is proposed that self-enhancement will be positively associated with a favourable general attitude to genetic engineering, a technology which offers powerful control over life (a primary planetary resource), the potential for career and reputation making scientific discoveries, and the potential for enormous wealth creation. A study by Dreezens et al. (2005) found a small to medium size (r = .29, p = .01) positive relationship between the value type power and a favourable attitude to genetically modified food. Therefore, the next hypothesis is:

H38 There will be a small to medium size positive correlation between scientists' scores on the higher order value dimension of self-enhancement and a favourable general moral attitude to genetic engineering.

The opposite higher order value dimension of 'self-transcendence' is comprised of the value types 'benevolence' and 'universalism', and has a more collectivist orientation towards the welfare of friends, all people and nature, and protection of the environment. It is proposed that self-transcendence will be positively associated with a precautionary approach to Promethean technologies. Genetic engineering is a technology with enormous potential social and moral implications for society and the environment – including the potential to cause great harm. Therefore, favourable global attitudes to genetic engineering will be negatively associated with self-transcendence. Dreezens et al. (2005) found a small (r = -.15) negative, though non-significant (however, as previously noted their study has poor statistical power), relationship between the value type universalism and a favourable attitude to genetically modified food. Therefore, the final hypothesis regarding relationships amongst the constructs in the nomological network is:

H39 There will be a small negative correlation between scientists' scores on the higher order value dimension of self-transcendence and a favourable global moral attitude to genetic engineering.

Testable hypotheses have now been proposed between all the new research constructs, the four higher order Schwartz value dimensions, and the concurrent criterion measure: general attitude to genetic engineering. This completes the description of the proposed conceptual relationships between the constructs of the nomological network.

Diagrams of nomological network hypotheses

Figures 5.1, 5.2, 5.3, 5.4, and 5.5 visually display the nomological relationships and hypotheses associated with the five new instruments and the constructs they are designed to measure. Each relationship is represented by one hypothesis. Altogether, 39 relationships have been hypothesised between the research constructs and existing instruments. For each of the new instruments (i.e., the two social responsibility instruments, the technological optimism instrument, the attitude to commercialisation of science instrument, and the attitude to democratisation of science instrument), directional correlational relationships are proposed (either positive or negative) and may therefore be tested using one-tailed tests.

Although subject to ongoing controversy (Aron & Aron, 1999), the conventional definition of small (.10), medium (.30) and large (>.50) correlations were proposed by Cohen (1988). According to Aron and Aron (1999, p. 89), "in psychology it is rare to obtain correlations that are greater than .40." Consequently, most of the correlations proposed in the hypotheses above are expected to have small to medium correlations. Fortunately, with a sample size of over 730 respondents, using 1-tailed significance tests, the statistical power to find relationships significant at the .05 level is reasonably good, even for small effect sizes, such as correlations of .10, statistical power is .84. As statistical power of between .8 and .9 is generally recommended (Aron & Aron, 1999), the current sample size just reaches adequacy in this respect (statistical power, precision, and experimentwise type I error due to multiple hypotheses testing will be discussed further in Chapter 7). One potential exception, to the expected small effect sizes, is the relationship between the two new social responsibility instruments (H3). These two instruments measure slightly different aspects of scientific social responsibility. One is designed to measure perception or the awareness of the need for social responsibility in science and technological development (i.e., the responsibility of science to society). The other is designed to measure moral judgment regarding personal behaviour to enhance social responsibility in research.

These two instruments correspond respectively to the first two stages of Rest's (1986) theory of moral behaviour. Rest claimed that each of the four stages of his model was conceptually independent and that success at one stage did not necessarily mean success at the next. Thus, although stage one (awareness or perception of a moral issue) is believed to be an important condition for stage two (judgment regarding the appropriate moral action), achievement at stage one is not necessarily sufficient for achievement at stage two. Thus, the two instruments are expected to have a large correlation (because they both measure an aspect of the same construct: social responsibility in scientific research). However, the relationship is not expected to be as high as that required for alternate form reliability (the correlation between two instruments designed to measure exactly the same construct), which, according to Anastasi (1976) should be greater than .80. For the two new instruments a correlation of between .50 to .60 would be a good supporting result (a stronger correlation than usually exists between psychological constructs that are not measuring the same variable, and less than that required for alternate form reliability of measures of exactly the same variable).

The next few pages present the diagrammatic representations of the 39 hypotheses.

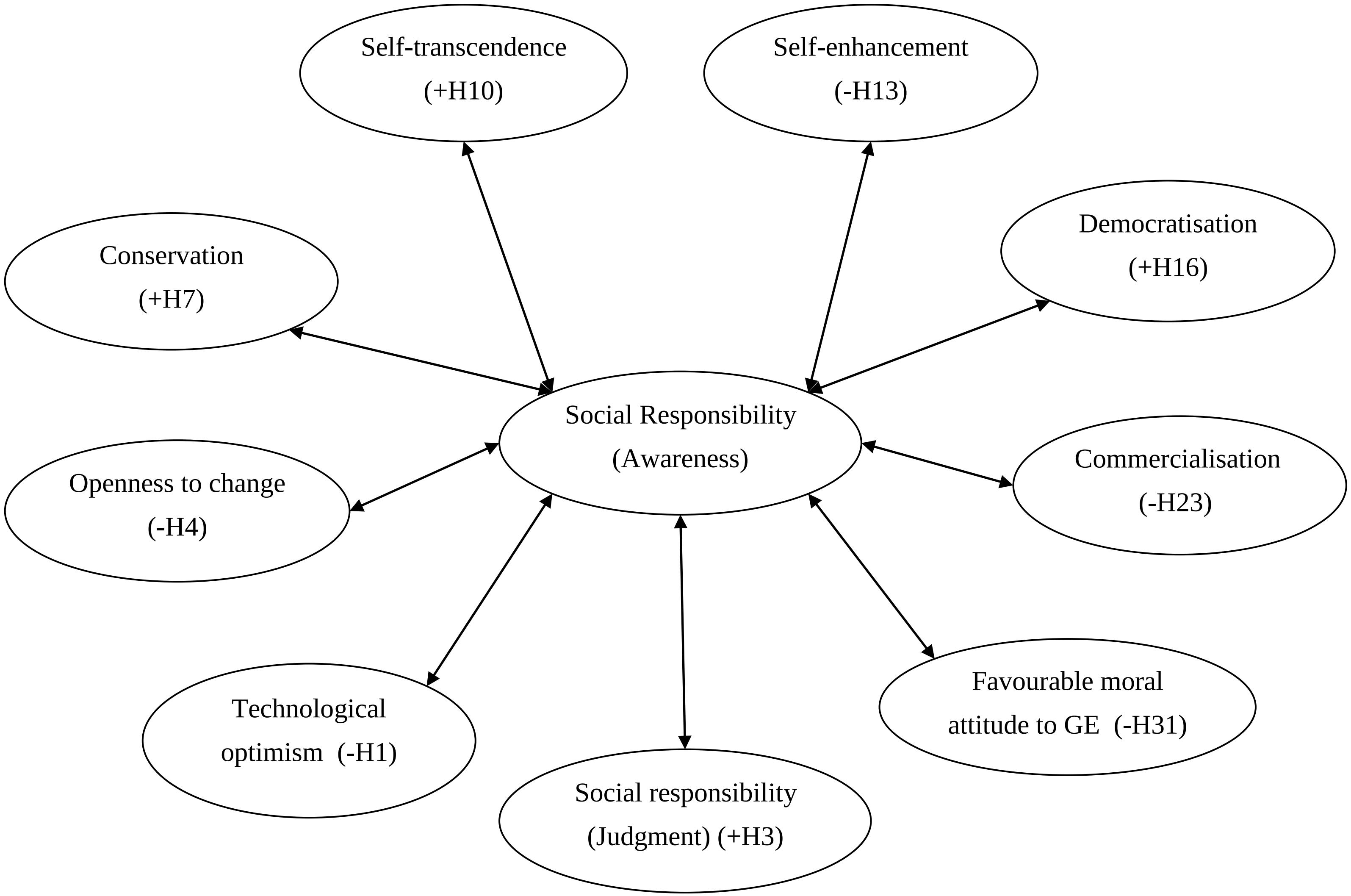

Figure 5.1. Nomological relationships for attitudes to social responsibility (Awareness). Hypotheses numbered with a '-' symbol (e.g., -H1) signify negative relationships, hypotheses numbered with a '+' symbol (e.g., +H3) signify positive relationships.

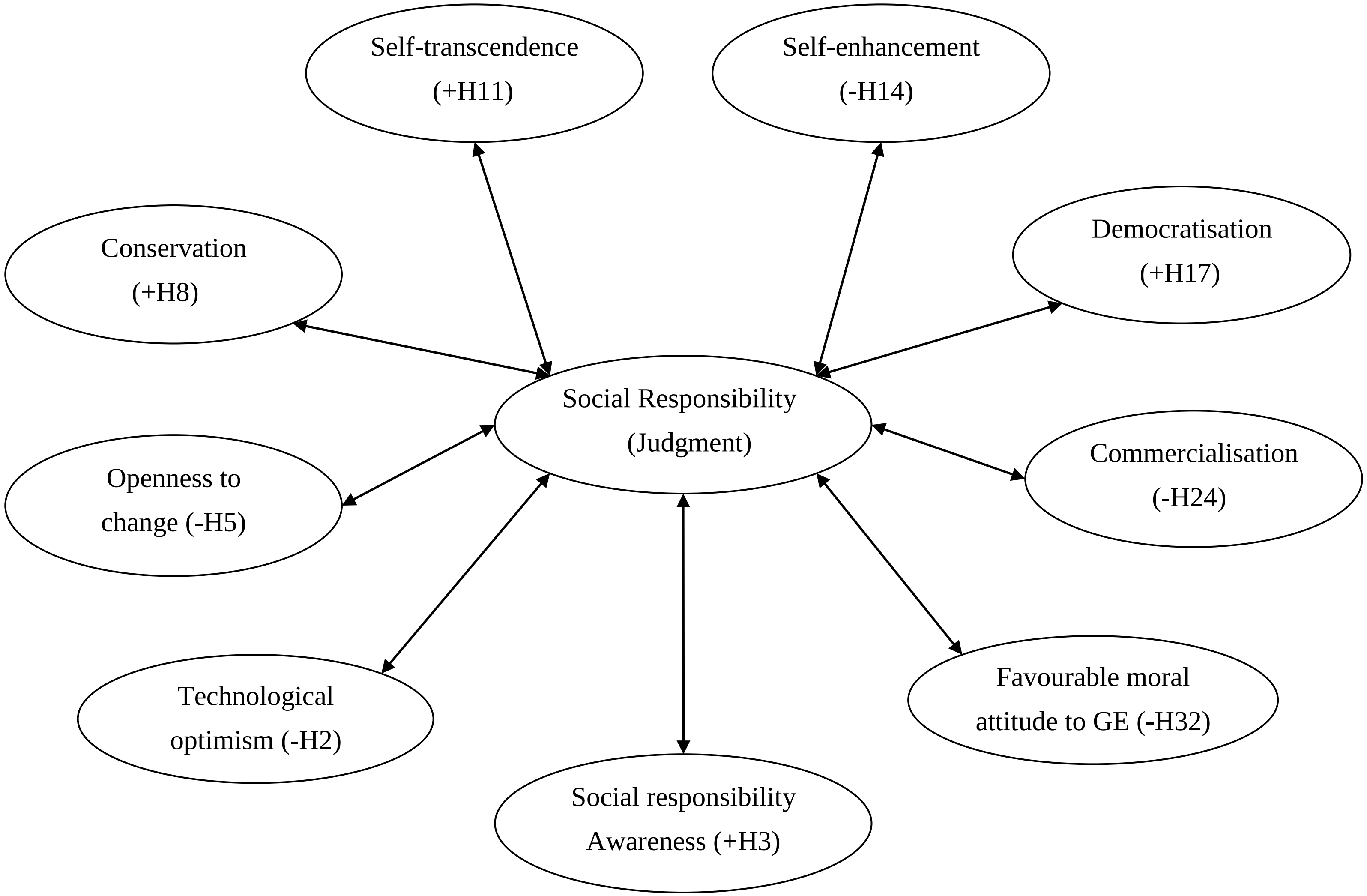

Figure 5.2. Nomological relationships for attitudes to social responsibility (Judgment). Hypotheses numbered with a '–' symbol (e.g., -H1) signify negative relationships, hypotheses numbered with a '+' symbol (e.g., +H3) signify positive relationships.

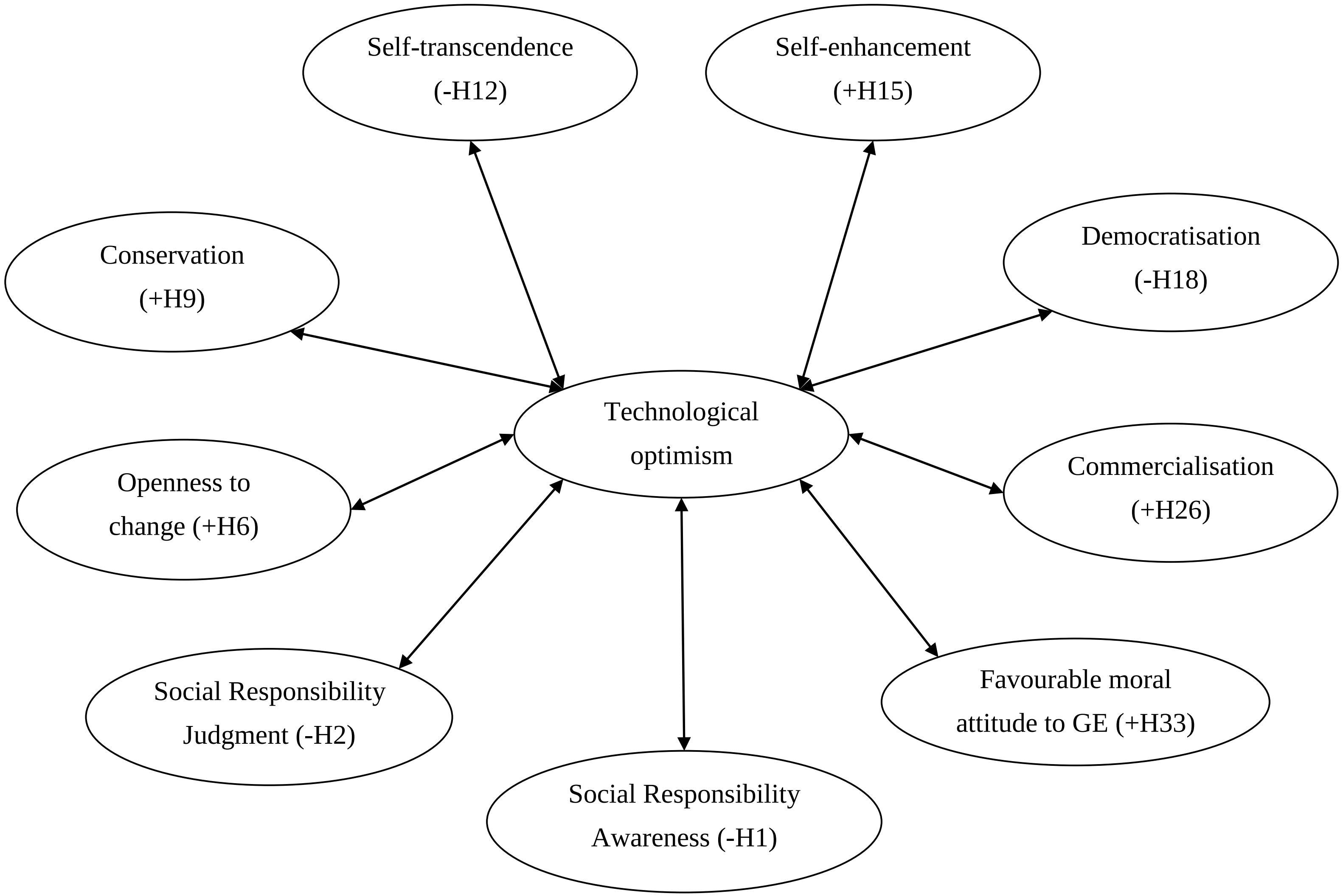

Figure 5.3. Nomological relationships for belief in technological optimism. Hypotheses numbered with a '–' symbol (e.g., -H1) signify negative relationships, hypotheses numbered with a '+' symbol (e.g., +H3) signify positive relationships.

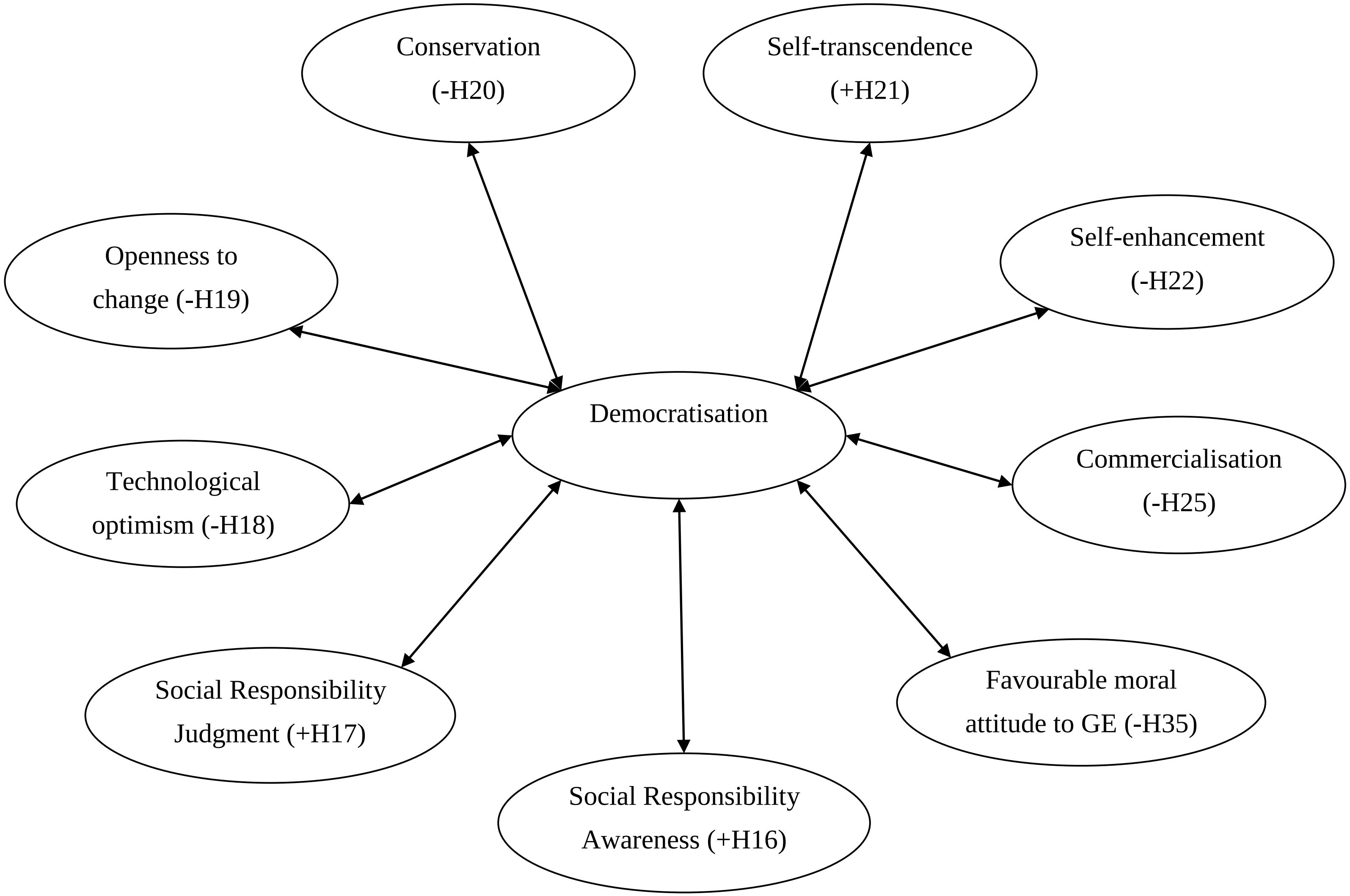

Figure 5.4. Nomological relationships for attitudes towards democratisation of science. Hypotheses numbered with a '–' symbol (e.g., -H1) signify negative relationships, hypotheses numbered with a '+' symbol (e.g., +H3) signify positive relationships.

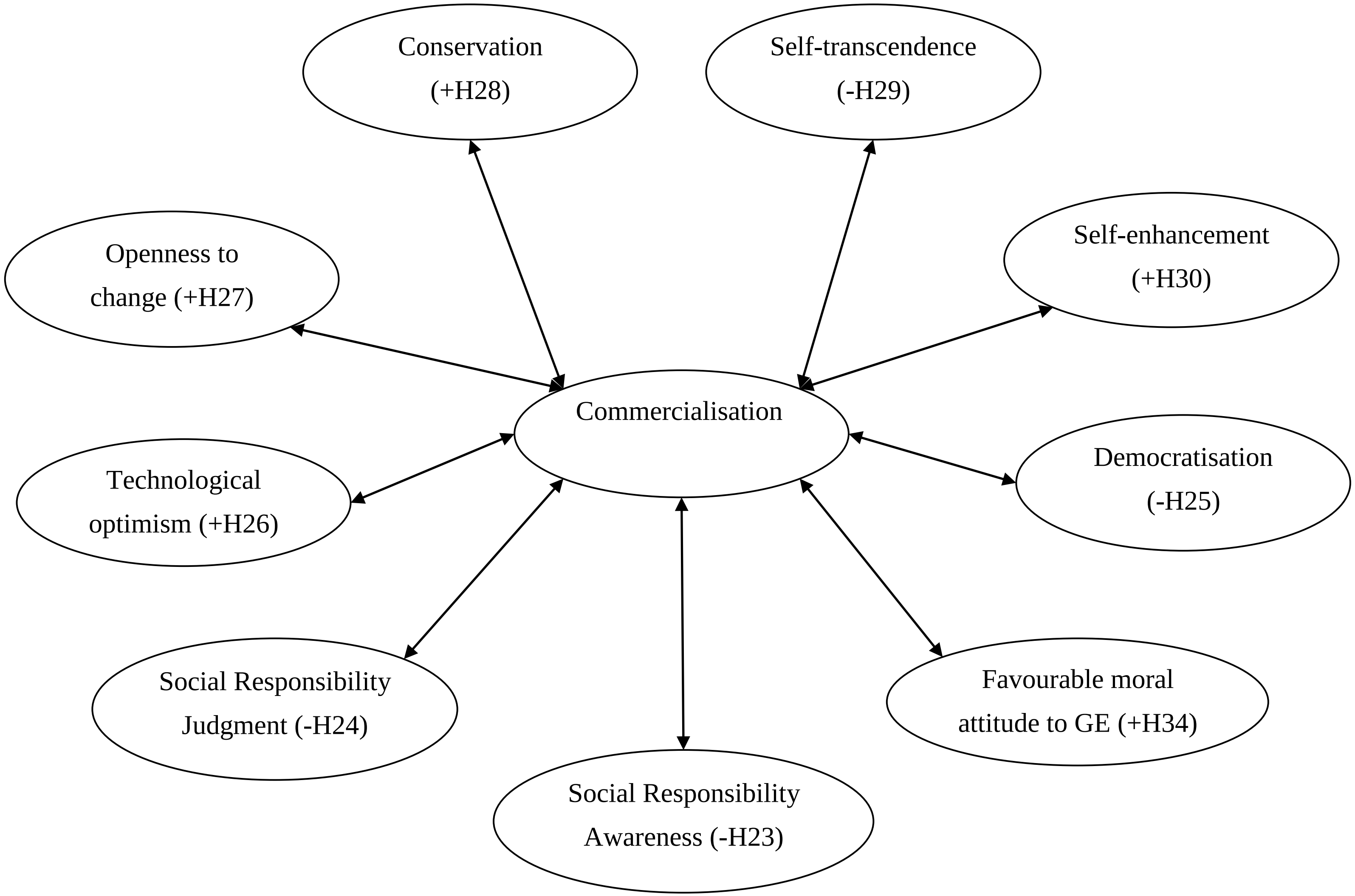

Figure 5.5. Nomological relationships for attitudes to commercialisation of science. Hypotheses numbered with a '–' symbol (e.g., -H1) signify negative relationships, hypotheses numbered with a '+' symbol (e.g., +H3) signify positive relationships.

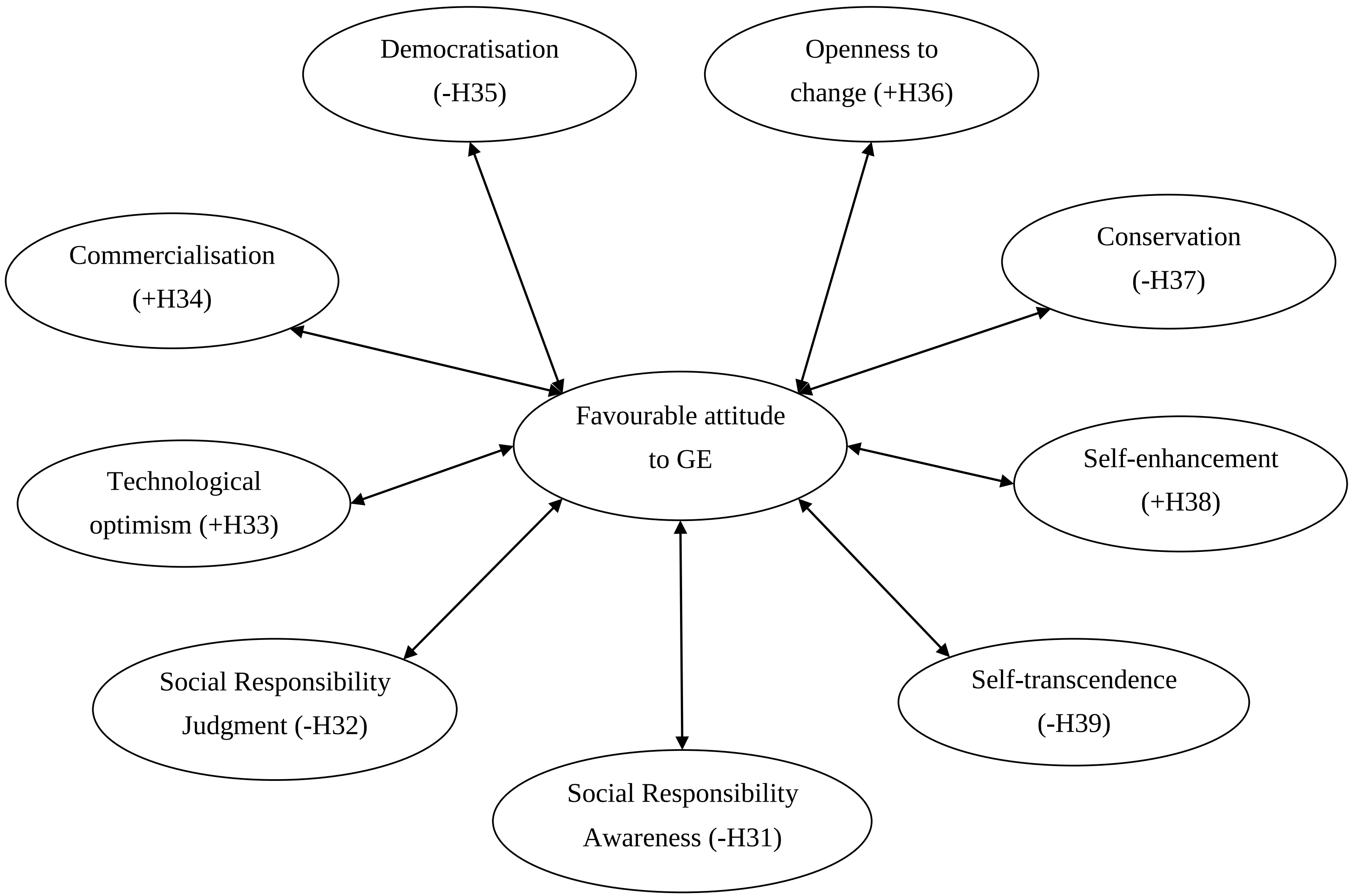

Figure 5.6. Nomological relationships for general attitudes to GE. Hypotheses numbered with a '–' symbol (e.g., -H1) signify negative relationships, hypotheses numbered with a '+' symbol (e.g., +H3) signify positive relationships.

Mixed Methods Research

This is a mixed methods research thesis. The rationale for using mixed methods is the exploratory nature of the research. While the need for social responsibility in scientific research has been identified by scientists and philosophers of technology, the construct domain has not previously been clearly defined, nor have instruments to measure the construct been developed. Qualitative methods are ideally suited to elucidating the construct domain, to determining the range of attitudes scientists have towards the issue, and for developing potential items to measure the construct.

However, because of the small sample size used in the qualitative study ($N = 22$) and because of the logical limitations of the unstructured interview process, the qualitative research is unsuitable for external generalisation (e.g., indicating the prevalence of particular attitudes held by the larger population from which the sample is drawn) or for finishing the development of the quantitative measures or testing their psychometric properties. Study 2, the quantitative survey, is an appropriate methodological approach for external generalisation. The quantitative survey also provides an appropriate data structure for analysing the psychometric properties of the new items and for selecting the most appropriate items for the construction of reliable and valid instruments to measure the research constructs.

Before reporting on the qualitative component of the current research (in Chapter 6) it is important to consider the historical circumstances that have given rise to the increasing legitimacy of qualitative research over the past three decades and the relationship between qualitative and quantitative research. In particular, this section focuses on the philosophical assumptions that underlie these two methodologies and the scholarly debate that has surrounded their use as techniques for the scientific analysis of the social realm.

Much of the discussion, debate, and perhaps confusion, surrounding qualitative and quantitative research over the past four decades hinged around the question of whether or not the methods used by the natural sciences were appropriate for the scientific examination of the social realm (Bryman, 2001). In general, purist quantitative researchers believed that they were, while purist qualitative researchers did not. Mixed method researchers considered either some aspects or even all aspects of the social realm were amenable to the methods of the natural sciences (Bryman, 2001). However, there was one aspect of the social realm that clearly differed from the natural realm and which provided one rationale for the use of subjective, qualitative methods. That is, the objects of study in the natural realm (e.g., molecules and atoms) do not imbue meanings into the natural world; here science was viewed as a search for explanation in terms of cause and effect. In contrast, the objects of study in the social realm (i.e., people) imbue meaning and relevance to its constituent objects (e.g., other people, social situations, institutions etc), and believe that such meaning is relevant to an understanding of people's actions (Schutz, 1962). From this perspective, science is viewed as a search for explanation through understanding (whether or not a causal explanation of behaviour is sought). Qualitative researchers claimed that human researchers were able to arrive at interpretive understandings of social action because of their own humanness and previous experience of social meaning (Neuman, 2000).

Methodological paradigms and philosophical assumptions

Morgan (2007) claimed that probably the biggest shift in social sciences from the period 1980 to 2000 was the renewed attention to qualitative research. He contended that the increased legitimacy of qualitative research was "justified through an emphasis on the contrast between epistemological stances such as realism and constructivism" (p. 53). However, the philosophical and methodological nature of qualitative research is still relatively contentious both within and without the qualitative research community (Tashakkori & Teddlie, 2003). The nature and understanding of qualitative research is still evolving and developing amongst qualitative practitioners (Creswell & Plano Clark, 2007; Elliot, Fischer, & Rennie, 1999; Tashakkori & Teddlie, 2003). A consequence of this is that terminology is often imprecise and inconsistent. It is claimed that this is to be expected as the approach evolves and until it is consolidated (Tashakkori & Teddlie, 2003).

Epistemology, ontology and paradigms

During the 1980s and 1990s, in what was sometimes referred to as the 'paradigm wars', there was considerable methodological disagreement between some members of the quantitative and qualitative research communities (Bryman, 2001). At its most extreme, qualitative researchers denied the scientific validity of quantitative research and, conversely, quantitative researchers denied the scientific validity of qualitative research (Morgan, 2007). Some scholars have claimed that the basis for this rejection of one methodology by the practitioners of the other methodology lay in different epistemological and ontological beliefs (Bryman, 2001; Neuman, 2000).

Quantitative research was traditionally associated with an objectivist/realist ontology and a positivist epistemology. Other related philosophical positions sometimes ascribed to quantitative research included empiricism, reductionism, determinism, realism, and modernism. The aim of quantitative researchers was to establish objective knowledge represented as regularities or laws (Bryman, 2001; Polkinghorne, 1983). Thus, from these assumptions, the principal purposes of quantitative research were: to test hypothesised relationships or causal explanations and theories, to find mathematical order amongst constituent elements of reality, to analyse factors of constructs, to develop psychometric measures, to generalise across populations, and to predict (Bryman, 2001). These are the purposes of Study 2 in the current work.

Qualitative research, on the other hand, was associated with a constructivist ontology (usually associated with the social constructionist movement), and an interpretivist epistemology. The aim was to understand the particulars, especially the meaning and context, of human experience and social life (Bryman, 2001; Elliot, et al., 1999). Other related philosophical positions sometimes ascribed to qualitative research included: hermeneutics, phenomenology, existentialism, indeterminism, humanism, nominalism and post-modernism. Thus, from these assumptions, the principal purposes of qualitative research were to: understand participants' perspectives, provide meaning and context, conduct exploratory research and, inductively develop constructs, hypotheses, and theories (Bryman, 2001). These are the purposes of Study 1 in the current work.

Each methodology also has a set of research methods, concepts and linguistic conventions that its practitioners tend to use and are, therefore, often associated with it (Bryman, 2001). For some scholars, particular methods, concepts and linguistic conventions were ineluctably embedded in particular epistemological and ontological ideologies (Hughes, 1990; Lincoln & Guba, 1985; Morgan & Smircich, 1980; Smith, 1983; Smith & Heshusius, 1986). However, empirical analysis of social research articles and their methods (Platt, 1986, 1996; Snizek, 1976) indicated that, in practice, researchers paid little attention to any supposed relationship between epistemological and ontological theories and research methods. It appeared that although links between philosophical assumptions and research methods were discernable, they were not absolute or determined (Bryman, 2001; Morgan, 2007; Neuman, 2000). While ontological and epistemological beliefs may influence research design and methods, it is not necessarily so.

Some researchers have taken a more pragmatic approach (Johnson & Onwuegbuzie, 2006; Morgan, 2007; Onwuegbuzie & Leech, 2005) and have not confined themselves to a particular set of ontological or epistemological beliefs. These authors also claimed that "true" knowledge can be obtained using both qualitative and quantitative research methodologies and that the dichotomy between the two methodologies was false. That is, quantitative methodologies were not necessarily positivist and qualitative methodologies were not necessarily interpretivist. They believed that it was acceptable, or even desirable, to mix and even integrate these methodologies in a single research program. They considered that both methodologies have weaknesses and strengths and the strengths of each should be utilised to enhance understanding of social phenomena. The choice of particular research methods, from a pragmatic standpoint, was at least as much determined by the research questions being asked, and the intended purpose or use to which the research results were to be put, as it was to the particular set of ontological and epistemological beliefs that the researcher held.

Onwuegbuzie and Leech (2005) identified three approaches along a continuum to the integration of quantitative and qualitative methodologies: purists, situationalists, and pragmatists. Purists were firmly embedded in one camp or the other and adhere to the *Incompatibility Thesis* (methods are logically incompatible and must not be mixed), pragmatists were at the other end of the continuum, they dismissed the Incompatibility Thesis, and mixed and integrated methodologies, while situationalists fell somewhere between the other two. Onwuegbuzie and Leech (2005, p. 380) claimed that "rather than representing bi-polar opposites, quantitative and qualitative research represents an interactive continuum" and that "neither tradition is independent of the other, nor can either school encompass the whole research process. Thus, both quantitative and qualitative research techniques are needed to gain a more complete understanding of phenomena". The perspective of King, Keohane and Verba was adopted in the current work:

> The two traditions appear quite different: indeed they sometimes seem to be at war. Our view is that these differences are mainly ones of style and specific techniques… Most research does not fit clearly into one category – qualitative or quantitative – or the other. The best often combine features of each. In the same research project, some data may be collected that is amenable to statistical analysis, while other equally significant information is not…Neither quantitative nor qualitative research is superior to the other. (King, Keohane & Verba, 1994, pp. 5-7)

Mixed Methods and Multimethod Research Strategies

Mixed methods research, as a particular research methodology, is relatively new and "still developing and will do so for years to come" (Tashakkori & Creswell, 2007, p. 3). In the first issue of the academic *Journal of Mixed Methods Research* the editors stated:

> Given that mixed methods research is still evolving, we believe that it is essential to keep the discussion open about the definition of mixed methods. This might seem a trivial or commonsense issue because many scholars are often certain about what constitutes a mixed methods study. Often writers will say that a mixed methods project is one that includes a qualitative and a quantitative substudy. Inconsistencies and disagreements start when one considers how the two substudies (or strands) are related to each other. (Tashakkori & Creswell, 2007, p. 3)

They listed seven different types of studies which researchers explicitly label *mixed methods.* In an effort to be inclusive they defined mixed methods as: "research in which the investigator collects and analyzes data, integrates the findings, and draws inferences using both qualitative and quantitative approaches or methods in a single study or program of inquiry" (p. 4). This definition is adopted in the current work. Considerable space was devoted to discussion of the above philosophical issues in the first edition of the *Journal of Mixed Methods Research* (Tashakkori & Creswell, 2007).

In the current work, the qualitative and quantitative studies were designed to answer different questions about the same construct. This reason for combining methods is referred to as complementarity (Greene, Caracelli, & Graham, 1989). Data from the results of one method (i.e., qualitative) were also used to inform the other (i.e., quantitative). This is referred to as a development purpose for combining methods (Greene, et al., 1989). Convergence of results from qualitative and quantitative methods is referred to as triangulation and helps increase confidence in the results (Greene, et al., 1989) of each study.

The current qualitative study was designed to explore the under-researched question of scientists' understanding of the concept of social responsibility in order to help define the construct. The quantitative research was designed to examine scientists' attitudes to the construct by developing and using two measures of scientists' attitudes to the construct. This was intended to serve the dual purposes of making generalisations about scientists' attitudes to social responsibility and testing the hypothesised relationships of the nomological network. Items for the quantitative research instruments to measure scientists' attitudes to social responsibility were mainly derived from statements made by participants in the qualitative study (i.e., the developmental purpose).

Some authors make a distinction between mixed methods and multimethod research strategies. For example, Morse (2004) considered that, in mixed methods research, one of the methods is a dominant overarching design and the other method is supplemental to it (however, other authors accept that some mixed method studies may place equal weight on the two methods e.g., Cresswell and Plano-Clark, 2007). Morse defined multimethod designs as those in which the use of each method represents a completely rigorous study in its own right. Multimethod approaches do not necessarily mix methods across the quantitative and qualitative approaches. In such a case, two different questions about the same research area are posed and different methods are independently used to answer each question.

The current work displays characteristics of both mixed methods and multimethod design as defined by Morse (2004), in that it is predominantly quantitative, but the qualitative study is designed to stand on its own. As noted above, the qualitative and quantitative studies in the current work answer different questions about the same construct and the results serve different purposes. However, it will be claimed that the two studies reinforce and support each other (i.e., triangulation of results).

The current work had both an exploratory component and explanatory component. The qualitative study was exploratory and sought to clarify what scientists understand by the construct of social responsibility regarding science and technology. The quantitative study also had a strong exploratory component in that the major purpose was to explore items for the development of new instruments to measure the research constructs. It also had an explanatory component in that it sought to explain scientists' attitudes to social responsibility in research through the antecedent constructs of personal values and technological optimism. It also sought to explain the consequent constructs of attitudes to commercialisation of science, attitudes to democratisation of science, and general attitude to genetic engineering, through the construct of attitude to social responsibility in research.

In mixed method terminology, the current work had a developmental purpose and was sequentially organised with the qualitative component conducted prior to and feeding into the quantitative component. Apart from this, the degree of integration between the qualitative and quantitative components was relatively limited. The qualitative research was used to define the domain of the social responsibility construct and participants' statements about the constructs were used to develop items for the instruments to measure the constructs. Integration also occurred in the triangulation and interpretation of the results.

Quantitative and qualitative presentation styles

Traditionally, quantitative research has been associated with scientific realism and the search for objective truth, whereas qualitative research has been associated with social constructivism and subjective interpretation of meaning. This has led to differences in the presentation styles of research reporting of qualitative and quantitative researchers (Bryman, 2001; Neuman, 2000).

In the past quantitative researchers have generally used the third person and other language and tense constructions, which removed themselves from the scientific data and writing (the invisible data collector and analyst), in the belief that the research data 'speaks for itself,' reflecting 'the truth that is out there' independent of the researcher. This traditional requirement of quantitative research reporting has been relaxed recently with use of the first person pronoun now being accepted by the American Psychological Association (American Psychological Association, 2009). To convey a sense of inevitability about the findings, whether or not the research proceeded in such a manner, the research process was usually presented as linear (Bryman, 2001; Gusfield, 1976). This style was intended to give the reader the impression that the research was objective and reflected the epistemological assumptions of scientific realism (Bryman, 2001).

Qualitative researchers, particularly those who assumed a social constructivist epistemology, have considered that such an approach conveyed a false impression of objectivity, and have preferred to use language constructions that, by including the researcher, acknowledged his/her role in the co-production of knowledge with the research participants (Bryman, 2001; Fontana & Frey, 2003). This writing style was intended to convey the subjectivity of the research process and reveal the researchers assumptions (and biases), or as it is sometimes called, the researcher's *positionality*. It was claimed that only by having access to this information can the reader make a rational evaluation of the data presented. Therefore, it is common in qualitative research reporting to use the first person pronoun to make the researcher visible in the research process, to state philosophical and other assumptions and potential biases, and to reflect on himself/herself as a research tool (Bannister, Burman, Parker, Taylor, & Tindall, 1994).

Neuman (2000, p. 473) claimed that qualitative research reporting has “fewer rules and less structure” than quantitative reporting and that “qualitative reports tend to be longer.” While the bulk of the current work takes the more common and widely accepted objectivist approach to science writing and reporting, the qualitative research (Study 1) uses a writing and presentation style, including the use of the first person pronoun, more in-line with the approach advocated by qualitative researchers.

Summary

A number of authors have claimed that empirical research regarding scientists’ attitudes to their wider social responsibilities to society was very meagre. Likewise, the conceptual nature of this responsibility was considered ill-defined and lacking in consensus, with few guidelines existing for scientists and a paucity of training, in this regard, in scientists’ educational programmes. The need for an increased understanding of these issues is made more urgent by the Promethean power of recent science and technology and the consequent increased social and moral implications for humans and all life on Gaia. The current work is intended to help address some of these knowledge deficits by examining the attitudes and beliefs of practicing scientists regarding their wider social responsibilities in an age of Promethean technologies.

This aim is addressed in several ways. First, the social and moral implications of human use of past technologies and potential uses of developing Promethean technologies (with particular reference to gene technologies) have been reviewed and explicated (Chapters 1 and 2). Second, reviews of theory and empirical research have helped identify a number of antecedent and consequent constructs related in a nomological network to the construct of social responsibility regarding science and technology (Chapters 3, 4 and 5). Third, a qualitative study (Study 1, Chapter 6) used in-depth, unstructured interviews to obtain scientists’ opinions and outline the domain of the wider social responsibilities of science and scientists. The results of Study 1 are a thematic model of the elements of scientists’ social responsibilities (i.e., a framework for scientific social responsibility). Such a framework may help provide moral guidelines for scientists and be useful as a training tool for students and scientists. Study 1 also produced a set of proposed question items for possible inclusion in instruments to measure constructs in the nomological network emerging from the literature review. Fourth, a quantitative questionnaire was designed and administered to a sample of New Zealand scientists (Study 2, Chapter 7). This survey contained the proposed items for the psychometric instruments intended to measure the previously identified constructs.

Items for the instruments were derived primarily from attitude statements, regarding the constructs, made by scientists in Study 1, and the reviews of the theoretical and empirical literature. Finally, scientists' general attitudes to a particular Promethean technology, genetic engineering, were canvassed in the survey, and results, including a comparison with public attitudes, are presented in Study 2 (Chapter 7). Scientists' attitudes to genetic engineering were also used as a concurrent criterion to help infer construct validity to the new measures of social responsibility in research.

To the knowledge of the author no existing psychometric instruments have been designed to measure scientists' attitude to social responsibility in scientific research. Such instruments are desirable and may be useful in a number of ways. First, they could be used as a 'before and after' test to measure the effects of ethical training programmes for scientists and science students. Second, because science and technology are continuing to become increasingly powerful in their social and moral implications, the issue of scientists' social responsibility will continue to grow and become more prominent (Jonas, 1985; Lenk, 1983; Luppicini, 2008; Moor, 2005; Small & Jollands, 2006). The instruments proposed may be used in time series studies to track changes over time in scientists' acceptance of their widened responsibilities to society. Third, if the instruments meet appropriate psychometric requirements, they could be used as tools to conduct further research into the topic of science and social responsibility. Fourth, for science organisations cognizant of their extended social responsibilities, they might be used as part of a selection battery for scientists, or for existing employees to determine which employees could most benefit from ethical training programmes.

Two instruments were designed to measure scientists' attitudes to social responsibility based on Pimple's (2002) characterisation of social responsibility in science as consisting of the responsibilities of the science community and the responsibilities of the individual scientist. The first instrument focuses on scientists' *awareness of the social and moral role of science in society* (stage 1 in Rest's psychological model of ethical behaviour). The second instrument focuses on the individual scientists' *social and moral judgments regarding personal actions and practices* in their research roles (stage 2 in Rest's model). Directional hypotheses regarding the relationship between the research constructs were used to define a nomological network to help provide evidence for the construct validity of the instruments. The development of the research instruments will be described in further detail in Chapters 6 (Study 1) and 7 (Study 2).

This chapter also provided an overview of the philosophical issues involved in mixed methods research, still a hot topic amongst mixed methods researchers as evidenced by recent articles in the *Journal of Mixed Methods Research*. The current work may be described as predominantly quantitative, with an embedded qualitative component. It is sequential and developmental with the qualitative component conducted first and results fed into the quantitative component to develop the construct measures. The purpose of the qualitative component is primarily exploratory while the purpose of the quantitative component is both exploratory and explanatory. In terms of the integration of methods the current work is closer to the concept of multimethod research than a fully integrated mixed method design as the different research methodologies' questions are complementary, though integration occurs for the purpose of development and the results triangulate in the interpretation phase.

The next chapter reports Study 1, the qualitative research component of the current work.

Chapter 6 - Study 1

This chapter reports a qualitative investigation of scientists' moral attitudes regarding the research question:

1) What are scientists' attitudes and beliefs regarding social responsibility in scientific research and technological development in an age of Promethean technologies?

Two further sub-areas related to the main question were also investigated:

a) What are scientists' attitudes to the commercialisation of science?

b) What are scientists' attitudes to the democratisation of science?

The two sub-questions [a) and b)] were originally investigated as part of the current work. However, the focus of this chapter will be on question 1. This is because the research regarding the two sub-questions has already been published in the peer reviewed literature (Small & Mallon, 2006) and at academic conferences (Small, 2005b; Small & Mallon, 2004), and because it was not the sole work of the current author (Professor Mary Mallon was co-author). The results from these sub-questions were reported in the literature review in Chapter 4 of the current work. However, measures for these constructs (i.e., the democratisation of science and the commercialisation of science) are developed in Chapter 7 and used as component constructs in the nomological network developed to test the construct validity of the new research instruments. The primary purpose of Study 1 was to help clarify the domain of scientists' wider social responsibility in an age of Promethean technology.

The second purpose of Study 1 was to provide information from which I could develop items for new psychometric instruments to measure scientists' attitudes to their wider social responsibilities to society. Throughout the Results and Discussion section of this chapter, items for the new instruments are proposed in no particular theoretical order, but rather, proximal to the data from which they were derived.

As with most technologies, Promethean technologies have the potential to be used for both good and for evil (Miller & Selgelid, 2007), either accidentally, as in the case of unknown or unforeseen consequences, or deliberately; either with malevolent intent or as known incidental negative side effects of a desirable application of the technology (Small & Jollands, 2006). However, because of the power and pervasiveness of the potential applications of Promethean technologies, the degree of potential good and evil is much greater than for past technologies

(Jonas, 1985; Lenk, 1983; Luppicini, 2008; Petrinovich, 1999; Small & Jollands, 2006).

My personal contention (and a central concept argued throughout this thesis), is that as science and technology become increasingly powerful they require an increasingly precautionary approach based on scientific foresighting to both their development and application, and that this necessitates extra responsibility on the part of scientists and technologists beyond their traditional scientific ethical norms. A number of previous writers, philosophers, scientists and technologists, have also argued along similar lines (e.g., Bulger, et al., 2002; Bunge, 1977; Cournand, 1977; Jonas, 1985; Lenk, 1983; Luppicini, 2008; Moor, 2005; Petrinovich, 1999; Van Potter & Whitehouse, 1998; Ziman, 1998).

Thus, the focus of this research was not on epistemic values, such as the traditional Mertonian scientific values of universalism, collegiality, disinterestedness, and organised scepticism (Merton, 1942a, 1973), except where these internal scientific norms impact on the question of the broader social responsibility of science to society. Rather, my focus was on scientists' wider external moral responsibilities regarding the application and use of their scientific discoveries, including the consequent technologies, by society. The epistemic ethics of scientists have received considerable previous research, with guidelines and moral codes being well developed (Cournand, 1977; Mahoney, 1979; Pimple, 2002; Prpic, 1998; Weil, 2002; Ziman, 2001). However, as evidenced in previous chapters, this is not the case for scientists' wider moral responsibilities to society (McCormick, et al., 2009; Pimple, 2002; Prpic, 1998; Weil, 2002, Ziman, 1998, 2001). In Study 1, I consider this question in a very general sense, mostly without reference to any particular technology. However, as most of my participants worked either in gene technology research or in related fields of research, when specific technologies are used as examples to illustrate concepts or points participants discussed, the examples are generally from the gene technology field. The central foci of Study 1 were:

- What is the range of attitudes, beliefs and values that scientists hold regarding their social and moral responsibilities to society? This information was expected to help clarify the domain of the construct of scientific social responsibility.
- What are the methods of ethical reasoning that underlie scientists' attitudes and beliefs regarding socially responsible research?

I was interested in what factors (variables, issues, constructs) scientists considered to be of moral significance, and why they considered them to be so. I was also interested in understanding the nature of scientists' ethical arguments: did they use traditional normative philosophical arguments (e.g., teleological ethical theories, deontological ethical theories, and virtue ethics) in their reasoning to describe and rationalise their attitudes and beliefs? What meta-ethical theories were assumed by their arguments (e.g., moral absolutism, ethical relativism, moral conventionalism)? Were their moral judgments consistent? Did they recognise inconsistencies? How did they rationalise inconsistencies? Did emotion play a role in their moral attitudes and beliefs?

Method

This was an exploratory qualitative study in which the data were collected by means of unstructured interviews. The purpose was to sample the range of beliefs and attitudes held by scientists regarding the principal research question and to analyse the nature of their ethical reasoning. "The aim of qualitative research is to understand and represent the experiences and actions of people as they encounter, engage, and live through situations" (Elliot, Fischer & Rennie, 1999, p. 216). The researcher strives to understand, as much as is possible, the phenomena being studied from the perspective of the study participants.

Nonetheless, most qualitative researchers accept that it is impossible to completely set aside one's own perspective and come to a totally objective analysis and understanding of the other's perspective; all researchers bring their own set of epistemological preferences, ontological and axiological beliefs to the research process (Blaikie, 1993). Within the qualitative research community there are a range of philosophical positions with which researchers sometimes align themselves. Thus, qualitative researchers may position themselves along a continuum from realism, post-positivism, critical realism, pragmatism, constructivism, critical theory and post-structuralism (Denzin & Linclon, 2003).

The research context

In order to provide the reader with appropriate knowledge to judge the credibility of qualitative research, many qualitative scholars recommend that researchers make clear their personal perspectives or *positionality* (Braun & Clarke, 2006; Holloway & Todres, 2003; W. J. Potter, 1996). In this tradition, I declare my own positionality to be aligned with the pragmatist camp (e.g., Morgan, 2007; Onwuegbuzie & Leech, 2005; Patton, 1988, 2002). I agree with the philosopher of science, Feyerabend (1975), that all methodologies have their limitations and that methodological choice is largely a creative and playful, subjective act on the part of the researcher.

I assume the pragmatists' position that in conducting research it is epistemologically acceptable to use whatever scientific methods prove useful to elucidate the particular research questions being asked, irrespective of whether the methods are usually considered as most suitable for particular ontological and epistemological positions (Morgan, 2007; Onwuegbuzie & Leech, 2005). While agreeing that total objectivity is an impossibility for a researcher, I believe that some methods help provide greater degrees of objectivity than other methods. However, I also believe that even highly subjective knowledge may provide valid scientific insight. Such insight will require confirmation from other sources, such as triangulation with other research (including quantitative research), or repetition by other researchers, or at the least, critical conceptual analysis by other researchers competent in the particular field. The process of subjecting one's research to the scrutiny of scientific peers provides a mechanism for assessing the intersubjectivity of research results (Bryman, 2001). In some knowledge areas, intersubjectivity may be as much verification that knowledge is "objective" as science can attain (Krasner & Houts, 1984).

I also assume the related belief that, in social science, observation by, and interaction with, a researcher may change the attitudes, beliefs or behaviours of the participants. This can be caused by the mere fact that the observed subjects are aware of the observation (Wilkinson, 2000), or in the case of unstructured interviews (as with the current research), the interaction between the researcher and the participant may influence how the participant thinks during the interview (and hence the research data captured), and even the participant's subsequent perspectives on the issue being studied, either temporarily or permanently. This effect is variously called the observer effect, reactivity, the experimenter effect (Wilkinson, 2000), or the Hawthorne Effect (McCarney, et al., 2007).

The degree to which this effect occurs may depend upon the particular research methods used. Interviewing, with intense interaction between the researcher and the participant, is a method of data capture that is particularly prone to this effect. It was my expectation (borne out during the interviews) that some of the participants in this study would not have given a great deal of thought to the research issue of scientists' social responsibility to society. Getting them to discuss and think deeply about this issue may well affect their future attitudes and beliefs. It is my belief that, in an age of Promethean science and technology, it is becoming increasingly important for scientists to consider such issues. Indeed, I have an agenda to help bring the issue to scientists' awareness and to help them consider their wider social responsibility to society.

The selection, coding and the interpretation of data contains a degree of subjectivity stemming from the knowledge, beliefs, attitudes and perceptions of the analyst. This particular deficiency in objectivity is known as observer bias (or observer-expectancy effect) and affects the researcher's interpretation of the observations (Wilkinson, 2000). This is a particular problem in social science, where actions may be interpreted in multiple ways by different observers. Observer bias may be present in research design and data collection methods (such as interviews), as well as the analysis and interpretation phase of research.

In a research project using the unstructured interview as the method of data collection, researcher subjectivity occurs at both the data collection and the analysis stages. Because of this, I consider that in this research, I am a co-creator, along with my interviewees, of the knowledge generated (Braun & Clarke, 2006). This position is gaining increasing acceptance in qualitative interview research. "Interviewers are increasingly seen as active participants in interactions with respondents, and interviews are seen as negotiated accomplishments of both interviewers and respondents" (Fontana & Frey, 2003). Therefore, in order to obtain a degree of intersubjectivity, it is particularly important that my philosophical positionality (assumptions) and relationship to the research participants is made clear, that the analysis is as rigorous as possible, that it is described accurately and in detail, and the research results and interpretation are considered coherent and meaningful to the knowledge audience (Denzin & Linclon, 2003).

The researcher as analyst: Assumptions and context

My philosophical position and research assumptions have been stated in the section above. It remains for my role and relationship to the research participants to be made clear to the reader. Throughout the period of this research, I have been employed full-time as scientist, and later senior scientist, in the roles of psychologist and bioethicist, at AgResearch, New Zealand's largest Crown Research Institute (CRI). I have worked on a number of projects examining the ethics of various gene technologies and both the public and scientists' attitudes towards them. I have built up considerable knowledge about gene technologies and am able to converse easily about the subject with scientists from the field. This is important as it helps build what Glaser and Strauss (1967) and Strauss and Corbin (1990) refer to as the *theoretical sensitivity of the researcher*. "Theoretical sensitivity refers to a personal quality of the researcher. It indicates an awareness of the subtleties of meaning of data....[It] refers to the attribute of having insight, the ability to give meaning to data, the capacity to understand, and capability to separate the pertinent from that which isn't" (Strauss & Corbin, 1990, p. 42).

To a certain extent, as a researcher and organisational insider I may be considered a participant observer having contextualised myself within the working environment of my study participants over a period of several years. In this role, as participant observer, I have operated sometimes in a covert manner (as in informal conversations with workmates about attitudes and ethics), and at other times overtly (as in the unstructured interviews comprising this research and organisational wide surveys of scientists' attitudes to such issues).

The role of participant observer, although not forming part of the data collected for analysis in this project, nonetheless, confers several advantages over simply interviewing participants (Bryman, 2001). As noted above, I have contextualised myself in the working environment of the scientists. This has made me familiar with the organisational context from within which scientists work. It has also enabled much closer contact with scientists and the kinds of activities that scientists do. Thus, the 'culture' of the scientist is familiar to me, as is the 'native' language of the science culture and, specifically, the theoretical language used in gene research and related technologies. It is also sometimes claimed that the participant observer becomes more sensitised to the context of research participants than the researcher who merely interviews them. However, the possible downside of immersion in the science culture is that features of one's own culture are often invisible to oneself (Bryman, 2001).

AgResearch, besides agricultural, farm systems and environmental research, is noted for its research into molecular biology and gene technology. Scientists at AgResearch experiment with genetic engineering and cloning of both animals and plants. Thirteen of the scientists interviewed were also employed by AgResearch. Seven were known to me before interviewing (and I to them), the other remainder were not; AgResearch employees are situated at a number of locations throughout New Zealand. While my relationship to the interviewees that I knew was relatively weak and at the level of acquaintanceship, rather than friendship, I believe that knowledge of my employment by AgResearch, and of my role as a scientist within the organisation, helped secure some of the interviews and also created an enhanced level of trust in me as an interviewer with a sympathetic understanding of their science (Fontana & Frey, 2003). The appearance (genuine) of empathy with, and interest in, their discipline was further enhanced by my knowledge of gene technology, which, because of the particular selection strategy followed, participants frequently used as examples in our discussion.

Mary Mallon, a professor of Human Resources with a strong background in qualitative research and practice, conducted three of the 22 interviews on my behalf (Interviewees 18, 19, & 20) and checked and verified the data coding and analysis of the sub-theme questions of commercialisation and democratisation of science. This sub-section of the research was jointly published in a special issue (Organising Science) of the journal *International Studies of Management and Organization* (Small & Mallon, 2006).

Sample selection strategy

As an exploratory, qualitative study, my purpose was to sample the range of attitudes and beliefs that scientists held about their ethical and social responsibility to society regarding their scientific research and technological developments in general. However, as most of the scientists interviewed worked on some aspect of science related to gene technologies, it was expected that discussion and examples would reference this particular Promethean technology. Therefore, the sample selection was purposive rather than random.

Several different sampling strategies were applied (Miles & Huberman, 1994). First, a *homogeneous* strategy defined the sample frame, that is, New Zealand scientists with a focus on molecular biology (gene technologies), either as molecular biologists, or as other specialist scientists studying the impacts of molecular biology. Next, strategies of *maximal variation* (attempting to obtain participants with widely different attitudes and beliefs) as well as *typical case* were applied within the sample frame. Finally, *snowball or chain* sampling was also used to acquire participants. The sample is not considered to be representative (in a proportional sense) of the population of scientists in New Zealand CRIs or universities. The data, therefore, are not generalisable, in a statistical sense, to the population of scientists from which my participants were drawn. However, due to the particular sampling strategies, the open-ended, unstructured nature of the interviews, the number of participants, and the fact that the interview process was stopped once no new data were being obtained (i.e., data redundancy was reached), it is probable that a considerable range of the attitudes and values of the scientific community involved in gene research were canvassed.

In order to operationalise the maximal variation strategy, I sought to sample both male and female scientists, scientists across a full spectrum of ages (and experience as scientists), scientists across a range of organisational levels e.g., junior scientists to very senior scientists, scientists known either for their strong support or opposition to genetic engineering, scientists who were molecular biologists, and scientists from other disciplines (though, as explained above, with an interest in the biological or social impacts of molecular biology). Variation in ethnicity was not possible due to the restricted ethnic nature of the sample frame. In order to operationalise the typical case strategy, scientists known for not adopting strong stances to gene technology (i.e., "middle of the roaders") were also sought – it was also expected that the maximal variation strategy would also likely include typical cases. Snowballing was expected to maintain the base sampling strategy.

Participants

Twenty-two scientists from three New Zealand Crown Research Institutes (CRIs) and one New Zealand University were interviewed (see Table 6.1). The three CRIs were: AgResearch (13 participants), Crop and Food (3 participants), HortResearch (2 participants), and the other institution was Massey University (4 participants –arranged and/or conducted by Mary Mallon). CRIs are owned by the New Zealand Government and charged with conducting research for the benefit of New Zealand while having fully commercialised goals and management practices.

Twelve potential participants known to myself (7) or Professor Mallon (5) as meeting one or more of the sample strategies of homogeneity, maximum variation and typical case were approached by myself (or by Professor Mallon), given detailed information of the purpose and methods of the research project and invited to participate. The 10 remaining participants were found using the snowball sampling technique. That is, at the conclusion of each interview participants were asked to suggest one scientist whom they knew who might be interested in participating and whom they believed might be able to contribute knowledgably to the research project. All invited scientists agreed to participate.

Interviewees ranged from a recently graduated scientist to senior industrial scientists leading large research projects, and university lecturers and professors. Several interviewees were internationally renowned in their field. Scientific disciplines of interviewees are presented in Table 6.1. Ten participants were female and 12 were male. The age of interviewees ranged from twenty-six to sixty, with a mean of 44 years and a standard deviation of 8.8 years (excluding one participant for whom age datum was not collected). On average participants had been working in their field of study for 15.3 yrs (*SD* = 8.6yrs) (excluding 3 participants for whom these data were not collected) and employed by their current employer for 10.3 yrs (*SD* = 9.1 yrs) (excluding 4 participants for whom these data were not collected). Twenty-one participants had PhDs and one had an MSc. All participants were of European ethnicity.

Table 6.1.

Interview Participants: Demographic Data

ID No	Sex	Age	Qual	Occupation	Company	Years in field	Years in company
1	M	43	PhD	Soil scientist	AgR	15	15
2	F	42	PhD	Plant molecular biologist	AgR	15	2
3	M	36	PhD	Plant molecular biologist	AgR	12	2
4	M	52	PhD	Entomologist	AgR	27	27
5	F	38	PhD	Plant ecologist	AgR	8	12
6	M	60	PhD	Animal mol. biologist	AgR	35	*
7	M	40	PhD	Animal mol. biologist	AgR	13	3
8	M	35	PhD	Ecological economist	AgR	6	1
9	F	44	PhD	Animal mol. biologist	AgR	20	20
10	F	30	PhD	Molecular biologist	AgR	2	2
11	F	43	PhD	Animal mol. biologist	AgR	15	13
12	F	26	MSc	Animal geneticist	AgR	1	1
13	M	40	PhD	Plant molecular biologist	AgR	13	2
14	M	53	PhD	Evolut./mol. biology	Uni	30	30
15	F	42	PhD	Plant molecular biologist	C&F	14	6
16	M	46	PhD	Plant molecular biologist	C&F	18	18
17	M	41	PhD	Plant molecular biologist	C&F	14	7
18	M	58	PhD	Evolutionary biologist	Uni	*	*
19	F	58	PhD	Plant molecular biologist	Uni	*	*
20	F	*	PhD	Plant molecular biologist	Uni	*	*
21	F	42	PhD	Plant molecular biologist	HortR	15	15
22	M	46	PhD	Plant molecular biologist	HortR	18	10

* Missing data

Procedure

The research project had received prior approval from Waikato University's Psychology Department Research and Ethics Committee. Permission was requested from the CEO's of AgResearch, HortResearch and Massey University to interview selected science staff (see Appendix 6.1. Letter requesting permission to interview scientists). All scientist participants were provided with written information about the project and a copy of the interview questions when first approached to participate (see Appendix 6.2: Narrative Interview Guide) and again at the beginning of their interview. All participants were informed of their rights to confidentiality and anonymity, their right to refuse to answer any specific questions, and to withdrawal from participation at any stage. Participants signed two copies of a standard University of Waikato human research participant consent form – one copy retained by them and the other retained by me (see Appendix 6.3. Participant Consent Form). Participants were given the opportunity to review the transcript of their interview and to change or remove any material they were not happy with. Thirteen participants took the opportunity to check the transcript. No participants chose to change their interview transcripts.

Interviews

Face-to-face qualitative interviews were conducted in the participants' place of work, in a private location, in 2002. Empirical and theoretical weaknesses, regarding objectivity in the nature of this type of unstructured interview, have previously been discussed in the section above (i.e., The researcher as analyst: Assumptions and context). Interviews lasted between one and two hours. Permission was sought to digitally record all interviews. Two participants declined to be recorded so extensive handwritten notes were taken during these two interviews. In addition to digitally recording the majority of interviews, brief handwritten notes, observations and demographic details were made for all participants. Recorder/operator malfunctions in two interviews meant that these two interviews were only partially recorded. However, in these two cases, handwritten notes taken during the interview were expanded upon within an hour of the interview finishing.

Although having considerable previous experience in conducting a range of different types of interviews, before beginning the interviews, I re-familiarised myself with academic literature regarding the conduct of qualitative interviews, including the kinds of questions often asked, and the skills and criteria required by the interviewer. The interview procedure was based on Kvale's (1996) principles regarding interview questions and interviewer criteria. The interview process used could be described as a purposive conversation being at the unstructured end of the interview continuum (Burgess, 1984; Malbon, 1999). That is, there was one main interview question (i.e., the research question described above) with a couple of potential probe questions. However, participants were free to raise and discuss any issue at all within the bounds of, or related to, the research question and probes. Consistent with the position of the interview as a negotiated text (Fontana & Frey, 2003) and the researcher as co-creator of the knowledge (Braun & Clarke, 2006), I was also free to pick up on any issue that participants raised and pursue it in further depth, as well as bring up other issues and new questions, sparked by the conversation.

Thus, both participants and I had considerable degrees of flexibility in directing the interview content which, along with the phrasing and sequencing of the interview conversation, varied from interview to interview. These features are common in qualitative interviews of the unstructured type (Bryman, 2001; Willig, 2001), where the researcher's intention is to acquire 'thick descriptions' or rich, detailed answers that reveal the participant's understanding and imbued meaning of the issue being researched.

This type of interview has the advantage of flexibility in the pursuit of interesting or novel lines of inquiry and is highly suited to exploratory research (Willig, 2001). However, it is important to note that this type of interview process, besides increasing the subjectivity (and reducing objectivity) of the data collected (as previously discussed), also confers analytical limitations on the data corpus. Although the same base question and probes (when necessary) were used with all participants, after this point, there was no standardisation of questions or discussion content across the participants.

Therefore, the structure (or lack of structure) of the interview format means that quantitative analysis of the data is nonsensical, in this case, being incompatible with the unstructured interview method used. It makes little sense to say that only 2 out of 22 participants mentioned 'factor X' when in the majority of interviews 'factor X' was not part of the interview conversation. Therefore, following other qualitative researchers (e.g., Lang, et al., 2003; Meehan, Vermeer, & Windsor, 2000), I refrain from precisely quantifying the number of scientists who held a particular belief, or point of view, preferring instead to give a sense of trends (this issue of prevalence of themes receives a more in-depth discussion in the next section). It should be appreciated that the error or level of uncertainty associated with such trends is unknown. Quantitative analyses will be reserved for Studies 2, which used data collection methods appropriate for quantification and statistical analysis.

Analysis

The interview transcripts were analysed manually (as opposed to computer based software) using the method of thematic analysis (Boyatzis, 1998; Braun & Clarke, 2006; Tuckett, 2005). "Thematic analysis is a method for identifying, analysing and reporting patterns (themes) within data" (Braun & Clarke, 2006, p. 79). Thematic analysis is an interpretive process in which the analyst identifies and selects text fragments (sometimes called data extracts) relevant to the research questions and develops codes to identify and describe patterns occurring in the text fragments. Codes are collated to form higher level themes. If desired, the thematic analysis may then be used for theory development, as is the purpose in *grounded theory* (Glaser, 1992; Glaser & Strauss, 1967; Strauss & Corbin, 1998).

Braun and Clarke (2006) claimed that, within psychology (and other disciplines), thematic analysis is a frequently used, largely unacknowledged and poorly demarcated qualitative analytic method. They noted that because it is generically used across a wide range of qualitative analysis methods, it is generally considered as a tool rather than a specific analysis method. For example, Boyatzis (1998) considered that, rather than being a method, it was a process that could be applied across a range of qualitative (and quantitative) research methods, irrespective of the ontological and epistemological position of the analyst. In contrast, Braun and Clarke argued that "thematic analysis should be considered a method in its own right" (p.78). They outlined the theory, application and evaluation of thematic analyses. They also claimed that thematic analysis is independent of, and can be applied across, a range of theoretical, ontological and epistemological approaches. As a method of analysis, it is consistent with the pragmatic philosophical assumptions underlying the current work. Braun and Clarke (2006) identified six phases of thematic analysis as presented in Table 6.2 below. This is the process that I used to analyse the interview data.

Table 6.2.

Phases of Thematic Analysis

	Phase	Description of the process
1.	Familiarise yourself with your data:	Transcribe data, reading and re-reading the data, noting down initial ideas.
2.	Generating initial codes:	Coding interesting features of the data in a systematic fashion across the entire data set, collating data relevant to each code.
3.	Searching for themes:	Collating codes into potential themes, gathering all data relevant to each potential theme.
4.	Reviewing themes:	Checking if the themes work in relation to the coded extracts (Level 1) and the entire data set (Level 2), generating a thematic 'map' of the analysis.
5.	Defining and naming the themes:	Ongoing analysis to refine the specifics of each theme, and the overall story the analysis tells, generating clear definitions and names for each theme.
6.	The final opportunity for analysis:	Selection of vivid, compelling extract examples, final analysis of extracts, relating back of the analysis to the research question and literature, producing a scholarly report of the analysis

Note. Table reproduced from Braun and Clarke (2006, p. 87).

Defining exactly what counts as a theme is also somewhat problematic. Braun and Clarke (2006, p. 82) claimed that “rigid rules really do not work” and that flexibility about what constitutes a theme must be maintained. According to Braun and Clarke the main feature of a theme is that it “captures something important about the data in relation to the research question, and represents some level of *patterned* response or meaning within the data set” (p. 82, emphasis in original). Boyatzis defines a theme as:

> …a pattern found in the information that at the minimum describes and organises possible observations or at the maximum interprets aspects of a phenomenon. A theme may be identified at the manifest level (directly observable in the information) or at the latent level (underlying the phenomenon). The themes may initially be generated inductively from the raw information or generated deductively from theory and previous research. (Boyatzis, 1998, p. vii)

There are two points important to the explication of the current research in the above quote from Boyatzis (1998). First, he noted that themes may be identified at the manifest or latent level. At a manifest level (referred to by some authors as ‘semantic’) it is the surface content of the text that the analyst is interested in. That is, the words the participant speaks are taken to directly reveal what he or she means or believes. At the latent level, the analyst is interested in the reasoning and underlying assumptions and constructions of the participant that give rise to the manifest utterances. For my research question I am primarily (though not only) interested in themes at the manifest level. That is, because the question seeks to discover what scientists consider their social responsibilities to society regarding their research are, without recourse to any specific technology, this information should be present in the data at the manifest level. However, in some instances, participants analysed their own responses, showing insight at the latent level (such as the ethical processes and theories that they were using in their moral judgments). I occasionally record and discuss such analysis by interviewees. As much as possible, I wish to tell the story in the words of my participants. Hence, the extensive use of participant quotes in the Results and Discussion section.

The second point to note from the above quote from Boyatzis (1998) is that two methods of developing themes from text have been identified. The first is inductive (sometimes call data-driven e.g., Braun & Clarke, 2006). Data-driven thematic analysis induces the themes directly from the data (e.g., grounded theory analysis), whereas with theory-driven thematic analysis the researcher approaches the data with specific theoretical concepts in mind and codes text extracts in relationship to the theoretical concepts. In the current work, the research question is primarily analysed inductively for manifest concepts (of course, it should be noted that due to my knowledge of theory and empirical research in the area, my inductive analysis cannot be considered free of pre-existing theory). However, there is also a degree of theoretical latent thematic analysis regarding types of moral reasoning (e.g., teleological, deontological, relativistic, absolutist, etc.) that underlie the participants' manifest attitudes.

The analysis and reporting of *prevalence* of themes in qualitative data is also a somewhat thorny issue, especially when the data comes from unstructured interviews. Prevalence may be measured in a number of arbitrary ways (Braun & Clarke, 2006), such as counting the number of data items (interviews in this case) in which they occurred, or the number of times it occurred across the entire data set (number of occurrences in all interviews). As discussed above, unstructured interviews conducted in the manner of the current research project are not suitable for such quantitative analysis, which, if given, tend to lead the reader to believe that an exact number has a greater or more meaningful relevance than is actually the case.

Indeed, because of this problem, the current conventions for representing prevalence in thematic analysis do not provide a tightly quantified measure. Thus, as examples of this practice, Braun and Clarke (2006) cited authors such as Meehan et al. (2000, p.372) "the majority of participants", Taylor and Ussher (2001, p.298) "many participants" and Braun et al., (2003, p.249) "a number of participants". Braun and Clarke claimed that these descriptors are employed to "suggest that a theme *really* existed in the data" (p.83, emphasis in original). They questioned how much this information actually tells us and suggested that this is an area of qualitative reporting that needs further debate about how and why the prevalence of themes is reported, and whether or not prevalence is important at all in some types of qualitative analysis.

In the case of Study 1 in the current work, prevalence is not important (and was not the purpose, because as argued above the unstructured nature of my interview process is inconsistent with counting the occurrence of particular themes). Rather, the purpose of the interview process was to define the domain range of the construct. While recognising the issues regarding the current conventions (and its inappropriateness for my data collection technique and purpose), in my analysis the terms 'a few', 'some' and 'most' will occasionally be used for convenience.

Somewhat similarly, the relationship between prevalence and the *importance* of a theme is not straight forward. Of greater significance than prevalence, is whether or not the theme "captures something important in relation to the overall research question" (Braun & Clarke, 2006, p. 82). From this perspective, even a theme that occurred only once across a whole data set (and hence has low prevalence) might be considered important if it addresses the core of the research question.

Phase 1: Transcription

Braun and Clarke (2006) recommended for the first phase of the analysis, familiarisation with the data, that the analyst should thoroughly immerse himself/herself in the data by reading and re-reading the data to gain familiarity with the "depth and breadth of the content" (p.87). Reading for analysis should be an active process in which meanings and patterns are sought. Some theorists (e.g., Bird, 2005; Lapadat & Lindsay, 1999) have claimed that transcribing verbal interview data is an excellent way to familiarity and should be viewed as an important data analytic phase with an interpretive aspect where meanings are being created.

Ten of the 20 digitally recorded interviews were transcribed by me, while the remaining interviews were transcribed by a professional transcriber. The transcription process was conducted within two weeks of each interview. I used the following process for transcription. Before beginning the transcription each interview recording was listened to in its entirety to gain a feel for its content and to aid my memory of the participant and the interview. Transcription required repeated listening to short sections of the recorded interviews with a verbatim account of all verbal utterances being typed into a MS Word document. After each interview had been transcribed (by either me or the professional transcriber) I checked the transcription against the recording, correcting errors found. While the transcripts have a reasonably high degree of accuracy, complete accuracy was not possible in all instances, as for example, when words or sentences were too quiet to hear or were obscured by other sounds on the recording. The 22 interviews (including the handwritten recorded notes) amounted to 225 single spaced, typed A4 pages of transcripts.

Phase 2: Coding

After transcription of a recorded interview, *coding*, the second phase of analysis, was undertaken. Strauss and Corbin (1990) referred to this task as *open coding*. Each transcript was read again. This time, text segments that I deemed meaningful and of relevance to the research question were highlighted on the transcript hardcopy and given a data-driven initial code. Next, the highlighted text segments were extracted from the interview transcript and placed in a MS Word document table along with the initial code and also with a reference locating the text extract within the transcript, so that if required the text segment could easily be located in its original context. This process was repeated for all interview transcripts.

A large amount of data was generated in this process; the initial table consisted of a document with more than 100 A4 single-spaced pages. In order to manage the data and the analysis, three broad meta-themes associated with the main research question and the two sub-topics were analysed separately. These 3 broad themes were: 1) the ethical and social responsibilities of science and scientists, 2) the democratisation of science, 3) the commercialisation/privatisation of science. Three tables, one each for the meta-themes, were then constructed with relevant text extracts and transcript location references.

Phase 3: The search for themes

Separate analyses were then conducted for each of these three meta-themes. The same data-driven, manifest thematic analysis process was used for all three meta-themes. The procedure was as follows. The codes from each of the meta-themes were listed and sorted into a number of different groups, on the basis of conceptual similarity, with reference to the original transcript documents being retained. The groups of collated codes are potential themes. In this way codes were combined to form the main themes of the analysis. Strauss and Corbin (1990) referred to this phase as *axial coding*. Note that in the current chapter, only the first meta-theme is analysed - the ethical and social responsibilities of science and scientists. As previously explained, the democratisation and commercialisation meta-themes have been reported elsewhere.

Next, in order to try and understand the data and the various meanings and relationships inherent between the induced themes, I spent a considerable amount of time trying to create thematic maps of the data (as recommended by Braun & Clarke, 2006). This is considered by qualitative researchers as a largely creative endeavour on the part of the analyst (Fontana & Frey, 2003). A variety of different thematic maps were created in an iterative process similar to the examples shown by Braun and Clarke. Initially large and complex thematic maps were eventually synthesized into smaller less complex maps either by various themes being discarded, due to their tangential relationship to the research questions, or by the amalgamation of relevant sub-themes into overarching themes. The result of this process was a collection of candidate themes and sub-themes to which text extracts were coded.

Phase 4: Reviewing themes

Phase 4 of the thematic analysis involved the refinement of themes and thematic maps. Themes and supporting text fragments were critically read and examined for robustness of the coherent patterns. During this process some themes were amalgamated when they seemed to be relatively homogeneous and in one instance a theme that contained heterogeneous text data (i.e., personal values) was deconstructed into two homogeneous themes (i.e., personal values and business norms). This process is consistent with Patton's (1990) two criteria for judging categories or themes: internal homogeneity and external heterogeneity. According to Patton, elements or concepts should be homogeneous within a theme and heterogeneous with elements and concepts in other themes.

Nonetheless, complete internal homogeneity and external heterogeneity were not achieved – some of the themes clearly have degrees of overlap or have elements in common with, or that relate to, elements within other themes. Within the current work, such connections may be seen where a single quotation is used to illustrate more than one theme (thus the reader will note the deliberate use of the same quote to illustrate different themes or sub-themes). When satisfied that the themes appeared coherent and relevant to my research question a final thematic map reflecting the finalised themes was created.

Next, following Braun and Clarke's (2006) guidelines, the validity of individual themes in relation to the entire data set and the accuracy of the thematic map as a reflection of the meanings and relevance evident in the data set were considered. This process involved a critical rereading of all the transcripts. During this process, any relevant text that had not previously been coded was allocated to the themes and sub-themes previously identified. Once the themes, sub-themes and the thematic map appeared to satisfactorily reflect the transcript data set, and no substantial revision seemed necessary, phase 4 was deemed complete.

Phase 5: Defining and naming themes

In this phase the text extracts of the various themes and sub-themes represented in the thematic map were organised into internally consistent, coherent accounts, accompanied by an analytical narrative. Definitions describing the content and scope of the themes and sub-themes were developed and then final names were assigned to each. Following Braun and Clarke's (2006) advice, the descriptions are brief (no more than a few sentences is recommended) and the names chosen are concise and immediately convey to the reader a sense of what the theme is about.

Phase 6: Producing the report

This is the last of the phases in thematic analysis as elucidated by Braun and Clarke (2006), and consists of writing up the story revealed by the thematic analysis. According to Braun and Clarke, the write-up should be a concise and coherent account of the story with sufficient text extracts to demonstrate evidence of the themes. Such extracts should be vivid examples of the issues being discussed and be embedded within an analytic, interpretive narrative. The output of this phase is produced below in the Results and Discussion section. It is common in qualitative research to combine results with discussion and to compare findings with previous empirical research (Bryman, 2001; Neuman, 2000).

However, as this work is a PhD thesis, rather than a journal article, my focus was on coherence, analysis and interpretation, with lots of illustrative text extracts, perhaps at the expense of conciseness. Because the participants in my research were all highly educated, articulate and frequently analysed and interpreted their own, and the science community's, positions and statements (as scientists their daily work involves analysis and interpretation), when apparent in the data, I have sometimes chosen to use participants' text extracts to provide both analysis and interpretation of the concepts under discussion. I believe that this technique helped to give increased voice to the participants.

Results and Discussion

Main themes and sub-themes: Descriptions and thematic maps

The analysis and model offered here is a thematic one, as opposed to being a causal model. Three main themes were developed from the data analysis of the meta-theme: *the wider social and moral responsibilities of science and scientists* (i.e., scientific social responsibility). These themes are: 1) *public good*, 2) *engagement*, and 3) *compliance*. Figure 6.1 is a high level thematic map depicting the 3 meta-themes and the main themes of scientists' and science's social responsibilities to society. The two meta-themes that are **not** the focus of this chapter (democratisation of science and commercialisation of science) are also shown in dashed boxes. These two meta-themes are also related to the themes of public good, engagement, and compliance. Each main theme of scientific social responsibility is briefly outlined first, after which the themes and sub-themes are discussed in greater detail.

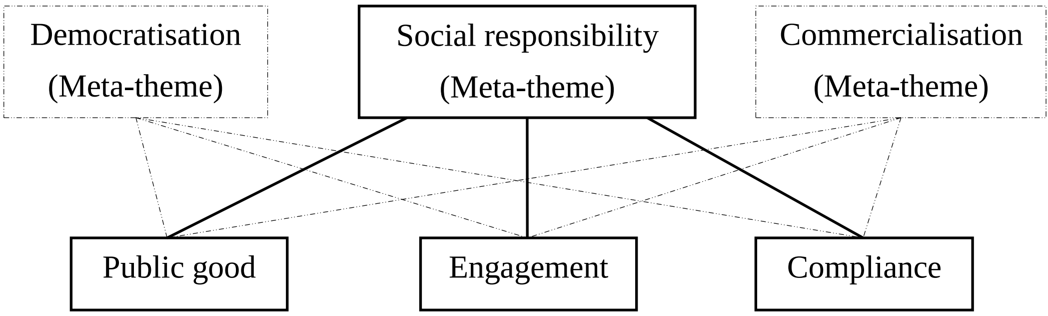

Figure 6.1. Thematic map of scientists' social responsibilities to society

These three main themes are described as follows.

1) Public good (theme and sub-themes are depicted in Fig. 6.2): describes the range of participant's beliefs about the responsibility of science and scientists to 'do good' or 'to do public good'. This range covers a continuum of beliefs from 'do no harm' through 'there is no imperative for science and scientists to do good' to 'science should be done for the public good'. Sub-themes of 'public good' are: *benefit/harm* – balancing societal benefits and harms, *knowledge* – its production and value, *technologies* – development, distribution and value, and *foresight* – contemplating and researching how potential technological applications impact on society, the environment and other objects of value.

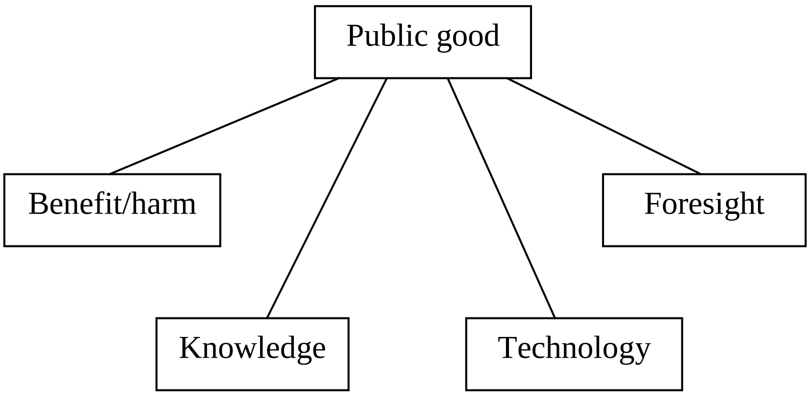

Figure 6.2. Sub-themes of the 'public good' theme.

2) Engagement (theme and sub-themes depicted in Fig. 6.3): describes scientists and the science community's responsibility to engage and communicate with society. Engagement has three sub-themes, *informing society* about the meaning and relevance of scientific knowledge and benefits and risks associated with new or developing technologies. The second sub-theme is *becoming informed* regarding public expectations of science and the science agenda. This involves the acceptability of research projects and technology developments as well as listening to the issues that concern the public. The third sub-theme is

integrity regarding engagement with the public. This applies to both informing society about research and the potential benefits and risks, including the reliability and validity of research results and the uncertainties associated with the potential risks and benefits, and becoming informed about what the public think, receiving this information with respect, and giving it appropriate significance in terms of scientific response.

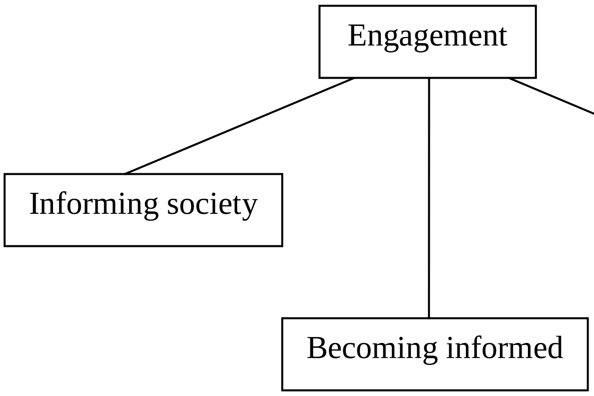

Figure 6.3. Sub-themes of the 'engagement' theme.

3) Compliance (theme and sub-themes depicted in Fig. 6.4): describes scientists' responsibility to comply with various norms and regulations.

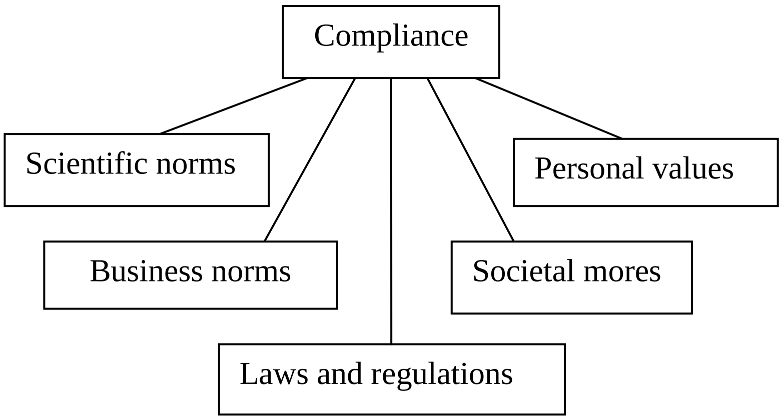

Figure 6.4. Sub-themes of 'compliance' theme.

Five sub-themes are identified under this theme. The first is compliance with *scientific norms* - the practices and processes that help produce sound scientific knowledge and which enhance the scientific community's ability to develop sound knowledge. These scientific norms are what Ziman (2001) refers to as the epistemic code of values of scientists. These are similar to the science values first popularised by Merton (Merton, 1942a). The second sub-theme is compliance with *business norms* - scientists employed in the commercial sector have extra norms related to employment by private or public companies. The third compliance sub-theme, applicable to all scientists, is *laws and regulations*. Fourth is *societal mores* – the values, norms and expectations of society, and lastly, *personal values*.

Public good

I now discuss and illustrate the theme of doing 'public good', along with its four sub-themes (benefit/harm, knowledge, technology, and foresighting). Although I treat each of these sub-themes as discrete, they are to a considerable extent intertwined. Thus, for example, *foresight* refers to the practice of imagining (and/or researching) the potential uses of *knowledge* and *technology* and considering whether, and how, they will be *beneficial* or *harmful* to society and *engaging* with the public to inform and discuss issues such as their concerns and what *regulations* should be applied in the context of the science, potential technologies and understanding of human behaviour. Thus, although foresight is categorised as belonging to the theme of doing public good, as just illustrated, it can clearly be related to elements of the themes of engagement and compliance.

All of the participants discussed the notion that science and scientists had a responsibility to 'do public good'. The majority believed that science had a responsibility to "do good" (e.g., respondent 2, hereafter respondents will be identified as: R1, or R2 etc.) or to "do public good" (e.g., R13). Participants made statements such as, "science should be done for the good of the greater world population" (R5), "scientists have a responsibility to do public good" (R15) and "I have a desire to do some sort of good for the community" (R8). For some participants it seemed almost unbelievable that a scientist would not want to do public good: "Why would you not want to do public good, I mean you don't go through, or I would know very few people who go through the system not wanting to do some good with their science. I have never met a scientist yet who said: I want to be evil with my research" (R17). Another participant stated: "Scientists, in general, tend to be very ethical people, they tend to be people who are there because they are interested in humanity and in solving things and problems to make things better" (R6).

While some participants stated that their desire to do good, through their research, was an altruistic desire, one participant questioned this saying, "I wouldn't say it was altruism either. I mean altruism would be showing selflessness, whereas, I think if you can do society good then you'd get something in return. I mean ultimately if I produce something that was beneficial to society you would hope you'd get rewarded for that" (R17). Contrary to the majority, a few participants argued that "there is no ethical imperative to do good" (R9) and “so I don’t have as like a preset that science should be necessarily for the good of humanity or for the good of the world – it’s more of a purist type pursuit – knowledge for knowledge’s sake…. it’s not the scientists’ primary activity to convert knowledge into public good, it is still to seek knowledge” (R21).

Nonetheless, even those participants who took this latter position argued that there is an ethical imperative, “not to do harm” (R9). One scientist taking this position questioned the idea that scientists (as a profession) had any more responsibility to do good than any other career. She opined, “Most scientists are trying to do good – to help people… however, scientists do not have any more of a responsibility than any other sector, bankers, shopkeepers, to do good. Society can’t demand more responsibility of scientists than they do of anybody else” (R11). However, this participant then immediately reflexively reconsidered her statement and raised a contrary argument: “Although, ministers and police are supposed to be particularly ethical. Expectations of scientists are more like ministers and police than perhaps car salesmen” (R11). Indeed, most participants seemed to consider science to be a ‘vocation’ that carried with it an obligation to be especially morally responsible. Considering the above information, the following item is proposed for the awareness of social responsibility instrument:

There is no ethical imperative for science to do good [10]

Note that the number in the square bracket, after the proposed items, is the item reference number in the two social responsibility instruments i.e., the number represents the order in which the items occur in the scientists’ survey in the quantitative research in Chapter 7 (see Appendix 7.1. Scientists’ Survey Instrument). Items referenced 1-10 are proposed for the ‘awareness of social responsibility’ instrument, while items referenced 11-20 are proposed for the ‘judgment of social responsibility’ instrument. Note also, that not all sub-themes discussed lead to the proposal of an item for one of these instruments, but rather, sub-themes are discussed in their own right, in order to elucidate scientists’ attitudes and beliefs regarding social responsibility of science and scientists.

Benefit/harm

Several of the participants couched their belief that science should be done for the public good, with reference to a beneficial purpose for the research: “Research should have a purpose that benefits society” (R7) and “there has to be a reasonably good need for it – a purpose even for blue sky research” (R3). Some arguing for this perspective thought that the purpose should be a benefit for society: “rather than knowledge for knowledge’s sake. [We] need to know how this knowledge is going to fit in, what can be done with it” (R6).

Others considered that such a criterion was too restrictive in that it was often impossible to predict the eventual benefits (or harms) of basic or blue skies research at the time at which it was being conducted, but that such research often proved to be very valuable and have public benefits at a later date. One participant gave an example of some basic research she had conducted that was now being used in an unforeseen way in medical research. She commented: "so it is not necessarily foreseeable [that] the area of research that I work, plant viruses, would ever have anything to do with medical research, but it is… it's been used for some unforeseen thing that nobody would have expected and so that's the beauty of discovery" (R21). Some participants considered that knowledge was intrinsically valuable and hence producing it was good or beneficial for society, independent of any utility it might currently or eventually have.

Not doing harm was almost universally considered to be an important social responsibility by sample participants, irrespective of whether they believed scientists had an obligation to 'do good'. One participant stated this principle as "first do no harm, not to do damage, not to make monsters" (R4). Several participants talked about the relevance of a Hippocratic Oath for scientists. However, in an apparent contrast to their position of 'no harm' a majority of participants also talked about 'balancing benefits and harms' – which clearly implies acceptance of some degree of harm. Several participants referred to utilitarianism (a teleological ethical theory) as their guiding ethical principle: "I tend to take a utilitarian approach to scientific ethics – what will the value of it be – how do the possible benefits of the research weigh up against the possible harms" (R6). Although 'not doing harm' was a moral ideal to be strived for, there was recognition that this was perhaps an impossible goal for at least three reasons.

First, there was the understanding that most scientific knowledge and resulting technologies could be used for both benefit and harm (e.g., dual-use technology Miller & Selgelid, 2007): "Almost any technology or field of science – medicine, physics, chemistry – can have potential lethal applications if used as weapons" (R13). Second, there was awareness that sometimes technological applications that provided benefits for some sectors of society contributed to harm in other sectors or for other stakeholder groups: "Scientists have a responsibility to think about whether their research is ethically justifiable – do we really need to know this thing? Is this knowledge worth the harm that it may cause, for example, animal suffering?'' (R12). Third, there was the observation that some technologies that produced benefits for society in one area produced negative consequences for society in another. The example of the motor car was used – the car gives the benefit of quick, reliable, autonomous transport at the expense of pollution, fossil fuel depletion, and road injuries and death caused by car accidents (Brandon, 2002). Like some of the bioethicists and technoethicists (e.g., Bulger, et al., 2002; Bunge, 1977; Jonas, 1985; Luppicini, 2008), most participants considered foresighting a social and moral responsibility of scientists. As one participant stated: "scientists have an obligation to help evaluate and understand both the potential benefits and potential risks associated with their fundamental research and with technological development" (R7). Based on the above illustrations of this theme, the following item is proposed for the judgment social responsibility instrument:

To evaluate possible benefits against possible harms when deciding on research projects [11]

Going back to the concept previously mentioned regarding the purpose of research, it seems that while some considered it too strong a criterion that all research must have a beneficial purpose, the vast majority of participating scientists were against research that had harm as its central purpose. Participants made comments such as "research into biological weapons is problematic if not really unethical" (R2) and "I think those kinds of areas, for example, nuclear weapons, biological warfare, is an area that should not be studied. Yes, very much" (R14). This latter participant is raising the idea of dangerous knowledge and forbidden areas of study (which I will return to shortly).

In regard to the prevention of harm, there were a number of potential areas of harm that were identified by participants. Similar to the results of Small et al. (2005) regarding public concerns about genetic engineering, the main potential areas of harm identified were the environment, people and animals. Participants made comments such as "need to be careful not to damage the environment or biodiversity" (R2), "do not cause problems for the environment" (R15), "should take care not to have any kind of negative impact on people" (R4), and "it is important to limit animal suffering for the sake of research" (R12). One scientist discussed how her attitude to the use of animals in research had changed over the years: "See one of the things I should have clarified, work that I wouldn't want to do. I used to do a lot of work with animals. And I didn't really have any problems with killing rats. I think that for three or four years of my life, I basically, three or four rats a week, that I had to kill to do the experiment. I wouldn't do that now" (R19). Since the publication of *Animal Liberation* by Peter Singer (1975) there has been growing awareness of the ethical aspects of the treatment of animals by society and researchers.

The safe practice of science and the safety of the technological products of science were other aspects of 'no harm' raised by participants: "Safety of the products of science is an important ethical issue" (R3) and "I think it is an ethical responsibility, is to, obviously in the kind of gene research that we do, to do things appropriately and safely…. So we have ethical and social responsibilities, I guess, to be safe" (R14). Based on the above discussion the following item is proposed for the awareness of social responsibility instrument:

The science community has a moral obligation to ensure that the products of science knowledge do not cause harm (e.g., to humans, animals, environment) [2].

Some participants also acknowledged accountability for harms that resulted from science and technology: "Corporations should be liable for any damage that is done as a result of their research or product development – why should the public pay the price for their mistakes?" (R4) and "Scientists have a responsibility for the use to which their technological discoveries are put…. I just think that if everybody blindly goes along not thinking about what they are actually doing and what it [research and technology] can be used for, then we have got a problem. Researchers should definitely be thinking about the future" (R13). This participant then went on to temper his claim with: "Although, if as a researcher you are an optimist and always trying to do public good then you don't tend to think what could be the negative things that can happen – whether it be natural disaster because it got mucked up and out of hand or whether somebody actually took it and modified it and used it for a different purpose. It is very difficult to think of all those different things – nobody's got a God's eye view where they can think of every different one" (R13).

The unpredictability of the eventual uses of science and technology was also raised by another participant who used it as an argument to claim that scientists' responsibility for the application and use of their technological discoveries is very limited: "It is often unclear how new knowledge can be applied and what technologies might be developed from it. Often the new knowledge will be combined with other bits of knowledge or technologies to produce things that scientists developing the fundamental knowledge could not have foreseen. Scientists cannot be held responsible for unforeseen uses of the knowledge they develop" (R7). This participant went on to attribute accountability to society: "It is up to society to decide which uses are ethical and which ones are unethical and to regulate the technologies in accordance with society's norms" (R7). For this participant, a scientist's responsibilities were limited to helping the public understand and evaluate both the potential benefits and risks of fundamental research and technological developments. This echoes the position espoused by Wolpert (1989, 1999) and described in Chapter 4. From the above reflections, the following item is proposed for the awareness of social responsibility instrument: ***The scientific community cannot be held ethically responsible for the use to which scientific discoveries are put*** [3].

Several participants expressed the opinion that because science was largely funded by the taxpayer that scientists were accountable for their research to the public. Noting taxpayer funding, one participant claimed, "The taxpayer ought to know what we are doing because we are accountable. And if we are doing something that the taxpayer disagrees with, then we shouldn't be doing it – but that's my opinion" (R19). However, she then goes on to use the *deficit theory of public understanding of science* (Irwin & Wynne, 1996) to moderate this stance: "The taxpayer is quite likely to be [an] uninformed person who can't make a judgement that's based on sound knowledge, and that's a problem, so I don't know, I don't know where you go" (R19).

The final topic regarding the sub-theme benefit/harm is the distribution of benefits and harms throughout society. This was viewed by a number of participants as a problem of equity. One participant, echoing ideas discussed in the literature review (see Chapter 1) from the Nobel Laureates (2001) statement and by Seragaldin (2002) observed, "increasing technological power is tending to increase the gap between the rich and the poor, between the Western world and the third world – this will create future problems unlikely to be resolved by peaceful social upheaval" (R2). Similarly, another scientist claimed that wealth distribution and lack of equity was perhaps the biggest social problem facing humanity (for an academic argument supporting this premise, see Wilkinson & Pickett, 2010). "Wealth distribution and equity, this is a huge area of future social problems in the 21st century. Lack of adequate distribution of wealth is going to cause major problems – perhaps one of the biggest problems facing humankind" (R4). One scientist claimed that "the practical benefits of research and technology need to be distributed to society – not just locked away in a scientific publication" (R7). Another felt "a responsibility to get the knowledge that I have discovered out there, into the community" (R8). He also observed that "I am funded, pretty much, by public money, so there is a responsibility that the information that I gain is, that I produce, is made available and is used, maybe in a utilitarian kind of sense, is used for the benefit of the NZ taxpayer, for the public good…. that's particularly the case in areas that I work in, like environmental impacts, where you are not getting a private provider picking up a lot of the stuff that we work on…. it often falls outside the standard market model…. the things we are looking at – systems implications of activity on the environment" (R8). From the above discussion the following item is proposed for the awareness of social responsibility instrument:

The benefits of science and technology should be distributed throughout society in a fair and equitable way [9].

Knowledge

I have previously alluded to the fact that some participants considered knowledge to be of intrinsic value – that is, the belief that, knowledge, in itself, irrespective of any potential utility, is a good thing and a public good: "I think that a healthy society is a society that values knowledge for its own sake. I think that the pendulum is much more the other way now, there's this feeling that the only good knowledge is knowledge that helps us make a buck" (R14). Another claimed, "I think we should be able to do science for science's sake, as long as people aren't being exploited and animals aren't being exploited" (R19). A third opined, "Knowledge for knowledge's sake – now there is a caveat to that, in that it's important that the science that is being done is well balanced because it's very important for science to be useful and caring of the environment and stuff. But I don't believe that it necessarily, absolutely has to be, it can be knowledge for knowledge's sake, some of which is applied" (R21). For participants' holding this belief, science was viewed as being, "about discovery – it's about making mankind more knowledgeable" (R1).

Like Wolpert (1989, 1999), some viewed scientific knowledge as 'value-free'. That is, they considered that knowledge in itself was neither good nor bad but rather it was the application to which people put the knowledge that could be classified as good or bad: "scientific knowledge is value-free – application of the knowledge has value" (R1) and "I don't think that knowledge itself can harm, but only what we do with the knowledge" (R2). A subtly different view was expressed as, "gathering scientific knowledge is neutral, value-free. It is the application of the technology that has ethical value" (R13). The difference resides in the word 'gathering'. Gathering knowledge is the activity of research rather than the subject of knowledge. However, even those who consider knowledge itself to be value-free may consider gathering knowledge to be a value-laden activity. Indeed, this is a major tenet of Science, Technology and Society Studies (STS); the choice of what knowledge to gather, who to gather it about, who may have access to it, and for what purpose, are highly value-laden issues, as is the issue of who will be the beneficiary of the knowledge and who might fall victim to its accidental, incidental, or malevolent harmful use (Hackett, et al., 2008). From the above discussion the following item is proposed for the awareness of social responsibility instrument:

Science is the value-free pursuit of true knowledge [7]

The notion referred to above by one participant, "that the only good knowledge is knowledge that helps us make a buck," (R14) refers to a value decision about the purpose of science, which we might call the *economisation of science*. This particular value, which several scientists claimed was the over-riding criterion for selection for science funding by the Foundation for Research Science and Technology (FRST)[2], for better or worse, is setting the current New Zealand science research agenda. It is a reflection of the ideological position of most Western governments that economic growth is necessarily beneficial and that the purpose of science should be to create economic growth.

Interestingly, the scientist who considered that "a healthy society is a society that values knowledge for its own sake" (R14) questioned the notion that all knowledge is good (and also the notion that knowledge itself is value-free) "it does come down to this really fundamental question. Is all knowledge good? I mean you could say, well the knowledge that allowed people to make the atomic weapons was not good…. I guess you have to come to the logical conclusion that not all knowledge is good. There is some knowledge that is actually evil, or as close to evil as you're ever going to get" (R14). It is, perhaps, true that some knowledge is more amenable to harmful use, and indeed, that the purpose behind the research that discovered a particular knowledge set may have been to commit harm, or that harm was caused to some group during the research process. Under such circumstances the research activity may be considered evil. However, it is not absolutely clear, that the knowledge so obtained, is itself evil.

Allied to the position that knowledge itself was value-free (even if gathering it is not) was the belief that all subjects or topics should be open to scientific research: "Any kind of knowledge should be tried to be gained because I don't think that knowledge, in itself, can harm" (R2). This participant raised the question of dangerous or forbidden knowledge (Commoner, 1966; Dainton, 1971; Joy, 2000). Despite her initial statement, she expressed subtle and complex attitudes to dangerous knowledge. She considered that some research should not be done due to a lack of knowledge about what the potential harms associated

[2] FRST was the New Zealand Government body for purchasing and funding scientific research.

with the research might be. “Some studies should not be done until we have a sufficient level of understanding of the possible dangers. Genetically engineered (GE) plants should not be released into the environment to study ecological effects – current knowledge is not good enough. Experimentation in containment is alright” (R2). In this passage, the participant was advocating an approach consistent with the precautionary principle (Kriebal, et al., 2001).

She considered that there was scientific hubris and arrogance in the face of lack of knowledge in the field of GE: “the current contention that 90% of our DNA is ‘junk DNA’. It is just that we cannot understand DNA. It is like when we read a book in a language that we do not understand or have not learned. But to say that all these letters are ‘junk’ is very scary” (R2). Her suspicions about this issue have since been confirmed with important roles being found for so-called ‘junk DNA’ (Ide, et al., 2010; Nowacki, et al., 2009), as noted in Chapter 2. This participant was also of the opinion that “It may not be OK to put some knowledge in the public arena, for example, biological and chemical warfare. However, those who want to find out probably can” (R2). Thus, although she considered some knowledge too dangerous for public release, she doubts that knowledge, once discovered, can be kept secret.

After the 2001 anthrax attacks in the US, editors of scientific journals met to consider the withholding from publication of biological information that could be used to develop weapons of mass destruction (Journal Editors and Authors Group, 2003). Other interview participants also noted research activities or technologies they thought should be forbidden: “Human cloning is something that’s just not done. Biological warfare, those kinds [of things] they are just not done…I guess certain things are off limit and why would you want to do it anyway?” (R16). Following the above discussion, the following item is proposed for the awareness of social responsibility instrument:

There are some fields of knowledge that are so potentially dangerous that they should not be researched [6].

However, it is a matter of record that some scientists not only want to do this kind of work but are actively engaged in such research. Although none of my participants said that they would like to do such research, some of them suggested reasons why other scientists might want to: “You do work with scientists that science is their absolute passion and they will keep going because they can scientifically do it, and I think that is a bit of a concern. The drive is to keep doing it because it’s a challenge to do something scientifically, like cloning humans, or whatever it might be. It’s part of the science ethos – the challenge of doing the undoable. It’s a bit of a concern, but I don’t know how you quite control that. Some people are so passionate about science they can’t divorce the science from the ethical side of it” (R10). Another participant expressed it like this: “One of the basic things of being with scientists is seeking the truth. And in terms of one of the glories and pleasures of being a scientist is just that that’s so much of a passion to find out how and why” (R21).

Besides the scientific passion for knowledge, a second reason suggested for scientists’ desire to work in forbidden areas was the desire for scientific status; to be the first to achieve an ‘impossible’ goal: “Why the hell do you need to clone a human? It’s really just so that someone can say ‘I cloned the first human being,’ here they are sort of hoping to be a bit of a hero” (R3). An achievement such as creating the first human clone would ensure scientific fame (or perhaps, infamy) and immortality throughout future human history – like being the first person to step on the moon. A third reason was also put forward. This related to the effects of commercialisation of science, “If the science is commercialised then the issue of money will over run anything else and you will, I think you will, not always get dishonest science, not at all, but very, very frequently, I think scientists will do ethically irresponsible things for the sake of money” (R12).

Several participants noted a problem that they and the scientific community in general faced in regard to the pace of discovery of scientific knowledge: “Things are moving so fast. It’s absolutely phenomenal, the amount of information. We cannot keep up with it. You can keep up with your own little area most of the time, but even then there’s still things that you miss. And to try and keep up with everything, that’s going on, you know, we’re just not superhuman, we can’t do it. The pace of science is a worry” (R19). Regarding the exponential growth of knowledge, see Kurzweil (2001, 2005) and Toffler (1971, 1980).

Technology

As discussed above, scientists have different opinions regarding the moral value of knowledge and technology. Even if they believe that knowledge is value-free and that no areas of knowledge should be restricted from research, they may still believe that some technologies should not be developed due to their potential for creating harm: “I certainly wouldn’t feel comfortable working on aspects like the atomic bomb or chemical warfare stuff or biological weapons… certainly not” (R7). When the purpose of research was to create technologies for which the foreseeable use was clearly to do harm, such work was considered unethical by most of the participants. This focus on the purpose of the technology is a teleological ethical consideration. For some participants a technology may be considered unethical because the purpose behind the development of the technology is expressly to do future harm. One participant did suggest that scientists who were employed by the military had different social responsibilities from other scientists: "A scientist's social responsibility varies with the organisation that they work for…. scientists employed by a CRI have a greater social responsibility than scientists employed by the military" (R4).

This scientist also believed that some technologies were inherently "better, more moral than other technologies, even military technologies, for example, military sensor technologies, sniffer technologies to hunt out biological agents" (R4). The military technologies referred to by the participant are clearly different from weapons in that their purpose is not to cause harm but rather to hunt out sources of potential harm – ostensibly for harm prevention. He cited other potentially good technologies "bio-diesel, growing renewable, biodegradable fuel, and bio-plastics" (R4). These technologies were good because he considered them beneficial for the environment. Perhaps, as this participant claimed, there are some technologies that can be considered unethical. Candidates for this category are those technologies that are developed for the purpose of causing harm and which do not have any applications that do not result in harm (landmines, nuclear, biological and chemical weapons seem to fulfil these criteria).

However, it seems clear that most technologies cannot be considered either ethical or unethical and, as is the case with knowledge, it is the application to which humans put the technology that is good or bad or that ranges along a good/bad continuum. Indeed, even many technologies developed by the military are classified as 'dual-use technologies'. A dual-use technology is generally considered to be a technology that has the potential to be used for hostile and/or peaceful purposes (Miller & Selgelid, 2007). Originally these were technologies developed for military purposes that had the potential for beneficial peacetime activities (e.g., nuclear technology has the potential for being used for atomic weapons or for generating electricity). However, the current crop of new Promethean technologies being developed by civil society (e.g., nanotechnology, genetic engineering, medical and cognitive technologies etc.) may also have massive potential for harmful and/or military application and are also considered dual-use technologies (Miller & Selgelid, 2007).

Weapons were not the only technologies considered inherently bad (by some participants) or that had primarily bad uses. In the next few paragraphs I will examine participants' attitudes to a particular controversial gene technology that elicits a wide range of different responses: cloning technology. My purpose in doing so is to show the range of responses and the types of moral reasoning that underlie the participants' attitudes to Promethean technologies. Several participants claimed that "cloning animals is unnecessary and unethical" (R9). However, perhaps the majority of participants were not opposed to cloning animals, as long as there were no animal welfare issues involved: "Identical twins are clones…it [animal cloning] doesn't bother me at all…. I mean, aside from the issues of animal welfare" (R11). In some cases, participants believed that it was acceptable to clone some animals but not others: "Cloning dogs, people's pets is unacceptable…. that is the next step to cloning children…. against cloning race horses or pets" but, from the same individual "cloning food animals, I don't really have a huge issue with that" (R10).

Reflectively analysing her attitudes to animal cloning, this scientist went on to state "maybe I'm finding it acceptable if it is for a commercial reality reason….I'm wondering if that is because, you know, married to a farmer and I have got that production side of me. Maybe if I was married to a company who was to make a truck load of money out of cloning pet animals and I could see the financial side of it, then probably I could feel quite differently" (R10). Here the participant is aware of an apparent contradiction in her moral reasoning and she attempts to resolve the conflict by observing that it is the contextual circumstances in which one is embedded that shapes one's feelings about what is ethically acceptable and what is not. After reflection on the contradiction in her manifest statements she analyses and resolves her contradiction by revealing her latent assumptions of ethical relativism and moral conventionalism. Her position seems to verify the earlier cited statement by participant 12 "I think scientists will do ethically irresponsible things for the sake of money." Participant 10 seemed to be indicating that, perhaps for her, financial profit could make a practice, which she would normally consider unethical (i.e., the cloning of companion animals), acceptable.

Whether or not they found animal reproductive cloning acceptable, almost all participants objected to human reproductive cloning: "Cloning humans is unethical" (R9). Participants made statements such as "I just don't think it needs to be done" (R6), "I would not do it…. it does not fit with the norms of our society" (R7), "as a scientist, if you have a conscience you would try to steer away from cloning humans or cloning people's dog…. I just can't see the point in it…. it just doesn't seem right" (R12) and "Human cloning, no, no way. No, I find that totally abhorrent" (R8). This latter participant showed considerable emotion when considering reproductive cloning (as did several others who objected to this application of cloning technology). The participants quoted here were expressing a deontological objection to human reproductive cloning. To them, the act of human reproductive cloning is considered wrong, unethical, irrespective of any possible justifying circumstances. They considered it to conflict with the ethical norms or moral principles of society. Currently, there is a UN ban on reproductive cloning (Arsanjani, 2006). While the cloning of pets was considered by some participants to be morally wrong there are commercial organisations (e.g., BioArts International and RNL Bio) who have built a business model based on this concept (Carlson, 2009; Mott, 2004). Perhaps if participant 10 above was employed by one of these organisations she might not consider cloning companion animals unethical.

Some participants also had teleological ethical arguments against human reproductive cloning "I can just see that there will be a lot of problems from cloning humans…. the poor thing that is cloned, growing up, I'm just worried that this individual would be considered to be more of a lab animal" (R12). Her teleological concerns were centred about the psychological impact of being a cloned person. Interestingly, this teleological argument also had a deontological aspect, in that she was concerned about the clone's likely treatment, particularly the potential lack of respect for the human dignity of the clone. In a Kantian (1998) tone she stated "every human being is a human being and should have the full respect of a human being" (R12).

No participants expressed an unreservedly positive attitude to human reproductive cloning (for an alternative perspective cf. the ethicist Strong, 2005). However, a couple of participants, while expressing their general deontological distaste for human reproductive cloning, also demonstrated teleological ethical reasoning and moral relativism, with respect to this technology, by stating that you need to make such decisions on a case-by-case basis, and implying that in some situations the resulting benefit may outweigh any other moral problems associated with the technology. For these scientists, whether human reproductive cloning is acceptable: "…depends on the application…. case-by-case scenarios and even on individual case-by-case human…. you could have an extreme situation whereby I think you could say you can understand why you're doing it…. it's very, very, naïve to say there is no situation in which it is justifiable…. I would be very, very, very much struggling to find a case where I would be happy for it to go. But there is no way I would say no, because I'm sure there would be a case that I haven't thought of that, that application in my mind is justifiable" (R13).

Although most participants had strong deontological objections to human reproductive cloning, therapeutic cloning was a concern to only some participants. Briefly, therapeutic cloning involves cloning a human from a somatic cell and harvesting the resulting embryo for stem cells for therapeutic intervention in the individual who donated the somatic cell. The clone or embryo is destroyed in the process (Human Genome Project Information, 2009). This technology is considered to hold huge medical potential in curing a wide variety of diseases, including potentially growing replacement organs. The technology also provides the benefits of compatibility with the tissue type of the cell donor – therefore, immunosuppressant drugs are not required in, for example, an organ transplant (Mooney & Mikos, 1999). Currently, embryonic stem cells are the most suitable for such medical wonders because of their pluripotency – that is, their plasticity to be transformed into any other type of cell in the human body. However, in the future, it is hoped that adult stem cells, which currently cannot be so readily transformed into the full range of cell types, may be used as a replacement for embryonic stem cells. This involves the direct creation of cells or organs from the adult stem cells without the intermediary step of the clone/embryo/potential human being.

Those participants morally objecting to human therapeutic cloning generally did so because it involves the creation and then destruction of an embryo which has the potential of becoming a human. Opponents of therapeutic cloning may argue, along deontological lines, that it is wrong to either create an embryo in such a manner and/or destroy a potential human or to treat a potential human as a 'use' or means to an end for some other person. Some compared it to abortion: "I come from like a Catholic upbringing so abortion is like real evil and all that" (R3), "Personally I really don't like that kind of work where you produce embryos to then donk them and do various things with them. And I have never really sat down and worked hard on myself and deciding, when is an embryo life?….I like contraception methods that don't abort the foetus… I never want to be involved in doing [embryonic] stem cell stuff" (R6), and "destroying the embryo, doesn't, to me, sound ethically appropriate, acceptable" (R8). These three participants were opposed even to 'waste' embryos from in vitro fertilisation (IVF) programs being used for stem cell therapy. However, all three of these participants (i.e., R3, R6, R8), while being totally opposed to stem cell therapies derived from therapeutic cloning for deontologically reasons, were completely in favour of stem cell therapies derived from adult stem cells, where embryos were neither required nor destroyed.

From this discussion of cloning technology we can see a wide range of different attitudes coming through regarding different potential uses of what is essentially a single technology. Thus, a few participants believed the technology, in all applications (animal reproductive, human reproductive, human therapeutic), to be unethical. From these individuals' perspectives, the technology itself may be considered unethical. These people primarily held deontological objections, but some also held teleological objections.

For the majority, however, it was a particular application (or applications) of the technology that was (were) unethical, sometimes for deontological reasons associated with particular circumstances, sometimes for teleological reasons, and sometimes for both, rather than anything inherent in the technology itself. Such reasoning and flexibility regarding particular circumstances reveals a latent ethical relativism underlying the moral judgments of these scientists.

In some cases deontological opposition is reinforced by teleological arguments, and in other cases, potential teleological benefits argue against (and may outweigh) deontological objections. For some, animal reproductive cloning was acceptable but human therapeutic and reproductive cloning was not, while for others, human therapeutic cloning was acceptable but human reproductive cloning was unacceptable under any conditions, no matter how great the benefit. For a small minority, even human reproductive cloning could be considered ethical under some (considered to be extreme) circumstances. Thus, there is a clear continuum of moral attitudes to cloning technology and its potential uses. In this continuum of attitudes we see a range of philosophical ethical and meta-ethical arguments being used or assumed, including: moral absolutism, moral relativism, conventionalism, deontological and teleological ethical reasoning.

Deontological ethics was a major consideration when the technologies under discussion were very controversial (such as cloning and GE), or radically different from current technologies. However, in general, the study participants were particularly concerned about teleological impacts of new technologies – how the technologies might be used in society and what the potential benefits and harms of those uses might be. In this regard attempting to ensure the safety of the products of science and technology was considered a major social responsibility of science and scientists. Several participants noted that as science gives us greater understanding of nature, as our knowledge becomes more comprehensive, then the potential power of possible new technologies to influence and affect the physical and social realms, for good or for bad, also increases. Put another way, the more profound the science, the more potentially powerful the technological uses and abuses become. Such arguments were common in the ethics of technology field (e.g., Bunge, 1977; Jonas, 1985; Luppicini, 2008; Moor, 2005). From the above discussion the following item is proposed for the awareness of social responsibility instrument:

The more powerful a technology is, the more important the evaluation of its ethical and social implications become [4]

An interesting perspective on the increasing power of technology was presented by one participant who stated: “I don’t have concerns over the power that science gives humans. I think, if we blow ourselves out of existence, big deal. What does it matter? It is just a little green-blue planet. Cosmically, it doesn’t matter…. I think there are going to be some huge disasters caused by inappropriate use…. Maybe in a hundred years time, I think people will realise the global effects and they will stop having this attitude of “I’m OK…. But it is going to take a couple of big disasters. Mankind doesn’t learn very well from history. It is not going to be pretty but I’m still confident that our species will survive and that we won’t go back to a pre-industrial age” (R13). While this participant had a near-to-medium term pessimistic view of human use of technology, he managed to maintain an overall optimistic attitude to technology and the long term future of society and humanity. Most participants, however, did not take quite such a cavalier attitude to short or medium term harm. Instead, they were concerned with trying to prevent such disasters.

To this end, similar to some of the theorists reviewed in earlier chapters (e.g., Bunge, 1977; Jonas, 1985; Luppicini, 2008; Moor, 2005), participants frequently suggested that an important social responsibility of scientists is *foresighting the applications and consequences*, both good and bad, of new knowledge and technologies. Hence, the final sub-theme of ‘Doing public good’ is: foresight. The purpose of foresighting is to help ensure the products of science and technology are safe, to help society become aware of potential harms, thus enabling societal action to minimise or mitigate through regulation and legislation, and to elucidate the potential benefits. Foresighting is necessary for a precautionary approach to technological development (Kriebal, et al., 2001). From the above discussion the following item is proposed for the awareness of social responsibility instrument:

The more powerful a technology is, the more important and relevant the precautionary principle becomes [5]

Foresighting

As discussed earlier, many of the participants believed that they had at least some responsibility for how their scientific discoveries and technological inventions were used by society: "Should we have responsibility? And I guess the answer is yes, although I was starting to say no, but I have come round…. Do scientists take responsibility? Probably not" (R8). This scientist then referred to a famous quote from Albert Einstein regarding scientists' responsibilities: "Concern for man and his fate must always form the chief interest of all technical endeavours. Never forget this in the midst of your diagrams and equations" (R8). Reflecting on his own attitude to scientific responsibility, he then stated: "It is a sad indictment on my own scientific endeavour, but I have never given much thought to these issues, about how they relate. So that is probably why I have gone round in circles to try and answer it" (R8). However, some scientists pointed out that it was impossible to predict all the possible uses to which new knowledge and technology could be put, and therefore, there were limits to the responsibility of science and scientists for societal use of technologies.

Nonetheless, many participants suggested that scientists have a responsibility to try to foresight the possible uses and abuses of science and technology: "…an obligation in evaluating developing technology, understanding the technology, looking at the risks….We don't do it. It's bad" (R7), and "Scientists doing basic or fundamental research have to have some sort of social responsibility, they have to be aware of the possible applications once it's gone past them. Because someone out there will pick up on what they are doing. Scientists have a responsibility to consider what the possible negative applications of their research could be, and they have to be willing to walk away from a project if they realise that its negative applications are too great" (R10). Two important concepts are introduced in this last quote. First, is the idea that, at some point, science and technology pass from the hands of the scientist and into the hands of society and people (other than scientists) who could possibly misuse it. Therefore, it is important for scientists to consider the possible negative applications. Second, is the idea of personal moral responsibility (which I shall return to in a later section), that is, the responsibility of scientists to exercise personal moral choice and abandon research whose potential for misuse and harm they consider too great.

Another scientist, while acknowledging that scientists had a responsibility to foresight both positive and negative uses of their technologies, observed that it was not always easy for scientists to consider the negative applications, "I just think that if everybody blindly goes along not thinking about what they are actually doing and what it [research and development] can be used for, and what it will be used for, then we have got a problem. Researchers should definitely be thinking about the future" (R13). Later in the interview he tempered this position with, "although, if as a researcher you are an optimist and always trying to do public good, then you don't tend to think what could be the negative things that can happen – whether it be natural disaster because it got mucked up and out of hand or whether somebody actually took it and modified it and used it for a different purpose. It's very difficult to think of all those different things. Nobody's got a God's eye view where they can think of every different one" (R13).

Part of the responsibility of foresighting is also in communicating the possible uses and misuses of technology to the public, thus, providing an opportunity for society to discuss the issues, raise any concerns they have, and participate in the decision-making process: "scientists have a responsibility to point out how their technologies could be used, for good and bad and to provide a forum to help society think about the issues and come to decisions about what is acceptable and what is not" (R11) and "to try and watch what is on the horizon, to make sure that the government of the day, as it were, is pre-warned that there will be these issues" (R20). Once society decides what is (or is not) acceptable then the science and the technology may be regulated by legislation. From the above discussion the following item is proposed for the judgment of social responsibility instrument:

To consider and dialogue with the public about the possible misuses to which knowledge gained from your research could be put [18].

Foresighting was considered necessary because, "Ethics is not just [compliance with] legislation because there can be holes in legislation. And the scientists can either choose to bring that to the legislators notice, then plug it, or chose to work around that… the technologies are moving so fast that our legislative system just simply will never keep pace. And this is where ethics comes in, that it's up to people working in these areas to say, look this is on the horizon…. so that ethics is much more, I think, ethical behaviour amongst scientists, than just adhering to the current legislation" (R20).

One mechanism scientists could use for foresighting was to: "look at things which are already known" (R2). That is, to evaluate similar kinds of existing technologies and look at what their impacts have been. Scientific research was seen as a tool for foresighting. Some scientists considered it important, after engaging in dialogue with the public, to research the issues of public concern –

though some wished to qualify this to concerns they considered genuine as opposed to false concerns or unanswerable questions: “I don’t think you need to do research to address concerns that are just not genuine… but we are concerned with animal health and wellbeing from the work we did [GE animals and clones]…. things like ‘playing God’ well, you are not going to do research to prove or disprove that” (R6).

While much of the purpose in foresighting was precautionary, through intent to prevent the harmful (mis)use of technology, some participants noted that a precautionary approach might also be interpreted as foresighting the elimination of existing harms through the adoption of a new technology. Thus, in such a situation, the precautionary approach would not be to slow the release of the technology but rather to hasten or encourage its development and argue against resistance to adoption. Arguing that our future planetary population would require vastly increased food production and that GE was the best means to achieve this, a couple of participants claimed that it was unethical not to research GE food applications. Such a position is frequently taken by advocates of GE (e.g., Fedoroff, et al., 2010).

Finally, for the sub-theme of foresighting, several participants pointed out the need to consider and evaluate the benefits and harms of technologies on a case-by-case basis: “…need to look at research on a case-by-case basis regarding public acceptability” (R9). This result is consistent with a study by Small (2001) in which a small sample size qualitative study of New Zealand environmental scientists (N = 12) found that they considered it necessary to evaluate GE products on a case-by-case basis. Similarly, Small (2005a) found that a majority of the NZ public also considered it necessary to evaluate GE products case-by-case (72% agreement in a 2003 survey and 83% agreement in a 2005 survey). For some technologies, it was argued that each case of use might need to be treated as a different case and evaluated on its own merits. An example of this has previously been discussed regarded cloning technology where many participants felt that some applications of cloning were acceptable but that others were not. However, as previously noted, even amongst this relatively homogeneous group of scientists there was considerable variability regarding what cases (uses) were acceptable and what were not. From the above discussion the following item is proposed for the judgment of social responsibility instrument:

To ensure that the process and development of research complies with the precautionary principle [16]

Engagement

I now discuss and illustrate the second of the three main themes; 'engagement' (with the public) along with its three sub-themes: *becoming informed*, *informing others*, and *integrity*. Again, although each sub-theme was treated as a discrete category, they are, in fact, pragmatically intertwined. It should be noted that elements of some of the sub-themes in the main theme of engagement were also found in, or were related to, elements in the main theme and sub-themes of doing public good and the main theme and sub-themes of compliance. Before discussing the sub-themes of informing, becoming informed and integrity, I first discuss issues participants raised regarding engagement in general. These issues are: the necessity of engagement; scientists as members of the public; methods of, and barriers to engagement and; public understanding of science.

Most participants considered that engagement of the science community with the public was a necessary part of what it means for a scientist to be socially responsible: "Being socially responsible in research means communicating with the public" (R4), "scientists need to listen to the public and engage in discussion with them over their work – including those who have very different viewpoints – this is not done enough" (R2), "scientists have a responsibility to participate in public debates over science…. if scientists aren't involved then a valuable part of the picture is missing" (R8), "Scientists have a social obligation to make their work known to the public…. I've made quite an effort to do that" (R11), "it is important to take the time to have this communication. It's very valuable to know that you are going in the right direction…. I think this communication between science and society is very important" (R21), "I think science, as a whole, has a lot to learn from the GM [genetic modification] debate, about keeping the public informed about what we are doing, because our kids nowadays are taught to challenge and ask questions" (R16), and "the science community has a responsibility to communicate with the public about science. But not all scientist are good at it" (R10). The earlier quotes in this paragraph speak to the responsibility of individual scientists to engage, whereas the latter quotes, recognising that not all scientists are good communicators, emphasise the role of the science community in engaging with society. Some considered that engagement with the public was necessary in order to: "create a balance to the disinformation spread by groups such as the Greens, MADGE, and GE Free NZ" (R15). From the above discussion the following item is proposed for the judgment of social responsibility instrument:

To participate in public debate and dialogue over contentious scientific issues [19].

A number of participants pointed out that although they were scientists they were also members of the public or various communities and that they could not entirely separate the two roles: “Although I am a scientist I don’t think I can ever split myself from also being a community member. So I don’t feel that my ethical responsibilities as a scientist are any different from my ethical responsibilities of being a mother, or being a member of the general community” (R10). This participant also believed that “I don’t think that if you look at scientists as a community versus the rest of the community that the range [of ethical viewpoints and behaviour] would be any different” (R10) and, as a consequence, “I don’t think that because you are a scientist that you definitely believe in all the things that science is doing” (R10).

Most frequently engagement was mentioned in terms of discussion, debate, dialogue, communication, education, informing the public or decision-makers, becoming informed about public attitudes, beliefs, concerns and moral boundaries and expectations. Participants considered engagement and communication could be formal, informal, structured, unstructured, and/or culturally appropriate, such as Hui. Ethical commissions, Royal Commissions, professional groups, interest and advocacy groups were all seen as having a role to play in the process of public engagement. Nonetheless, how to engage was considered difficult, “I think it is very important to have a method, and this is something that is not well developed….I don’t think that we have a good way for interacting between science and society” (R21).

Public debates on science issues were seen by some participants as beneficial and, although initially focussed on extreme views, eventually reached a more nuanced middle ground. One participant used the example of the very public GE debate in New Zealand “where the debate has been taken to the public. There was a lot of rubbish said on both sides, but in the end people came back, on the whole, to a more middle ground. So scientists you once heard saying there are no problems are now saying, “Yeah, well, there are issues. On both sides a lot of people aren’t saying the extreme stuff any more…. they are arguing about real issues” (R11).

However, another scientist took a quite a different view of the GE debates, claiming that debates were often a setup that polarised opinions: “Public debate, that’s a ‘them and us thing’. That is, the debates have been disastrous in terms of polarising, because you’re asked to come along to a debate, and this happened to be, this is how I got into the whole public talk stuff. And it was quite definitely set up as 'them and us'. And even though I was asked to explain the technology in a very basic way, I was on the practitioner's side, therefore, I was pro without any question. And the other people were all anti, without any question, basically" (R20). Several scientists who had actively participated in GE debates felt that they had been trapped or set up by the organisers. Their reaction to this was that they felt reluctant to participate in such debates in future unless they were fairly organised and managed: "It is right that scientific research should be open to public scrutiny, but it has to be a fair process" (R6). Some participants had attended 'dialogue events' where there had been a concerted effort and process structure designed to minimise confrontational engagement and greater time allowed for participants to engage and come to understand the viewpoints of the other. These events were considered much better than shorter public debates or meetings, but on the downside, they involved greater commitment and economic and time requirements.

The media were also viewed as a possible mechanism for engagement with the public. It was recognised that "Public interest in science issues is created by the media" (R15) and that "People are learning how to use the press more to tell the public about what they are doing. And that seems to be a fairly efficient way of getting out to a lot of people quickly" (R22). Some considered that the media could be a better ally of science: "I think they could be more of our friends than they are" (R19), but that it would require, "having more positive stories in the media about the good things that are occurring in science as opposed to just focussing on controversial science. The media don't tend to pick up on the good stories – just the negative ones" (R10). This participant thought that there should be, "more stories in the media about non-traditional stereotype scientists e.g., woman scientists, instead of middle class, middle aged, white males. I don't think woman are seen as corporate, or as the slightly crazy person in a white coat" (R10).

However, in general, participants held a poor view of science journalism in New Zealand and believed that the media, "…are a barrier. They present things out of context and distorted. They sensationalise the issues rather than presenting fair and balanced points of view" (R15), and "I think the media has got a lot of responsibility for a lot of bad press that scientists get" (R19). One scientist claimed that because of the poor quality of science journalism in New Zealand our public are, "poorly informed, except at the level of slogans" (R18). Other scientists were wary of the press in terms of misinterpretation and misreporting.

That is, they claimed journalists did not understand their science and did not report interviews with them accurately. Due to previous bad experiences with the media, some of the scientists interviewed would no longer let stories go to print unless they had the opportunity to review them first. This also made scientists wary of media reports of the work of other scientists: "I've got to the stage now that I won't let anything go into the newspaper that I haven't read…. When I do read articles I think, well I just don't know whether I should believe this because I know I have been misreported and it's quite likely that other people are as well" (R19).

Other barriers to engagement were also raised. The difficulties associated with the communication of complex scientific concepts was raised by several participants: "It's a difficult process because the science that's being done is very technical and society is very large and multifaceted" (R21), and "its just the difficulty of explaining what you do because the work we do is so specialised that most people don't really want to listen about it, because they're shut off, because it's like gobbledegook to them" (R3). The *complexity of science* argument is related to the deficit theory of public understanding of science which will be discussed further below.

The commercialisation of science was viewed by some as placing institutional barriers on scientists' ability to engage with the public. In order to protect commercial advantage companies often required that scientists seek permission to talk to the public or the media about their work: "there's institutional barriers ….so like in AgResearch, often like, you can't actually go and talk to the press unless you get official approval, and I agree with that because most people haven't got the skill of dealing with the media anyway….[but], some people might feel quite differently to me about it…. they might feel that they should be allowed to talk more openly" (R3). Companies may also insist on censoring press releases and restricting publication of some results until patents have been applied for and received. This restriction on release of information may also apply to discussions with other scientists.

A further barrier that could limit engagement was peer pressure from the science community. In respect to GE one participant had this to say: "our science general manager stood up and said we are going to be doing a lot of media releases on genetic engineering so please make sure that you stand up for what we are saying. And that you tell everyone that genetic engineering is good…. I think it would be very hard for a scientist to come out and say I'm unsure in public. To do that you would feel like you were going against the science community" (R10).

One senior, internationally renowned scientist, talked about the difficulty of speaking out about social issues or problems in science due to the conservative nature of science and scientists: “It’s a very hard thing to do. You’ve got to be exceedingly brave. And particularly because scientists are so conservative they don’t like contrary opinion and they don’t like people disagreeing with them. And it is very hard from that point of view and so I notice that people tend to get more outspoken, particularly about social issues as they relate to science, as they get older. Because they, you could say, in one sense, because they have the mana then to be able to do that” (R14). He then went on to suggest an additional reason why older scientists are more willing to speak out and, by implication, gives the reason of career protection and progression for young scientists remaining silent: “But also because they [older scientists] are less afraid of what might happen to their careers…. since, presumably, they have well established ones and they are beyond those kind of effects” (R14).

Other scientists talked about the desire for career progression as a restraint on public engagement and the dissemination of their research: “Career progression. My career progression is based on the number of papers I produce, the number of conferences I attend, number of networks that I make…. It’s about getting out there and pumping out new information…. If I spend all of the rest of my career making sure that people heard about my [previous research] findings and didn’t pursue new knowledge, then I wouldn’t get anywhere” (R8). This is an explanation for lack of public engagement due to the lack of recognition of public engagement activities as a valued part of progressing one’s scientific career: “I think a barrier that we [scientists] have in being socially responsible, is not giving value to time and the process of this [science and society] interaction… you’re not producing results…. in fact, you are impinging on the time that you could be doing experimentation…it’s the lack of valuing that time and allocating it to the process” (R21). Thus, given the current emphases of scientific culture on the production of new knowledge, the rational means to develop one’s science career is to allocate as much time as possible to conducting new science rather than disseminating old science to the public.

Lack of recognition of public engagement activities was also highlighted by the distain with which some scientists hold popularisers of science. Referring to the evolutionary biologist and populariser of science, Stephen Jay Gould, one participant (an internationally recognised evolutionary biologist) stated, “There was a lot of stuff in the obituaries about how his only contribution was really to write for the public. And the tone is very clear. The tone of those comments is negative, whereas in fact, I would have thought, and by the way, that was manifestly untrue. Stephen Jay Gould made absolutely fundamental and enormous contributions, almost more than any other evolutionary biologist, over the time that he was active and writing” (R14).

This participant went on to question why this might be: “Why do scientists kind of criticise people for writing for the public? It’s the demeaning thing, it demeans science almost” and then suggests an additional reason “The worry here is that there is a thing inherent in science that we know and we’re not going to tell you, because if we tell you, then you know too, and we’ve lost all our power. So, in fact, knowledge is power” (R14). Thus, according to this scientist, not engaging with society can be a source of power for scientists. He also considered that the writing style scientists were trained in is a barrier to engagement: “Only scientists would read, or scientist would be bothered with, quite frankly” (R14). Similarly, some participants considered, “Scientific jargon can be a barrier to social responsibility…. it can be a screen for scientists to hide behind…. a barrier to honest communication” (R11).

Several participants pointed out that not all scientists are suited to the role of engaging with the public: “I think you almost need specific positions for that because it’s very hard, or quite often people go into science because they’re a bit out of the ordinary. You could go to a conference in which you will find there will be ten people stand up and talk that are dreadful at standing up and talking and one person who is a natural…. if you’re going to talk to the public, you need a natural…. it comes down to personality, some people are good at it, some people are crap at it” (R17). Another participant took the position that “Individual scientists do not have a responsibility to communicate with the public, because some are not good communicators and might do more harm than good.” However, he was still of the view that “It is preferable that scientists do communicate with the public, if they are able” (R13). These scientists considered the most important thing was that it needed to be the right person for the job: “Some people just don’t have the right mannerisms to come across in an appropriate manner.… so, you’ve got to find the right person…. that’s not to say that people shouldn’t be allowed to do public talks…. but, I think the person is really important…. they’ve got to be seen as being honourable, I suppose, and believable” (R16). Several participants saw a role for, “training scientists in the art of communicating with the public” (R2).

Participants noted that often it is people with extreme views, both members of the public and scientists, who tended to engage in public debate regarding science issues: “What happens in science is that you get the extremes talking. But there is a hell of a lot of people that sit in the middle and don’t talk. Because they don’t feel strongly one way or the other” (R10). Another scientist noted that this led to difficulty in gauging the true level of public concern: “Meetings and gatherings, so forth, while they will give you better feedback, they probably don’t reach enough people to actually be that useful. More than likely you just meet certain types of people, generally very pro or anti. So you are never quite sure [whether] you actually are talking to an incredible minority, or are you really talking to the common voice that’s coming from the community. Sometimes it’s difficult to gauge what is happening” (R22). Although this scientist was aware of the anecdotal nature of his personal experience of public engagement, some scientists, generally those who had been heavily involved in public debates did not seem to have this awareness. Rather, they considered the New Zealand public to be much more strongly opposed to GE than the empirical evidence would suggest (Small, et al., 2005; Small, 2005, 2007).

The public understanding of science was considered an issue for many of the participants. Indeed, educating the public was considered a major reason for the necessity of public engagement: “We need to make sure the public are more educated about science so that they understand the debate… the GM debate has got really out hand…. the public just don’t understand enough science to appreciate the issues” (R16), “The public are not well informed on a lot of science issues. They need to be better informed to have any meaningful or relevant input into the science agenda…. Some people (e.g., GE Free NZ and MADGE) have outlandish views on what we molecular biologists do; uniformed and irrational” (R15), and “The taxpayer is quite likely to be an uninformed person who can’t make a judgment that’s based on sound knowledge…I think the biggest problem that we’ve got is to try and educate the public to a level that they can be confident with what we are doing” (R19).

In the public understanding of science literature, this latter position is known as the *deficit theory,* that is, if only the public understood more about science then they would support what science is doing. Empirical research generally does not support the deficit theory (Evans & Durant, 1995; Georges Gaskell, Bauer, Durant, & Allum, 1999; Irwin & Wynne, 1996; Marris, 2001; Pardo & Calvo, 2002). Interestingly, participant 19’s next statement somewhat deflates her argument: “…and in saying that, I’m not even confident that my colleagues are doing the right thing. I actually don’t blame the public for being sceptical, I really don’t” (R19). Thus, we have an individual, well versed in science, who, nonetheless, does not always feel confident with either her fellow scientists or the science agenda.

The deficit theory is related to the earlier discussed issue of the complexity of science. Several of the participants voiced concern about the complexity of science, regarding engaging with the public, and expressed strong support for the deficit theory. However, support for the deficit theory was not unanimous amongst participants; even sometimes amongst individuals who noted the complexity of science as a problem. Indeed, several participants viewed the deficit theory as little more than scientific arrogance: "Some scientists have this thing I find incredibly patronising and rude, where they stand up and say the public just needs to be better educated. And every time I hear that, I just cringe, because it is so arrogant" (R10), and "It is arrogant scientists who claim that the public are ignorant, that they are incapable of understanding science. My mum had this quote on her windowsill from Ernest Rutherford saying, 'if a scientist can't explain what he is doing to the cleaning lady then he doesn't really know'. Some scientists do get quite arrogant; the education system that they have been through can lead them to think they are intellectually superior" (R11).

A number of scientists believed that the public also had a responsibility to engage with science. That is, engagement is not just a one way process which is entirely the scientists', or the science community's, responsibility. The public also have a responsibility to become informed about science: "…but that is not their [scientists] sole responsibility and public should seek to educate themselves too" (R18), and "I don't believe it solely rests on the shoulders of scientists and that people who point the finger at scientists doing evil things need to get involved and be part of the decision-making process and get off your arse…. scientists are part of society and we are moving forward together. And, there's a time for society people to be complacent, but there's also a time to be active and that if this is something that gets you going, then get involved" (R21). One scientist claimed that "some pressure groups, like the Greens, have their power through lack of engagement, in their refusal to look at issues and find common ground (R18).

The process of engagement may be viewed as having three main components; informing or educating the public, listening to the public and becoming informed about their values, beliefs, expectations and concerns, and conducting engagement with honesty and integrity.

Informing the public

One important aspect of public engagement is informing the public about science. As discussed above, a number of participants considered that the public were lacking in the necessary scientific knowledge to participate meaningfully in discussion about science and the science agenda. These people placed importance on scientists helping to raise levels of public knowledge regarding science and, therefore, regarded public education as an important role in which scientists could participate: “We need to make sure the public is more educated about science” (R16). For others, the public had a right to know what science was doing and scientists had a responsibility to provide that information: “…responsibility to disseminate information about the research that we are doing. It is important that scientists do this” (R15), “Scientists have got to get out there and talk about the things that they are doing” (R10) and “[we] need to keep the public informed” (R3).

For some there was an element of scientists being accountable to their fund providers: “the taxpayer ought to know what we are doing because we are accountable” (R19) and, therefore, scientists have a responsibility to keep the public informed as to: “...the goals of research, products that might result, potential benefits and harms” (R4). The need to help society become aware of the potential implications of new science and technology was also an important responsibility for some participants: “It’s up to people working in these areas to say: look, this is on the horizon” (R20). One participant, while bemoaning scientists’ lack of willingness to participate in helping to keep the public informed, offered a reason for this lack of engagement: “Scientists don’t disseminate knowledge and its implications for future environments or future wellbeing comprehensively enough…. Scientists are often scared of telling the public about their work because they fear it will be misinterpreted” (R1).

Participants’ discussions centred about the need to keep the public informed and reasons for this, as well as the types of things or issues that scientists should be informing the public about. Several participants considered it important that scientists point out how new technologies could be used for good or bad: “A scientist should be being honest and saying we’ve had this finding, now it could be used for this, it could be used for that, this is unethical” (R11). This participant viewed this precautionary foresighting role as important in that it could help to facilitate societal decision-making “I think society also has to decide, there’s a lot of, sort of ethical issues that society has to decide, but scientists should not be making it difficult for society to make those choices” (R11). Keeping the public informed about potential technology applications and ethical issues is strongly interconnected with the sub-theme of foresighting. Here, however, the emphasis is on communicating the insights from foresighting activities to the public or specific sectors of the public: "…future watch, to try and watch what was on the horizon and to make sure the government of the day was pre-warned that there will be these issues" (R20). From the discussion above the following item is proposed for the judgment of social responsibility instrument:

To give the public clear guidance on the reliability and validity of scientific conclusions regarding potential benefits and risks [13]

For some participants, scientists had a responsibility to participate in informing and educating the public because they saw it as necessary in order to balance what they construed as misinformation coming from other sectors such as the media, pressure groups and Internet. "Scientists need to create a balance to the misinformation spread by groups such as the Greens, MADGE (Mothers Against Genetic Engineering), and GE Free NZ" (R15), and "the issue with the public at the moment with the Internet and everything like that…. you can get as much misinformation as you like, like white noise to drown out the real message" (R17). This participant saw a specialist role for science communicators: "You almost need specific positions for that because it's very hard" (R17). One participant considered that there needed to be special processes or methods to communicate technical information to the public: "It's very important to have a method and this is something that's not very well developed…it's a difficult process because the science that's being done is very technical" (R21). Another considered it essential that information was communicated to the public in jargon free language but that scientists, generally, are not trained for this.

Becoming informed

Another component of engaging with the public was *becoming informed* as to public attitudes and moral values regarding science and technological development. This sub-theme might also be called *listening to the public*. Several participants made statements to the effect that science should be conducted within the moral boundaries of society: "The wider issues of ethics, I see, is working within the norms of society values…it's working within the boundaries that you feel….ethical society are comfortable with" (R16), "[a scientist has] responsibility to match or at least be cognisant of the community's ethical opinions and to give back to research within those boundaries" (R21), and "becoming informed about what society finds acceptable" (R9). In order to comply with public morality, scientists need to listen to the public to become cognisant of their issues and concerns: " [one of] the factors that enhance our [scientists'] responsibility is getting to know more about what the public are interested in and what their fears are and concerns about" (R6), "…just getting out and talking to people and seeing what they think and what they understand and don't understand" (R5), and "it is very important to listen to the public" (R2). From the above discussion the following item is proposed for the judgment of social responsibility instrument:

To become informed about what society finds acceptable or unacceptable in scientific research [17].

Several participants emphasised the need to engage with members of the public who share very different points of view from themselves: "What scientists should do is engage in discussions with the public as far as possible about their research, but also especially with people who might have a different angle on the problems, so with environmentalists, with people from groups which are not necessarily very positive towards whatever a scientist is doing, so that we can get a broader perspective on whatever we are working on" (R2). Others noted the importance of becoming informed about different cultural perspectives and, in New Zealand, about the responsibility of becoming informed regarding Maori perspectives: "…to some extent like, I take into account Maori views on things" (R3). When scientists listen to the public they can gain insight into socially appropriate research and technology development: "…mixing with non-scientists…. and getting feedback from them…. doing work based on what they are asking…. not just going off and doing something and saying this is what you need to do. I take the stance where I listen…. going off and doing something and then forcing it on the general public isn't very responsible" (R5).

One scientist, who had been heavily involved in public engagement activities in the area of GE, believed that there were lessons to be learnt from the GE debate: "…but it's appreciation of what society thinks about what we are doing. I believe we haven't done that really well in the past in many cases. GM [genetic modification] is a good example of that. In all honesty we have come into that with something of arrogance 20 years ago, believing society would accept what we're doing…. I think science as a whole has got a lot to learn from the GM debate…. about keeping the public informed about what we are doing… about engaging the public well enough, early enough" (#16). In general, most participants believed that the public did have a right to have some say in the setting of the science agenda. However, there was considerable variation with respect to the amount of influence the public should be able to have. This aspect of engagement (sometimes referred to as the democratisation of science) was briefly discussed in the literature review of the current work (see Chapter 4). For a more detailed discussion of scientists' attitudes to the democratisation of science see Small and Mallon (2006).

Integrity

Honesty and integrity in engaging with the public were mentioned by several participants as essential: “Being honest and open with either the public or with the funders or whatever about the outcomes of the work” (R3), “that they [scientists] are honest about what they are doing and that they are up front about what they are doing and they are doing it well” (R11), “To report scientific findings with honesty and integrity” (R4), and “To ensure that the science that you do, that the results, findings are actually reported as they are recorded. And reported in a way that enables people to interpret them…. so that you provide sufficient data for people to draw their own conclusions” (R1). Several aspects of honesty and integrity are embedded in these quotes. First, scientists should be honest and open about what it is that they are doing, second, they should be honest about reporting the outcomes or results of the research, which also involves providing enough information about the research to enable the reader to make judgments about the reliability, validity and quality of the findings, and third, that the research be competently performed.

Another participant considered transparency to be the crucial ingredient of integrity in engagement: “Transparency is the main ethical responsibility [of scientists]. It is extremely important to be open rather than secretive. Transparency gives the public the opportunity to see what scientists are doing, it puts research up for public scrutiny. In this way a scientist’s ethical responsibilities will be moderated by the community. The public will judge whether you can go ahead and do it…. if the researchers transparently declare what they are doing and get funding from a public body then clearly the public body is saying this work is for the public good. Total transparency necessarily implies total honesty and integrity in research” (R13).

One aspect of integrity in engagement with the public was demonstrating scientific integrity. In this respect some participants considered it essential that work should be peer reviewed before being communicated to the public “if you’ve had a result that you think is really important but it hasn’t been published in a peer reviewed journal, that is the one way for other scientists to know that it’s been sort of looked at and its right. I mean, I think there is a big responsibility not to ring the Herald and say I have found the cure for this or that and give false hope to people” (R11). The issue of peer review is discussed further in the section on scientific norms below. The purposes for which scientists used the media was an issue for some participants who considered that when engaging with the media it should not be purely for the ends of the scientist: “…having responsibility, not to get up and grab the media for their own purposes. I feel quite strongly about that….we should be communicating with the public, but we shouldn't be communicating for our own ends, just because funding is about to happen and we want to make a big splash" (R11). Thus, scientists have a responsibility to subject their work to the scrutiny of their peers, to use the media with integrity, and to report their findings accurately and not to make dubious claims which could unrealistically raise people's hopes about what science can achieve: "Scientists have a responsibility to ensure that benefits and risks are not exaggerated" (R5). From the above discussion the following item is proposed for the judgment of social responsibility instrument:

To refrain from exaggerating the potential benefits or minimising the potential risks [12].

Nonetheless it was recognised by some participants that "Scientists don't get the real message right every time, you know, they make mistakes, just like everybody else. But that's the difficult thing, that is, getting what is at the time known to be state of the art, and getting that message across to the public" (R17). Here there is acknowledgment that science is a process that works towards getting at 'the truth' and that what is considered correct knowledge today may need to be revised in the light of new research and findings. Related to this concept is the responsibility of scientists to advise the public about the certainty (or lack) of their findings and to help interpret the meaning and implications: "There is a responsibility to ensure that scientific uncertainty and/or confidence in data is made transparent" (R4).

Several participants, noting that scientists are like other members of the public, observed that there will be honest scientists and dishonest scientists in the same way that there are honest and dishonest members of the public: "If you look at a spectrum of scientists you will have honest scientists, dishonest scientists and the same range as you would maybe within any other profession" (R17). One participant reflecting on why scientists might be dishonest suggested: "…money is one thing, fame is another. You know that scientists aren't honest, because if they were you wouldn't get the retractions of journal articles that you get. And I think that's a real shame because I think, you know, we don't do ourselves any service by not being upfront and admitting that you are wrong. We need to admit that we don't know everything, I mean that's the reason why we are scientists, because we don't know and we want to find out" (R19).

However, in contrast, several participants took a more positive view of scientists' moral character being of the opinion that, in general, scientists tended to be ethical people: “Scientists that I know are very ethical people, they really are. Scientists basically tend to be people who as a rule…. tend to be not mercenary….they tend to be people who are there because they are interested in humanity and interested in solving things and problems and issues to make for better” (R6), and “there’s been very, very, few scientists who do behave in unethical ways…. some scientists are arrogant but not unethical” (R11).

Several participant noted that scientists who engage with the public have, “…got to be seen to be honourable, I suppose, and believable” (R16). Thus, not only was it important for scientists engaging with the public to have integrity, it was also important that they be credible in the eyes of the public. While scientists were, by virtue of their career and knowledge set, likely to have a certain amount of credibility in regard to communicating science issues, credibility was also partly a matter of having appropriate communication skills: “Maybe there’s a high level of credibility that comes from scientists, but sometimes they are not the best at communicating” (R22). As earlier discussed, this led some participants to suggest that specialist science communication positions were required.

Participants considered integrity an important aspect of public engagement. Integrity on the part of scientists was considered an essential component to help to create and maintain public trust in science and scientists; an issue that some of the interviewees were concerned about and which has recently become a major concern for governments and science organisations such as the British Royal Society. Note that integrity regarding conducting research and reporting the process and the research outcomes is also a scientific norm, particularly in respect to reporting to the scientific community.

Compliance

The last main theme of scientists’ social responsibility was compliance. Compliance refers to scientists’ responsibility to comply with various norms, values and regulations. Five sub-themes were identified under this theme. They were compliance with *scientific norms, business norms, laws and regulations, societal mores,* and *personal values*.

Scientific norms refer to the practices and processes that help produce sound scientific knowledge and which enhance the scientific community’s ability to develop sound knowledge. Compliance with scientific norms might be considered as scientific integrity and there is considerable overlap between this concept and integrity in engagement with the public. Similarly, there is clearly a considerable degree of crossover between the sub-themes of compliance. Many personal values are derived from or consistent with societal mores, while societal mores are also often reflected in laws and regulations: “Collective ethics and social responsibility is reflected in government policies and regulations” (R9). Scientific norms also usually reflect societal mores and laws and regulations while being consistent with many widely held personal values of science practitioners.

However, there may also be areas of difference or conflict between the sub-themes: “Ethics is not just legislation because there can be holes in legislation….technologies are moving so fast that our legislative system just simply will never keep pace” (R20). The implication is that laws and regulations tend to lag behind societal mores. Personal values (and laws and regulations) also sometimes conflict with societal mores; a number of participants expressed ethical disgust regarding working on military projects or for tobacco companies and yet such projects are not against the law and significant segments of both society and the science community clearly support them. Therefore, the five sub-themes may be considered to be related, but different, compliance mechanisms through which scientists and society evaluate and enact scientific social responsibility.

All participants expressed the need for scientists to be socially responsible with most suggesting compliance with at least one or more of the five identified mechanisms for evaluating scientific social responsibility. One scientist, somewhat typically, stated: “It is up to society to decide which uses [of science and technology] are ethical and which ones are unethical and to regulate the technological use in accordance with society’s norms” (#7). This scientist expressed the idea that it was important to regulate science based upon societal mores. Another made the comment, “Although I am a scientist, I don’t think I can ever split myself off from also being a community member…. So I don’t feel that my ethical responsibilities as a scientist are any different to my ethical responsibilities as being a mother or being a member of the general community….I could never work on tobacco ….I guess we all have our things which we feel we could work on and things that we don’t…. I want to be proud of what I do” (R10). This participant was suggesting that because scientists are also members of society their scientific ethical responsibilities are similar and should be consistent with society’s values. Non-compliance with her personal values was inconsistent with personal identity and self-esteem. Recall that some scholars consider personal values central to the concept of self-identity (e.g., Feather, 1988; Hitlin, 2003). Although her personal values were important to her when considering social responsibility as a scientists, she, nonetheless, recognised that personal values may vary from individual to individual and within a community.

She went on to say, “You can get scientists with a very big range of ethical views…. I don’t think that if you look at scientists as a community versus the rest of the community that the range would be any different” (R10).

While laws and regulations are legally or professionally compulsory, encoded in writing, and hence clearly definable, the other four mechanisms carry no such legal weight and the perception of what is a scientific norm or societal more may vary from individual to individual, place to place, and time to time, just as do personal values.

Scientific norms

Scientific norms are all about ensuring the integrity of scientific knowledge, the integrity of the mechanisms and processes through which that knowledge is generated and disseminated, and about the behaviour of scientists in regard to the rest of the science community (Cournand & Meyer, 1976; Pimple, 2002; Ziman, 1998). Many of the research participants viewed science as a process that “…is seeking the truth” (R21) and it is, therefore, important that “The research process is honest and has integrity” (R1). This is similar to Merton’s (1942a) *principle of universalism* (quality of a scientific work should be judged on the basis of its scientific merits or significance alone) or as Cournand and Meyer (1976) reformulated it, *honesty*. However, it was recognised that in many situations, scientific certainty (the ‘truth’ about reality) is difficult if not impossible to achieve: “As a scientist you can never stand up and say that you are 100% sure that this won’t affect your child or whatever. In science you can never be 100% sure about anything” (R10). This concept, which is similar to Merton’s (1942a) scientific norm *the principle of organised scepticism* and Cournand and Meyer’s *doubt of certitude,* was viewed as posing a difficulty regarding communication with the public: “…so you stand up and say I’m 99% sure that eating this tomato won’t adversely affect your child. The media will immediately hang on that 1% that you are not sure” (R10).

One of the main ideas that scientists embraced to try to approach the truth is the concept of objectivity in research: “So seeking the truth means that you’re trying to be objective as possible” (R21), “I have a responsibility to pursue new knowledge in a way that’s honest and accurate…. in a way that has integrity” (R8), and “it’s just to be honest as best you can, to do things in the best manner possible” (R17). This is similar to the scientific norm that Merton (1942a) called the *principle of disinterestedness* (the setting aside of personal motives for a focus on the advancement of science) and which Cournand and Meyer (Cournand & Meyer, 1976) reformulated as *objectivity*. However, even participants arguing for objectivity recognised that total objectivity in scientific research is not possible: "I'm just aware that none of us are objective and we can attempt to be but there are all sorts of reasons for not being objective" (R21, cf. with her first statement above in this paragraph). Another participant stated, "I think it's a big illusion when scientists think that whatever they do that they are kind of objective. They are not and no one is really objective…what we think depends on where we live. And it's never free of the society we live in or the environment we live in" (R2).

One aspect of objectivity that was considered important by several participants was being open-minded and open to considering other alternatives: "Scientists have a responsibility to be open-minded about the interpretation of their research results – not to start with too much of a preconceived idea of what they will find. They need to be able to revise their hypotheses in the light of their research results. Accepted scientific theory must be open to challenge in the light of new evidence" (R11). Cournand and Meyer's (1976) scientific norm of *tolerance* is similar to the concept of keeping an open mind. Another participant stated "Keeping an open mind is an important scientific ideal. But it is actually probably completely untrue. I think most people [scientists] are very closed-minded and once they get an idea and a particular style or technique of research they often stick to it, to their detriment" (R13). Nonetheless, aiming for 'the truth' and 'objectivity' was, even if technically impossible, considered by most participants to be a laudable scientific goal. As far as I was able to discern, all the scientists interviewed could be classified as scientific realists.

Several participants talked about the need to be honest regarding the reporting of findings to both the public and the scientific community: "…that the research results are presented honestly – the scientific integrity of data" (R1), "…being honest and open with either the public or with the funders or whatever about the outcomes of the work. So you are not sort of like hidden away doing some work that you are not accountable for" (R3), and "[Scientists] have a responsibility to tell the truth and not manipulate data for the sake of getting publications" (R12). One responsibility scientists had towards other scientists in regard to reporting research was: "…that you recognise other people's inputs, acknowledge other people's work, and that when you claim a thing as being yours, that it really is" (R16). Cournand and Meyer (1977) claimed that this obligation of scientists to acknowledge their sources springs from the scientific norms of objectivity and honesty.

An important aspect of reporting results accurately and honestly was to include sufficient information: "…that's really central, if you are going to conduct a piece of research, that it is reported as it occurs. You provide the reader with sufficient information about the background, about the methodology, about the sensitivity of any techniques you use. So they can also make an interpretation of your results, your findings and your conclusions" (R1). Sufficient information also helped truth seeking in terms of enabling further criteria for scientific integrity; that the research be repeatable, testable and falsifiable "What constitutes, or the values of, what is good science come back to issues around repeatability, testability and falsifiability" (R22).

Sufficient information enables other researchers to repeat a piece of research, test the same hypothesis again and check that the results are the same (within conventional parameters), or if not, question or falsify the results and hypothesis. Falsification of a hypothesis or theory is an important method of gaining information about what the world is like, through determining what it is not like, eliminating both potential possibilities and falsely held beliefs. Once a hypothesis or theory has been firmly falsified through sufficient disconfirmation instances further researching it wastes valuable research resources.

Some participants made suggestions about how scientific objectivity and integrity could be enhanced. One claimed that there was an increasing separation between scientific knowledge and other knowledge sets (e.g., indigenous knowledge) and that "The scientific way of looking at the world isn't the only way of looking at the world" (R14). This participant stated that scientists needed to: "…be increasingly critical of their own perspective on the world…need to immerse yourself in those other knowledge systems" (R14). Another scientist echoed this perspective but introduced the concept of peer critiquing as an aid to cultural constraints to objectivity: "And then you get even less and less objective …your ideas will filter through your own cultural setting and your sub-cultural setting. So that's why it's really important to have this peer critiquing, where at least you can try to see from different cultures or different perspectives. And to try and get around that constraint of your objectivity" (R21).

Peer critiquing or peer review was considered an essential tool of scientific integrity: "Another of those basic sort of principles around seeking the truth, is the way that we go about that in terms of peer critiquing" (R21), "…work within the context of peer reviewed science, you work within the norms of appropriate controls and everything is there, just a standard sign of good practice that you do follow the accepted norms" (R16), and "I guess collectively by peer reviewing accurately and having checks and balances in place then that's where, maybe is, that collective social responsibility comes in" (R17). Scientists also had a responsibility, "…to critique fellow scientists' work objectively and constructively" (R13). Most considered peer reviewing fellow scientists' work a socially responsible and important part of belonging to the science community.

It was also considered important to have had your work peer reviewed before presenting it to the public "to ensure that you have subjected your results to peer review before presenting to the public – to ensure that your peers believe your work is adequate" (R11). Interestingly, despite scientists' apparent faith in the peer review process, empirical research has consistently suggested that peer review is quite unreliable (and hence not valid); agreement between reviewers often being little better than chance (Ceci, Peters, & Plotkin, 1985; Cole, Cole, & Simon, 1981; Horrobin, 2001; Peters & Ceci, 1981; Rothwell & Martyn, 2000; Scott, 1974). Paradoxically, the very process that scientists claimed as a guarantee of the validity of their work, when subjected to scientific analysis, turns out to be of questionable validity.

An area that several participants believed was inadequately addressed by the science community, and that was hindered by the process of scientific validation through peer reviewed journal publications, was the reporting of hypothesis falsification or negative results: "…and that's where - one of the things we haven't been doing well - is that we would get a negative result, or no result, we often don't report it. And that is just as valid, often, as the result that supports the hypothesis" (R1). Journals also had a responsibility in this regard, "[Scientists] have the responsibility to also publish negative data, in case they should find something negative, and as for the publishers they have the responsibility to also take papers that have negative data, instead of well, it just seems like a trend to me, that all I am seeing there, is all this positive nice results, while I'm sure there is a lot of negative results up there as well that never really gets published" (R12). This echoes the concern previously expressed by Mahoney (1979, see Chapter 4) of a confirmation bias in scientific publication, which he attributes to an over-emphasis on null hypothesis testing.

In general, publishers are not interested in publishing negative results (Mahoney, 1979) unless they are particularly robust and provide a disconfirmation instance of a hypothesis or theory that is only moderately well integrated into the wider theoretical context. Positive data or confirmation instances of hypotheses or theories seem psychologically more deserving of publication than negative results because they appear to increase the verisimilitude of scientific knowledge with reality in a more precise manner than negative data. That is, psychologically, positive data suggest that one hypothesis out of many potential hypotheses is likely to be right, thus potentially eliminating the rest. Whereas negative data indicates one hypothesis is likely to be wrong, eliminating that hypothesis but remaining silent about the many other potential hypotheses. However, this is actually a logical illusion. Assumption of the truth of a hypothesis from a confirmation instance is a logical fallacy known as affirming the consequent. This fallacy takes the form: if X then Y, Y therefore X. The fallacy is easily perceived when the argument form is given empirical content e.g., Take hypothesis *x* that 'all swans are black', if *y* is a black swan, it would clearly be wrong to affirm that an instance of *y* proves 'all swans are black.'

As a few participants suggested, and as is argued above, negative results do provide information and unless they are published and moved into the codified body of scientific knowledge then researchers may needlessly repeat research in blind avenues. The availability of negative results is also important for use in meta-analytical studies which seek to mathematically synthesise independent research results regarding a particular hypothesis, thereby giving much greater certainty and effect size accuracy than individual statistical studies (Hunter & Schmidt, 1990).

Scientists also had a responsibility, "…to be competent in their area of research" (R6). A major component of competence was, "…keep[ing] up with all the changes and developments that are going on" (R17) in their area of research. Nonetheless, in an age of exponentially expanding scientific information (Kurzweil, 2001, 2005; Toffler, 1971, 1980), it was realised that even being familiar with all the research in one's own area could be a monumental task.

It was considered by some to be irresponsible to make public comments about an area of science outside one's area of expertise. One GE scientist (a strong public advocate), demonstrated considerable anger about opposition to GE from other scientists whom he considered were spreading misinformation: "I think it's got political leanings for certain people, as an avenue of making a political name….and there was a lot of misinformation that was just taken as being, it comes back to the first point, irresponsible scientists speaking out….I mean not validating their own information, speaking outside their area of expertise to make a political point, and others got on the bandwagon. I mean there are certain individuals in the science community out there who are irresponsibly opposed to GE" (R16).

Although academic freedom was traditionally considered a scientific value or norm this was now considered to be largely a thing of the past for many scientists: "Academic freedom, this is a mindset that a lot of academic people have….and yet that's gone out with the ark. Years ago there was academic freedom, you got an academic position at a university, you could do whatever you like in terms of research, but you can't anymore" (R19). In general though, scientists in commercial research institutes were considered to have less academic freedom than scientists at universities. However, most participants viewed academic freedom as also declining in universities, especially as they became more commercialised. Nonetheless, some participants argued that some academic freedom was beneficial for science: "Scientists need a certain amount of academic freedom – otherwise knowledge development will be restricted" (R3), and "at least in a certain proportion of science, I think, you should have total academic freedom, within ethical standards" (R21). Another participant believed in academic freedom at the level of basic or fundamental research, but not necessarily for applied research: "Some applied research should be restricted" (R9).

The question of how much science should be applied research and how much should be basic research was related to social responsibility for some participants: "I don't think it's socially responsible for all scientists to do totally basic research. It would be insane. Nor do I think it's socially responsible for all scientists to do absolutely applied research. It is short term thinking, not future planning. So it is socially responsible for scientists to be doing the whole portfolio of research" (R21). The commercialisation and economisation of science, with its focus on quick financial returns, was seen as shifting the balance away from basic science and towards applied research. While applied research was viewed as having more immediate public benefits, basic research was considered very important for the long term development of science. The implications of basic research were often not clear at the time, but several participants noted that most applied research currently being conducted was the result of previous basic research. Thus, basic research was viewed as a scientific norm necessary for continued scientific progress.

Business norms

Academics were viewed as being in a better position to do basic research than commercial scientists because of their greater academic freedom. Commercial scientists, on the other hand, were viewed as having a greater responsibility towards their employing organisation and generally a greater need to produce applied science that would lead to more immediate economic returns. Scientists working for commercial organisations were also limited in their ability to follow the scientific norm of sharing their discoveries with the rest of the science community because of commercial sensitivity: “If you work in a company where everything is protected then you can’t publish” (R10). Commercial research organisations had a need to develop and patent intellectual property in order to ensure a return from their research investments, this usually involved withholding publication until patents were granted. This was seen as having a negative impact on science: “…it does affect science, because the way that we try and do science is by building on what other people discovered. We don’t know what other people have discovered. We are re-inventing the wheel all the time” (R10). Scientists’ attitudes to the commercialisation of science were briefly discussed in Chapter 4 and a fuller discussion of this issue, as seen from the perspective of the current sample of scientists, may be found in Small and Mallon (2006). Business norms and/or corporate and institutional pressure were also sometimes considered to conflict with the application of personal values to scientific research and technological development. This issue will be further discussed with examples from participants in the section below on compliance with personal values.

Laws and regulations

Most participants considered that a major social responsibility of scientists was compliance with laws and ethical regulations, “…first of all its legislation” (R20), “We have to abide by ethical regulation. I am involved with animal research and human research and I have enough social responsibility myself that I wouldn’t even think about it without going through the appropriate channels” (R19), “[there are] actually quite strong ethical guidelines already in legislation, especially in New Zealand….so it is regulated by the government and so we have to work within those guidelines (R3), and “I’m really proud to be living in New Zealand where we address that [ethical boundaries on GE] through our ERMA [Environmental Risk Management Authority] applications” (R21). From these considerations the following item is proposed for the judgment of social responsibility instrument:

To ensure that approval for research is gained from the appropriate ethical authorities [15].

Despite her pride in the ERMA regulatory process this scientist went on to state that while she thought ERMA was necessary, she had reservations about the degree of restriction that ERMA placed on her area of science, genetic engineering. She criticised the current ERMA requirements as being very frustrating. In her opinion, it was far more restrictive than necessary (for social rather than scientific reasons), and hence acted as an impediment to scientific research. She expressed concern that if the regulations were too strict (i.e., without good scientific reasons) then scientists would either be tempted to ignore them or give up and choose to work overseas in a less constrained environment “there is a possibility…that it becomes socially irresponsible to have it [ERMA regulations] that tight…scientist will actually just choose not to work in New Zealand because it’s too damn hard to work within the regulations and that’s not socially responsible” (R21).

Compliance with animal welfare standards in research was cited as important by most participants. There are a number of pieces of legislation in New Zealand relevant to animal welfare including the Animal Welfare Act, the Agricultural Compounds and Veterinary Medicines (ACVM) Act and the Animal Products Act. All experimentation involving animals requires approval from an Animal Ethics Committee. However, some scientists noted that although they had to have ethical approval for research interventions with animals, farmers, in some cases, could do much the same kinds of interventions with farm animals without any such bureaucratic procedures being required. Thus, for some scientists, there appeared to be an inconsistency between regulations governing research practices with animals and allowable animal treatment practices of the rest of the (in particular farming) community: “…white tape…its incredibly frustrating…I’m running trials and the work I’m doing on the animals is not different to what a farmer’s doing. So I’m just injecting the things that a farmer injects them with, but I have to fill out five bits of paper to do it” (R10).

A couple of participants noted that, particularly in the past, there was a discrepancy between the legal requirements for animal research and human research: “We’ve always had animal ethics but not human, it’s an interesting one, we haven’t always had human ethics….It wasn’t anything like it is now” (R19). This scientist worked for a university and noted that university researchers are now required to have permission from ethics committees for any human research. Most viewed this as a good thing. One participant tempered this point of view with the perspective that it was part of the changing nature of universities reflecting a continuing loss of academic freedom. Outside the university environment, however, there is still no requirement to have research with humans approved by an ethics committee. Researchers outside university are only restricted by the standard laws of the land that all residents are subject to, and to various ethical codes of professional bodies to which they may belong.

Various professional bodies have codes of ethics with which, while not being legally binding, their members are supposed to comply. In fields that involve research with humans, such as psychology, there are specific ethical requirements for such work. Transgression of professional codes of ethics may result in censure or even expulsion from the professional body. Different attitudes to compliance with ethical codes and regulations were noted amongst different research communities. One participant claimed that "there is still are a subset of people who work in medical schools and hospitals who don't think that they have to abide by the same ethical regulations that we [university scientists] do because they are medical people" (R19). This participant also noted what she considered a ludicrous discrepancy between human research ethics regarding the conduct and the consequences of research: "…see that [developing the atom bomb] is something you don't have to have ethical approval for. Is it because it doesn't involve working with people? The consequences of using that technology on the people, that was the damage" (R19).

Several participants noted intellectual property rights and patents as legislative tools with which scientists were required to comply. Most of these participants were of the opinion that these were important tools for scientific development, especially in a commercialised science environment: "Patenting is an acceptable way to protect the knowledge that has been generated and reap a return on research investment" (R7). However, several also noted a drawback to scientific social responsibility caused by these legal tools: "Intellectual property and patenting prevents scientists from going public with their plans; confidentiality is a barrier to discussion with the public about what scientists are doing" (R2).

A few participants noted that, due to the Treaty of Waitangi, there was a requirement to consult with Maori regarding research that may impact upon them. Another piece of legislation that affects scientists in New Zealand is the Hazardous Substances and New Organisms (HSNO) Act (administered by ERMA). The main concern of this act is the safety of herbicides, insecticides, fungicides, molluscicides, plant growth regulators (PGRs), fumigants, agricultural detergents and sanitisers, and veterinary medicines. Non-compliance with this act can earn fines of up $500,000 and three month prison terms. As documented earlier, many participants noted that ensuring the products of science and technology were safe for humans, animals and the environment was an important social and ethical responsibility of scientists. Finally, regarding compliance with legislation, one participant noted that "ethical behaviour amongst scientists is much more than just adhering to current legislation….because there can be holes in legislation" (R20).

Societal mores

Many societal mores are enshrined in legislation. However, many are not and instead are unregulated values and norms widely held by particular communities. Many societal mores are compatible with scientific norms and personal values, but again, they are not identical sets. Thus, although there is considerable overlap with many elements in common amongst these sub-themes of compliance, they are not the same. Elements in common to societal mores, scientific norms and personal values, relevant to research practices, probably include not to do harm (or at least balancing benefits and harms), animal welfare and the safety of products. These issues have already received considerable discussion above, particularly in the theme of doing public good and its sub-theme benefit/harm. Suffice it to say, the concern here is compliance with those values, standards and regulations.

Nonetheless, even within these common elements, there are variations in belief within society. Indeed, it is important to note that there is considerable variation in the values held, within and across different communities within society at large, and even between individuals within a relatively homogeneous community (as, for example, is demonstrated in this research with a relatively homogeneous group of scientists). Similarly, individual and societal values and ethical beliefs may change over time and with variations in personal or societal circumstances (Small, 2004a, 2004b). As one participant noted "what is ethics, what is morality, what is socially acceptable behaviour…. could vary enormously…. [given different circumstances] what I considered was acceptable would change dramatically" (R17). He then went on to point how inconsistent our moral behaviour can be "one injured New Zealander is worth 123 dead famine victims….morals and ethics change [dependent] on the circumstances. How much of your lifestyle and your freedom that you have, here in New Zealand, would you give up to make other people equal to that?" (R17). These two quotes suggest the participant's belief in cultural relativism and moral conventionalism.

For many participants a prerequisite to being socially responsible was to be ethical in one's research. Ethics and social responsibility were generally seen as entwined constructs: "[The] main issue of social responsibility, one of the social responsibilities, is being ethical, so that is, sort of, all linked together" (R6). For some, transparency in research was an essential component of being socially responsible, in that, if the public was fully aware of what was occurring in science then they would be in a position to have scientists comply with societal mores. "Transparency is the main ethical responsibility…. Transparency gives the public the opportunity to see what scientists are doing, it puts research up for public ethical scrutiny. In this way a scientist's ethical responsibilities will be moderated by the community. The public will judge whether you can go ahead and do it" (#13). Transparency is strongly linked to the theme of engagement, particularly the sub-theme of informing the public.

Most participants believed that scientific research should comply with the ethical values and norms of society: "The wider issue of ethics, I see, is working within the norms of society values" (R16), "[Scientists have] responsibilities to match or at least be cognisant of communities' ethical opinions and try to give back to research within those boundaries" (R22), "Research should comply with the ethical and social norms of society" (R7), and "I have a responsibility to make sure that my science and investigation is done in a way that is acceptable to the community" (R8). As previously discussed, foresighting the potential ethical and unethical uses of science and technology was considered by some as an essential element of socially responsible research. One reason given for this was that it is "up to society to ban applications which are unethical… in line with the social norms in culture" (R7).

One participant proffered the view that the collective ethics of society were reflected in government policies and legislation (R9). Another claimed, "as long as you work in an organisation that is responsible or answers to the government then you work very much within the bounds of social sensibility" (R17). In a similar vein, another participant considered that ethics committees acted as a proxy for societal mores (R18). Seeking approval of ethical committees for research was considered a mechanism for compliance with societal mores: "...have to have ethical approval…. go through the appropriate channels… [Society] has put those boundaries, I guess, on us, so we have to work within them" (R19).

However, while accepting that science should generally comply with the moral boundaries of society, a few scientists expressed the opinion that societal moral values were not static but changed over time "it's like what is socially acceptable at the time, and perhaps, in 100 years, a different method would be more acceptable" (R5). This opinion led some participants to believe that science had a right to challenge society's moral boundaries: "Science needs to push the ethical envelope sometimes – do research that is on the boundary of what the public see as being ethical. Historically, a lot of beneficial progress has been made by science doing this" (R3), and "there is probably also a case to be made for scientists to try and push boundaries, because often the boundaries end up going outside social norms and societal values and things that are accepted socially now" (R8). Thus, these participants questioned whether strict compliance with societal mores was always appropriate to the truth seeking endeavour of science. From these considerations the following item is proposed for the awareness of social responsibility instrument:

Science must sometimes push the boundaries of social and ethical acceptability in order to advance knowledge [1].

Participant 8 used the example of Galileo, whose scientific advocacy of Copernicus' heliocentric model of the solar system clashed with the dogma and social and moral conventions of the Catholic Church of the time. Hindsight has proven Galileo and Copernicus right and the historical, social and moral conventions of the Catholic Church wrong (Gribbin, 2002; Silver, 1998). Darwin's theory of evolution was also cited as an example of an historically justified challenge to the scientific, social and moral conventions of his time. These participants argued that such examples show that sometimes challenging what is socially and morally acceptable can lead to scientific progress and even bring about change in social and moral beliefs.

These two revolutionary theories changed the moral status of humankind. No longer was 'man' or humankind the centre of the universe and qualitatively different from animals as Descartes had claimed. Humankind's importance, moral status, and difference from other animals were irrevocably diminished by these two theories (Gribbin, 2002; Silver, 1998). This new scientific understanding opened the way for a new moral relationship between humans and the rest of the natural world (Small, 2004a, 2004b).

A few participants challenged the current dogma underlying political investment and control of science, previously referred to in this thesis as the *economisation of science*; the believe that economic growth is an unconditional good and that the main purpose for government support of science is to create economic growth (see Small & Mallon, 2006, for a more detail discussion of the sample scientists' attitudes to this issue).

A number of participants noted factors that helped facilitate compliance with societal mores including, "…Royal Commissions, ethical committees, science cafes, public debates – involving scientists and people from the community" (R2). Others suggested that "socially responsible behaviour can be enhanced through awareness of issues, moral consciousness raising" (R4) and "a greater focus on ethics in the science community" (R12). Several advocated for: "…ethical education in science training" (e.g., R2, R6, R7, R12, and R18). The democratisation of science was also advocated by some, “Doing science based on what the public want rather than based on what scientists want” (R5). Another opined that “Social pressure is one of the strongest pressures to be socially responsible” (R8). These considerations lead to the proposal of the following item for the awareness of social responsibility instrument:

Ethical training should be an integral part of scientific training [8]

Personal values

Many participants argued that scientists had a responsibility to only work on projects that complied with their personal values: “I think scientists have a responsibility in terms of thinking about whether their research is ethical, whether they can justify it ethically….I think that everyone should search in their own conscience and see whether they can justify it” (R12), and “I think every individual has to balance those standards, if you like, those parameters with what they are doing, and who they are doing it for, and why they are doing it. I’d like to think I’m very principled in society, do things that I think are worthwhile doing” (R17). Another participant related compliance with personal values to self-esteem and self-identity: “We all have our things that we could work on and things that we don’t….I want to be proud of what I do. So I don’t want to feel like I have to hush, hush because I’m concerned that I’m causing harm to someone or something” (R10). The arguments given in this paragraph and the following ones are similar to the normative theory of virtue ethics where one attempts to be a good person and do the right thing by consulting one’s conscience.

Some participants made claims that they would not work on research they considered unethical, “If you find it morally and ethically unacceptable to be doing a particular line of work then, thinking of all the pain you’d go through at night as you are lying in bed and things, yes, I wouldn’t do it and I would think anybody who did was silly” (R6), “It means there are some research projects I just wouldn’t do (R19), and “But I certainly wouldn’t do work I didn’t feel comfortable with. I would certainly look for an alternative job” (R11). Some felt that choosing the projects that you worked on, or the employer that you worked for, was one way in which scientists could exercise their personal values in research. “Scientists can choose their place of employment. This choice should be made with regard to the ethics of the employer and the type of research that the employer conducts and its compatibility with the scientist’s ethical and social values” (R4), “You can chose the area of your research and employment to be consistent with your ethical beliefs” (R10), and “Before I was a scientist, there were certain jobs I probably wouldn’t have done. And the same with being a scientist, there are certain jobs and certain things I wouldn't do. And I have left jobs on principle" (R17). From these considerations the following item is proposed for the judgment of social responsibility instrument:

To refrain from conducting work in areas that you find morally questionable [14].

One scientist, whose real passion was for basic research rather than applied research, observed that this caused her a personal moral dilemma because applied research held the possibility of more immediately alleviating existing pain and suffering in the world. "This is my personal social dilemma. Do I do something that is immediately useful for people who have a need, or do I do something that is, I have more personal passion, desire to do because it zings my brain and is of no certain immediate use to anyone?" (R21). However, along with a number of other participants, she believed that it would be short sighted for science to just focus on applied research and that basic research was essential for science and society over the long term. "Nor do I think it's socially responsible for all scientists to do absolutely applied research, its short term thinking not future planning…. Are you doing outputs for this year or outputs for 50 years? So I think that knowledge can be used for public good and it can be used directly or immediately or in the longer term" (R21).

It was noted by several participants that different people, and different scientists, had different personal values. "To me, social responsibility means to do things that are morally acceptable, and there is always a fine line there, some people have different morals than others" (R5), "Different scientists have different thresholds as to what their social responsibility is" (R10), "…really it's an individual thing….morals and ethics change [dependent] on the circumstances" (R17), and "Ethics is a personal thing. So while you might say, I won't work on that project, I wouldn't feel ethically comfortable, you can't say he or she should not be doing it. Not in a democracy like ours" (R11). These statements indicated latent underlying beliefs in ethical relativity and moral subjectivism.

However, in contrast, to this last participant's point of view, other participants noted areas of research that they thought should be forbidden to all researchers: "I think those kinds of areas, for example, nuclear weapons, biological warfare, is an area that I think should not be studied. Yes very much" (R14). And, "Human cloning, something that's just not done. Biological warfare, those kinds of things, are just not done" (R16). These latter statements conveyed a tone of latent moral absolutism and ethical objectivism underlying the participants' reasoning.

The next quote makes explicit the notion that not all scientists support all science activities or all aspects of the science agenda: “I don’t think that because you are a scientist that you definitely believe in all the things that science is doing” (R10). This was demonstrated by several of the research participants regarding specific aspects of GE research (see also the earlier discussion of attitudes to different applications of cloning technology). Amongst the participants was an animal reproductive scientist (R9) who was quite concerned about the release of GE plants because she believed that it was impossible to contain GE plants (because of pollen dispersal) and that they, therefore, represented a substantial threat to the environment. She considered that there was not enough scientific knowledge to accurately predict the long term environmental effects – a precautionary teleological argument. On the other hand, she was relatively comfortable about transgenic animals, especially if developed for medical purposes (i.e. as bioreactors for medicines) and as long as there were no bad animal welfare impacts, believing GE animals to be easy to contain. Her concerns were entirely teleological, she was not deontologically opposed to the manipulation of either plant or animal genomes. Her position was that the teleological risks associated with GE plants were greater than that posed by GE animals.

A plant GE scientist when asked her opinion on plant and animal gene technologies said “I must confess I don’t have very deep ethical concerns, at least not in the plant area… so in general I do not have ethical concerns in changing the genome of the plant. But I have environmental concerns” (R2). Like the animal scientist, she was not deontological opposed to GE plants but, unlike some other GE plant scientists she also had teleological concerns about potential environmental impacts. She was strongly opposed to the release of GE plants in the environment because she also considered that we lacked the scientific knowledge to understand the environmental implications, and hence precaution was the greater virtue. However, she differed from the animal reproductive scientist when it came to the manipulation of animal genomes. She stated, “Animals, it is more difficult, especially when it goes into the region of apes and primates” (R2). She explained that she had some kind of a ‘sliding proximity to human scale’ where it was perhaps alright to do things to some animals but not others. “Kind of a sliding scale, yes…. it’s not really based on…. rational decisions, it’s more… I feel closer to animals where I can see that they are almost human. Like apes or chimpanzees or something like that” (R2). Here she was expressing a deontological objection to manipulation of the genome of higher animals, based primarily on emotional feelings of species proximity. She did not hold such deontological concern for, “lower order creatures, for example, a spider, which I usually kill when I see” (R2). Another plant GE scientist was also reticent about animal experimentation, again, from an emotive perspective “I guess the reason I am sort of moving more into plant research is I didn’t feel like experimenting on animals very much” (R3).

Several participants made personal moral statements about research they would not do. Many, such as, not working on military applications of technology (e.g., nuclear or biological weapons), cloning humans or animals, experiments which involved animal suffering, and working on projects which have (from the perspective of the individual involved) a high potential to cause harm (e.g., field trials of GE plants), have previously been quoted. Participants also made personal moral statements about their perceived moral responsibilities in research, the things they should try to ensure or achieve during the process of research. Most of these have also previously been quoted. Examples included being competent and up to date in your area of research, ensuring the safety of the products of science and technology, ensuring approval from appropriate ethical bodies, complying with animal welfare standards, limiting animal suffering, choosing areas of research compliant with personal moral values, working within society’s ethical boundaries, foresighting the possible impacts of research, alerting the public to social and moral implications of research, disseminating the products of research to both the science community and the public, and reporting research to the public in jargon free language.

Participants noted a number of factors which could compromise a scientist’s compliance with his/her own personal moral values or with acting socially responsible in research and technological development. Interestingly, while passion for science, the drive to understand how things work, is considered by many scientists to be one of their main motivations for taking up a career in science (Fisher, et al., 2005; Keysar & Kosmin, 2008), several participants suggested that it could also inhibit socially responsible behaviour in research. Generally, this criticism was couched as a reflection of the behaviour of ‘other scientists’ rather than being attributed to the informant. “You do work with scientists, that science is their absolute passion and they will keep going because they scientifically can do it… it’s a challenge to do something scientifically like cloning humans… its part of the science ethos, the challenge of doing the undoable. It’s a bit of a concern” (R10), “Scientists can get so engrossed and so sure that what they are doing is the right thing that they lose the big picture and in losing the big picture, and losing what is going on in the real world with real people, that they become a bit biased and socially irresponsible" (R5), and "scientific elitism may make scientists not want to open their work to public scrutiny or comply with regulations that restrict or take something from their science" (R2).

Also compromising the scientist's ability to comply with their own personal values was a network of issues around science funding. These included the political drive for science to deliver economic goals, the increasing privatisation of science, corporate or institutional demands on scientists, and fashion in science. Because science is becoming increasingly privatised and publicly funded science is being increasing controlled by political processes aimed primarily at economic growth, scientists considered they are being increasingly pressured to conduct research that compromises social responsibility and public good. "The huge push at the moment [is] for science to result in money or making money. I don't think that, that makes for responsible science, because the goals there is to make money its not to be responsible…. it's not for public good anymore even though it might be in the guise of public good, I think that sometimes scientists can be led astray" (R5). One senior science leader claimed: "Profit maximising is only one route to nirvana and not necessarily the shortest…. Scientists have a moral obligation to put the good of society ahead of commercial profit" (R4). These considerations lead to the proposal of the following item for the judgment of social responsibility instrument:

To put the good of society ahead of commercial profits [20].

Another scientist considered that "If the science is commercialised then the issue of money will overrun anything else and you will, I think you will not always get dishonest science, not at all, but very, very frequently, I think scientists will do ethically irresponsible things for the sake of money" (R12). A scientist's personal financial situation was also posited as having the potential to sway them to act for companies in ways that they would prefer not to "If you are working for a company and you're financially strapped or you're in debt and things like that then you would be more inclined to give the company what they wanted. I mean it's just survival sort of aspect I guess" (R17).

The allocation of science funding was seen as having the potential to restrict scientists' ability to work in the areas that they considered would deliver the greatest public good. "We are really getting pushed [by] the science funding…. It's the way of keeping your job going or to continue having funding…. [scientists] might work on something they didn't agree with…. there were no other projects to work on and that's where the funding was" (R10). She went on to give an example: "The way things have gone in terms of the traditional, say quantitative genetics and plant and animal breeding approaches, funding has just been ripped out of the system. And so you've almost been forced to go into the more biotech type approaches to get funding. And you can see that with traditional breeders they don't necessarily believe in that technology, that it's going to improve our plants or animals as much as people say it is" (R10). For the latter participant and the next one, there was an element of fashion dictating research: "so if you've got an occupation that's maybe not flavour of the month anymore, and people don't see the relevance to it anymore, because of some other development, you'd be under a lot of pressure to maintain that piece of work. And vice versa, you may have things that are not flavour of the month but you can still see the benefits and possibilities of it. And so, therefore, you have to then go against what is perceived out there to carry on that work" (R17).

Corporations and institutions that employed scientists were also viewed as compromising their ability to be true to their own personal values. "What is starting to bother me is the focus of our CRIs in New Zealand and the balance between science excellence and science and commercial gain…. it's just being able to speak out your concerns and you got the corporate view of how you should speak out…. it's a difficult balance and I see it becoming more of a barrier as other avenues or other aspects of science come before having a public debate, is this corporate view of what you can say and what you can't say" (R16). Another senior scientist also considered that CRI's and their employees were placed in conflicted situations by Government or commercial requirements: "And that the problem is, in my institute, is that the drivers for profit maximisation are not necessary internal, there's some very severe pressures on our institute externally. And I really have a lot of sympathy for those that are trying to balance their personal values and views with the pressures that are being imparted by the government on the institute. I think it's a really tough environment, actually very conflicted" (R4). Another CRI scientist leading a research team working in the area of genetic engineering and cloning stated "If your employer, or through commercial pressure and whatever, I'm not just saying commercial pressure, but if your employer decides that this is a priority area and you don't agree with that then you can be put into a situation, I imagine, where you are working against your ethical and your social responsibilities. And certainly I know within my own area of work there were some people who were not that comfortable with what was being done" (R6).

Conclusions

Study 1 had three central aims. 1) To determine scientists' beliefs about the elements that compose scientists' wider social and moral responsibilities in the process of scientific research and technological development (i.e., define the construct domain), 2) to determine the ethical processes and theories that scientists used when thinking about their social and moral responsibilities to society, and 3) to use the data gathered from scientists' interviews to develop items for instruments to measure scientists' attitudes to social and moral responsibility in scientific research and technological development. The first aim was accomplished with the development and elucidation of thematic maps showing the elements of scientists' conceptualisation of their social and moral responsibilities to society. Interspersed throughout the Results and Discussion, I have analysed scientists' ethical reasoning processes relating them to ethical theories and metaethical theories to accomplish the second aim. The third aim, which is the basis for the integration of the qualitative and quantitative studies, is addressed in the following section.

A thematic model of the elements of scientists' social and moral responsibilities in scientific research and technological innovation has been developed on the basis of interviews with scientists. To the author's knowledge, no such model previously existed. However, in recent years, several scholars have commented on the need for such a model (e.g., Pimple, 2002; Prpic, 1998; Weil, 2002). Three main themes emerged from the interview data regarding the social and moral responsibilities of science to society: Doing public good, engagement with the public and compliance with relevant norms. Each of these themes had a number of sub-themes. These have been described, analysed and illustrated with the use of quotes from participants. In many cases, study participants (who were all highly educated scientists) reflexively analysed their own statements, recognised inconsistencies and contradictions in their beliefs, attitudes, and values, either just noting the inconsistency or, in some cases, trying to resolve it sometimes through philosophical manoeuvres, such as ethical relativism or moral conventionalism.

While most participants generally agreed on the elements (i.e., themes and sub-themes) that constituted scientific social responsibility, there was usually a range of different attitudes and personal positions regarding these elements. Scientists' viewpoints were often complex, multifaceted and sometimes contradictory, perhaps reflecting the complex contradictory environment in which they worked. Although traditionally scientists often considered their work to be a public good, usually associated with the concept of knowledge as good in itself, given the significant negative impacts of science and technology on society, life and the environment (and the potential challenging existential risks of Promethean technologies), as argued in the first three chapters, such an ethic can no longer be maintained.

A new or increased ethic of social and moral responsibility on the part of scientists to society is required. Many scientists recognise this, at least to some degree. However, an increased responsibility poses difficulty for many scientists. It is in conflict with some of the traditional ethics of science, thus causing conflict and inconsistency in scientists' attitudes. Science was traditionally considered the value free, objective pursuit of true knowledge, conducted for the public good, with scientists being allowed academic freedom. Although in recent years, the concepts of value-free science, scientific objectivity and academic freedom have all been subjected to strong theoretical (and commercial) attack, they are still concepts that resonate strongly with many scientists.

Taking an increased social and moral responsibility for the science produced means giving up the concept that science is a value-free pursuit, and that scientists must remain objective and disinterested, as opposed to being advocates. It also means giving up the idea that scientists are entitled to research whatever they like and accepting the concept that society has a right to oversee and even govern (albeit in conjunction with scientists and politicians) particular aspects of research and technological development. The purpose and value of the new ethic was apparent to a large proportion of the study participants. However, what was not apparent to many was how to resolve and balance these new responsibilities in the face of their previous scientific ethic and norms.

While some participants had given considerable thought to the issues canvassed, most had not, and a number of them stated this to me during the interviews. Most participants appeared to find the interview quite challenging, but also interesting and self-revealing. They frequently noticed that the positions they first responded with had weaknesses that they then felt obliged to examine, explain or modify. Once stimulated to think about the issue, nearly all of them recognised it as being an important concern, with several telling me that they would need to consider it further and our conversation made them think a little differently about some of the work they were doing, or could potentially be doing. Scientists' social and moral responsibility to society is a growing issue which is currently moving into the consciousness of scientists as well as the public. Yet scientists are still struggling to understand the complexities of the issue, the developing nature of their individual roles, the role of the science community, the role of the public, the role of government, the role of commercial science organisations and the potential social and moral impacts of Promethean technologies.

All three of the major normative ethical theories (deontology, teleology and virtue ethics) could be seen in participants' reasoning. However, while some participants focussed on deontological concerns regarding some issues or technologies, the majority of participants tended to focus on teleological concerns. However, nearly all participants showed evidence of both deontological and teleological moral reasoning. When individuals took a deontological stand against a particular technology (e.g., cloning), there was often a strong expression of emotion associated with their objection. An element of virtue ethics was evident in some participants' exhortations to follow one's conscience in regard to compliance with their personal values. Evidence of the use of various meta-ethical theories (e.g., ethical relativism, ethical objectivism, moral realism, moral absolutism, moral conventionalism, and moral subjectivism) to support, explain, or as underlying constructs necessary for, particular moral positions, was found and noted in the analysis.

Question items for social responsibility instruments

As signalled previously, two new instruments are being developed to measure scientists' attitudes to social and moral responsibility in research and technological development. The rationale for developing two instruments with different foci, as previously explained (Chapter 5), comes from Pimple's (2002) observation that while the science community has moral obligations to society, individual scientists also have some moral obligations to society "…no scientist is responsible for setting the research agenda for the nation or the world" and "…granted that no one scientist can bear the burden alone, it is still true that each scientists has an obligation to carry some part of the burden…. but clearly science as an institution and scientists as a group do have such a moral obligation" (p. 198).

Thus, the focus of the first instrument is about awareness and sensitivity to the social and moral responsibilities of science to society, while the focus of the second instrument is on moral judgments about behavioural principles and personal actions scientists can follow to help ensure their research is socially responsible. The development of two instruments to measure different theoretical components of scientific social responsibility was also designed to be congruent with Rest's (1979, 1986) 4-stage psychological theory of ethical behaviour (presented in chapter 3).

The focus on scientists' perceptions (awareness) regarding the social and moral responsibilities of science to society relates to the first stage of Rest's (1979, 1986) theory of the logical processes involved in ethical behaviour; awareness of a moral issue. Philosophers have also claimed that moral awareness and sensitivity is a necessary prerequisite to moral reasoning (Blum, 1991; Sherwin, 2001). All the items in the moral awareness instrument address the issue of the recognition of the moral responsibilities of science to society (see p.213 for proposed items for moral awareness instrument) and, therefore, are congruent with the first stage of Rest's theory moral of behaviour. The focus on behavioural principles, to guide personal actions of scientists, relates to the second stage of Rest's model; moral judgment. The moral judgment instrument measures scientists' attitudes to performing certain actions during the context of the research process i.e., the importance they place on behavioural principles/actions guiding socially responsible research conduct. These actions were identified by participants in Study 1 as being important components of scientists' social responsibilities to society. Responses to questions in this instrument entail having made a moral judgment regarding these specified actions in a research context (see page 214 for proposed items for moral judgment instrument) and, therefore, are congruent with the second stage of Rest's theory of moral behaviour.

Most of the items for the two instruments are derived directly from Study 1, and for some items, parts of their wording are verbatim quotes from Study 1 participants. However, in developing the items, I was cognizant of the theoretical and empirical research previously reported in the current work, and this has influenced some items composing the instrument. It was my aim to construct an instrument that would have a relatively small number of items (10 for each instrument) and which would access a general factor of the multidimensional concept of scientific social responsibility. The awareness instrument consists of items 1-10, having a 5-point Likert scale (1 = *strongly disagree*, 2 = *disagree*, 3 = *neutral*, 4 = *agree*, 5 = *strongly agree*). As is apparent from a perusal of the items of this instrument, in order to form a directionally consistent instrument, some of the items in the instrument need to be reverse scored. The second instrument consists of items 10-20, in which the respondents are requested "to rate the importance of the following principles to you as a scientist living and working within society". The response scale consists of 5 options (1 = *not important*, 2 = *of* *little importance*, 3 = *moderately important*, 4 = *important*, and 5 = *very important*). Below are the 20 items.

Science-society interface: Moral awareness instrument

1. Science must sometimes push the boundaries of social and ethical acceptability in order to advance knowledge.
2. The science community has a moral obligation to ensure that the products of scientific knowledge do not cause harm (e.g., to humans, animals, environment).
3. The science community cannot be held ethically responsible for the use to which scientific discoveries are put.
4. The more powerful a technology is the more important the evaluation of its ethical and social implications become.
5. The more powerful a technology is the more important and relevant the precautionary principle becomes.
6. There are some fields of knowledge that are so potentially dangerous that they should not be researched.
7. Science is the value free pursuit of true knowledge.
8. Ethical training should be an integral part of scientific training.
9. The benefits of science and technology should be distributed throughout society in a fair and equitable way.
10. There is no ethical imperative for science to "do good."

Scientists' responsibilities: Moral judgement instrument

1. To evaluate possible benefits against possible harms when deciding on research projects.
2. To refrain from exaggerating the potential benefits or minimising the potential risks associated with research.
3. To give the public clear guidance on the reliability and validity of scientific conclusions regarding potential benefits and risks.
4. To refrain from conducting work in areas that you find morally questionable.
5. To ensure that approval for research is gained from the appropriate ethical authorities.
6. To ensure that the process and development of research complies with the precautionary principle.
7. To become informed about what society finds acceptable or unacceptable in scientific research.

8. To consider, and dialogue with the public about, the possible misuses to which knowledge gained from your research could be put.
9. To participate in public debate and dialogue over contentious scientific issues.
10. To put the good of society ahead of commercial profits.

I also tried to ensure adequate coverage of as many of the themes, as possible, that were identified in Study 1 as being relevant to the concept of scientists' social responsibilities to society. To this end, I constructed a table with a row for each of the main themes and sub-themes, discussed above, and a column to record all the items that conceptually related to each sub-theme and a column to record the counts of items related to each sub-theme. The criterion for item allocation to a sub-theme was that, in order to understand or operationalise the item, use or knowledge of the sub-theme construct is necessary. Table 6.3 below presents this data.

With the exception of business norms (one item) all sub-themes were conceptually related to at least 3 items. All 20 items were conceptually related to the compliance sub-theme of personal values. This is understandable and perhaps desirable as the instruments are designed to measure personal attitudes of scientists regarding their personal and the science community's social and moral responsibilities to society. Fifteen of the 20 items were conceptually related to the compliance sub-theme of societal mores. Again, this is consistent with the purpose of the instrument.

Other sub-themes that were conceptually related to a large number of the items were benefit/harm (11 items), knowledge (11 items), technology (10 items) and foresighting (10 items). All 20 items were conceptually related to the sub-themes of doing public good and compliance, while five items were conceptually related to the sub-themes of engagement. Therefore, from a conceptual perspective, I consider that the content domain of scientists' social and moral responsibilities to society, as revealed in the qualitative interviews, is adequately covered by the quantitative instrument items.

The methodological processes used in this study were highly subjective. Although the work on the democratisation and commercialisation of science was subject to reliability procedures with my co-author, Prof. Mary Mallon, the work reported in this chapter is a co-construction of the study participants and myself and was not subject to reliability analysis with another researcher. The interview conversations were very unstructured and free flowing.

Table 6.3.

Instrument Items Related to Each Theme and Sub-theme of the Social and Moral Responsibility Construct[1]

Themes/Sub-themes	Items related to sub-themes[2]	No. of items relating to each theme and sub-theme
Public Good		All 20 items relate to public good and sub-themes
Benefit/harm	2, 3, 7, 9, 10, 11, 12, 13, 18, 19, 20	11
Knowledge	1, 6, 7, 8, 12, 13, 14, 16, 17, 18, 19	11
Technology	2, 3, 4, 5, 14, 15, 16, 17, 18, 19	10
Foresighting	3, 4, 5, 6, 8, 11, 16, 18, 19, 20	10
Engagement		5 items relate to engagement and sub-themes
Informing	12, 13, 18, 19	4
Becoming informed	17, 18, 19	3
Integrity	12, 13, 18, 19	4
Compliance		All 20 items relate to sub-themes of compliance
Laws and regulations	2, 4, 5, 15, 17	5
Scientific norms	2, 8, 10, 15, 17	5
Business norms	20	1
Societal mores	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 15, 17, 18, 19, 20	15
Personal values	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20	20

Note: [1]These are personal judgments made by the author, the reliability of these judgments has not been evaluated.
[2]Numbers in this column are the reference numbers of the items composing the two social and moral responsibility instruments.

The same topics and sub-topics were not necessarily discussed with all participants. I selected the relevant text extracts and decided on the coding structures. I determined the themes and sub-themes. And, although significant portions of the analyses were quotes from the high functioning individuals participating in my study, it was I who selected those analytical quotes for inclusion in this document. Likewise, I analysed the ethical processes that participants used while discussing the issues and I selected the items for inclusion in the proposed instruments to measure scientists' attitudes to social responsibility.

This degree of subjectivity raises flags regarding the credibility of the research. Would another analyst conducting similar research have selected the same text fragments as being relevant, found the same themes and sub-themes, and seen the same latent ethical beliefs underlying scientists' attitudes? Ultimately, scientific credibility must be "…agreed by an audience – a scientific community" (Salmon, 2003, p. 26). I agree with Salmon that it is "…a social act…what the audience accepts is what it *agrees* to accept" (2003, emphasis in original). These are questions that the reader must decide for themselves. Is it a coherent account? Does it make sense? Does it convey a believable story? Is it consistent with what the reader knows about science and scientists? Is it consistent with related literature? Is it relevant or meaningful to other researchers, scientists or the general public? Such questions are relevant to both qualitative and quantitative research.

In this chapter (and throughout this thesis) I have tried to convey a more comprehensive understanding of science, scientists, and social responsibility. Of course, as noted by a number of the study participants, in science, one study (generally) proves little; replication and reproducibility are the keys to good science, despite their infrequent use (J. Potter, 1996). A qualitative study with only 22 participating scientists can make few claims about the prevalence or distribution of attitudes amongst the wider population of scientists. However, what it can do is show the range of attitudes and beliefs, and the complexity and richness of participants' reasoning, in a manner that would be difficult to achieve with quantitative research.

I hope that through triangulation and consistency of findings, a degree of credibility will be conferred to the qualitative results by using the statements made by participants as items in the research instruments in the quantitative component. In Chapter 7, Study 2, the instruments will be subject to psychometric analysis for reliability, factorial structure, dimensionality, and construct validity. If reliable and valid measures can be obtained from these items, and consistency between responses to them and the analyses presented in this chapter are found, then the two studies will go some way towards providing support for each other, thus conferring some degree of confidence and understanding to the results of both studies.

Chapter 7- Study 2

Introduction

For the past half century, because of the Promethean power of modern technologies, a number of scientists, science commentators, sociologists of science, philosophers of technology, and ethicists, have argued the need for an increased ethic of social responsibility in scientific research and technological development (e.g., Abelson, 1970; Bradshaw & Bekoff, 2001; Bulger, et al., 2002; Bunge, 1977; Dainton, 1971; Jonas, 1985; Joy, 2000; Lenk, 1983; Lubchenco, 1998; Luppicini, 2008; Moor, 2005; Pimple, 2002; Van R. Potter, 1971; Russell & Einstein, 1955; Shine, 1989; Ziman, 1998). However, little is known about scientists' attitudes concerning ethics and social responsibility (McCormick, et al., 2009; Pimple, 2002; Prpic, 1998; Weil, 2002). Yet this information is crucial since scientists must first perceive ethics and social responsibility as important before their behaviours are likely to reflect the greater social responsibility required by increasing technological power (Bebeau, et al., 1995; Blum, 1991; Rest, 1979, 1986; Sherwin, 2001).

From the literature reviewed and the results of Study 1, a survey was designed for administration to scientists. The survey contained proposed items for five new instruments to measure constructs forming a nomological network focussed around and including the concept of social responsibility in scientific research. The survey also contained items from the Schwartz Value Survey (1992) to measure the 'higher order value dimensions' and an instrument developed by Small et al. (2005) to measure 'general attitudes to genetic engineering'. These two existing instruments also formed part of the nomological network of constructs designed to test and infer the construct validity of the new instruments.

The primary objectives of Study 2 were: 1) to test the psychometric properties (i.e., unidimensionality and reliability) of two instruments designed to measure scientists' attitudes to social responsibility in research (potential items were developed in Chapter 6, Study 1), 2) to assess the instruments' concurrent and construct validities by testing hypotheses describing conceptual relationships between the constructs in a nomological network, 3) to investigate and describe scientists' general attitudes to social responsibility in scientific research, 4) to examine scientists' attitude to a particular Promethean technology, genetic engineering (GE), and 5) to compare scientists' attitudes to GE with those of the public. As noted above, research had not previously been conducted into scientists' attitudes to their broader social and moral responsibilities, nor are there any existing instruments to measure this important aspect of the science-society interface.

Due to the lack of existing instruments to measure some of the other constructs in the nomological network, three further instruments were developed in the current study. Items for two of these instruments (attitude to the democratisation of science and attitude to the commercialisation of science) were derived from Small (2005b), and Small and Mallon (2004, 2006) (see literature review - Chapter 4). Items for the third instrument (technological optimism) were derived from several sources (Costanza, 1989; Daly, 1996; Daly & Cobb, 1994; George Gaskell, et al., 2004; Huesemann, 2001; Kriebal, et al., 2001; Krier & Gillette, 1985; National Science Board, 1977; Rollin, 1996; Ticky, 2004, see literature review - Chapter 3). In the present chapter the psychometric properties of these instruments will also be described and their construct validity tested by examination of the conceptual relationships proposed in the nomological network in which they are conceptually embedded.

Overview of chapter layout

In the Method section of this chapter the survey sample and research procedures are described followed by a discussion of the analysis procedures to test the psychometric properties of new instruments. Next, the questionnaire is described and the psychometric properties of the two existing instruments (i.e., the Schwartz Value Survey and the general attitude to GE instrument) are tested using confirmatory factor analysis (CFA) and reliability analysis. Because these were existing instruments developed on samples independent of the current sample, CFA was conducted on the whole sample (i.e., N = 733) for these two instruments.

The results and discussion are combined in one section. In the Results and Discussion section the psychometric properties of the five proposed new instruments are examined and the instruments refined. The data sample was divided into two equal halves, the first half for conducting exploratory factor analysis (EFA, n = 366) to develop the preliminary scales and the second half for conducting confirmatory factor analysis (CFA - holdout sample, n = 366) for purifying the dimensionality of the scales. Preliminary scales were developed using principal axis factoring (PAF) on the EFA data set to select the best items, with poor performing items dropped prior to CFA. Then CFA was used to refine the measures and determine the goodness-of-fit of the proposed factor models on the holdout cross-validation sample. Next, reliability analyses, using Cronbach's coefficient alpha, were conducted on the refined instruments for the whole sample (N = 733).

Descriptive statistics for instrument scores are reported to elucidate and describe the sample scientists' attitudes to democratisation of science, commercialisation of science, technological optimism, social responsibility in research and general attitude to genetic engineering. Next, a comparison of scientists' and the New Zealand public's attitude to GE is presented. Finally, the research hypotheses (see Chapter 5) comprising the nomological network are tested. These hypotheses describe the relationship between the research instruments, including the new instruments and the existing instruments. For both the descriptive statistics and testing the research hypotheses the whole data set was used, except for the correlations with the attitude to GE scale, the reason for which is explained in the appropriate section below.

Method

Sample and Procedures

Sample

Science organisations. Six Crown Research Institutes (CRIs) were invited to participate: AgResearch (AgR), HortResearch (HortR), Crop and Food (C&F), Landcare, Environmental Science Research (ESR), and Industrial Research Limited (IRL). There are nine Crown Research Institutes in New Zealand. They are scientific research organisations owned by the government and run on a commercial basis, but charged with producing public good science. As organisational size is approximately double the sample frame of scientists a rough idea of the size of these organisations can easily be calculated from data in Table 7.1. All scientists and science technicians working for these six organisations who met the criterion of having a tertiary qualification were invited to participate. In total, 2125 scientists and science technicians were invited to participate. The web-based survey application was entered by 1014 potential respondents, 47.7% of invitees. Of those who entered the survey website, 733 (72.3%) submitted a valid survey back to the researcher, giving an overall survey response rate of 34.5%. In comparison, Sommer (2010), who conducted a survey of New Zealand scientists in 2008, had a response rate of 38.6%. Table 7.1 shows sample frames, respondent numbers and response rates for each participating organisation.

Table 7.1.

Sample: Organisation, Sample Frame, Respondent Count and Response Rate

Organisation	Sample frame	Respondent count	Response rate
AgResearch	690	303	44%
HortResearch	335	136	41%
Crop and Food	270	80	30%
Landcare	330	68	21%
ESR	250	78	31%
IRL	250	78	31%
Total	2125	729 + 4 no id	34.5%

Note. CRI = Crown Research Institute

Age and ethnicity. The oldest respondent was 81years and the youngest 21, the mean age was 41.2 years and the *SD* of respondents' age was 11.3 years (15 respondents did not give their age). Three hundred respondents (40.9%) were female and 427 (58.3%) were male (6 respondents did not report gender). Ethnicity was reported by 716 respondents (17 non-responses); 534 (72.9%) reported being New Zealand European, 10 (1.4%) were Maori, 3 (0.4%) were Pacific Islanders, 41 (5.6%) were Asian, and 128 (17.5%) reported their ethnicity as other (over half of these reported being a European of one kind or another, boosting European ethnicity to about 82% of the sample).

Science seniority. In response to seniority, 209 (28.5%) reported being senior scientists, 250 (34.1%) were scientists, 219 (29.9%) were science technicians and 49 (6.7%) reported as other. The other category consisted primarily of research associates, engineers, post-doctoral researchers, and information specialists (there were 6 non-responses to this question).

Education and religion. Fifty-six respondents (7.6%) had a diploma or certificate as their highest academic qualification, 157 (21.4%) had Bachelors degrees, 13 (1.8%) had Honours degrees, 155 (21.1%) had Masters degrees, 333 (45.5%) had PhDs, and 14 (1.9%) reported other qualifications. Respondents were asked their religion, to which 374 (51%) replied no religion, 285 (38.9%) replied Christian, there were six Buddhists (0.8%), five Muslims (0.7%), five Hindus (0.7%), three Jews (0.4%), 41 others (5.6%), and 14 (1.9%) non-responses.

Scientific disciplines. The major scientific disciplines in which respondents worked were animal science, ecology, microbiology and plant science. Table 7.2 presents the respondents' current main areas of research.

Table 7.2

Respondents' Current Main Areas of Scientific Research

Research area	Frequency	Percent
Animal science	103	14.1
Chemistry	48	6.5
Computer science	8	1.1
Ecology/ environmental science	89	12.1
Economics	3	0.4
Engineering	31	4.2
Entomology	39	5.3
Food science	37	5.0
Health science	26	3.5
Mathematics/statistics	17	2.3
Microbiology/molecular biology	103	14.1
Physics	32	4.4
Plant science	130	17.7
Social science	16	2.2
Other	45	6.1
Missing	6	.8
Total	733	100

Sample representativeness. Comparisons with the composition of Sommer's (2010) sample are relevant to the issue of sample representativeness. Sommer's sample included university scientists as well as scientists employed by CRIs, whereas the current sample was composed exclusively of CRI scientists. Only 23.2% of Sommer's CRI scientists were female, whereas 40.9% of the current sample was female. This is a striking difference. Sommer claimed that female scientists made up 32.4% of the population of scientists in NZ. Sommer's sample is under-representative of New Zealand female scientists, while the sample from the current study is over-representative. Ethnicity is relatively similar between the two samples. Sommer's sample contained a greater percentage of engineers (10.5 % vs. 4.2%), mathematicians (7.2% vs. 3.4%), health scientists (10.6% vs. 3.5%), and social and behavioural scientists (16.1% vs. 2.2%). The current sample contained more environmental scientists than Sommer's sample (12.1% vs. 7.8%). Differences between Sommer's (2010) sample and the current sample were likely due to non-inclusion of university scientists in the current sample. Given these differences, the current sample cannot claim to be representative of all New

Zealand scientists. Therefore, generalisations from the current sample to the New Zealand science population or the larger world population of scientist should not be drawn on the basis of this study alone.

Item non-response. Half of the item non-responses in the survey were associated with just 5 individual cases. Excluding these cases (*n*=728) there was a total of 108,472 possible item responses of which 108,058 (99.62%) were completed, resulting in a 0.38% item non-response rate. Note that although the five cases of high non-response were not removed from the sample, for all analyses conducted (unless otherwise specified), all cases with relevant missing data were excluded through listwise deletion (thus sample size may vary slightly across different analyses). Item non-response was very low, and with the large sample size, missing values have negligible impact on results.

Procedures

The research project received prior approval from Waikato University's Psychology Department Research and Ethics Committee as a PhD study. The survey was first drafted in a Microsoft Word document (see Appendix 7.1. Scientists' Survey Instrument) and then transferred to a web-based form using the SurveyPro software. A web-based survey was considered appropriate for the sample frame of Crown Research Institute (CRI) scientists, as all scientists working for the six participating CRIs had email addresses. A web-based survey also has the advantage of not requiring data transcription into a statistical analysis programme, which can be a source of error through wrongly transcribed data. The researcher initially trialled the survey himself several times and corrected obvious defects.

Next, 20 scientists from AgResearch from several different scientific disciplines were asked to pilot the survey. For the first ten of these pilot trials the researcher sat in the room and observed the trial respondents, who were asked to vocalise their thoughts while completing the survey. The researcher noted comments, questions and criticisms. Revisions were made to the survey to take account of relevant comments and observations. The other ten pilot respondents completed the survey unobserved at their own convenience. After completion of the survey they then gave oral feedback and some also gave written notes to the researcher. A few further minor revisions deemed necessary by the participants or the researcher were made. The trial data were removed from the survey software database before the invitation to participate in the survey was emailed to the sample.

Numerous additional questions were included in the survey that do not directly relate to the current work (to prevent confusion these additional questions are not included in Appendix 7.1). The reason for this is that the researcher was employed full-time by AgResearch while collecting the current data and was also employed on other related FORST (Foundation for Research Science and Technology – the New Zealand Government science funding agency) funded projects. Therefore, for reasons of convenience, cost saving and expediency, data collection for these projects was conducted concurrently in the survey.

Via email contact with the CEOs of six NZ Crown Research Institutes (CRIs), access was sought and gained for participation of their science staff in a survey of scientists (see Appendix 7.2. Letter requesting permission to conduct survey). Permission was also obtained to identify the participating organisations (though not the individual participants) in the current work. Once the CEOs had consented to participation, the researcher was put in contact with the Human Resource Managers of each of the CRIs in order to obtain the email addresses of scientists and science technicians in their employ. A database of email addresses was constructed and an email was then sent to all scientists and science technicians with a tertiary science qualification, for whom emails addressed were obtained (*N* = 2125). As far as is known, this sample frame is equal to the scientist and science technician population in these six CRIs.

The email invited them to participate in a web-based survey and provided them with a hotlink to the survey web-site. The survey software allocated a unique ID number to each participant based upon order of entry to the survey website. Thus, ID numbers were generated and recorded for all persons who responded to the email request and visited the survey website, even if they did not complete the survey, or chose not to submit their data.

Once a week for four weeks the email invitation was sent to the sample, asking them to ignore if they had previously responded, and again inviting them to participate if they had not (see Appendix 7.3. Canvassing email to potential survey participants). The canvassing email informed potential participants that a good response rate helps to increase the external validity of survey data and results. However, as is necessary to meet the ethical requirement of informed consent, they were also informed that participation was voluntary, that they could pass over any question they did not want to answer, and that they could withdraw from the survey by using the back arrow of their web browser at any time until they submitted their data. They were informed that all responses would be anonymous, that only aggregate group data would be published, and that because of the data collection process, even the researcher would be unaware of their identity (unless they chose to make their identity known). Therefore, their confidentiality was assured.

The sample was informed that electronically submitting the completed survey questionnaire to the researcher (i.e., clicking the submit button) would be considered as giving informed consent for their participation in the research project. After four weeks the survey was closed off, the website disabled and the data downloaded into an Access database. The data were exported from the Access database into SPSS 14 for analysis.

Analysis

Data screening

Missing data. As previously noted missing data were minimal: for all items in all scales (with the exception of the general attitude to GE scale) the maximum number of cases with a missing response was 10 (out of 733). The general attitude to GE scale was a little different as will be explained in the section reporting and analysing this instrument. Where data relevant to a particular analysis were missing the cases were either listwise deleted or the method of handling them is described in the relevant sections.

Normality and outliers. All variables were screened for normality: histograms, normal Q-Q plots, and box plots were examined, and skewness statistics, standard error of skewness, kurtosis statistics and standard error of kurtosis calculated. While the graphs all indicated that the distributions of all items were relatively normal, statistics suggested most items were either skewed or had some kurtosis, and all items were non-normally distributed as defined by the Kolmogorov-Smirnov test of normality. However, this test is notoriously over sensitive to sample size (Tabachnick & Fidell, 1996). Skewness and kurtosis statistics for variables may be found in Appendix 7.4. Kurtosis is considered unimportant as sample size well exceeds 200, the number at which, according to Tabachnick and Fidell (1996) the effects of kurtosis on variance disappears. Tabachnick and Fidell (1996, p. 73) advised that “In a large sample, a variable with statistically significant skewness often does not deviate enough from normality to make a substantive difference in the analysis.” They also noted that “if all the variables are skewed to about the same moderate extent, improvements of analysis with transformation are often marginal” (p. 82).

The following process was used to handle both non-normality and also univariate and multivariate outliers. All main analyses were done twice (i.e., exploratory and confirmatory factor analyses, and the nomological network correlation matrix): first, with no transformation or outlier deletion and second, with non-normal variables transformed and univariate and multivariate outliers deleted. The results were then compared to determine if there were any substantive differences and whether transformation and outlier deletion were necessary. In the data cleaning process, all variables with a skewness statistic more than twice the standard error of skewness were, if negatively skewed, reflected, as advised by Tabachnick and Fidell (1996), and then all skewed variables were transformed using the square root function (skewness was slight to moderate in all cases). After re-running normality checks (skewness, kurtosis, box plots and normal Q-Q plots) to ensure the effectiveness of the transformations, univariate outliers (identified from box plots) and multivariate outliers for each scale (detected using Mahalanobis distances: χ^2 α set at .001, as advised by Tabachnick and Fidell) were deleted.

Then the confirmatory factor analyses (CFA) and the nomological network correlation matrix of the two conditions (i.e., cleaned and non-cleaned) were compared for substantive differences. For three scales (awareness, technological optimism, and democratisation) the cleaned data produced slightly improved CFA model fits on some indices, for the judgment scale the CFA fit indices remained the same and for the commercialisation and general attitude to GE scale the CFA fit was slightly poorer on some indices. However, none of these differences were substantive and both methods resulted in development of the same models. For the nomological network correlation matrix small differences were found, most usually at the third decimal place (indicating irrelevance of the data cleaning process to this analysis), but occasionally at the second decimal place. Of the six correlations (out of 39) that changed at the second decimal digit one increased by .03, two increased by .02, and three increased by .01. Due to the negligible differences resulting from transformation and outlier deletion (and the difficulty involved in interpreting transformed data); all analyses reported are conducted on untransformed data in which the outliers have been retained.

Validity

Content validity (the extent to which the content of an instrument is relevant to the construct or characteristic being measured) was assumed by the use of statements made by interviewees on the subject in Study 1 and by allocation of the items to the emergent themes and sub-themes of social responsibility (see Chapter 6, Study 1, Table 6.3, p. 215). One of the main foci of this study (Study 2) was on inferring construct validity in the new instruments. The construct validity of an instrument is the extent to which an instrument measures the theoretical construct that it was intended to measure (Anastasi, 1976; Borsboom, Mellenbergh, & Heerden, 2003). Construct validity is an elusive ideal and, as noted in Chapter 5, there is no *well accepted* statistic that accurately measures or describes construct validity (Smith, 2005a, 2005b). Numerous authors have noted that construct validation is an ongoing process never finished (Cronbach & Meehl, 1955; Maher & Gottesman, 2005; Smith, 2005a; Westen & Rosenthal, 2005).

For a psychological instrument to have construct validity, two main requirements must be met: reliability and homogeneity. Most authors have claimed the construct must be unidimensional or homogeneous (e.g., Costello & Osborne, 2005; Drewes, 2009; Gerbing & Anderson, 1988; Hattie, 1985; McDonald, 1981; Smith, McCarthy, & Zapolski, 2009). A two-step process consisting of exploratory and confirmatory factor analysis is recommended for developing unidimensional scales (Gerbing & Anderson, 1988). After a unidimensional scale has been developed it is subjected to reliability analysis. I shall return to a fuller discussion of unidimensionality after briefly discussing the second requirement that the instrument must be reliable (Anastasi, 1976; Nunnally, 1978).

Reliability

According to Anastasi, "reliability refers to the consistency of scores obtained by the same person when examined with the same test on different occasions, or with different sets of equivalent items" (p. 103). When using a single administration of an instrument (as is the case in the current work) by far the most common reliability index reported is Cronbach's coefficient alpha (Cronbach, 1951), which is a lower bound measure of reliability (Sijtsma, 2009a). That is, it underestimates the true reliability of an instrument (Sijtsma, 2009b).

Instrument reliability is a necessary but not sufficient condition for validity. According to classic reliability theory the upper limit of validity is the square root of the reliability of the criterion variable. The true relationship between a criterion and its predictor will be attenuated by unreliability in either instrument (Schmidt & Hunter, 1996; Schmitt, 1996). Some authors have suggested correcting for unreliability in predictor and criterion by dividing the observed correlation by the product of the square root of their reliabilities (Lord & Novick, 1968; Schmidt & Hunter, 1996; Schmitt, 1996).

Although some authors prefer a coefficient alpha approaching .90 (Aron & Aron, 1999), Nunnally (1978) recommended striving for an alpha higher than .70 for psychometric instruments. However, Nunnally suggested that, in the early stages of research and instrument development, an alpha of .60, or even as low as .50, may be adequate. Other authors have suggested alphas of .60 or higher are acceptable dependent on test use, item face validity and interpretability (Armor, 1974; Schmitt, 1996). Using the example of the commonly used .70 cut-off value, Schmitt (1996) warned against the dogmatic use of a particular cut-off value of alpha and made the crucial point that

> Even relatively low (e.g., .50) levels of criterion reliability do not seriously attenuate validity coefficients….Even with reliability as low as .49, the upper limit of validity is .70. When a measure has other desirable properties, such as meaningful content coverage of some domain and reasonable unidimensionality, this low reliability may not be a major impediment to its use. (Schmitt, 1996, pp. 350-352)

This point is important for the current research because the nomological network is essentially a series of 'validity coefficients' with correlations between construct measures and other constructs to which they are related and which they predict or are predicted by (also one of the new instruments has a low coefficient alpha of .57). Gerbing and Anderson (1988) recommended reliability analysis after CFA to ensure that factor subscale scores are not determined primarily by error measurement. Cronbach's coefficient alpha was used to measure reliability and the analysis conducted using SPSS 14.

Scale unidimensionality: Exploratory and confirmatory factor analysis

Scale unidimensionality. According to Drewes (2009, p. 259), "Unidimensionality is generally defined as the condition wherein a set of items measures the same latent attribute, trait, or psychological functioning." Hattie (1985, p. 49) claimed: "That a set of items forming an instrument all measure just one thing in common is a most critical and basic assumption of measurement theory."

The rationale for requiring unidimensionality is that a single composite score (e.g., summated, or mean of, items) composed of multiple dimensions is difficult to interpret and consequently that "construct validation/theory test has theoretical uncertainty built into it" (Smith, et al., 2009, p. 273). That is, the different dimensions in a multidimensional score may relate differently to the other constructs in a nomological network (Reise, Waller, & Comrey, 2000). In such a case it is impossible to tell what the contribution of each dimension of the composite score is to the other constructs, thus the use of a single composite multidimensional score may obscure predictive and/or causal relationships. As Smith et al. (2009, p. 277) explained: "Only measures of unidimensional constructs can lay claim to explaining psychological processes and hence to explaining possible causal activity."

Although coefficient alpha has commonly been used as an indicator of unidimensionality, as noted in the previous section on reliability, they are not the same thing (Cortina, 1993; S. B. Green, Lissitz, & Mulaik, 1977; Hattie, 1985; Schmitt, 1996). Currently, the most widely used methods of inferring scale unidimensionality are various types of exploratory and/or confirmatory factor analysis. In the early stages of scale development, exploratory factor analysis (EFA) is commonly used to assess dimensionality and refine the measure by item deletion to provide preliminary scales (e.g., Aupperle, 1984; Cohen, Pant, & Sharp, 1993; Singhapakdi, Vitell, Rallapalli, & Kraft, 1996).

Exploratory factor analysis. For EFA, Costello and Osborne (2005) recommended factor analysis rather than the more commonly used principal components analysis (PCA). They claimed that factor analysis better reflects the nature of the population, that is, factor analysis is considered to have greater external validity than PCA and be more generalisable to other samples and groups, as it does not inflate the variance estimates (Costello & Osborne, 2005). Of the six methods of factor analysis available in most statistical packages (such as SPSS and SAS), if the data are relatively normally distributed, Costello and Osborne claimed the most appropriate factor extraction method is *maximum likelihood* (ML) as it allows computation of goodness-of-fit indices. However, if the data are significantly non-normal, then the method of *principal axis factoring* (PAF) is more appropriate (Costello & Osborne, 2005; Fabrigar, Wegener, MacCallum, & Strahan, 1999). This method is also more commonly used.

Responses to items in all of the five new scales are significantly non-normal, in terms of significant results on the Kolomogorov-Smirnov test with the Lilliefors Significance Correction (although this statistic tends to reject normality with large sample sizes). Also, for almost all of the items, either the skewness statistic was more than twice the standard error of skewness, or the kurtosis statistic was more than twice the standard error of kurtosis, or both (see Appendix 7.4, Table A7.4.1). Therefore, PAF was used in the current study for the EFA to develop the preliminary scales.

The Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) was used to test whether the proposed set of scale items was factorable. Bartlett's (1950) test of sphericity, which uses the chi-square statistic to test the null hypothesis that the items in the population correlation matrix are uncorrelated (i.e., the correlation matrix is an identity matrix), was also considered, but rejected due to its extreme sensitivity to sample size (Tabachnick & Fidell, 1996). The KMO statistic is an index for comparing the magnitude of the observed correlation coefficients with the magnitudes of the partial correlation coefficients. It is based on the principle that the more common variance that is shared between the set of items the less the partial correlation between any two items (i.e., unique variance which the two items share). The KMO statistic has a range from 0.0 to 1.0. Kaiser (1974) recommended a minimum KMO value of .5 for a factorable set of items.

To determine the number of factors to retain for rotation in EFA, Cattell's (1966) scree test is considered effective (Costello & Osborne, 2005; Reise, et al., 2000) and was used in conjunction with eigenvalues and observation of the item-total correlation matrix. As any factor with an eigenvalue of less than 1.0 accounts for less variance than any individual item in the scale, factors with an eigenvalue of less than 1.0 were not considered. An oblique rotation (such as oblimin) is recommended rather than an orthoganol rotation as this allows correlation between the factors, a situation that is often the case in psychology (Costello & Osborne, 2005; Reise, et al., 2000). It also produces the same results as an orthoganol rotation, if the factors are truly uncorrelated. Therefore, in the current work, to develop preliminary scales, PAF factor analysis was used with oblimin rotation when more than 1 factor was extracted.

Some authors have recommended that to be retained in a scale the minimum loading of an item on to a factor should be at least .30 (e.g., Costello & Osborne, 2005), Tabachnick and Fidell (1996) suggested .32 (which means the item shares approximately 10% overlapping variance with other items in the factor), while other authors recommended a minimum loading of .40 (e.g., Churchill, 1979). However, Tabachnick and Fidell claimed, "Choice of the cut-off size of loadings to be interpreted is a matter of researcher preference" (Tabachnick & Fidell, 1996, p. 677). In the current work a midrange value of .35 was used as the minimum loading. This value was also used by Bottari, Dassa, Rainville, and Dutil (2009) in a recent factorial validity study. SPSS 14 was used to conduct the EFA.

Confirmatory factor analysis. However, Gerbing and Anderson (1988) claimed that the unidimensionality of the scale developed using EFA should then be assessed and refined using confirmatory factor analysis (CFA). They stated “confirmatory factor analysis affords a stricter interpretation of unidimensionality than can be provided by more traditional methods such as coefficient alpha, item-total correlations, and exploratory factor analysis” (p. 186), and “exploratory factor analysis can be a useful *preliminary* technique for scale construction but… a subsequent confirmatory analysis would be needed to evaluate, and likely refine, the resulting scales” (emphasis in original p. 189).

Amos 6 was used to conduct maximum likelihood CFA. Although questions have been raised regarding maximum likelihood CFA under the violation of multivariate normality, recent studies suggest that “ML [maximum likelihood CFA] seems to be quite robust against the violation of the normality assumption” (Schermelleh-Engel, Moosbrugger, & Muller, 2003, p. 26). Therefore, the items comprising the five new scales were tested for unidimensionality using maximum likelihood CFA to determine the goodness-of-fit of the items to a single latent variable (here referred to as a ‘Model’).

The most well known goodness-of-fit index is the chi-square statistic (a non-significant chi-square statistic indicates that the model fits the data). However, care must be taken when using the chi-square statistic to reject goodness-of-fit. It is well known that the significance of this statistic is very sensitive to large sample size and a number of authors caution against sole reliance on it for rejection of goodness-of-fit under such circumstances (Anderson & Gerbing, 1992; Bearden, Sharma, & Teel, 1982; Bentler & Bonett, 1980). Fortunately, there is a range of other indices available which provide descriptive criteria for goodness-of-fit evaluation (Schermelleh-Engel, et al., 2003). However, as debate exists around most of these indices regarding the effects of sample size or model complexity, and there is only rough consensus as to what value of the various indices constitutes a ‘good fit’, it is generally recommended that a range of fit indices be considered simultaneously (e.g., Schermelleh-Engel, et al., 2003; Wheaton, 1987).

Therefore, in addition to the chi-square statistic (χ^2), the following indices will all be considered: χ^2/df ratios, the goodness-of-fit index (GFI), the Tucker-Lewis coefficient (TLI, also known as the Bentler-Bonett non-normed fit index - NNFI), the comparative fit index (CFI), the root mean square residual index (RMR) and the root mean square error of approximation (RMSEA). The ratio of χ^2/df should be as small as possible for good model fit. Schermellah-Engel et al. (2003, p. 33) claimed that although “there exist no absolute standards, a ratio between 2 and 3 is indicative of a "good" or "acceptable" data-model fit, respectively”. For the GFI, TLI and CFI indices a value of 1.0 represents a perfect fit. A GFI of .95 is considered a good fit and values greater than .90 are considered acceptable (Schermelleh-Engel, et al., 2003). As a rule of thumb, Bentler and Bonett (1980) suggested CFI and TLI indices above .90 indicate acceptable fit.

The root mean square residual index (RMR) and the root mean square error of approximation (RMSEA) are indices for which 0 represents a perfect fit. The rule of thumb for these indices is the smaller the better – values less than or equal to .05 indicate a good fit on the RMSEA, values between .05 and .08 an adequate fit and values greater than .10 are not acceptable, while the acceptable upper limit of the RMR is difficult to determine and "depends on the sizes of the variances and covariances of the observed variables" (Schermelleh-Engel, et al., 2003, p. 38). Currently, the goodness-of-fit index conventions are poorly established. Academic debate is ongoing as to exactly which are the best indices and what cut-off values constitutes good fit under CFA (Hu & Bentler, 1999; Schermelleh-Engel, et al., 2003), and hence the unidimensionality of a scale. And, as we shall also see, the indices are not always congruent with one another; suggesting lack of reliability and raising questions about their validity. Arbitrary cut-off values add to the dubious nature of these indices. Recall both Hattie (1985) and Segars (1997) claimed there were *no effective indices of the unidimensionality* of a set of items.

Sample and holdout sample. Technically, CFA should be performed on a second independent cross-validation sample (Schermelleh-Engel, et al., 2003). In the current study, because of the reasonably large sample size (in relation to factor analysis) it was possible to divide the sample into two random halves, conduct EFA on the first half and then CFA on the second half (the hold-out cross-validation sample). With 366 cases in each sample, the samples easily meet the rule of thumb requirements of a subject to item ratio of 1:10 for factor analysis (Costello & Osborne, 2005) or "*at least 300 cases for factor analysis*" (Tabachnick & Fidell, 1996, p. 640). This two step EFA-CFA process was followed in the development of the current instruments. Table 7.3 presents a comparison of descriptive statistics for the EFA sample and the CFA sample. The original data set was divided in two by taking every second case in the data file (i.e., every second respondent) for the CFA data set.

Table 7.3.

Comparison of Descriptive Statistics: EFA Sample and CFA Sample

Demographic	EFA Sample	CFA Sample
n	366	366
Mean Age	40.6 years	41.7 years
Gender	42.6% female	39.9% female
Ethnicity		
NZ Euro	73%	72.7%
Maori	2.2%	.5%
Pacific Islander	.3%	.5%
Asian	5.7%	5.5%
Other	17.2%	17.8
Religion		
No religion	53.3%	48.9%
Christian	36.6%	41.0%
Buddhist	.8%	.8%
Muslim	.8%	.5%
Jewish	.8%	-
Hindu	-	1.4%
Other	5.7%	5.5%
Employer		
AgResearch	40.2%	42.6%
HortResearch	21.3%	15.8%
Crop and Food	11.5%	10.4%
Landcare	8.7%	9.8%
Environmental Science Research	9.0%	8.5%
Industrial Research Limited	8.7%	12.3%
Highest qualification		
Diploma/certificate	7.7%	7.7%
Bachelors degree	23%	19.7%
Masters degree	19.7%	22.7%
Doctorate	45.9%	45.1%
Other	3.3%	4.1%

Overall the two sets look as comparable as can be expected from a random division and they function as two independent samples from a single population.

Questionnaire and Existing Measures

Questionnaire

The 149 item web-based survey consisted of 106 items that are part of the current research: 11 items collected demographic material, six items were designed to collect information about attitudes to democratisation of science, nine items were designed to collect information about attitudes to the commercialisation of science, 10 items were designed to collect information about scientists' awareness of the social responsibility of science to society, 10 items were designed to collect information about scientists' judgments about personal actions to enhance their social responsibility in research, five items were designed to collect information about attitudes to technological optimism, 16 items collected information on attitudes to GE, and 37 items were from the Schwartz Value Survey. The specific measures are discussed in detail below.

In the questionnaire, all instruments which used Likert scales were scored: 1 = *strongly disagree, 3= neutral,* to 5 = *strongly agree*. However, in four of the new research instruments using Likert scales (i.e., democratisation of science, commercialisation of science, moral awareness and technological optimism) some question items were reverse worded with respect to the scale direction. For the analyses of these instruments (i.e., reliability, factorial dimensionality, and validity), reverse worded items in instruments were reverse coded in order to give them the same directionality as the other items in the instrument.

Schwartz value survey

General values were measured with items from the Schwartz value survey as shown in Table 7.4. Not all of the 56 items of the instrument were used due to space constraints in the questionnaire. Following Schultz and Zelezny (1998, 1999), 37 items were selected. They provided the following justification for selection of these items:

> Items were selected based on the empirical locations of each value in regions generated from a series of smallest space analyses reported by Schwartz (1994). We selected the four items with the greatest frequency of occurrence in each of the ten primary regions; the selected items were those that emerged most often in the appropriate value-type region in 97 independent samples from 44 countries. (1999, p. 259)

However, for one value type (universalism) two of the four items used in the current study differ from the items used by Schultz and Zelezny (1998, 1999). Schultz and Zelezny used four of the original nine items from the universalism scale: protecting the environment, a world of beauty, unity with nature, and broad-minded. In the current study, a world of beauty and broad-minded were replaced with two of the other nine original Schwartz items: social justice, and a world at peace. The reason for swapping these items was that they are more congruent with the two areas of primary concern regarding the impacts of Promethean science and technology on Gaia elucidated in Chapter 1. These concerns were the natural environment and social justice. Note that the two items used by Schultz and Zelezny, although not used, were also collected in the current work. The two four-item scales (i.e., the four items used by Schultz and Zelezny and the four items used in the current work) had a correlation of .98.

Table 7.4.

Higher Order Value Dimensions, Value Types, Value Items and Alpha

4 Higher order value dimensions	Alpha[a]	10 Value types	37 Value items
Self-transcendence (Trans)	.82	Universalism	Protecting the environment, Unity with nature, Social justice, A world of peace.
		Benevolence	Helpful, Honest, Forgiving, Loyal.
Self-enhancement (Enhan)	.80	Power	Social power, Authority, Wealth, Preserving my public image.
		Achievement	Successful, Capable, Ambitious, Influential.
Openness to change (Opn)	.84	Self-direction	Creativity, Curious, Freedom, Choosing own goals.
		Stimulation	Daring, A varied life, An exciting life.
		Hedonism	Pleasure, Enjoying life.
Conservation (Con)	.84	Tradition	Devout, Respect for tradition, Humble, Moderate.
		Conformity	Politeness, Honouring parents and elders, Obedient, Self-discipline.
		Security	Clean, National security, Social order, Family security.

Notes. [a]Cronbach's coefficient alpha for the higher order value dimensions.

Following the instructions of Schwartz (1992), respondents were asked to rate each of the value-items 'as a guiding principle in my life' from -1 = *opposed to my values*, 0 = *not important*, 2 = *important*, 4 = *very important* to 5 = *of supreme importance*. Note that Schwartz used a 9-point scale (-1 to 7) rather than the 7-point scale used here. Scores for value types were calculated by taking the mean of responses. As recommended by Schwartz, scores for the four higher order value dimensions were calculated by taking the mean of all items in the value types comprising the higher order dimension. The value types comprising each of the four higher order value dimensions and the value items comprising the value types can be found in Table 7.4.

As the hypotheses forming the nomological network use only the higher order value dimensions, only data regarding these dimensions are reported here. Although the Schwartz value types and higher order value dimensions are claimed to be cross-culturally and universally valid, because a subset of values was used in the current study (however, note, as explained above, these subsets have been used in previous studies), confirmatory factor analysis was conducted to examine the factor structure of the higher order dimensions. As this was not a new instrument, and was developed on samples independent of the current one, EFA was not required and the CFA analysis could be conducted on the whole sample (N = 733) rather than just the holdout sample.

The value type scores (means of the value type) were used as the variables for the higher order Schwartz value dimensions. Table 7.5 presents the fit statistics for the higher order Schwartz value dimension model. The chi-square statistic is significant at the .001 level indicating rejection of fit. As previously noted this statistic is very sensitive to sample size and should not be entirely relied on in such situations. The GFI, RMR and CFI indices indicate a reasonable fit while the χ^2/df, TLI, and RMSEA indices suggest a poor fit. The incongruity of the results from these indices (which are all supposed to measure unidimensionality) not only raises question about the scale, but also raises doubts as to the validity and practicality of the indices and cut-off points themselves.

Table 7.5.

CFA Results for Schwartz Value Survey Higher-Order Dimensions (N = 733)

Model	χ^2	*df*	χ^2/df	GFI	TLI	CFI	RMR	RMSEA [90% CI]
4 Higher order factors	298.52 ($p < .001$)	28	10.7	.93	.86	.91	.04	.11 [.103, .127]

The path diagram is presented in Figure 7.1. Note that the diagram includes a path between the achievement value type and the higher order dimension openness to change; this modification considerably improved the fit. However it leads to a concern about the self-enhancement dimension.

In Figure 7.1 the values on the path arrows from the factor (i.e., the unobserved variable) to the observed variables (i.e., value types) represent the correlations between the items and the factor (i.e., factor loading). The values beside the observed variable boxes represent the squared factor loadings on the items (i.e., the percentage of variance of each item explained by the factor). As can be seen from Figure 7.1, the intercorrelations amongst the four higher order dimensions were reasonably high between adjacent dimensions (range: .37 to .57) and lower between opposing dimensions (i.e., .03 and .26), as would be expected from Schwartz's theory (see Figure 3.2, Chapter 3, p. 76).

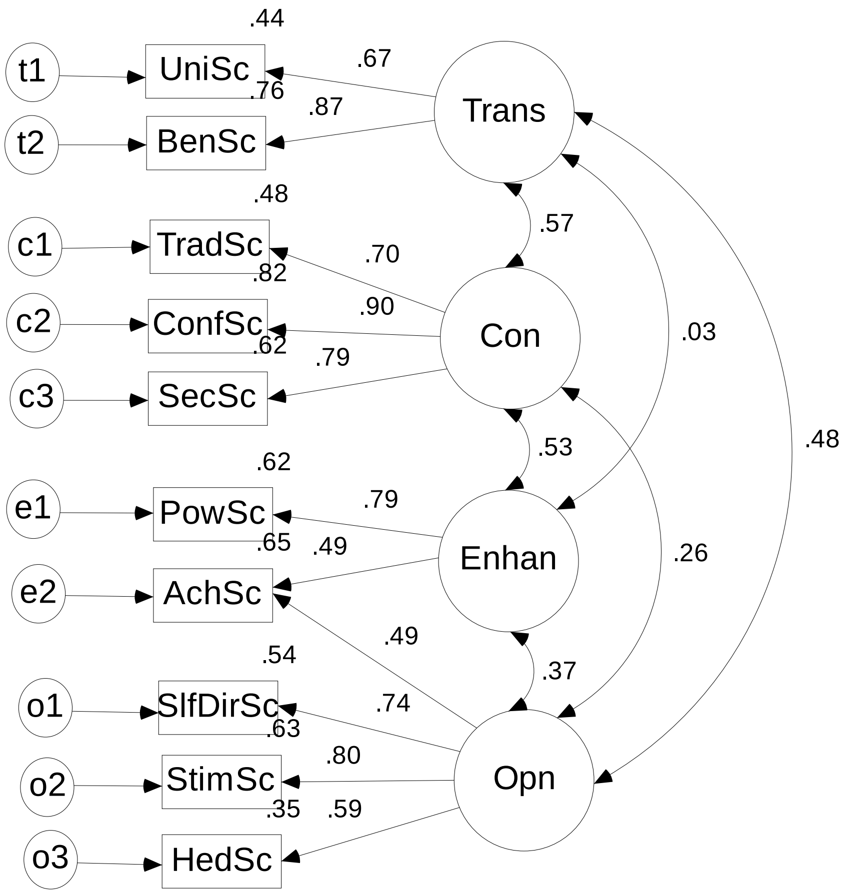

Figure 7.1. CFA path diagram for Schwartz higher-order value dimensions.

Coefficient alpha reliabilities for the higher order value dimensions (calculated using all the items from the relevant value types) can be found in Table 7.4. The reliabilities of all the four higher order value dimensions were good. Despite the reservations regarding the higher order value dimension of self-enhancement (which needs to be considered in interpreting the results), as an integral part of the research design, and, in particular, given the voluminous research supporting this instrument, less than perfect results from a single study should be considered with caution. Therefore, the Schwartz higher order value dimensions were used as part of the nomological network to help establish construct validity in the new instruments and the theoretical relationships between the constructs.

General attitude to genetic engineering

The second existing research instrument is a scale developed by Small, Parminter and Fisher (2005) on a sample of the New Zealand public (N = 842). This 11 item instrument measures general attitude to genetic engineering (GE). In the current work, the instrument was adapted a little: only nine of the items were used for reasons that will be explained below. All items were measured using a 5 point Likert scale (1 = *strongly disagree*, 5 = *strongly agree*), however, for these items, respondents also had the opportunity to answer 'don't know' (the reason for this is to make the data in the scientists' survey comparable to the public survey data). 'Don't know' responses in the attitude to GE instrument are treated as missing cases and are listwise deleted in all analyses. Of the 733 respondents, 549 responded to all nine GE items. Thus, in the nomological network analysis, all correlations of instruments with the attitude to GE instrument have a sample size of approximately 549.

The original Small et al. (2005) instrument consisted of four subscales: deontological moral values regarding GE (here referred to as *intrinsic values regarding GE*, or for brevity, *intrinsic values*); teleological beliefs about the (moral) consequences of GE (here referred to as *beliefs about the extrinsic moral consequences of GE*, or for brevity, *extrinsic beliefs*), trust in authorities responsible for GE (*trust*), and perception of social consensus regarding GE (*social consensus*). Although the subscales comprising general attitude to GE represent conceptually distinct constructs, Small et al. (2005) reported that they were all highly intercorrelated (rs ranging from .60 to .76, p <.001 for all correlations). Coefficient alphas for the four subscales were reported as ranging from .72 to .93, while alpha for all 11 items was reported as .93. They reported that factor analysis of the 11 item instrument yielded a single factor with an eigenvalue greater than 1, thus indicating a single general factor underlying all items. Small et al. reported that the general attitude to GE scale accounted for 61% of the variance of a concurrent criterion: intention to purchase a specific GE milk product. The general attitude to GE instrument was further tested on an independent sample of the New Zealand public with similar results to those reported above (Ah Yuk-Winters, 2009).

However, one subscale, 'perception of social consensus regarding GE' is not strictly an attitude. The general attitude to GE instrument was originally designed to predict behavioural intentions about GE (i.e., intention to purchase a GE product) and is based on the Fishbein and Ajzen (1975) theory of planned behaviour/reasoned action. In this theory, attitude towards the value object, and perception of the social norms of relevant others regarding the value object, are considered to influence the behavioural intention of the agent. Because it is not an attitude of the agent, in the current work, the perception of social consensus subscale was deleted from the general attitude to GE instrument. Therefore, the general attitude to GE instrument comprised three subscales (intrinsic values, extrinsic beliefs and trust in responsible authorities) with three items each, giving a total of nine items in the instrument. The instrument items (including descriptive statistics) and subscales, along with coefficient alpha for each subscale for the scientists' sample are presented in Table 7.6.

Table 7.6.

General Attitude to GE, subscales and items (n = 549)

Subscale	Alpha[a]	Item	*M* (*SD*)	95% CI
Intrinsic values	.90	GE fits with my cultural and spiritual beliefs.	3.52 (1.06)	[3.43, 3.61]
		GE fits with my moral principles.	3.60 (1.03)	[3.51, 3.69]
		It is acceptable to GE animals for human benefit.	3.53 (1.11)	[3.44, 3.62]
Extrinsic beliefs	.82	GE will help cure the world's major diseases.	3.48 (1.00)	[3.40, 3.57]
		GE will help solve the world's food problems.	3.11 (1.14)	[3.02, 3.21]
		GE products are environmentally friendly.	2.94 (.97)	[2.86, 3.02]
Trust in responsible authorities	.79	I trust the regulatory authorities about GE.	3.07 (.98)	[2.99, 3.15]
		I trust scientists about GE.	3.42 (.92)	[3.34, 3.50]
		I trust companies about GE.	2.26 (.91)	[2.19, 2.34]

Notes. Response scale: 1= *strongly disagree*, 3 = *neutral*, 5 = *strongly agree*, 6 = *don't know*. All cases where participant responded 'don't know' to any of the 9 items were listwise deleted from analysis reducing sample size from 733 to 549.
[a]Coefficient alpha for subscales.

The mean of the intrinsic value subscale was 3.55 (*SD* = .97), 95% CI [3.47, 3.63]; the mean of the extrinsic belief scale was 3.18 (*SD* = .88), 95% CI [3.10, 3.25], and for the trust in responsible authorities scale the mean was 2.92 (*SD* = .79), 95% CI [2.85, 2.98]. The mean score for the overall general attitude to GE scale for the scientists' sample was 3.22 (*SD* = .76), 95% CI [3.15, 3.28], indicating that, overall, they had a moderately favourable attitude to GE.

Because this was an established instrument developed on a sample independent of the current study, the CFA analysis was conducted on the whole sample, with cases which had 'missing items' (i.e., true missing and 'don't know' responses) listwise deleted from analyses (leaving an *n* of 549). Although Small et al. (2005) treated the scale as a single factor model (Model 1: a single latent factor underlying all the observed variables), two slightly different but equally valid approaches are: 1) to treat each subscale as a factor: three latent factors underlying the nine observed variables (Model 2) or, 2) to use the means of the sub-scales as variables (thus increasing variable reliability): one latent factor with three observed variables, each variable comprising three items (Model 3). These three different models were tested using CFA to determine which model had the best goodness-of-fit characteristics. Goodness-of-fit indices for the three models are presented in Table 7.7.

As can be seen from Table 7.7, despite the 9 item instrument having a coefficient alpha of .91, Model 1 is a poor fit on all indices. Model 2 still performs poorly on the chi-square, the χ^2/df and the RMSEA indices, but performs adequately on the other fit indices. Model 3 also performs poorly on the chi-square, the χ^2/df and the RMSEA indices but performs very well on the GFI, TLI and RMR. Overall, Model 3 performs best on the fit indices.

Table 7.7.

CFA Results for General Attitude to GE Instrument (n=549)

Model	χ^2	*df*	χ^2/df	GFI	TLI	CFI	RMR	RMSEA [90% CI]
Model1 (1 factor 9 variables)	715.3 ($p < .001$)	27	26.5	.74	.70	.78	.09	.216 [.203, .230]
Model 2 (3 factors 9 variables)	190.9 ($p = .001$)	24	7.96	.93	.92	.95	.06	.113 [.029, .119]
Model 3 (1 factor, 3 variables)	13.04 ($p < .001$)	1	13.0	.99	.94	.98	.05	.149 [.084, .225]

However, again note the inconsistent results of the goodness-of-fit indices, supposedly all measuring unidimensionality. Model 3, having only a single factor (i.e., being unidimensional) also makes for a simpler nomological network analysis. The path diagram for Model 3 is presented in Figure 7.2.

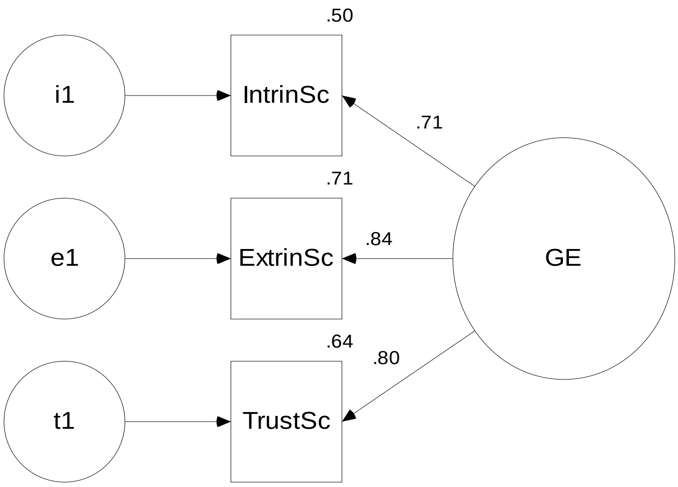

Figure 7.2. CFA path diagram for attitude to GE instrument.

Coefficient alphas for the three subscales were: intrinsic value subscale = .90, extrinsic belief subscale = .82, and trust subscale = .79. Small et al. (2005) report similar coefficient alphas for these scales. Using the three subscale means as variables in a higher order factor scale (general attitude to GE) returned a coefficient alpha of .83 for the general attitude to GE instrument. Due to its superior performance on the fit indices, and good reliability, Model 3 (i.e., the means of each of the three subscales treated as variables of the general attitude to GE scale) will be used as the concurrent criterion for inferring construct validity in the five new instruments in the nomological network. Because some of the fit indices are not particularly good (i.e., the χ^2 the χ^2/df and the RMSEA) caution must be expressed regarding the results of analyses using the GE instrument.

Results and Discussion

First, the psychometric properties of the five new instruments are examined using the two-step EFA-CFA process described in the Method section of this chapter. Descriptive statistics for instrument items are presented for the interested reader. However, they receive minimal discussion as the primary focus is on the instruments' psychometric properties and the samples' responses to the instruments. Next is a brief comparison between the attitudes of the New Zealand public and the current science sample to a particular Promethean technology, genetic engineering. Finally, the nomological network with its 39 hypothesised relationships designed to infer construct validity to the new instruments is examined.

Democratisation of science scale

Six items measured scientists' attitudes to democratisation of science (see Table 7.8). These items were derived from the qualitative study, reported previously, by Small and Mallon (2006). The process used to extract suitable items from the interview data was the same as that described in Chapter 6 (Study 1) used to derive items for the moral awareness and moral judgment instruments. The attitude to democratisation of science instrument used a 5-point Likert response scale (see Appendix 7.1). All democratisation items received responses across the full range (1-5).

After reverse coding items D4, D5, D6, in order to give all items the same directionality, an exploratory PAF analysis with oblimin rotation and missing values listwise deleted was conducted on the six proposed items using the EFA data set. The KMO MSA statistic was .78, within an appropriate range for assumption of factorability (Coakes, Steed, & Dzidic, 2006). The KMO values of the individual items in the scale (data from the anti-image correlation matrix) for the democratisation items were all above .5, ranging from .74 to .85 indicating that all items are acceptable for inclusion in the instrument (Coakes, et al., 2006). Examination of eigenvalues and the scree plot (see Fig. 7.3) indicated a one factor solution with an eigenvalue of 2.57, accounting for 42.78% of the variance.

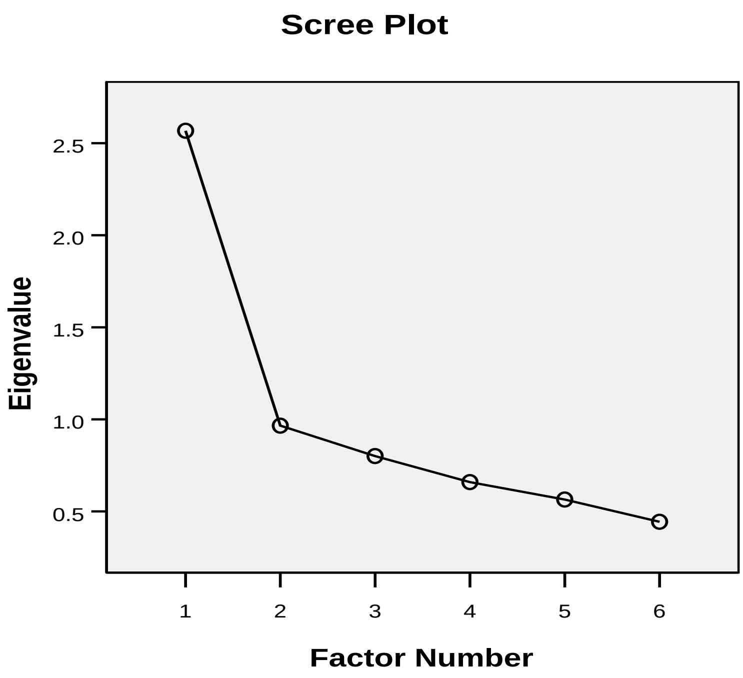

Figure 7.3. Democratisation scree plot.

Descriptive statistics and factor loadings (the correlation of the item with the factor) for the democratisation items are given in Table 7.8. Item D3 was the only item that did not meet the factor loading requirement of .35. Therefore, item D3 was deleted from the scale. The EFA suggested a one factor model of democratisation comprising five items D1, D2, D4, D5 and D6.

Table 7.8

Democratisation Items: Factor Loadings and Descriptive Statistics [a]

No	Item	Factor Loading	*M* (*SD*)	95% CI
D1	The science community has a duty to consult and dialogue with the public regarding the directions of science.	**.50**	4.02 (.83)	[3.96, 4.08]
D2	The public has a right to influence the amount of funding that is directed to different areas of research.	**.53**	3.30 (.95)	[3.23, 3.37]
D3	Science should respect and act within the mores of society	.31	3.98 (.84)	[3.92, 4.04]
D4[b]	The public lack the necessary scientific literacy to properly participate in setting the scientific research agenda.	**.71**	3.54 (.97)	[3.47, 3.61]
D5[b]	Public participation in setting the research agenda should be limited to issues regarding culture, spirituality and ethics.	**.55**	2.84 (1.04)	[2.77, 2.92]
D6[b]	Giving the public a significant public role in setting the science agenda will impede scientific progress.	**.73**	3.43 (1.03)	[3.35, 3.50]

Note. EFA data set, n = 366. Extraction method: Principal axis factoring. 1 factor extracted, missing cases listwise deleted. Factor loadings > .34 are in boldface. CI = confidence interval.

[a]Descriptive statistics (*M*, *SD*, and 95% CI) are for whole sample (N = 722, listwise deletion of missing cases). [b]For the factor analyses these items **were reverse coded** to maintain scale directionality. However, for item descriptive statistics (i.e., *M*, *SD*, CI), in the above table, these items **have not been reverse coded** so that the statistics remains consistent with the direction of the response scale: 1= *strongly disagree*, 3 = *neutral*, 5 = *strongly agree*.

Confirmatory factor analysis was then conducted on this model. The proposed one factor model performed very well on all the goodness-of-fit indices (see Table 7.9) including the chi-square statistic which had a p value larger than .05 (a non-significant chi-square statistic indicates that the model fits the data). The χ^2/df ratio was close to 2 and the GFI, TLI, and CFI indices are all very close to 1 (within the recommended good fit values), and the RMR and RMSEA indices are both acceptable.

Table 7.9

CFA Results for Democratisation Instrument (n=366)

Model	χ^2	*df*	χ^2/df	GFI	TLI	CFI	RMR	RMSEA [90% CI]
One factor, 5 items	11.04 (p = .051)	5	2.21	.99	.97	.98	.03	.06 [.000, .104]

Figure 7.4 presents the path model for the five-item democratisation instrument. Coefficient alpha for the five item democratisation scale was a reasonable .74 (for the entire data set, *N*=733). The five-item democratisation scale was used in the nomological network analysis.

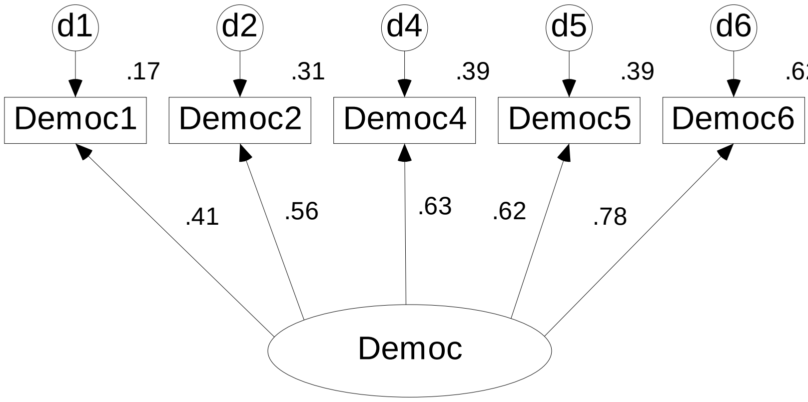

Figure 7.4. CFA path diagram for democratisation instrument.

Commercialisation of science scale

Nine items measured scientists' attitudes to commercialisation of science (see Table 7.10). These items were derived from the qualitative study reported by Small and Mallon (2006). The process used to extract suitable items from the interview data was the same as described in Chapter 6 (Study 1) to derive items for the awareness and judgment instruments. The attitude to commercialisation of science instrument used a 5-point Likert response scale. All items received responses across the full range.

Using the EFA data set an exploratory PAF analysis, with oblimin rotation and missing values listwise deleted, was conducted on the nine proposed items. The KMO MSA statistic was .85, within an appropriate range for assumption of factorability. Measures of sampling adequacy (MSA – from the anti-image correlation matrix) for the commercialisation items were all above .5 ranging from .80 to .90 indicating that all items are acceptable for inclusion in the instrument.
The analysis yielded two factors with an eigenvalue greater than 1. Factor 1 had an eigenvalue of 3.84 and accounted for 42.63% of the variance, while factor 2 had an eigenvalue of 1.11 accounting for 12.28% of the variance.

Table 7.10.

Commercialisation Items: Factor Loadings and Descriptive Statistics[a]

No.	Item	Factor loading	M (SD)	95% CI
C1	Commercialisation has had a positive effect on scientific progress.	.75	2.78 (1.06)	[2.70, 2.85]
C2[b]	Commercialisation inhibits the production of public good science	.67	3.58 (1.02)	[3.50, 3.65]
C3	Commercialisation increases transparency and public participation in science.	.59	2.46 (1.02)	[2.39, 2.54]
C4[b]	Commercialisation reduces public trust in science and scientists.	.60	3.52 (1.02)	[3.44, 3.59]
C5[b]	Commercialisation promotes the profit imperative at the expense of the precautionary principle.	.48	3.72 (.91)	[3.65, 3.79]
C6[b]	Commercialisation increases the probability of ethical misconduct by scientists.	52	3.23 (1.08)	[3.15, 3.31]
C7	Commercialisation enhances the free flow of scientific knowledge.	.52	2.10 (1.12)	[2.02, 2.19]
C8[b]	Commercialisation has been detrimental to scientists' working conditions.	.61	3.36 (1.05)	[3.29, 3.44]
C9	Commercialisation increases scientific innovation	.60	2.85 (1.05)	[2.77, 2.93]

Notes. EFA data set (n = 366). Extraction method: Principal axis factoring, 1 factor extraction, missing cases listwise deleted, factor loadings > .34 are in boldface. CI = confidence interval.

[a]Descriptive statistics (*M*, *SD* and 95% CI) are for whole sample (N = 712, listwise deletion of missing values). [b]For the factor analyses these items **were reverse coded** to maintain scale directionality. However, for item descriptive statistics (i.e., *M*, *SD*, CI), in the above table, these items **have not been reverse coded** so that the statistics remains consistent with the direction of the response scale: 1= *strongly disagree*, 3 = *neutral*, 5 = *strongly agree*.

However, the scree plot suggested a single factor solution (see Figure 7.5). Therefore, a one factor forced extraction was also performed. The one factor extraction produced a factor matrix in which all items met the .35 loading criterion (see Table 7.10 above).

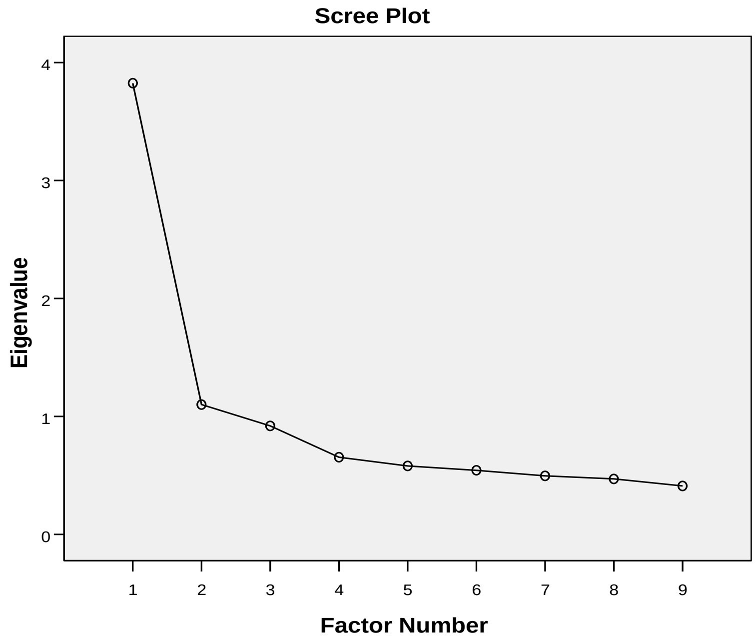

Figure 7.5. Commercialisation scree plot.

Therefore, all 9 items were taken forward for testing and refinement using maximum likelihood CFA. The nine item scale performed adequately on four of the seven fit indices, but poorly on the other three. However, by deleting items 4, 5 and 6, an improved six-item, single factor model was found. The values for all fit indices for this model represent an excellent fit, suggesting a unidimensional scale. The goodness-of-fit indices for this model are presented in Table 7.11.

Table 7.11.

CFA Results for Commercialisation Instrument (n = 366)

Model	χ^2	*df*	χ^2/df	GFI	TLI	CFI	RMR	RMSEA [90% CI]
1 factor, 6 items	15.25 (*p* = .08)	9	1.7	.99	.98	.99	.03	.04 [.000, .080]

Figure 7.6 presents the path model. Coefficient alpha for the whole sample was a healthy .80 for the six item single factor instrument. This instrument was used to represent the construct of attitude to commercialisation of science in the nomological network analysis.

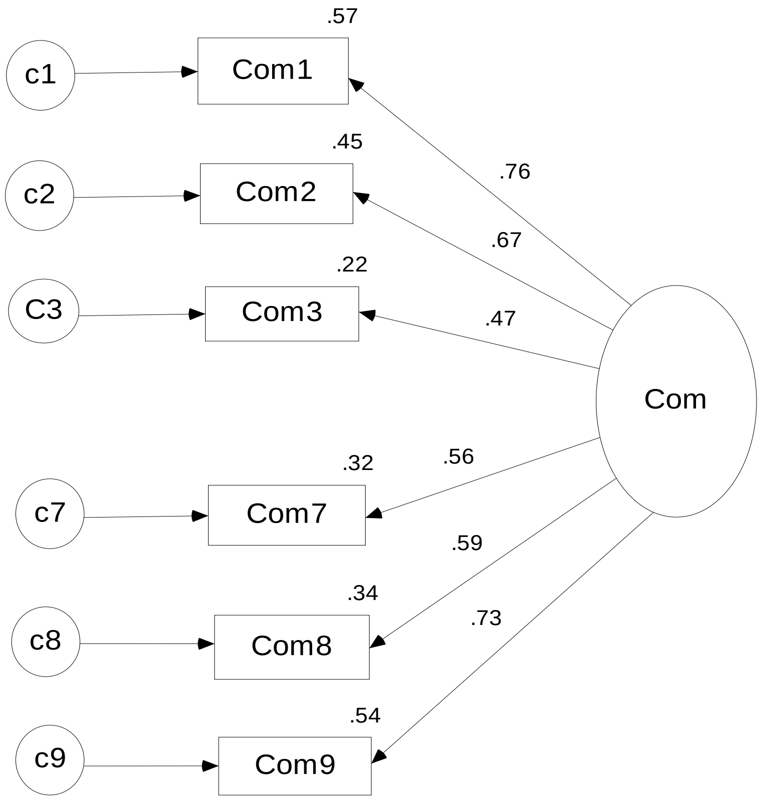

Figure 7.6. CFA path diagram for commercialisation.

Technological optimism scale

Five items were proposed to measure scientists' degree of technological optimism. These items were proposed on the basis of the theoretical construct as discussed in the literature and reported in Chapter 3 of the current work. The attitude to technological optimism instrument used a 5-point Likert response scale (see Appendix 7.1). All technological optimism items received responses across the full range (1-5).

Using the EFA data set an exploratory PAF analysis, with oblimin rotation and missing values listwise deleted, was conducted on the five proposed items. The KMO MSA was .64, just adequate for assumption of factorability. Measures of sampling adequacy (MSA – from the anti-image correlation matrix) for the technological optimism items were all above .5, ranging from .52 to .64, indicating that all items are acceptable for inclusion in the instrument. The analysis yielded two factors with an eigenvalue greater than 1. Factor 1 had an eigenvalue of 1.87 and accounted for 37.40% of the variance while factor 2 had an eigenvalue of 1.04 accounting for 20.76% of the variance.

After oblimin rotation, the pattern matrix showed that item T5 (M = 1.56, 95% CI [1.49, 1.62]) loaded very poorly on Factor 1 (-.01) and Factor 2 (.10), so this item was dropped from further analysis and the EFA rerun with items T1 to

T4. The KMO MSA statistic (.64) again indicated the correlation matrix was just adequate for assumption of factorability. This time a single factor was found with an eigenvalue of 1.86 accounting for 46.45% of the variance. The scree plot for the four items is presented in Figure 7.7.

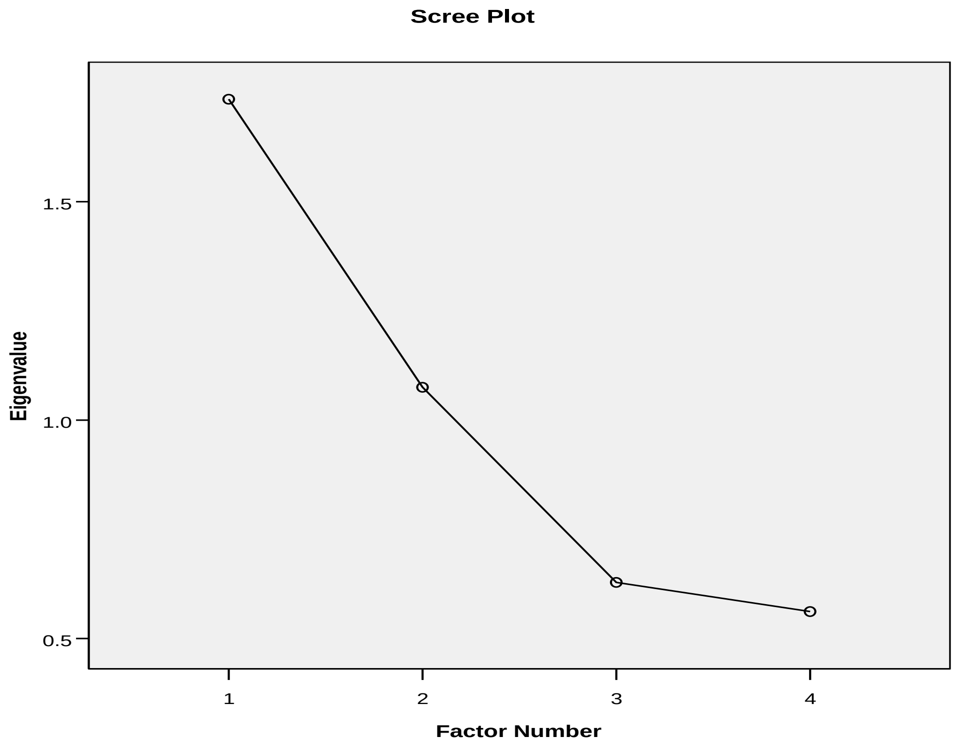

Figure 7.7. Technological optimism factor scree plot.

Items T2 (factor loading = .41, *M* = 3.82, 95% CI [3.74, 3.89]), T3 (factor loading = .72, *M* = 3.04, [2.96, 3.13]) and item T4 (factor loading = .69, *M* = 3.04, 95% CI [2.97, 3.12) reached the cut-off criterion, however, item T1 (factor loading .32, *M* = 2.13, 95% [2.05, 2.20]) did not reach the .35 criterion and was deleted from the scale. Thus, a three item model emerged from the EFA data set.

Next, the 3 item technological optimism model was analysed using maximum likelihood CFA on the holdout sample. Goodness-of-fit indices for the technological optimism instrument are presented in Table 7.12. Clearly, the instrument does not perform well on most of these fit indices.

Table 7.12.

CFA Results for Technological Optimism Instrument (n = 366)

Model	χ^2	*df*	χ^2/df	GFI	TLI	CFI	RMR	RMSEA [90% CI]
Model 1, 1 factor	15.2 ($p < .001$)	1	15.2	.97	.43	.81	.09	.19 [.118, .290]

The only index on which it performed well was the goodness-of-fit index (GFI). Figure 7.8 presents the path diagram for the technological optimism instrument.

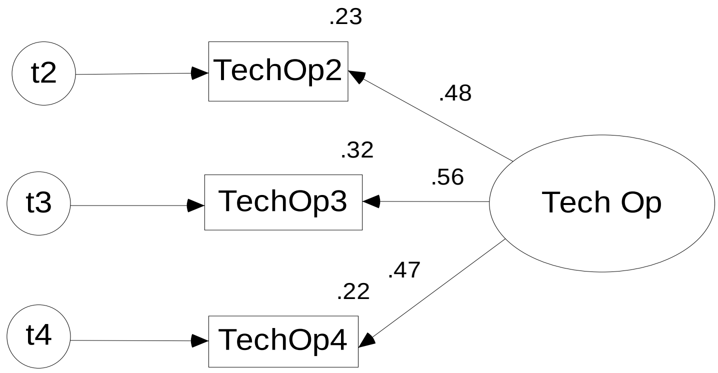

Figure 7.8. CFA path diagram for technological optimism instrument.

As can be observed from the path diagram, all items reached the .35 criterion. Further improvements in the scale were not possible. Coefficient alpha for the three item scale (.57) was calculated for the whole sample (N = 733). Clearly, this instrument has relatively poor psychometric properties. While many authors would consider reliabilities between .5 and .6 as unacceptably low, some authors (e.g., Armor, 1974; Nunnally, 1978; Schmitt, 1996) have claimed that reliabilities at this level are adequate for an early stage research instrument. Therefore, taking into account the above data it was decided to use the three item instrument for testing the nomological network. However, it must be noted that, due to its poor psychometric qualities, any hypotheses or relationships investigated must be considered provisional and treated with caution.

Scientists' attitudes to social responsibility scales

Two measures of attitudes to scientific social responsibility were developed. The first, *moral awareness*, was designed to measure scientists' awareness of the social and moral responsibilities of science to society. The second, *moral judgment*, was designed to measure scientists' judgments regarding personal actions believed to enhance social and moral responsibility in research. Items for these instruments were developed in Study 1 (reported in Chapter 6).

Awareness of science-society moral issues

Ten items were proposed to measure this construct (see Table 7.13). Additionally, because item D3, 'science should respect and act within the mores of society' (which was deleted from the democratisation scale), has a conceptual similarity to the awareness construct, it was included in this analysis, making a total of 11 items. The awareness of responsibility of science to society instrument used a 5-point Likert response scale. All awareness items received responses across the full range (1-5).

First, using the EFA data set, an exploratory PAF analysis with missing values listwise deleted and oblimin rotation was conducted on the 11 items. The KMO statistic was .74, within an appropriate range for assumption of factorability. Measures of sampling adequacy (MSA – from the anti-image correlation matrix) for the awareness items were all above .5 ranging from .63 to .86 indicating that all items are acceptable for inclusion in the analysis.

The analysis yielded three factors with an eigenvalue greater than 1. Factor 1 had an eigenvalue of 2.90, accounting for 26.36% of the variance and Factor 2 had an eigenvalue of 1.31, accounting for 11.94% of the variance, while Factor 3 had an eigenvalue of 1.14 accounting for 10.37% of the variance. However, examination of the scree plot (see Figure 7.9) suggested a one factor solution.

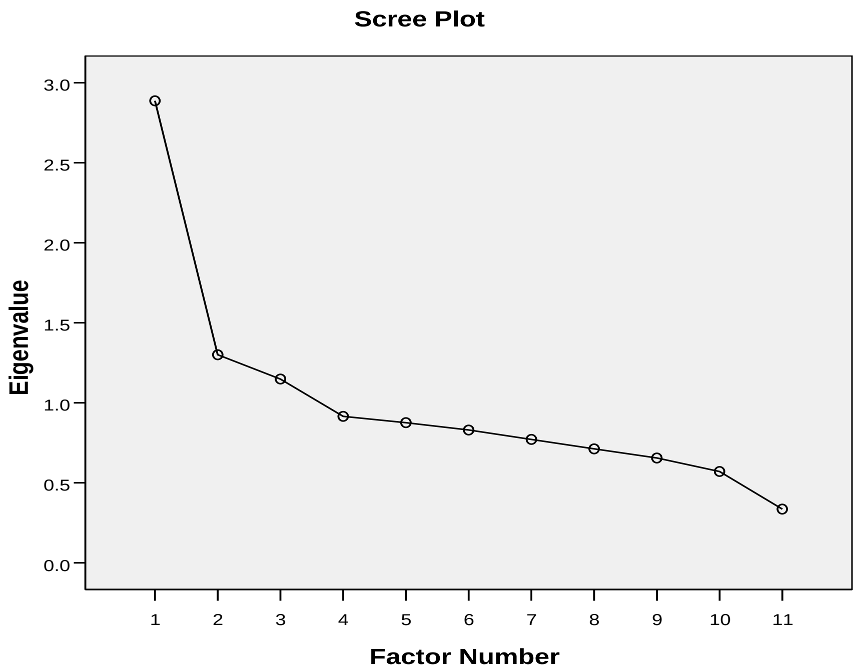

Figure 7.9. Awareness scree plot.

When the factor structure is ambiguous, as in this case, some authors (e.g., Costello & Osborne, 2005; Tabachnick & Fidell, 1996) recommend running the EFA with a range of factors extracted and opting for the extraction giving the most interpretable results. Therefore, both a one factor and a two factor extraction were also performed. As the second factor only loaded moderately on two items, the one factor extraction was adopted. The factor matrix showed that items A1 and A7 did not meet the loading criterion of .35 and these items were deleted from further analysis and the single factor EFA extraction rerun (see Table 7.13).

Table 7.13.

Awareness Instrument: Factor Loadings and Descriptive Statistics [a]

No	Item	Factor loading	*M* (*SD*)	95% CI
D3	Science should respect and act within the mores of society.	**.43**	3.97 (.84)	[3.91, 4.03]
A1[b]	Science must sometimes push the boundaries of social and ethical acceptability in order to advance knowledge	-	3.78 (.88)	[3.71, 3.84]
A2	The science community has a moral obligation to ensure that the products of scientific knowledge do not cause harm (e.g., to humans, animals, environment).	**.52**	4.18 (.88)	[4.11, 4.24]
A3[b]	The science community cannot be held ethically responsible for the uses to which scientific discoveries are put.	**.48**	3.19 (1.12)	[3.11, 3.28]
A4	The more powerful a technology is the more important the evaluation of its ethical and social implications becomes.	**.59**	4.04 (.81)	[3.98, 4.10]
A5	The more powerful a technology is the more relevant the precautionary principle becomes.	**.59**	3.93 (.86)	[3.87, 4.00]
A6	There are some fields of knowledge so potentially dangerous that they should not be researched	**.36**	2.72 (1.12)	[2.64, 2.80]
A7[b]	Science is the value-free pursuit of true knowledge	-	3.08 (1.14)	[3.00, 3.17]
A8	Ethical training should be an integral part of scientific training	**.52**	3.92 (.81)	[3.86, 3.97]
A9	The benefits of science and technology should be distributed throughout society in a fair and equitable way	**.39**	3.93 (.82)	[3.87, 4.00]
A10[b]	There is no ethical imperative for science to 'do good'.	**.44**	2.60 (1.03)	[2.53, 2.68]

Notes. Items A1 and A7 deleted from EFA. EFA data set n = 366, extraction method: principal axis factoring, missing cases listwise deleted. Factor loadings > .34 are in boldface. CI = confidence interval.

[a]Descriptive statistics (*M*, *SD* and 95% CI) are for whole sample (N = 706, listwise deletion of missing cases). [b]For the factor analyses these items **were reverse coded** to maintain scale directionality. However, for item descriptive statistics (i.e., *M*, *SD*, CI), in the above table, these items **have not been reverse coded** so that the statistics remains consistent with the direction of the response scale: 1= *strongly disagree*, 3 = *neutral*, 5 = *strongly agree*.

This time factor loadings ranged from .36 to .59, suggesting a nine item single factor model. This model was tested using CFA on the holdout sample. The model was a poor fit with several items not meeting the .35 cut-off criterion. However, rerunning the analysis with item A5 deleted produced an eight item single factor model with excellent goodness-of-fit indices with all items meeting the .35 criterion. Table 7.14 presents goodness-of-fit indices for this model.

Table 7.14

CFA Results for Awareness Instrument (n = 366)

Model	χ^2	*df*	χ^2/df	GFI	TLI	CFI	RMR	RMSEA [90% CI]
8 items, 1 factor	25.54 (*p* = .18)	20	1.27	.98	.97	.97	.03	.03 [.000, .056]

Figure 7.10 shows the path diagram for the eight item single factor model. As is apparent from the squared correlations in the path diagram (Figure 7.10), the factor only explains a small percentage of the variance of each of the items (range = .14 to .28, mean = .20), thus, by far the majority of the variance in each item remains unexplained.

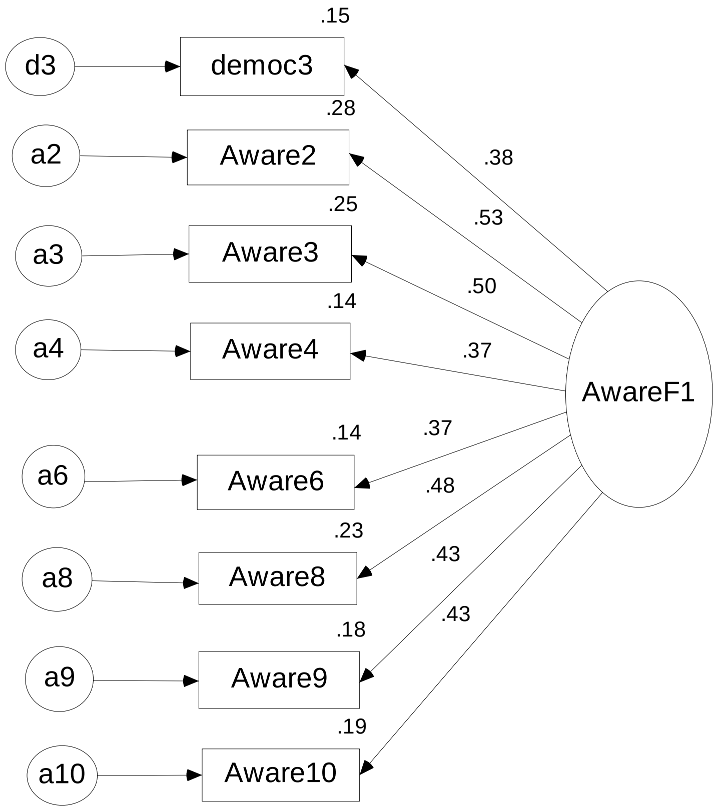

Figure 7.10. CFA path diagram for awareness instrument.

This suggests that the scale taps into a broad construct regarding the awareness of need for social responsibility in research (perhaps helping to explain the relatively low coefficient alpha). Coefficient alpha for the 8 item instrument (.67) was calculated for the whole sample (*N* = 733). Although coefficient alpha for the awareness scale is not high, it is in the acceptable range for an early stage research instrument.

Judgment regarding personal responsibilities

Ten items were proposed to measure this construct (see Table 7.15). The instrument consisted of a question: How important are the following principles to you as a scientist living and working within society? The ten statements had a 5-point response scale (1 = *Not important*, 3 = *Moderately important,* 5 = *Very important*). All judgment items received responses across the full range (1-5).

Exploratory PAF analysis was conducted on the EFA data set with missing values listwise deleted and oblimin rotation. The KMO statistic was .87, within an appropriate range for assumption of factorability. Measures of sampling adequacy ranged from .82 to .88, indicating all items were acceptable for inclusion. Although two factors had an eigenvalue greater than 1.0 (Factor 1 eigenvalue 3.76, Factor 2 eigenvalue 1.15, accounting for 37.63% and 11.56% of the variance respectively), the scree plot (see Fig. 7.11) suggested a one factor solution.

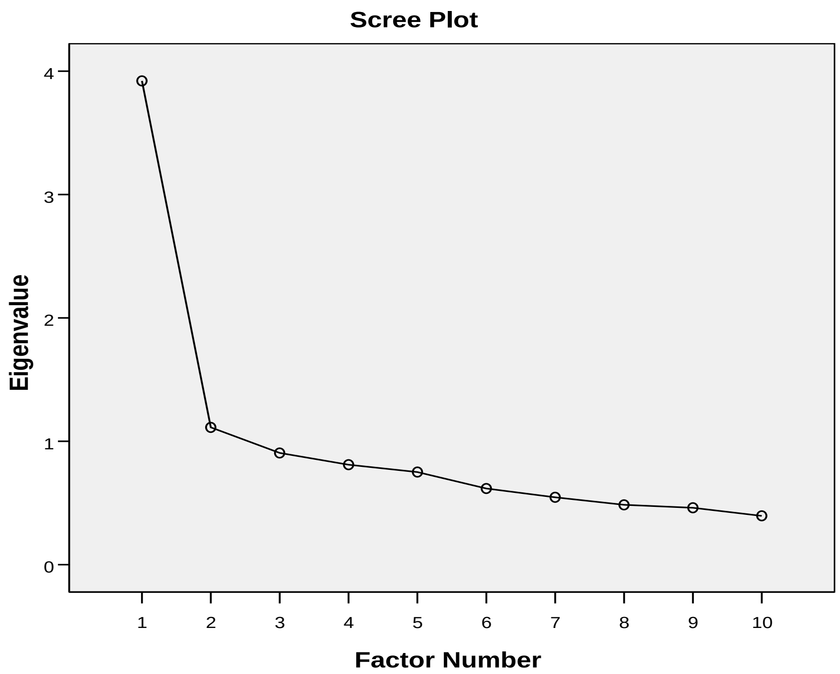

Figure 7.11. Judgement scree plot.

Therefore, EFA PAF one and two factor extractions were conducted. However, as the one factor solution proved best in the CFA (and was more congruent with the scree plot interpretation) only this solution is discussed further. As Table 7.15 shows, all items loaded on to the factor above the .35 criterion (range: .45 to .71). These data suggested a viable one factor model.

Table 7.15.

Judgement Instrument: Factor Loadings and Descriptive Statistics[a]

No	Item	Factor loadings	*M* (*SD*)	95% CI
J1	To evaluate possible benefits against harms when deciding on research projects.	**.52**	3.89 (.80)	[3.83, 3.95]
J2	To refrain from exaggerating the potential benefits or minimising the potential risks associated with research.	**.50**	4.13 (.80)	[4.07, 4.19]
J3	To give the public clear guidance on the reliability and validity of scientific conclusions regarding potential benefits and risks.	**.56**	4.27 (.70)	[4.22, 4.32]
J4	To refrain from conducting work in areas that you find morally questionable.	**.44**	4.02 (.92)	[3.95, 4.09]
J5	To ensure that approval for research is gained from the appropriate ethical authorities.	**.48**	4.11 (.92)	[4.04, 4.18]
J6	To ensure that the process and development of research complies with the precautionary principle.	**.49**	3.69 (.89)	[3.63, 3.76]
J7	To become informed about what society finds acceptable or unacceptable in scientific research.	**.70**	3.46 (.90)	[3.40, 3.53]
J8	To consider and dialogue with the public about the possible misuses to which knowledge gained from your research could be put.	**.70**	3.44 (.94)	[3.37, 3.51]
J9	To participate in public debate and dialogue over contentious scientific issues.	**.60**	3.61 (.97)	[3.54, 3.68]
J10	To put the good of society ahead of commercial profit.	**.52**	4.10 (.87)	[4.04, 4.17]

Notes. EFA data set $n = 366$, extraction method: Principal axis factoring, missing cases listwise deleted. 1 factor was extracted. Factor loadings > .34 are in boldface.
[a]Descriptive statistics (*M, SD* and 95% CI) are for whole sample ($N = 713$, listwise deletion of missing cases). Response scale: 1 = *not important*, 3 = *moderately important*, 5 = *very important*.

Next, the ten item one factor model was tested and refined on the holdout CFA data set using maximum likelihood CFA. Initially, the model was a poor fit. Deletion of items J3, J8, and J9 produced a revised one factor model with reasonably good fit (see Table 7.16).

Table 7.16.

CFA Results for Judgment Instrument (n=366)

Model	χ^2	*df*	χ^2/df	GFI	TLI	CFI	RMR	RMSEA [90% CI]
7 items, 1-factor	31.82 (*p* = .004)	14	2.27	.98	.95	.97	.03	.06 [.032, .086]

While the model has a significant chi-square statistics ($p < .01$), as previously noted this statistic is very sensitive to sample size. Hoelter's critical number for $p < .01$ is 335, less than the sample size of 366, suggesting that the descriptive goodness-of-fit indices are a better indication of fit than chi-square. All of the remaining fit indices indicate adequate to very good fit. The seven item instrument appears unidimensional.

The path diagram for this model is displayed in Figure 7.12.

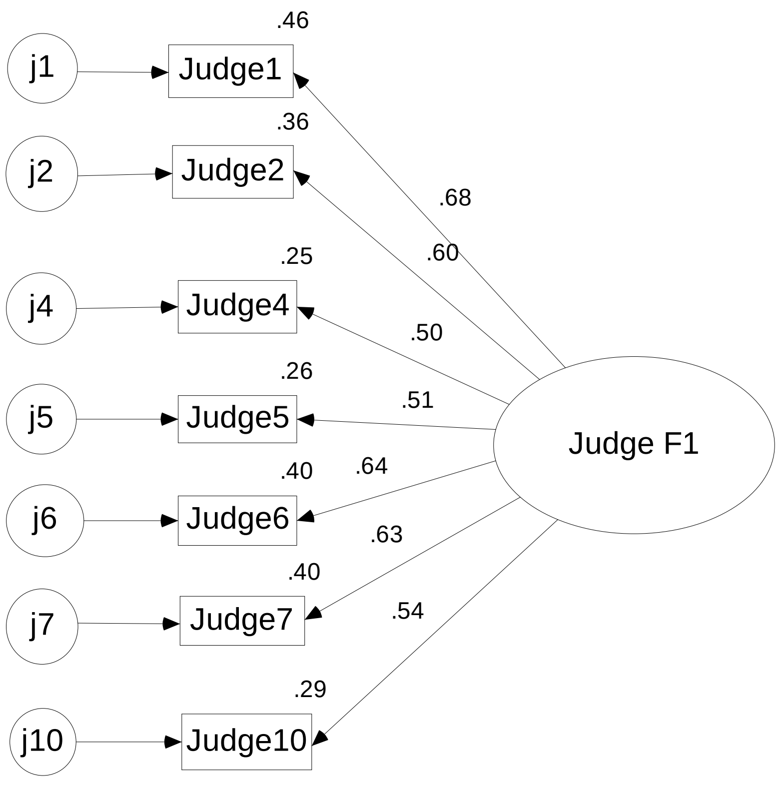

Figure 7.12. CFA path diagram for judgment instrument.

Next, coefficient alpha was calculated for the moral judgment instrument on the whole sample, returning a reasonable reliability value of .76. This model was used for analysis of the nomological network. It conforms to the intention of the research to develop relatively short scales that capture the broad construct of scientific social responsibility.

Summary of Research Instruments' Properties

Items for five new instruments have been proposed and then developed using EFA, and refined with CFA on a holdout sample. Reliability was assessed using coefficient alpha, a lower bound, reliability statistic. The first instrument, *attitudes to the democratisation of science*, is a five-item, single factor scale with excellent goodness-of-fit characteristics and a reasonable coefficient alpha of .74. The second instrument, *attitudes to the commercialisation of science*, is a seven-item, single factor scale with excellent goodness-of-fit characteristics and a good coefficient alpha of .80.

The third instrument, *technological optimism*, was a poor instrument comprised of three items. It performed poorly on most of the goodness-of-fit indices, although it met acceptable levels on the GFI index. However, its reliability was low (.57), even for an early stage research instrument. Caution is required regarding the use of this instrument. The fourth instrument was designed to measure scientists' *awareness for the need for social responsibility in research*. Eleven items were proposed and tested for this instrument. An eight item single factor solution was settled on with excellent goodness-of-fit characteristics Coefficient alpha was acceptable though relatively poor at .67. The fifth new instrument developed for the current work was designed to measure *judgment regarding personal actions believed to enhance social responsibility of scientists conducting research* (hereafter referred to as *scientists' moral judgement* or *judgment* for brevity). Ten items were proposed to measure this construct. After EFA and CFA a seven item one factor solution with good to excellent goodness-of-fit characteristics was settled on. Coefficient alpha for the instrument was reasonable at .76.

Two existing instruments were also proposed as part of the nomological network: the Schwartz higher order value dimensions and a general attitude to GE instrument. These instruments were also subject to CFA analyses (over the entire sample as the scientists' sample was independent of the sample from which these instruments were developed). The factor structure and reliability of the four higher order Schwartz value dimensions (Schwartz, 1992) were examined for the sample. Three of the four higher order dimensions demonstrated good internal (convergent) and external (divergent) discriminant validity and had good reliability (coefficient alphas above .8). The higher order dimension self-enhancement was problematic. One of its constituent subscales (achievement value type) loaded weakly on the relevant extracted factor and cross-loaded moderately on to the extracted factor representing openness to change. While performing poorly on some goodness-of-fit indices, the four factor higher order model performed acceptably on the GFI, CFI and RMR indices. Nomological network results using the self-enhancement scale will need to be considered carefully in light of this result.

Finally, an instrument developed by Small, Parminter and Fisher (2005), 'general attitude to GE', which was used in this thesis as a concurrent criterion in the nomological network for the five new instruments, was tested for goodness-of-fit and reliability. CFA analysis indicated that the scale performed best on a range of goodness-of-fit indices when the three subscales were treated as variables in a higher order general factor (Model 3). Model 3 performed excellently on four out of seven goodness-of-fit indices and had a good alpha coefficient of .83. Table 7.17 presents descriptive statistics for the above instruments.

Table 7.17

Descriptive Statistics for Research Instruments

Instrument	*No. Items*	*N*[a]	*M*	*SD*	95% CI	Alpha[b]	Skew[c]
Democratisation[d]	5	726	3.10	.67	[3.05, 3.15]	.74	.15
Commercialisation[d]	7	726	2.54	.74	[2.49, 2.60]	.80	.22*
Technological optimism[d]	3	726	3.31	.78	[3.25, 3.36]	.57	-.31*
Awareness[d]	8	726	3.63	.51	[3.59, 3.66]	.67	-.24*
Judgement[e]	7	726	3.92	.56	[3.88, 3.96]	.76	-.47*
Self-transcendence[f]	8	726	3.44	.67	[3.39, 3.49]	.82	-.11
Self-enhancement[f]	8	726	2.04	.66	[1.99, 2.09]	.80	.21*
Openness to change[f]	9	726	3.11	.70	[3.06, 3.16]	.84	.00
Conservation[f]	12	726	2.49	.73	[2.43, 2.54]	.84	-.06
General attitude to GE[g]	9	549	3.22	.77	[3.15, 3.28]	.83	-.50*

Notes. CI = confidence interval.
[a]Listwise deletion of missing values. [b]Cronbach's coefficient alpha for each of the research instruments. [c] Std error of skewness = .09 for all except general attitude to GE scale which = .11, *skewness statistic more than twice std. error of skewness. [d]Response scale: 1 = *strongly disagree*, 3 = *neutral*, 5 = *strongly agree*. [e]Response scale: 1 = *not important*, 3 = *moderately important*, 5 = *very important*. [f]Response scale: -1 = *opposed to my values*, 0 = *not important*, 2 = *moderately important*, 4 = *very important*, 5 = *of supreme importance* (note that the mid-point of the scale is 2). [g]Response scale: 1= *strongly disagree*, 3 = *neutral*, 5 = *strongly agree*, 6 = *don't know*. Listwise deletion of missing values (including all cases where participants responded 'don't know' to any of the 9 items) left a sample of *n* = 549 from the original sample *N* = 733.

As can be seen from Table 7.17, the sample scientists had a mildly positive attitude to the democratisation of science, a strongly negative attitude to the commercialisation of science, and a moderately positive belief in technological optimism. They had a strong awareness of the need for social responsibility in research (awareness scale) and a very strong positive attitude regarding personal behaviour to enhance social responsibility in research (judgment scale). The results also suggest that scientists had a moderately supportive attitude to GE. Their strongest value was self-transcendence and their weakest value was self-enhancement. This value structure is congruent with both Study 1 and 2 results which found that scientists were generally strongly supportive of the idea that science should ‘do public good.’

One potential problem previously noted is that the sample cannot be claimed to be representative of all New Zealand scientists (as the comparison with Sommer’s survey showed; see Method section, this chapter), which casts doubt on the external validity of the instruments developed. Therefore, a further test of the five models and instruments developed using the two-step EFA-CFA process for scale development was carried out. Some authors (e.g., Bagozzi & Youjae, 1988; Costello & Osborne, 2005; Reise, et al., 2000) have recommended that psychometric scales should be tested on independent populations using CFA (note that the EFA and CFA subsamples used in the analyses above while being independent samples both come from the same underlying population, i.e., CRI scientists). If the goodness-of-fit is acceptable in different underlying populations then, according to these authors, this strengthens the case for generalisability of the scales and models. One easy way to split the sample to represent two different underlying populations is to divide it on the basis of gender to represent male scientists and female scientists. Therefore, for this analysis, the scientists’ sample was split by gender into two independent samples (male n = 426, female n = 300) and for both samples the new instruments were tested for goodness-of-fit using CFA. Generally, the research instruments performed well on this additional test. For all the new instruments most of the fit indices were as good or nearly as good as in the CFA holdout cross-validation sample for both male and female samples (the technological optimism scale still performed poorly). The chi-square statistic was not usually as good in the male and female samples, nor was χ^2/df. However, all of the other goodness-of-fit indices were either within the acceptable range or as good as the indices for these scales in the CFA holdout sample. Thus, despite problems with the sample’s representativeness, this result helps strengthen the case for the generalisability and external validity of the new instruments.

Another potential problem that can be observed from Table 7.17 is the non-normality of some of the instruments as indicated by the skew statistics. Note that some of the instruments also had mild kurtosis, however, Tabachnick and Fidell (1996) claimed that kurtosis is only a problem if sample sizes are less than 200.

Tabachnick and Fidell recommended transforming non-normally distributed variables "…in all situations unless there is some reason not too" (p. 82). Four of the new instruments and two of the existing instruments had skew statistics more than twice the standard error of skew. The concern is that non-normality may distort (attenuate) correlations between the instruments that comprise the nomological network. However, the skew statistics are relatively small and examination of the relevant histograms and normal Q-Q plots suggested that the instruments were relatively normally distributed. Tabachnick and Fidell noted that if the variables are skewed to about the same (moderate) extent, transformation may bring only marginal improvements. They also noted that transforming data may cause problems with interpretation of the results. Therefore, the decision was made to do the nomological network correlations with and without transformation and compare the results to determine if transformation was really necessary in the current case.

The six skewed instruments were transformed as per Tabachnick and Fidell's (1996) recommendations. First, the four negatively skewed instruments (judgement, awareness, technological optimism and general attitude to GE) were reflected. Because all six instruments were only slightly to moderately skewed, as indicated by histograms and normal Q-Q plots, they were transformed using the square root function, as advised by Tabachnick and Fidell. Next, skewness statistics and plots were generated for the transformed variables. Five instruments improved with their skewness being reduced to less than twice their standard error of skewness, although little difference was noticed in their normal Q-Q plots. However, the self-enhancement value dimension became moderately negatively skewed, indicating transformation provided no advantage. The 39 correlations in the nomological network were calculated with the four transformed instruments and each correlation compared with the corresponding correlations in an untransformed nomological network correlation matrix. For 38 of the correlations the difference between the transformed and untransformed data was less than .01. For the 39th correlation the difference was less than .02. These negligible results indicated that transformation made no practical difference for the purposes of the current study. Therefore, transformation was considered as introducing unnecessary complexity and the data reported in the nomological network analysis are all untransformed.

Comparison of Scientists' and Public Attitudes to GE

As the global attitude to GE instrument was also administered to a sample of the New Zealand public (N = 860) at the same time (May 2005) as the scientists' survey was conducted (Small, 2005a), comparison was possible. As can be seen from Table 7.18, the public demonstrated a less positive attitude to GE than scientists on all the subscales and the combined general attitude to GE scale.

Table 7.18.

General Attitude to GE and Subscales: Public-Science Sample Comparison

Scale	Mean		Mean difference	t	df	Sig.[a]	Cohen's d[b]
	Scientists	Public					
Intrinsic	3.55	2.78	.77	12.65	1155	.001	0.74
Extrinsic	3.18	2.93	.25	4.48	1155	.001	0.27
Trust	2.92	2.46	.46	8.77	1155	.001	0.51
Att. to GE	3.22	2.72	.50	9.97	1155	.001	0.59

Notes. Independent samples t-test, equal variances not assumed. Scientists' sample n = 549, public sample n = 608, cases with missing values (including 'don't know' responses) excluded from analysis. Response scale: 1= *strongly disagree*, 3 = *neutral*, 5 = *strongly agree*, 6 = *don't know*. Coefficient alpha for general attitude to GE instrument was .87 for the public sample and .83 for the scientist sample (using 3 subscale means as scale variables in both cases).

[a]2-tailed test.

[b]Cohen's d = (science mean – public mean)/ SD Pooled, where SD Pooled = square root [(science SD squared + public SD squared)/2]

Independent samples t-tests (equal variance not assumed: as Levine's test for equality of variance was significant [$p \leq .001$] in all four cases) between the public and scientists on the three subscales and the general attitude to GE scale showed this difference was significant in all four cases at the $p < .001$ level (2-tailed). Cohen's d, a measure of the effect size of the mean difference, (which is independent of sample size, unlike the t-test), is shown for the four cases in Table 7.18. For Cohen's d statistic, 0.2 is considered a small effect size, 0.5 a medium effect size, and > 0.8 is considered a large effect size (Cohen, 1988).

The mean difference effect size for the intrinsic values scale was the greatest, bordering on large at 0.74, indicating that this is a major source of difference in attitude to GE for scientists and the public. The smallest effect size difference was for the extrinsic belief scale (a small effect size at d = 0.27). Of the three subscales this one was rated the most positive by the public. However, the public rated all three subscales negatively (i.e., significantly below the scale neutral midpoint of 3): intrinsic value 99% CI [2.66, 2.89]; extrinsic belief 95% CI [2.83, 3.00]; trust in responsible authorities 99% CI [2.35, 2.56]. Whereas scientists rated intrinsic value, 99% CI [3.44, 3.66], and extrinsic belief 99% CI [3.08, 3.28], positively, they rated trust in responsible authorities negatively, 99%

CI [2.83, 3.00]. Examination of Table 7.6 (p. 239) shows that, of the three items in the trust subscale, scientists were neutral regarding trust in regulators, quite positive regarding trust in scientists, but very negative regarding trust in companies. Whereas the New Zealand public held a negative general attitude to GE 99% CI [2.63, 2.81], scientists held a positive general attitude 99% CI [3.13, 3.30].

Construct Validity: Nomological Network and Scales

Hypotheses were proposed about the relationships between these five new constructs, the Schwartz higher order value dimensions and general attitude to genetic engineering. Altogether, 39 directional hypotheses were proposed (these hypotheses proposed 20 negative relationships and 19 positive relationships between the instruments- see Chapters 3, 4, and 5). Approximate effect sizes were predicted for 20 of the 39 hypotheses. These relationships form a nomological network which may be used to help infer the construct validity of the new instruments.

Sample size, statistical power and precision of analysis

All the hypotheses are directional. This means that 1-tailed significance tests of the correlations are appropriate. All correlations in the nomological network, except those involving the general attitude to GE scale, had sample sizes between 723 and 732. Correlations involving the general attitude to GE scale had sample sizes between 546 and 549. With a 1-tailed test and sample size of 723, a correlation as low as .07 will be significant at the .05 level; correlations larger than .12 will be significant at the .001 level. The statistical power to detect a significant ($p < .05$) correlation, as low as .07, is .59, to detect a small effect size correlation of .10 statistical power is .85, and to detect a small to medium correlation of .20 statistical power is .99.

Therefore, the current research has a large enough sample size to just meet the generally recommended statistical power of .8 to .9 (Aron & Aron, 1999) for a small effect size such as correlations of .10 at the Type I error level of alpha equals .05. However, even a sample of 723 is less than optimal given that statistical power should ideally be .95 (Cohen, 1990). As most of the correlations in the current work were expected to be small or medium, this would require a sample size of about 1300 (at this number, the Type II error rate, beta, is .05, equal to the alpha error rate). With the current sample size the precision of the correlation statistic with alpha set at .05 is ± .07 (i.e., 95% confidence interval), with alpha set at .01 (i.e. 99% CI) it is ± .10, and with alpha set at .001 it is .12.

With 39 statistical tests conducted, the experimentwise (sometimes referred to as family wise) Type I error rate is greatly escalated (40 tests would by chance alone return 2 correlations significant at the .05 level). One method of correcting for Type I error due to multiple hypotheses tests is the Bonferroni procedure (Hochberg & Tamhane, 1987). However, the Bonferroni adjustment is problematic, as will be shown in the analysis of the nomological network results. Nevertheless, because of its popularity amongst the psychological community (however, cf. Cohen, 1990 for a critical perspective on the Bonferroni procedure), it was assumed to be a valid procedure. With this procedure, a new experimentwise alpha level is set by dividing .05 by the number of hypotheses being tested (i.e., 39). In the current case this sets a Bonferroni per–test significance criterion of .0013. Thus, using the Bonferroni adjustment, only correlations in the nomological network that have a *p* value of .001 or less are considered significant. With the current sample size only observed correlations greater than .12 can reach this level of significance. Actual *p* values and 95% confidence intervals for all hypotheses tested in the nomological network will be reported below, as is advised in the APA Publication Manual 6th Edition (American Psychological Association, 2009).

Correlations between the variables

Correlations between all variables except the four Schwartz higher order value dimensions are bivariate. Schwartz (1992, p. 53) claimed that individuals and groups differ in "the ways in which they distribute their importance ratings across the rating scale" and that it was "desirable to control statistically for differences in scale use… when correlating value priorities with other variables." In the case of correlations with other variables involving the higher order value indices, Schwartz (p. 53) recommended: "Analyses using these indexes should also be controlled for scale use differences by partialing out each individual's mean importance rating for the 56 single values." As previously explained, 37 single values were used in the current work. Therefore, the mean of these 37 value items was calculated for each individual and coded as a new variable in the SPSS data file. As recommended by Schwartz, all correlations reported for hypotheses involving the higher order value dimensions are partial correlations with this mean value controlled for.

The correlation matrix for the research instruments is presented in Table 7.19. Each correlation in the matrix is a test of one of the 39 hypotheses. All correlations above .06 are significant at p <.05, all correlations .10 and above are significant at $p < .01$, and all correlations above .12 are significant at $p < .001$. For analysis of the nomological network only correlations .12 and above and which therefore meet the Bonferroni adjusted per-test significance criterion of .0013 will be considered significant.

Table 7.19

Correlations Between the Research Instruments

		1	2	3	4	5	10
1	Democratisation						
2	Commercialisation	-.15					
3	Awareness	.30	-.08				
4	Judgment	.31	-.14	.55			
5	Tech optimism	-.15	.21	-.19	-.08		
6	Self-transcendence[a]	.29	-.27	.36	.42	-.21	-.20
7	Self-enhancement[a]	-.17	.24	-.26	-.32	.20	.23
8	Openness[a]	-.02	-.04	-.20	-.10	.06	.13
9	Conservation[a]	-.08	.07	.09	-.01	-.04	-.12
10	General Att. to GE	-.30	.21	-.40	-.28	.39	

Notes: 1-tailed Pearson correlations. All correlations greater than .06 are significant at $p \leq .05$. All correlations .10 and above are significant at $p < .01$. All correlations greater than .12 are significant at $p < .001$. Missing values pairwise deleted, N ranges from 723 to 731, except for correlations with general attitude to GE for which n ranges from 546-549 (cases with 'don't know' responses deleted – see Method section: General Attitude to Genetic Engineering).

[a] Partial correlations as recommended by Schwartz (1992).

Evidence is provided for construct validity of the instruments and for the theory (i.e., the nomological network of relationships) if the hypothesised relationships are found to be significant and in the right direction (Cronbach & Meehl, 1955). The greater number of statistically significant hypotheses, in the right direction, the greater the confidence in the construct validity of the instruments, and the theory relating the constructs. However, note that for providing evidence for the nomological network, it is **not** the size of the correlation that is the crucial issue. Rather, even low, effectively non-substantial, correlations can provide evidence for support of the network and hence validity of the instruments and theory (Smith, 2005a; Westen & Rosenthal, 2003).

Indeed, the prediction of no relationship between instruments may also provide evidence for construct validity by demonstrating the instrument has discriminant validity: that is, it does not correlate with instruments that measure constructs for which either theory or empirical evidence suggests no relationship (Campbell & Fiske, 1959; Smith, 2005a; Westen & Rosenthal, 2003). If from theory (or previous empirical research) one can accurately predict the strength (i.e., small, medium, large) of the relationships in the nomological network, then the construct validity of both the instruments and the theory is enhanced (Meehl, 1978, 1990; Smith, 2005a; Westen & Rosenthal, 2003). If precise predictions of effect size are hypothesised, these can be compared with the observed correlations. For such cases, Westen and Rosenthal proposed a correlation statistic to measure construct validity. Their construct validity coefficient is based on contrast analysis and indicates "the extent to which the observed pattern of correlations in a convergent-discriminant validity matrix matches the theoretically predicted pattern of correlations" (Westen & Rosenthal, 2003, p. 608).

Results of the nomological network hypotheses tests

Hypothesis 1. *There will be a small to medium negative correlation between technological optimism and scientists' awareness of the need for social responsibility in scientific research and development.* The correlation between technological optimism and awareness was -.19 ($p < .001$), 95% CI [-.26, -.12]. Therefore, the null hypothesis was rejected and Hypothesis 1 was supported at the Bonferroni adjusted level of .001. Slight previous empirical evidence suggested a small to medium size correlation between these two constructs. The observed relationship was small.

Hypothesis 2. *There will be a small to medium negative correlation between technological optimism and scientists' judgments of the importance of specific personal behaviours to enhance social responsibility in scientific research and development.* The correlation between technological optimism and judgment was -.08 ($p = .02$), 95% CI [.01, .15]. Therefore, the null hypothesis cannot be rejected and Hypothesis 2 was not supported at the Bonferroni adjusted level of .001. Slight previous empirical evidence suggested a small to medium size correlation between these two constructs. The observed relationship was small. This result suggests that technological optimism and judgments about socially responsible behaviours in research are only very slightly related constructs.

Hypothesis 3. *There will be a large positive correlation between awareness of the need for social responsibility in scientific research and judgments of the importance of specific personal behaviours to enhance social responsibility in scientific research and development.* The correlation between awareness and judgment was .55 ($p < .001$, 95% CI [.50, .60]. Therefore, the null hypothesis was rejected and Hypothesis 3 was supported at the Bonferroni adjusted level of .001. As predicted by conceptual considerations, the correlation was large.

Hypothesis 4. *There will be a small negative correlation between the higher order value dimension, openness to change, and scientists' awareness of the need for social responsibility in scientific research and development.* The correlation between openness to change and awareness is -.20 ($p < .001$), 95% CI [-.27, -.13]. This result was significant. Therefore, the null hypothesis was rejected and Hypothesis 4 was supported at the Bonferroni adjusted level of .001. This result is similar in size (i.e., small), but differs from the non-significant results of Fritzche and Oz (2007) and Beckmann et al. (1997), reported in Chapter 3, in that it is significant. However, both of those studies lacked adequate statistical power to detect a small correlation at conventionally acceptable levels. As expected from previous empirical research, the correlation was a small effect size.

Hypothesis 5. *There will be a small negative correlation between the higher order value dimension, openness to change, and scientists' judgments of the importance of specific personal behaviours to enhance social responsibility in scientific research and development.* The correlation between openness to change and judgment was -.10 ($p = .005$), 95% CI [-.17, -.03]. Therefore, the null hypothesis cannot be rejected and Hypothesis 5 was not supported at the Bonferroni adjusted level of .001. This result, although non-significant was similar in effect size to the non-significant (.05 level) results of the underpowered Fritzche and Oz (2007) and Beckmann et al. (1997) studies reported in Chapter 3. As expected from previous empirical research, the correlation was small.

Hypothesis 6. *There will be a positive correlation between the higher order value dimension, openness to change, and the construct of technological optimism.* The correlation between openness to change and technological optimism was .06 ($p =.05$), 95% CI [-.01, .14]. Therefore, the null hypothesis cannot be rejected and Hypothesis 6 was not supported at the Bonferroni adjusted level of .001. No previous empirical evidence was available to make a prediction regarding the size of the effect. The relationship between technological optimism and openness to change is so small that the constructs appear almost unrelated.

Hypothesis 7. *There will be a small positive correlation between the higher order value dimension, conservation, and scientists' awareness of the need for social responsibility in scientific research and development.* The correlation between conservation and awareness was .09 ($p = .01$), 95% CI [.02, .16]. Therefore, the null hypothesis cannot be rejected and Hypothesis 7 was not supported at the Bonferroni adjusted level of .001. Recall that the conceptual and empirical evidence was mixed regarding the direction of this hypothesis and a small correlation was expected (see Chapter 3, p. 78).

Hypothesis 8. *There will be a small positive correlation between the higher order value dimension, conservation, and scientists' judgments of the importance of specific personal behaviours to enhance social responsibility in scientific research and development.* The correlation between conservation and judgment was -.01 ($p = .37$), 95% CI [-.08, .06]. Therefore, the null hypothesis cannot be rejected and Hypothesis 8 was not supported at the Bonferroni adjusted level of .001 (note although tiny, the correlation was **not** in the predicted direction). Recall that the conceptual and empirical evidence was mixed regarding the direction of this hypothesis and a small correlation was expected (see Chapter 3, pp. 78-79). This result suggests that conservation and judgment regarding social responsibility are almost completely unrelated to one another.

Hypothesis 9. *There will be a small positive correlation between the higher order value dimension, conservation, and scientists' attitudes to technological optimism.* The correlation between conservation and technological optimism was -.04 ($p = .15$), 95% CI [-.11, .03]. Therefore, the null hypothesis cannot be rejected and Hypothesis 9 was not supported at the Bonferroni adjusted level of .001 (note that the correlation was **not** in the predicted direction). However, there were conflicting conceptual arguments about this hypothesis and any relationship was expected to be small (see Chapter 3, p. 79). This result suggests that conservation and technological optimism are almost completely unrelated to one another.

Hypothesis 10. *There will be a medium size positive correlation between the higher order value dimension, self-transcendence, and scientists' awareness of the need for social responsibility in scientific research and development.* The correlation between self-transcendence and awareness was .36 ($p <.001$), 95% CI [.29, .42]. Therefore, the null hypothesis was rejected and Hypothesis 10 was supported at the Bonferroni adjusted level of .001. As expected from past empirical research, this correlation was a medium effect size (see Chapter 3, pp. 79-80).

Hypothesis 11. *There will be a medium size positive correlation between the higher order value dimension, self-transcendence, and scientists' judgments of the importance of specific personal behaviours to enhance social responsibility in scientific research and development.* The correlation between self-transcendence and judgment was .42 ($p < .001$), 95% CI [.36, .49]. Therefore, the null hypothesis was rejected and Hypothesis 11 was supported at the Bonferroni adjusted level of .001. As expected from past empirical research this correlation was a medium effect size (see Chapter 3, p. 80).

Hypothesis 12. *There will be a small to medium size negative correlation between the higher order value dimension, self-transcendence, and scientists' belief in technological optimism.* The correlation between self-transcendence and technological optimism was -.21 (p < .001), 95% CI [-.28, -.14]. Therefore, the null hypothesis was rejected and Hypothesis 12 was supported at the Bonferroni adjusted level of .001. As expected from past empirical research, the effect size was in the small to medium range.

Hypothesis 13. *There will be a small to medium size negative correlation between the higher order value dimension, self-enhancement, and scientists' awareness of the need for social responsibility in scientific research and development.* The correlation between self-enhancement and awareness was -.26 (p < .001), 95% CI [-.33, -.19]. Therefore, the null hypothesis was rejected and Hypothesis 13 was supported at the Bonferroni adjusted level of .001. As expected from past empirical research, the effect size was in the small to medium range.

Hypothesis 14. *There will be a small to medium size negative correlation between the higher order value dimension, self-enhancement, and scientists' judgments of the importance of specific personal behaviours to enhance social responsibility in scientific research and development.* The correlation between self-enhancement and judgment was -.32 (p < .001), 95% CI [-.38, -.25]. Therefore, the null hypothesis was rejected and Hypothesis 14 was supported at the Bonferroni adjusted level of .001. As expected from past empirical research, the effect size was in the small to medium range.

Hypothesis 15. *There will be a positive correlation between the higher order value dimension, self-enhancement, and the construct of technological optimism.* The correlation between self-enhancement and technological optimism was .20 (p < .001), 95% CI [.13, .27]. Therefore, the null hypothesis was rejected and Hypothesis 15 was supported at the Bonferroni adjusted level .001. No empirical evidence was available to make a prediction regarding the size of the effect. The observed relationship was a small effect size.

Hypothesis 16. *There will be a positive correlation between scientists' favourable attitude to the democratisation of science and their awareness of the need for social responsibility in scientific research and development.* The correlation between favourable attitudes to democratisation and awareness is .30 (p < .001), 95% CI [.23, .36]. Therefore, the null hypothesis was rejected and Hypothesis 16 was supported at the Bonferroni adjusted level of .001. No previous empirical evidence regarding the likely effect size was found; hence no prediction was made regarding the effect size. The observed relationship was a medium effect size.

Hypothesis 17. *There will be a positive correlation between scientists' favourable attitude to the democratisation of science and their judgments of the importance of specific personal behaviours to enhance social responsibility in scientific research and development.* The correlation between favourable attitudes to democratisation and judgment was .31 ($p < .001$), 95% CI [.24, .37]. Therefore, the null hypothesis was rejected and Hypothesis 17 was supported at the Bonferroni adjusted level of .001. No previous empirical evidence regarding the likely effect size was found; hence no prediction was made regarding the effect size. The observed relationship was a medium effect size.

Hypothesis 18. *There will be a negative correlation between scientists' favourable attitude to the democratisation of science and their belief in technological optimism.* The correlation between favourable attitudes to democratisation and technological optimism was -.15 ($p < .001$), 95% CI [-.22, -.08]. Therefore, the null hypothesis was rejected and Hypothesis 18 was supported at the Bonferroni adjusted level of .001. No previous empirical evidence regarding the likely effect size was found; hence no prediction was made regarding the effect size. The observed relationship was a small effect size.

Hypothesis 19. *There will be a small negative correlation between scientists' favourable attitude to the democratisation of science and the higher order value dimension openness to change.* The correlation between favourable attitude to democratisation and openness to change was -.02 ($p = .31$), 95% CI [-.09, .05]. Therefore, the null hypothesis cannot be rejected and Hypothesis 19 was not supported at the Bonferroni adjusted level of .001. Recall that there were competing conceptual arguments regarding whether this relationship would be positive or negative and no empirical data were available to suggest direction or size of the relationship (see Chapter 4, p. 104). Therefore, any relationship was hypothesised to be small. The observed correlation suggested that attitude to democratisation of science and openness to change are not substantively related to one another.

Hypothesis 20. *There will be a small negative correlation between scientists' favourable attitude to the democratisation of science and the higher order value dimension of conservation.* The correlation between favourable attitudes to democratisation and conservation is -.08 ($p = .02$), 95% CI [-.15, -.01]. Therefore, the null hypothesis cannot be rejected and Hypothesis 20 was not supported at the Bonferroni adjusted level of .001. On conceptual grounds, the relationship was expected to be a small effect size.

Hypothesis 21. *There will be a positive correlation between scientists' favourable attitude to democratisation of science and the higher order value dimension self-transcendence.* The correlation between favourable attitudes to democratisation and self-transcendence was .29 ($p < .001$), 95% CI [.22, .36]. Therefore, the null hypothesis was rejected and Hypothesis 21 was supported at the Bonferroni adjusted level of .001. No prediction was made regarding the size of the relationship as no empirical evidence was found which suggested a likely effect size. The observed correlation represents a medium effect size.

Hypothesis 22. *There will be a negative correlation between scientists' favourable attitude to democratisation of science and the higher order value dimension of self-enhancement.* The correlation between favourable attitudes to democratisation and self-enhancement was -.17 ($p < .001$), 95% CI [-.24, -.10]. Therefore, the null hypothesis was rejected and Hypothesis 22 was supported at the Bonferroni adjusted level of .001. No prediction was made regarding the size of the relationship as no empirical evidence was found which suggested a likely effect size. The observed correlation represents a small effect size.

Hypothesis 23. *There will be a negative correlation between scientists' favourable attitude to the commercialisation of science and their awareness of the need for social responsibility in scientific research and development.* The correlation between favourable attitudes to commercialisation and awareness was -.08 ($p = .01$), 95% CI [-.15, -.01]. Therefore, the null hypothesis cannot be rejected and Hypothesis 23 was not supported at the Bonferroni adjusted level of .001. No prediction was made regarding the size of the relationship as no empirical evidence was found which suggested a likely effect size. The observed correlation was a small effect size.

Hypothesis 24. *There will be a negative correlation between scientists' favourable attitude to the commercialisation of science and their judgments of the importance of specific behaviours to enhance social responsibility in scientific research and development.* The correlation between favourable attitudes to commercialisation and judgment is -.14 ($p < .001$), 95% CI [-.21, -.07]. Therefore, the null hypothesis was rejected and Hypothesis 24 was supported at the Bonferroni adjusted level of .001. No prediction was made regarding the size of the relationship as no empirical evidence was found which suggested a likely effect size. The observed correlation was a small effect size.

Hypothesis 25. *There will be a negative correlation between scientists' favourable attitude to the commercialisation of science and a favourable attitude to the democratisation of science.* The correlation between favourable attitude to commercialisation and democratisation is -.15 ($p < .001$), 95% CI [-.22, -.08]. Therefore, the null hypothesis was rejected and Hypothesis 25 was supported at the Bonferroni adjusted level of .001. No prediction was made regarding the size of the relationship as no empirical evidence was found which suggested a likely effect size. The observed correlation was a small effect size.

Hypothesis 26. *There will be a medium size positive correlation between scientists' favourable attitude to the commercialisation of science and their belief in technological optimism.* The correlation between favourable attitudes to commercialisation and technological optimism is .21 ($p < .001$), 95% CI [.14, .28]. Therefore, the null hypothesis was rejected and Hypothesis 26 was supported at the Bonferroni adjusted level of .001. A medium size relationship was predicted from the slight available empirical evidence; the observed correlation was a small to medium effect size.

Hypothesis 27. *There will be a small positive correlation between scientists' favourable attitude to the commercialisation of science and the higher order value dimension of openness to change.* The correlation between favourable attitudes to commercialisation and openness to change was -.04 ($p = .13$), 95% CI [-.11, .03]. Not only was the result non-significant but the correlation sign was in the wrong direction. The null hypothesis cannot be rejected and Hypothesis 27 was not supported at the Bonferroni adjusted level of .001. However, recall that there was no previous empirical evidence found regarding this relationship, that there were contradictory conceptual arguments for the direction of the relationship, and that any relationship was predicted to be small (see Chapter 4, pp. 108-109). The result suggested that the constructs of attitude to commercialisation of science and openness to change are not substantively related to one another.

Hypothesis 28. *There will be a small positive correlation between scientists' favourable attitude to the commercialisation of science and the higher order value dimension of conservation.* The correlation between favourable attitudes to commercialisation and conservation was .07 ($p = .04$), 95% CI [.00, .14]. Therefore, the null hypothesis cannot be rejected and Hypothesis 28 was not supported at the Bonferroni adjusted level of .001. Recall that there was no previous empirical research found about the relationship between these constructs, that there were contradictory conceptual arguments for the direction of the relationship, and that any relationship was predicted to be small (see Chapter 4, p.

109). The observed correlation is small suggesting that the relationship between the constructs is very slight.

Hypothesis 29. *There will be a negative correlation between scientists' favourable attitude to the commercialisation of science and the higher order value dimension self-transcendence.* The correlation between favourable attitudes to commercialisation and self-transcendence was -.27 ($p < .001$), 95% CI [-.34, -.20]. Therefore, the null hypothesis was rejected and Hypothesis 29 was supported at the Bonferroni adjusted level of .001. No prediction was made concerning the effect size of the relationship as no previous empirical research was found regarding the relationship between the two constructs. The observed correlation was a small to medium effect size.

Hypothesis 30. *There will be a positive correlation between scientists' favourable attitude to the commercialisation of science and the higher order value dimension self-enhancement.* The correlation between favourable attitudes to commercialisation and self-enhancement is .24 ($p <.001$), 95% CI [.17, .31]. Therefore, the null hypothesis was rejected and Hypothesis 30 was supported at the Bonferroni adjusted level of .001. No prediction was made concerning the effect size of the relationship as no previous empirical research was found regarding the relationship between the two constructs. The observed correlation was a small effect size.

Hypothesis 31. *There will be a negative correlation between scientists' awareness of the need for social responsibility in scientific research and development and their favourable general moral attitude to genetic engineering.* The correlation between awareness and general attitude to GE was -.40 ($p < .001$), 95% CI [-.47, -.33]. Therefore, the null hypothesis was rejected and Hypothesis 31 was supported at the Bonferroni adjusted level of .001. As no previous empirical research was found which might indicate the strength of the effect size, no prediction was made in this respect. The observed correlation was a medium effect size.

Hypothesis 32. *There will be a negative correlation between scientists' judgments of the importance of specific personal behaviours to enhance social responsibility in scientific research and development and their favourable general moral attitude to genetic engineering.* The correlation between judgment and general attitude to GE was -.28 ($p < .001$), 95% CI [-.36, -.20]. Therefore, the null hypothesis was rejected and Hypothesis 32 was supported at the Bonferroni adjusted level of .001. As no previous empirical research was found which might indicate the strength of the effect size, no prediction was made in this respect. The observed correlation was a small to medium effect size.

Hypothesis 33. *There will be a positive correlation between scientists' belief in technological optimism and their favourable general moral attitude to genetic engineering.* The correlation between technological optimism and general attitude to GE was .39 ($p < .001$), 95% CI [.32, .46]. Therefore, the null hypothesis was rejected and Hypothesis 33 was supported at the Bonferroni adjusted level of .001. As no previous empirical research was found which might indicate the strength of the effect size, no prediction was made in this respect. The observed correlation was a medium effect size.

Hypothesis 34. *There will be a positive correlation between scientists' favourable attitude to the commercialisation of science and favourable general moral attitude to genetic engineering.* The correlation between commercialisation and general attitude to GE was .21 ($p < .001$), 95% CI [.13, .29]. Therefore, the null hypothesis was rejected and Hypothesis 34 was supported at the Bonferroni adjusted level of .001. As no previous empirical research was found which might indicate the strength of the effect size, no prediction was made in this respect. The observed correlation was a small to medium effect size.

Hypothesis 35. *There will be a negative correlation between scientists' favourable attitude to the democratisation of science and favourable general moral attitude to genetic engineering.* The correlation between democratisation and general attitude to GE was -.30 ($p < .001$), 95% CI [-.37, -.22]. Therefore, the null hypothesis was rejected and Hypothesis 35 was supported at the Bonferroni adjusted level of .001. As no previous empirical research was found which might indicate the strength of the effect size, no prediction was made in this respect. The observed correlation was a medium effect size.

Hypothesis 36. *There will be a positive correlation between scientists' scores on the higher order value dimension of openness to change and favourable general moral attitude to genetic engineering.* The correlation between openness to change and general attitude to GE was .13 ($p < .001$), 95% CI [.05, .21]. Therefore, the null hypothesis was rejected and Hypothesis 36 was supported at the Bonferroni adjusted level of .001. As no previous empirical research was found which might indicate the strength of the effect size, no prediction was made in this respect. The observed correlation was a small effect size.

Hypothesis 37. *There will be a negative correlation between scientists' scores on the higher order value dimension of conservation and favourable general moral attitude to genetic engineering.* The correlation between conservation and general attitude to GE was -.12 (p = .003), 95% CI [-.20, -.04]. Therefore, the null hypothesis cannot be rejected and Hypothesis 37 was not supported at the Bonferroni adjusted level of .001. As no previous empirical research was found which might indicate the strength of the effect size, no prediction was made in this respect. The observed correlation was a small effect size.

Hypothesis 38. *There will be a small to medium size positive correlation between scientists' scores on the higher order value dimension of self-enhancement and favourable general moral attitude to genetic engineering.* The correlation between self-enhancement and general attitude to GE was .23 (p < .001), 95% CI [.15, .31]. Therefore, the null hypothesis was rejected and Hypothesis 38 was supported at the Bonferroni adjusted level of .001. From the slight previous empirical data, a small to medium effect size relationship was predicted. The observed correlation was in the small to medium effect size range.

Hypothesis 39. *There will be a small negative correlation between scientists' scores on the higher order value dimension of self-transcendence and favourable general moral attitude to genetic engineering.* The correlation between self-transcendence and general attitude to GE was -.20 (p < .001), 95% CI [-.28, -.12]. Therefore, the null hypothesis was rejected and Hypothesis 39 was supported at the Bonferroni adjusted level of .001. From the slight previous empirical data, a small effect size relationship was predicted. The observed correlation was a small effect size.

Interpreting the results of the nomological network analysis

Altogether, 27 of the 39 directional hypotheses comprising the nomological network were significant at the Bonferroni adjusted level of $p < .001$, all of these significant correlations were in the hypothesised direction. Thirty one of the hypotheses were supported at the $p < .01$ level (in the right direction) and 34 at level of $p < .05$ (in the right direction). With 39 statistical tests conducted, the experimentwise Type I error rate when alpha is .05 is expected to produce two false positive hypotheses. From the above analysis, a problem with the Bonferroni adjustment is immediately apparent, in regard to the nomological network analysis. In order to avoid just two false positive hypotheses at the .05 level, the Bonferroni adjustment eliminated seven hypotheses (34 - 27 =7) which would otherwise have been significant. Assuming that use of the Bonferroni procedure did actually eliminate the two real false positives, it also created five false negative results in the current analysis. Thus, while the Bonferroni adjustment controls for Type I error, it does so at the expense of increasing Type II error, by getting rid of the smaller relationships, some of which are real. This problem with the Bonferroni procedure has been alluded to by Cohen (1990) and discussed by Silverstein (1986).

If there is a large sample size this may not be a problem, particularly if the aim of the research design is to discover substantive relationships. However, the current research is designed to validate a nomological network. In this case, even small, non-substantive relationships can provide evidential support for the construct validity of the nomological network (Campbell & Fiske, 1959; Meehl, 1978, 1990; Smith, 2005a; Westen & Rosenthal, 2003), particularly if such results are suggested by previous empirical research. Application of the Bonferroni procedure needs to be accompanied by logical analysis of the statistical meaning of results in relation to the research design and the question under analysis. In the current nomological network, many of the relationships were hypothesised to be small. There were six observed correlations of .07 or less. Recall that for correlations this small, with the current sample, statistical power at the .05 level was only .59. Therefore, by chance two of these six non-significant relationships are likely to be false negatives. Thus, for a nomological network analysis (with individual hypothesis alphas set at .05) the two false positives and two false negatives effectively cancel each other out. This reasoning suggests that out of the 39 hypotheses 34 would truly be significant (free of experimentwise multiple test error).

Use of the Bonferroni procedure to eliminate the experimentwise multiple test problem means that the current study lacks adequate statistical power to find significance for any relationship less than .12. As previously noted, an adequate sample size for the nomological network analysis would be about N = 1300, with a sample of this size the Bonferroni adjustment would no longer be problematic. Use of the Bonferroni adjustment, in the current case, makes for a conservative analysis of the nomological network. It also obscures some small but true relationships. Of the 12 non-significant relationships (using the Bonferroni procedure i.e. $p > .001$) in the nomological network the only way to determine which seven are true and which five are false is to repeat the study with independent samples (Simes, 1986), preferably a number of times.

Of the 39 hypotheses, predictions of the likely effect size, based on previous empirical results or theoretical considerations, were made for 20 hypotheses. However, the author was not bold enough to predict point estimates on the basis of the often slight available empirical evidence, and therefore used Cohen's

(1988) conventions of small, medium and large. Of these 20 effect size predictions, 17 were in the predicted range. Correct prediction of effect size (based on previous literature) enhances confidence in the nomological network (Meehl, 1978, 1990; Smith, 2005a; Westen & Rosenthal, 2003), confirms previous research, and anchors the current research results in the extant theory and literature. When there is no extant literature regarding the relationship between two constructs, effect size may sometimes be predicted (guessed at) on theoretical grounds, but often, as was the case for a number of hypotheses (19) in the current work, it is difficult or impossible to specify a likely effect size for the relationship.

How conclusive are the results of the nomological network analysis? First, let us consider prediction of the sign of the correlations. An analogy may be drawn between predicting the direction of a correlation and tossing a coin. For each correlation or coin toss there are two possibilities, so the chances of any single correct prediction are .5 (assuming zero, and non-significant correlation are coded as wrongly called coin tosses). Thus, using the stringent Bonferroni adjusted data, the nomological network results, if occurring by chance, would be like predicting 27 correct independent coin tosses out of 39. Applying the binomial theorem, the probability of this occurring by chance is p = .0119[3], providing a moderate degree of confidence for the construct validity of the nomological network. (As a comparison, if alpha had been set at .05 instead of the Bonferroni adjusted .001, the probability of predicting 34 correct directional relations out of 39 would be 1 in 823,000).

One other rough test may also be applied. This test considers the degree of accuracy of the predicted pattern of effect sizes. This is one of Westen and Rosenthal's (2003) construct validity coefficients. In this case the test is rough, because point estimates for the correlations were not specified in the hypotheses. Rather the relationships were predicted to be small, small to medium, medium or large. Also, due to lack of a good reason for doing so, no predictions were made regarding effect size for 19 of the 39 hypotheses. For the purpose of this analysis Cohen's (1988) standard effect size conventions were used (a small correlation is .1, a medium correlation is .3, and a large correlation is .5). A small-to-medium correlation was, admittedly somewhat arbitrarily, assigned a value of .25 for this analysis. These values are used as the predicted point estimate effect sizes for calculating Westen and Rosenthal construct validity coefficient. As only 20 hypotheses predicted effect size, this analysis only examines about half of the nomological network.

[3] I am indebited to Dr. Paul Shortland for calculating this probability.

Westen and Rosenthal's $r_{alerting\text{-}CV}$ validity coefficient is essentially the correlation between the predicted effect sizes and the observed effect sizes. Table 7.20 presents the data required for calculating $r_{alerting\text{-}CV}$.

Table 7.20

Predicted and Observed Correlations and Transformations for Calculating Westen and Rosenthal's $r_{alerting\text{-}CV}$

Hypothesis no.	Predicted correlation X	Observed correlations Y	Demeaned predicted X λs	Z_y
h1	-.25	-.19	-.27	-0.19
h2	-.25	-.08	-.27	-0.08
h3	.5	.55	.48	0.62
h4	-.1	-.2	-.12	-0.20
h5	-.1	-.1	-.12	-0.10
h7	.1	.09	.08	0.09
h8	.1	-.01	.08	-0.01
h9	.1	-.04	.08	-0.04
h10	.3	.36	.28	0.38
h11	.3	.42	.28	0.45
h12	-.25	-.21	-.27	-0.21
h13	-.25	-.26	-.27	-0.27
h14	-.25	-.32	-.27	-0.33
h19	-.1	-.02	-.12	-0.02
h20	-.1	-.08	-.12	-0.08
h26	.3	.21	.28	0.21
h27	.1	-.04	.08	-0.04
h28	.1	.07	.08	0.07
h38	.25	.23	.23	0.23
h39	-.1	-.2	-.12	-0.20
M	0.02		0.0	

Notes. Z_y is the Fisher Z transformed observed correlation

The validity coefficient, $r_{alerting\text{-}CV}$, is the correlation between λs and Z_ys, where λ is the demeaned predicted correlation and Z_y is the Fisher Z transformed observed correlation.. For the 20 predicted and observed correlations $r_{alerting\text{-}CV}$ = .93 ($p < .001$) 95% CI [.83, .97]. Note that Westen and Rosenthal (2003) advised using Fisher *Z* transformations of the observed *r*s (in order to improve normality), and demeaned lambdas of the predicted *r*s, before calculating the validity coefficient. Demeaned lambdas are calculated "by subtracting the mean predicted value from each predicted value so that the sum of the ‘demeaned’ predicted values is zero” (Westen & Rosenthal, 2003, p. 612). Westen and Rosenthal called this coefficient an “‘alerting’ correlation because it is a rough, readily interpretable index that can alert the researcher to possible trends of interest” (p. 610). The $r_{alerting\text{-}CV}$ of .93 suggests that the predicted pattern of values provide an accurate portrayal of the pattern of correlations found for the 20 hypotheses for which effect sizes were predicted. This result suggested good construct validity for the half of the nomological network represented by these 20 hypotheses.

Meehl (1978, 1990) called such predictions of effect sizes to test theories ‘risky tests of theories’. He claimed that prediction of the expected effect sizes is much more informative than traditional nomological network construct validation. Discussing this concept, Smith (2005a, p. 399) stated the case as follows “if the outcome is close to predictions, one has demonstrated much stronger support for one’s theory than if one had merely confirming a positive relationship between two variables”.

Because the new instruments’ reliabilities were generally moderate (coefficient alphas ranged from .57 to .80) the correlations between them were attenuated by the degree of unreliability of each measure. Thus, the true correlations between the underlying constructs will actually be higher than the observed ones (similar to the use of the Bonferroni adjustment, uncorrected instrument unreliability makes the nomological network analysis more conservative). Likewise, because some of the instruments have some degree of skewness towards their maximum or minimum values, the range of their dispersion is restricted at their upper or lower limit and therefore their correlations could also be attenuated for this reason. Attenuation of the correlation coefficient will be greater when both instruments are skewed. Instruments which demonstrated some skewness were commercialisation, awareness, judgment, and general attitude to GE. Visual examination of the scatter plots of the various instruments graphed against one another suggested that the relationships most likely to be attenuated by skewness in the instruments were between commercialisation and judgment and awareness and judgment. However, in the current case, as noted previously, transformation of the instruments made only tiny, insubstantial changes to correlations between the instruments, and was therefore, considered unnecessary for the nomological network analysis. Therefore, this potential source of correlation attenuation is not an issue in the current study.

Some of the correlations, although significant, represent relatively small effect sizes (i.e., .13 to .25), indicating that the relationships are not strong and that only a relatively small percent of the variance of one construct is explained by the related construct. However, weak relationships, such as these, are common in psychology (Aron & Aron, 1999), and as previously explained, even small relationships can provide supportive evidence for the validity of a nomological network by demonstrating the instrument has discriminant validity (Campbell & Fiske, 1959; Meehl, 1978, 1990; Smith, 2005a; Westen & Rosenthal, 2003). There were a few exceptions where correlations were medium or large. One correlation was large (≥ .5) and 8 other correlations were medium ($.30 \leq r < .50$) and a further 12 were small to medium ($.20 \leq r < .30$). Eighteen correlations were small ($0.0 \leq r \leq .20$). The large correlation (.55) was between the moral awareness instrument and scientists' moral judgment instrument. This relationship was expected to be strong because they are both measures of social responsibility in science and psychologists and philosophers generally consider awareness of an ethical issue a necessary (though not sufficient) condition for ethical reasoning and judgment to occur.

As predicted, a medium strength correlation was found between the higher order value dimension self-transcendence and judgement (.42) and between self-transcendence and awareness (.36). Self-transcendence has previously been found to be related to moral behaviour (Crilly, et al., 2008; Fritzsche & Oz, 2007; Helkama, et al., 2003; Lan, et al., 2008) and environmental concern (Beckmann, et al., 1997; Schultz & Zelezny, 1998, 1999; Stern, et al., 1995). Therefore, the current findings are consistent with and confirm previous empirical research.

A medium sized negative correlation of -.40 was found between awareness of social responsibility and favourable attitude to GE, indicating that scientists who were more aware of the social and moral responsibilities of science to society were more likely to be concerned about the potential impacts of genetic engineering and have a conservative or more negative attitude regarding the technology. Similarly, judgment of the importance of personal actions designed to enhance social responsibility in research was also negatively related ($r = -.28$) to a favourable attitude to GE.

As predicted, a medium sized negative correlation of -.32 was found between self-enhancement and judgment and -.26 between self-enhancement and awareness. Self-enhancement has previously been found to be negatively related to ethical decision-making (Fritzsche & Oz, 2007), negatively related to moral reasoning (Crilly, et al., 2008) and negatively related to moral sensitivity (Myyry

& Helkama, 2002). Self-enhancement was positively related to a favourable attitude to GE (.23). Previous empirical research has indicated that the value type of power (one of the two value types comprising self-enhancement) was positively related (r = .29) to favourable attitudes to GE food, while the value type of universalism (one of the two value types comprising self-transcendence) was negatively (though non-significantly) related (r = -.15) to favourable attitudes to GE food (Dreezens, et al., 2005). The lack of a statistically significant relationship between universalism and favourable attitude to GE food in the Dreezens et al. study is likely due to the study's lack of statistical power.

The current research also asked three questions relevant to this issue.

1. GE foods products are safe for human consumption (correlation with: universalism = -.17, p < .001; with self-transcendence = -.13, p < .001, 1-tailed tests).
2. I would feel good about eating food from GE plants (correlation with: universalism = -.21 p < .001; with self-transcendence = -.20, p < .001, 1-tailed tests).
3. I would feel good about eating food from GE animals (correlation with: universalism = -.22, p < .001; with self-transcendence = -.22, p < .001, 1-tailed tests).

Thus, data from the current research not only supports Dreezens et al's. (2005) significant findings but also suggests that the non-significant negative relationship they found between universalism and attitude to GE food is actually a real relationship (see Chapter 5 for more details of the Dreezens et al's. study).

Attitude to the democratisation of science had a medium size positive correlation with moral awareness (.30) and scientists' moral judgment (.31) and also with self-transcendence (.29), but a negative medium sized correlation with favourable attitude to GE (-.30). Small and Mallon (2006) found in their qualitative study that scientists considered some aspects of democratisation and commercialisation to be in conceptual opposition and, in a similar vein, the current study found a negative correlation between these two constructs (r = -.15). A favourable attitude to the commercialisation of science was negatively correlated with moral judgment (r = -.14) and self-transcendence (r = -.27), but positively correlated with technological optimism (r = .24) and a favourable attitude to GE (r = .21). Technological optimism was positively correlated with a favourable attitudes to GE (r = .39) and to commercialisation of science (r = .21).

Conclusion

In this chapter five new psychometric scales measuring aspects related to scientists' understanding and practice of social responsibility in research have been developed. Items for these instruments were derived from the qualitative Study 1 (Chapter 6). A two stage EFA – CFA process was used to develop and refine the scales and determine their degree of unidimensionality. Coefficient alpha was used to determine the scales reliabilities. Four of the new scales (democratisation of science, commercialisation of science, moral awareness and moral judgment) are unidimensional as indicated by a range of goodness-of-fit indices and have reasonable to good reliability. The fifth scale, technological optimism performed poorly on six out of seven goodness-of-fit indices (but performed adequately on the GFI) and also performed poorly in the reliability analysis (α = .57). This instrument must be considered with some caution, and future work is needed to improve it. However, it is worth noting that the technological optimism scale did perform as theoretically predicted in the nomological network. This provides some support that the scale does measure the intended construct.

These new instruments were embedded in a nomological network for analysis of construct validity. Two existing instruments were also included in the nomological network of constructs. The first was the Schwartz Value Survey (consisting of four separate scales), an instrument extensively examined and used in extant psychological literature. The second, a relatively new instrument, measured general attitude to GE. This instrument was used as a concurrent criterion for testing the new instruments. These existing instruments were also checked for unidimensionality using CFA on the whole sample. The attitude to GE instrument performed very well on four out of seven goodness-of-fit indices. However, poor performance on the other three goodness-of-fit indices raised some questions regarding the scales unidimensionality. The Schwartz higher order value dimensions performed adequately on three out of seven goodness-of-fit indices and poorly on the other four. The results of this analysis raised questions regarding the unidimensionality of one of the higher order value dimensions (self-enhancement). Therefore, some caution is required regarding the use of both of these existing instruments. However, these scales also performed very much as predicted in the nomological network analyses, lending some support to their construct validity.

The nomological network consisted of 39 hypothesised relationships between the 10 scales. Two methods of testing the construct validity of the nomological network (and hence the construct validity of the new instruments) were used. First, the direction (i.e., the sign) of the correlation between the 39 hypothesised relationships was predicted and tested at the Bonferroni adjusted probability level of .001. Of the 27 significant relationships found, all were in the predicted direction. As previously noted, use of the Bonferroni adjustment provides a very conservative analysis of the nomological network relationships. Overall, this result provides reasonable support for the nomological network, even with the reservations expressed regarding the technological optimism, attitude to GE and self-enhancement scales.

The second method of testing the construct validity of the nomological network was a concept promoted by Meehl (1978, 1990) called *risky tests of theories* which called for more precise predictions than just the direction of the relationship. This test requires that expected effect sizes are predicted for the intercorrelations in the nomological network. Comparisons can then be made between the hypothesised correlation effect size pattern and the observed pattern of correlation effect sizes. While this may be done by qualitatively examining the patterns, more recently Western and Rosenthal suggested a quantitative measure for the analysis. This involves the correlation of the predicted effect sizes with the observed effect sizes of the nomological network relationships. They proposed this measure as a construct validity coefficient. An inherent difficulty associated with this construct validity coefficient is that it is often difficult to predict the likely effect size if theory is poorly developed or there is no previous empirical evidence regarding a likely effect size.

In the current study this was a relatively crude measure of the construct validity of the nomological network because effect size predictions could only be made for 20 of the 39 hypotheses. Also, the predictions of effect size were not point estimates but rather were in terms of the effect size conventions for correlations in the behavioural sciences (i.e., small, medium, and large). Of the 20 effect sizes predicted 17 were clearly in the predicted size range. Westen and Rosenthal's construct validity coefficient for the 20 hypotheses was $r_{alerting\text{-}CV}$ = .93. Although this measurement must be cautiously considered given the limitations just expressed, nonetheless the results do appear promising for the construct validity of the nomological network and the scales used to measure its constructs.

Furthermore, the pattern of intercorrelations amongst the instruments suggests they have discriminant and convergent validity. The high degree of confirmation of the empirically and conceptually developed theoretical hypotheses implies a high degree of internal consistency in the nomological network. The results of the current work are also externally consistent with previous empirical findings regarding the same or similar constructs, as the number of correctly predicted effect sizes indicated. All things considered, these results provide excellent initial support for the proposed nomological network and help to infer construct validity to the new instruments.

Of course, as discussed previously, demonstrating construct validity is an ongoing empirical process. Any one experiment or statistical study can only be considered as one confirmation (or disconfirmation) instance of the hypotheses or theories being proposed or tested. Replication, as noted by a number of scientists in Study 1 (Chapter 6), is the key to good science. Further study limitations and implications will be considered in the concluding chapter.

Chapter 8 - Conclusion

Modern science and technology are giving humans increasing power and control over both nature and human destiny. The power of science and technology to impact Gaia is now so great that human use of the gifts of Prometheus pose potential existential threats to humanity and much of the rest of life on Earth (Bostrum, 2002). Suzuki (2010, p. 2) claimed: "We are so dazzled by our own inventiveness that we are blinded to the consequences of technology. We have very suddenly become a major planetary force." We seem to be at a crucial crossroad in planetary and evolutionary history. The approaching existential crises (e.g., Brown, 2008; Flannery, 2009; Lubchenco, 1998; Meadows et al, 1992; Nobel Laureates, 2001; Raven, 2002; Suzuki, 2010; Wackernagel & Rees, 1996), rooted in humanity's development and use of science and technology (e.g., Bunge, 1977; Jonas, 1985; Luppicini, 2008), are real, and currently on an imminent path (as briefly catalogued in Chapter 1). Some experts believe that we have already passed the point of no return; that tipping points have been reached which will eventually see at least half to two-thirds of the planet unfit for human habitation (e.g., Lovelock, 2006; Sherwood & Huber, 2010). Others, such as the renowned environmentalists David Suzuki (2010) and Tim Flannery (2009) believe that, if we act immediately, both locally and globally, we may be able to mitigate some of the damage and preserve the bulk of the planet for future generations.

Scientists are the creators and developers of science and technology. The role that they have played, and continue to play, in the development of the knowledge and capabilities which now enable humanity to create and actualise existential risk gives them an extra responsibility to society: to ensure the wise use of their discoveries and creations (Bunge, 1977; Jonas, 1985; Ziman, 1998, 2001). While a 'technological fix' is by no means assured (Costanza, 1989; Daly, 1996; Huesemann, 2001; Krier & Gillette, 1985), it is certain that the problems that currently face Gaia will not be solved without science and technology. Scientists have an important role in bringing to public attention the nature of the crises and in the development of appropriate responses and appropriate sustainable solutions and technologies (e.g., Bunge, 1977; Jonas, 1985; Lubchenco, 1998; Luppicini, 2008; Moor, 2005; Ziman, 1998).

Given the extraordinary circumstances that face us, and their existential quality, immediate global action is imperative (Flannery, 2009; Lovelock, 2006; Lubchenco, 1998; Nobel Laureates, 2001, 2007; Suzuki, 2010). Scientists are a key link in addressing this problem. They understand science and are in a favoured position to understand the implications and consequences of science and technology, and their potential application by humans. The application of scientific disciplines provides the only source of methodologically sound foresight about potential consequences and the future (Jonas, 1985).

A number of scientists (e.g., Bradshaw & Bekoff, 2001; Cournand, 1977; Rotblat, 1999; Russell & Einstein, 1955; Sakharov, 1981; Ziman 1998) and philosophers of technology (e.g., Bunge, 1977; Jonas, 1985; Luppicini, 2008; Moor, 2005) have addressed the issue of the wider social responsibilities of science and scientists. However, as documented in earlier chapters, 1) empirical research into scientists' attitude to this important issue is almost non-existent (Hackett, 2002, McCormick, et al., 2009; Pimple, 2002; Prpic, 1998; Weil, 2002), and 2) there is no consensus as to exactly what the wider social responsibilities of science to society are (Pimple, 2002; Weil, 2002). Because of scientists' role in the production of knowledge and technology their attitudes and actions regarding scientific social responsibility will be important for addressing the potential existential crises and for scientific foresighting of the social and moral implications of emerging Promethean technologies.

Synthesis of Research Findings and Contribution to Literature

The contribution of this thesis is to address these two little-researched issues through two distinct but interrelated studies. The first study used qualitative methodology to explore the concept domain of scientific social responsibility. This study helped to address what Pimple (2002, p.189) described as "the disturbing gap" regarding the lack of characterisation of this domain, The second study, using a quantitative approach, built upon the ontological and epistemological elements identified in Study 1 to develop psychometric measures for two theoretical constructs of social responsibility and three related constructs: attitude to democratisation of science, attitude to commercialisation of science and technological optimism. These measures provided insight into the sample scientists' attitudes, beliefs, and moral judgments regarding science, technology and society. Gene technology provided an example of a Promethean science in which the more abstract concept of social responsibility could be embedded and respondents' attitudes, beliefs, values and latent moral and meta-ethical reasoning processes made more contextually concrete and overt. These values, beliefs, and reasoning processes were examined through the lens of the ethical theories reviewed in Chapter 3. It was found that philosophical moral theories are applied by scientists in reflective analysis of their science practice.

Three primary conceptual themes regarding scientific social responsibility emerged from Study 1: doing public good; engagement with society; and compliance with laws, regulations, and societal and scientific mores. Each of these themes was explicated via a series of sub-themes and illustrated by extensive quotes from participants. These themes and sub-themes provide the beginnings of a framework for categorising and understanding the domain and the elements of scientific social responsibility. Although the framework is taxonomical in nature rather than causal, elements from within the domain framework are likely to be causally linked to each other. The framework provides a source of elements for further exploration and use in causal modelling of aspects of scientific social responsibility.

Such a framework may be useful for a range of purposes. Scientific research organisations, looking to improve their social responsibility, may base strategies, activities and employee training programmes around elements of the framework. Scientists, interested in enhancing social responsibility in their own research work, may use the framework as a checklist to guide and help them practise socially responsible research. Educational institutes may use the framework as a component in the ethics education of scientists in training. Scientific societies may use the framework to help with the continuing development of ethical standards and for developing recommendations for members' practise and behaviour. Responsibilities difficult for individuals to implement could be managed and implemented by scientific societies.

Study 1 explored the complexity of scientific social responsibility by revealing the conflicting values and beliefs that scientists expressed about science and their responsibilities to society, including both their optimism and enthusiasm for science and their reservations and concerns about how science is being used. Like the technoethicists (e.g., Bunge, 1977; Jonas, 1985; Luppicini, 2008), the ecologists (e.g., Bradshaw and Bekoff, 2001; Flannery, 2009; Lovelock, 2006; Suzuki, 2010), the physicians (e.g., Cournand, 1977; Shine, 1989; Physicians for Social Responsibility, n.d.), and the physicists (e.g., Abelson, 1970; Rotblat, 1999; Sakarov, 1981, Ziman, 2001) reviewed in Chapters 3 and 4, the scientists in Study 1 expressed concern about the potential for social and ecological harm arising from the everyday use of technology (e.g., over-population, resource depletion, pollution, social inequity). Like a range of scholars and scientists whose views were discussed in the literature review (e.g., Bostrom, 2002; Carter, 1989; Katz, 2001; Nobel Laureates, 2001; Preston, 2010; Rees, 2003; Russell & Einstein 1959; Small and Jollands, 2006) they also expressed concern regarding the potential use of new and emerging technologies as weapons, observing the 'dual-use' nature of many such technologies (Carter, 1989; Miller & Selgelid, 2007; Preston, 2010).

As noted in the literature review, common to the fields of applied ethics most relevant to science and technological development (i.e., environmental ethics, bioethics and deep bioethics, and technoethics) are calls for an extended ethic of value concerned with the future of humankind, other creatures dependent on human power, and the dignity of nature (Bunge, 1977; Jonas, 1985; Lenk, 1983; Leopold, 2001; Naess, 1973; Potter & Whitehouse 1998) and an extended ethic of responsibility of science to society (e.g., Bulger et al., 2002; Bunge, 1977; Jonas, 1985; Ziman 1998, 2001). Interviewees suggested a range of mechanisms for enhancing the social responsibility of science. Many of these mechanisms echoed ideas proposed by the scholars and scientists reviewed in earlier chapters. They included: the need for greater precaution in the development of science and technology (e.g., Costanza, 1989; Jonas, 1985; Krier & Gillette, 1985), the need for earlier and better engagement between science and society (e.g., Hackett, et al., 2008; House of Lords Select Committee on Science and Technology; Irwin, 2008; Marris, 2001), the need for an increased focus on social responsibility by individual scientists (e.g., Bradshaw & Bekoff, 2001; Cournand, 1977; Jonas, 1985; Rotblat, 1999; Sakarov, 1981; Ziman, 2001) and the need for scientific foresighting (Jonas 1985; Slaughter, 2007).

Through the mechanism of focussing on a particular Promethean technology, gene technologies, the moral reasoning and the latent meta-ethical positions of scientists were unveiled. Evidence was found in Study 1 for deontological (Kant, 1998), teleological (Hurstone, 2009), and virtue ethics (Aristotle, 1996) approaches to reasoning regarding the issue of scientific social responsibility and gene technologies. Attitudes regarding gene technologies also revealed latent meta-ethical beliefs of interviewees, including ethical relativism (Pojman, 1998a), moral objectivism (Ross, 1998), moral realism (Sayre-McCord, 2009), moral absolutism (Kant, 1998), moral conventionalism (Pojman, 1998d), and moral subjectivism (Nietzsche, 1998). Although public attitudes to gene technology and genetic engineering have received considerable research attention, little empirical research has been conducted on scientists' attitudes to these technologies. This thesis contributes knowledge regarding this issue, both from Study 1 and Study 2. Study 2 also contributes a comparison of scientists' attitudes to GE with those of the New Zealand public.

From the statements scientists made regarding the domain of social responsibility, items were proposed as the content for two instruments to measure aspects of scientists' attitude to social responsibility. Items congruent with the first stage of Rest's (1979, 1986) model of moral behaviour (moral awareness) were selected for one instrument and items congruent with the second stage of Rest's model (moral judgment) were selected for the second instrument. The primary purpose of Study 2 was to develop these items into psychometrically robust instruments suitable for use in future research.

Validity of the new instruments and the nomological network

Study 2 administered the potential items for five new instruments to a sample of 733 scientists working at six New Zealand Crown Research Institutes. Two existing psychometric instruments were also administered in the research questionnaire: the Schwartz Values Survey (which incorporates four sub-scales) and an instrument to measure attitude to genetic engineering (a sub-field of gene technologies). Thirty-nine relationships between the five new instruments, the four sub-scales of the Schwartz Values Survey and the attitude to GE instrument were proposed on conceptual, theoretical and empirical grounds to form the beginnings of a testable nomological network about scientific social responsibility and its antecedent and consequent constructs. The relationships between each pair of constructs described in the nomological network were defined by hypotheses indicating the direction of their correlation and, in about half of the cases, their approximate strength (i.e., effect size).

Each hypothesis tested (with the proviso of the test having adequate statistical power) makes a small contribution to knowledge either by demonstrating a new relationship (or lack of it) or by being a confirming or disconfirming instance of a relationship previously reported in the literature. As argued by the scientists in Study 1 (see Chapter 6, pp. 194-195) this is true irrespective of whether the results are positive (i.e., significant) or negative (non-significant). The nomological network was proposed as a test of the construct validity of the new measures and their theoretical relationships. A nomological network is an "interlocking system of laws which constitute a theory" (Cronbach & Meehl, 1955, p.290). The nomological network constitutes the beginnings of a new theory about scientific social responsibility – a further contribution of this work. Additionally, as there were no existing measures in the literature for the constructs comprising the nomological network, the new measures constitute new tools to examine the concept of scientific social responsibility.

The network, characterised by the relationships between the constructs of democratisation of science, commercialisation of science, technological optimism, awareness of science's responsibility to society, judgment about personally responsible behaviour, and personal values, is in its early phase of development. It is still ill defined in respect of numerous other potentially relevant constructs (Cronbach & Meehl, 1955; Smith, 2005a, 2005b). The nomological network, proposed in Study 2 to test construct validity of the new instruments, is a small sub-set of the themes and sub-themes of the social responsibility domain framework developed in Study 1. Study 1 provides a rich resource of themes, sub-themes and ideas that could be mined for future investigation as measurable constructs for the extension of the nomological network and continued analysis of its theoretical structure and causal relationships.

In Study 2, as recommended by various methodological theorists for scale development (e.g., Smith et al., 2009; Reise, et al., 2000; Fabrigar, et al., 1999), exploratory and confirmatory factor analyses were used to select items which formed easily interpretable, unidimensional and reliable measures. Single factor scales for four of the new measures showed good to excellent goodness-of-fit on a range of appropriate indices (indicating their unidimensionality) and reasonable to good reliability, as measured by coefficient alpha. The fifth instrument (which measured technological optimism) had a single factor which performed poorly on most fit indices but demonstrated acceptable goodness-of-fit on the GFI index; it also had a relatively poor coefficient alpha of .57. This instrument represented a potential weakness in the nomological network analysis: low reliability attenuates correlations and multidimensionality obscures causal relationships. However, the correlations between technological optimism and the other constructs in the network are not dissimilar to the correlations between the other constructs, and the relationships were either in the predicted direction and/or in the predicted effect size range. While the technological optimism instrument would clearly benefit from further development in future work, it appears adequate for its current use as a construct in the current nomological network (Reise et al., 2000).

There was a methodological concern about the unidimensionality of the self-enhancement higher order value dimension. Concerns were also flagged regarding the scale to measure attitude to GE, which performed well on four goodness-of-fit indices but not on three others. However, similar to the technological optimism instrument, the self-enhancement and the attitude to GE scales' relationships with other constructs were as theoretically predicted, again suggesting that the psychometric properties of these scales, although perhaps not ideal, were adequate for current purposes (Reise et al., 2000).

The results of the hypotheses tests were encouraging; there was a high degree of correspondence between both the predicted direction and magnitude of the relationships in the nomological network and of the empirically observed pattern and size of correlations. An estimate of the probability of the observed accuracy of the hypotheses of the correlations' directions occurring by chance was made using the binomial theorem: p = .0119. Because of the use of the Bonferroni procedure this is a very conservative estimate. Of the 20 hypotheses for which the effect size magnitude was predicted, the correlation between the predicted correlations and the observed correlations was a very high .93 (Westen & Rosenthal 2003), an admittedly rough validity coefficient measure covering only a subset of the nomological network (see Chapter 7). Despite some reservations about the validity of these latter two indicators, the results, taken as a whole, provide good support for the theoretical relationships depicted by the nomological network and the construct validity of the instruments. The research instruments provide considerable new information about the attitudes of the sample of scientists to the related issues of scientific social responsibility, the democratisation of science and the commercialisation of science.

Democratisation of science

In general, the scientists were in favour of the democratisation of science (see Table 7.17), believing that the public had a right to exercise some influence over the directions and agendas of science (see Table 7.8, item D2). This result is similar to the previously reported conclusion of Sommer (2010, p.24), that New Zealand scientists had an inclination for "citizen involvement over strict expertise." However, echoing the deficit theory of public understanding of science (Irwin & Wynne, 1996; Evans and Durant, 1995), they also expressed reservations about the knowledge and ability of the public to understand science and its implications (see Table 7.8, item D4). They expressed concern regarding the potential of the practice of democratisation of science to impede scientific progress (see Table 7.8, item D6). These quantitative results support and reinforce the qualitative findings of Small and Mallon (2004, 2006) and Small (2005b) reported in Chapter 4.

Commercialisation of science

The scientists in the survey were generally apprehensive about the effects of the commercialisation of science (see Table 7.17), believing that it retards scientific progress, inhibits the production of public good science (Nowotny, et al., 2003; Krimsky, 2004), reduces scientific transparency, is detrimental to public trust in science and scientists (Eichelbaum, Allan, Fleming & Randerson, 2001; Polkinghorne, 2000), impairs the transfer of scientific knowledge, and decreases scientific innovation. Again, these quantitative results (see Table 7.10, C1, C2, C3, C4, C7, C9) support and confirm the qualitative findings of Small and Mallon (2004, 2006) reported in Chapter 4.

Technological optimism

Responses to the technological optimism instrument (as it currently stands), illustrated a moderate degree of technological optimism (Krier & Gillette, 1985) amongst the sample scientists (see Table 7.17). This result is consistent with previously reported research (National Science Board, 1977; Rollins, 1996; Ticky, 2004). However, as previously noted, this scale is psychometrically weak and results must be treated as provisional, with further research required to make the instrument better and to check the results of analyses in which it was used. Initial observations from this scale indicate that scientists' concerns about technology were primarily centred on the likely consequences of human application of technologies, rather than the ability of science to generate appropriate solutions to human and environmental problems.

Social responsibility

Previously, no instruments were specifically designed to measure scientific social responsibility, nor was the construct of scientists' social responsibility well defined. The contribution of the current thesis has been to make a start at addressing both of these gaps in the literature. First, Study 1 developed a framework for the domain of scientific social responsibility. Second, Study 2 developed sound psychometric measures to investigate this domain. The data were obtained through the use of mixed-method, qualitative-quantitative research. The research and hypotheses were informed by and based on a detailed literature review with reference to, and integration with, normative and applied ethical theories from philosophy, psychological theories of moral behaviour and, where available, past empirical research.

Good empirical support was found for the nomological network – indicating that it represents the beginnings of a theoretical model of scientific social responsibility. The 39 hypotheses comprising the nomological network referenced relevant theory and empirical findings (where these were available) as discussed and explicated in Chapters 3 and 4. Thus, there was a high level of integration with existing theory. For 20 of the hypotheses, past empirical findings led to the prediction of approximate effects sizes, Of these 20 hypotheses, 17 were found to be in the predicted range, providing strong evidence that the findings of the Study 2 are consistent with previous empirical research.

In some cases, relationships (with similar effect sizes in both the existing literature and the current work) which were reported as non-significant in previous literature (e.g., Beckmann, et al., 1997; Fritzsche and Oz, 2007), were shown to be significant in Study 2 (e.g., see hypothesis 4 & 5, p. 265). As previously explained, this difference was due to inadequate statistical power in the original research. Tight integration with theory and previous empirical research helps provide confidence in the data, the new instruments and the theoretical model.

On the basis of Rest's (1976, 1983) theory about the psychological processes leading to moral behaviour, two instruments were developed to measure scientists' attitude to social responsibility. One measured respondents' awareness of the responsibility of science to society (moral awareness). The other measured their judgment of the importance of personal actions during the research process (moral judgment). Awareness or perception of a moral issue is stage 1 of Rest's (1979, 1986) theory of the four stages of moral behaviour. Judgment or decision-making about what the morally correct actions are, when one is aware of a moral issue, is stage 2 of Rest's theory.

Moral awareness instrument. As reported in Chapter 7, this eight item instrument is unidimensional with respectable CFA goodness-of-fit indices and reasonable reliability. This measure is designed to be congruent with the first stage of Rest's (1979, 1986) model of moral behaviour; all the items in the moral awareness instrument are designed to measure to what degree the respondent is aware of the responsibility of science to society i.e. are they aware of, and do they believe that, science has a moral responsibility to society. The final version of the moral awareness instrument is below.

Please indicate your level of agreement with the following statements (5 point Likert scale: 1 = Strongly disagree to 5 = Strongly agree).

1. Science should respect and act within the mores of society.
2. The science community has a moral obligation to ensure that the products of scientific knowledge do not cause harm (e.g., to humans, animals, environment).
3. The science community cannot be held ethically responsible for the uses to which scientific discoveries are put.
4. The more powerful a technology is the more important the evaluation of its ethical and social implications becomes.
5. There are some fields of knowledge so potentially dangerous that they should not be researched.
6. Ethical training should be an integral part of scientific training.
7. The benefits of science and technology should be distributed throughout society in a fair and equitable way.
8. There is no ethical imperative for science to 'do good'.

The moral awareness instrument indicated that scientists were moderately to strongly aware of the responsibility of science to society (see Table 7.17). On the basis of responses to a single item, Sommer (2010) made a similar conclusion in his study of New Zealand scientists. Very strong agreement was given to the propositions that: 'the science community has a moral obligation to ensure that the products of scientific knowledge do not cause harm to humans, animals or the environment.' This confirms the finding in Study 1, where all the scientists interviewed believed there was a moral imperative to not cause harm. The statement: 'the more powerful a technology is the more important the evaluation of its ethical and social implications becomes' also received very strong agreement (see Table 7.13 for means and 95% confidence intervals of scale items). Thus, the scientists participating in the survey tended to support the contentions of the technoethicists (Bunge, 1975; Jonas, 1985; Lenk, 1983;

Luppicini, 2008; Moor, 2005) reviewed in Chapter 3. As suggested by participants in Study 1, and argued on analytical grounds by Jonas (1985), one important social responsibility of scientists is to foresight the social, ecological and moral impacts of emerging technologies.

The statement that 'the benefits of science and technology should be distributed throughout society in a fair and equitable way' also received strong support. In contrast, but consistent with the above findings, the negatively worded statement 'there is no ethical imperative for science to do good' received significant disagreement from the scientists (see Table 7.13, p. 251). These data indicated the sample scientists' awareness of moral issues related to science and technology and suggested a strong desire to use science and technology for the public good. In a similar vein, a study by Fisher, et al., (2005) indicated that one of the strongest motivations for going into a science career was an altruistic desire to use science for the betterment of society. This observation is also consistent with the finding in the current research that the strongest of the scientists' Schwartz higher-order value dimensions was self-transcendence (see Table 7.17, p. 257).

However, Study 2 (supporting and triangulating the findings of Study 1) also indicated there was ambivalence in scientists' attitude towards the responsibility of science to society. Although strongly agreeing that 'science should respect and act within the mores of society', somewhat antithetically scientists also strongly agreed that 'science must sometimes push the boundaries of social and ethical acceptability in order to advance knowledge' (note that this question was a proposed item that did not make it into the final scale). Similarly, even though as noted before, they believed that powerful technologies require greater ethical and social evaluation, there was general disagreement that 'there are some fields of knowledge so potentially dangerous that they should not be researched.' Additionally, there was positive, though weak, agreement that 'the science community cannot be held responsible for the uses to which scientific discoveries are put.'

These ambivalent attitudes might be interpreted as representing historical and current conflicts regarding the reality of the production of scientific knowledge in the 21st Century and science's moral obligations to society (Hagedijk, 2001; Krimsky, 2004; Mirowski & Sent, 2008; Nowotny, et al., 2003; Olivieri, 2003; Ziman, 1994). These authors document the transition of science from a public good activity with high levels of academic freedom and a strong focus on basic science, in which knowledge was considered a good in itself (i.e., knowledge is of intrinsic value), to a commercialised science environment with much greater restrictions on academic freedom and a focus on applied science to achieve commercial or political goals (i.e., knowledge is of extrinsic value).

Historically, the chief reward for the contribution of scientific knowledge to humanity was fame and honour with a place in the history of science. Such attribution of credit has long been a scientific norm. Few scientists would not wish to receive some credit for the benefits to society that accrue from their discoveries. This helps explain the high importance placed by scientists in Study 1 on the publication process, authorship issues and citation of the originators of ideas and discoveries. However, the flip side of praise and credit is accountability and responsibility. But, as history shows, and scientists in Study 1 noted, scientists often cannot control how their knowledge is used once it leaves their hands. Therefore, with some reason, they are reluctant to be held accountable for 'misuse' of their discoveries and technologies, as indicated by Study 2.

Scientists are becoming increasingly aware of the detrimental impacts of the application of science and technology on society and the environment (e.g., Bradshaw & Bekoff, 2001; Lubchenco, 1998; Nobel Laureates, 2001, 2007; Physicians for Social Responsibility, n.d.; Russell & Einstein, 1955). Historically, positive impacts tended to dominate the science discourse, but the rising existential crises are now placing a focus on negative impacts. As the creators of technological knowledge, generally scientists do feel some responsibility for its impacts. However, there is an asymmetry between the acceptance of credit for the production of knowledge used beneficially and the acceptance of accountability for production of knowledge used for harm.

Nonetheless, perhaps because of the historical precedent of academic freedom and the historical knowledge that in some important past conflicts between science and the culture and mores of the day, science has been proven correct (Gribben, 2002; Silver, 1998: Small, 2004a, 2004b), scientists are still willing to challenge social and moral convention and to research fields of knowledge that have significant potential to be used for harmful ends. To be fair to scientists, asymmetry between credit and accountability for the production of knowledge may be unavoidable, particularly if, as is often the case, new technologies fall into the category of dual-use technologies (Carter, 1989; Miller & Selgelid, 2007; Preston, 2010). Nonetheless, it remains true that unless someone produced the knowledge in question it could not have been used for harm. Scientists are a part of the causal chain in the production of both benefit and harm to Gaia.

As the impacts of resource depletion and climate change become more pronounced, it is likely that scientists will become increasingly aware of the social responsibility of science to society. As noted above, scientists were keen to see the benefits of science and technology distributed more equitably throughout society, and perhaps one of the key issues in respect to equity and scientific social responsibility will be that of intergenerational justice and equity (Slaughter, 2007). Two of the potential crises documented in Chapter 1, resource depletion and pollution (climate change is a result of carbon pollution), are clearly issues of intergenerational justice and equity. The relationship between scientific social responsibility and the concept of intergenerational justice and equity has received little specific attention in this thesis. However, it is an area ripe for future research and expansion of the scientific social responsibility construct.

Moral judgment instrument. As reported in Chapter 7, this seven item instrument is unidimensional, with respectable CFA goodness-of-fit indices and has respectable reliability. The items in this instrument were about the importance of personal actions that scientists could take to help ensure science and technology are developed and used in a socially responsible manner. This measure is designed to be congruent with the second stage of Rest's (1979, 1986) model of moral behaviour (moral judgment). That is, in order to respond to these questions the respondent must have been able to make a decision about whether (and to what degree) the described action/behaviour is morally appropriate, and how important it is to do it in the situation or context. The finalised moral judgement instrument is below.

How important are the following principles to you as a scientist living and working within society? (1 = Not at all important, 2 = Of little importance, 3 = Moderately important, 4 = Important, 5 = Very important)

1. To evaluate possible benefits against harms when deciding on research projects.
2. To refrain from exaggerating the potential benefits or minimising the potential risks associated with research.
3. To refrain from conducting work in areas that you find morally questionable.

4. To ensure that approval for research is gained from the appropriate ethical authorities.
5. To ensure that the process and development of research complies with the precautionary principle.
6. To become informed about what society finds acceptable or unacceptable in scientific research.
7. To put the good of society ahead of commercial profit.

The strongest positive responses in the survey were to the items in the moral judgement instrument. The moral judgment instrument indicated that the scientists in the sample were highly aware of the appropriate moral actions and placed high importance on them (see Table 7.17). Particularly important to them was 'giving the public clear guidance on the reliability and validity of scientific conclusions regarding potential benefit and harm' and 'refraining from exaggerating the potential benefits or minimising the potential risks associated with research' (see Table 7.15 for means and 95% confident intervals of individual items in the scale). This is a quantitative confirmation of the importance scientists in Study 1 placed on these actions. These actions both imply foresighting social and moral implications for society and moral integrity of engagement with the public, two sub-themes from the scientific social responsibility framework.

Also judged highly important were 'ensuring that approval for research is gained from appropriate ethical authorities', and 'putting the good of society ahead of commercial profit'. While the latter is consistent with the Study 1 theme of 'doing good', it is clear that it may run into conflict with one of the sub-themes of the 'compliance' theme i.e., 'business norms'. 'Refraining from conducting work in areas they considered morally questionable' was also rated as highly important. This result reflects the importance to scientists of compliance with their 'personal values' (a sub-theme of the compliance theme from Study 1). Several scientists in Study 1 expressed strong feelings about the importance of compliance with personal values and Study 2 confirms that most CRI scientists also considered it important.

Previous research indicated that values are related to moral behaviour (Bardi & Schwartz, 2003; Hitlin, 2003; Schwartz, 2006) and to moral perception and moral judgment (Abdolmohammadi & Baker, 2006; Crilly, et al., 2008; Fritzsche & Oz, 2007; Helkama, et al., 2003; Lan, et al., 2008; Lan, et al., 2010). Results presented in Chapter 7 (and summarised in the next section below) confirmed these previous findings, with Schwartz's higher order value dimensions of self-transcendence and self-enhancement having significant, medium sized correlations with the social responsibility instruments, significant small to medium correlations with the democratisation instrument, the commercialisation instrument and the attitude to GE instrument (see Table 7.19).

Rated as important, although much less so than the above activities, were 'becoming informed about what society finds acceptable or unacceptable in scientific research' and 'considering and dialoguing with the public about the possible misuses to which knowledge gained from their research could be put'. These two aspects of engagement with the public are slightly different from the ones in the above paragraph, in that they involve scientists taking advice from the public rather than giving the public advice. 'Informing society' and 'becoming informed' were two of the sub-themes of the engagement theme of the social responsibility framework developed in Study 1. The lesser importance placed on 'becoming informed' is consistent with findings regarding scientists' attitudes to democratisation of science and their tendency to believe the deficit theory of public understanding of science as indicated by both Studies 1 and 2, and consistent with the literature (Irwin & Wynne, 1996; Evans and Durant, 1995).

Relationships between the research constructs.

The two social responsibility instruments were strongly correlated as predicted (r = .55), a large effect size as defined by Cohen's (1988) conventions for the behavioural sciences. As expected, these two instruments showed similar patterns of intercorrelations with the other instruments in that their relationships with other constructs were the same sign. However, as was also expected, the strength of the relationships of the two social responsibility instruments varied with other constructs, demonstrating discriminant validity (see Table 7.19, p. 263) and non-redundancy between the two social responsibility instruments. Social responsibility, as measured by these two instruments, was positively correlated with favourable attitudes to the democratisation of science and the value of self-transcendence (medium effect sizes). In contrast, social responsibility was negatively correlated with the value of self-enhancement and negatively correlated with favourable attitudes to genetic engineering (medium effect sizes). Additionally, there were small negative correlations between social responsibility and a favourable attitude to commercialisation of science and belief in technological optimism.

The empirical relationships between the ten constructs measured in Study 2 are highly congruent with the theoretical relationships defined in the proposed nomological network. This gives support to the construct validity of the five new scales (and also to the five existing scales). It also tells us something new about ‘how the world is’ by relating new constructs to existing theory and giving initial evidence as to the sizes of the relationships. However, as previously noted, this is only a beginning in the understanding of these constructs and in defining and measuring their theoretical and empirical structures.

In statistically based sciences (i.e., reliant on the null hypothesis or correlation analysis), single studies can rarely suffice (Cohen, 1990). Numerous quantitative studies of the relationship between two constructs (preferable using different methodologies in order to avoid method error) are required in order to accurately determine mean effect size and their dispersion parameters, as results from individual studies tend to fall along a normal distribution. Meta-analysis is statistical technique developed to integrate a series of such single studies and determine precise effect sizes and confidence intervals of relationships (Hunter and Schmidt, 1990). Without the benefit of and hindsight from numerous studies (or very large sample sizes), it is impossible to tell from an individual study, where along the distribution of effect sizes the study’s results lie.

Scientists’ attitude to genetic engineering.

Scientists were generally in favour of the Promethean technology of genetic engineering (see Table 7.17), despite their concern that it may have negative impacts on humans, animals and the environment (see Table 7.6 for means and 95% confidence intervals of individual items in the attitude to GE scale). They believed moderately strongly that GE will help to cure the world’s major diseases, and were weakly positive about GE helping to solve the world’s food problems. Given the relatively successful history of recent scientific medicine and the proof in principle of many gene technologies (see Chapter 2), their faith in the medical application of GE appears warranted. Their ambivalence over the benefits of gene technology to feed the world also has a clear basis in history. The current quandary of starvation in some parts of the globe and enormous waste and gluttony in others, suggests that, at least up until the present time, food distribution rather than scarcity has been the problem (however, with exponentially increasing population, declining water and soil availability, and declining oil production, true food scarcity will soon be a reality). In the 20th

century the only real constraint to the abolition of hunger was lack of human will to do so (Lappe, et al., 1998). If past behaviour is a good predictor of future behaviour, even if GE technology could increase food production to keep up with population growth, it is no guarantee that humans will choose to use the technology to end hunger or inequity.

The scientists were moderately strongly in agreement that GE fitted with their cultural, spiritual, and moral beliefs and principles. They also moderately strongly believed that it was acceptable to genetically engineer animals for human benefit. However, they strongly distrusted private companies and corporations regarding GE technology. While scientists expressed optimism about the promise of gene science and technology and asserted its moral validity, their concerns were centred on how humans, particularly within the auspices of corporations, will apply them and the potential negative consequences for humans, animals and the environment. Also, although they were in favour of using gene technologies on humans for therapeutic purposes, they were strongly opposed to its use for human enhancement. Scientists appeared to question humanity's ability to wisely use the Promethean technology of GE. They also appeared concerned about the societal impacts of laissez-faire market ideology on the likely applications of GE technologies.

Comparison of scientists' and public attitudes to GE.

Because the practises and behaviours that are considered socially and morally responsible are at least partly a function of public opinion and acceptance (moral conventionalism), the relationship between scientists' and the public's attitudes to controversial science issues is an important source of information regarding scientific social responsibility (see Table 7.18). In the case of GE, the public were optimistic about the medical benefits of GE (although less so than scientists), and shared scientists' ambivalence about the application of GE to food production. However, the public were more concerned about potential negative impacts on humans, animals and the environment than scientists, and they were more distrusting of the scientific and regulatory authorities responsible for the development and control of the technology. However, scientists' and the public both held similar levels of distrust in private companies and corporations regarding GE. The public were less in agreement than scientists that gene technology fitted with their cultural, spiritual and moral values and beliefs.

The Interface Between Science, Technology and Society

There are important implications to be derived from this comparison between scientists' and public attitudes to the Promethean science of gene technology. The gaps between public attitudes and the attitudes of scientists to GE (and other controversial technologies) show the broad general areas that scientists, regulators and companies developing GE products must address if they are to fulfil their social and moral obligations to society. These are the issues of public concern, to gain and maintain public trust, scientists must address them. If scientists want a licence from the public to continue research and technological development in areas of controversial or Promethean science, they must demonstrate that they are seriously researching, or otherwise addressing, the public's concerns (Marris, 2001; Marris, et al., 2002).

The social responsibility framework developed in Chapter 6 provides a mechanism and checklist for scientists to engage with society and to understand and address public concerns. If science and scientists cannot offer solid reassurance to the public that their concerns are being taken seriously and that public good is being protected, then the public have a right to withdraw support from the science in question. If public attitudes are overwhelmingly against particular scientific research or applications, then it behoves scientists to present an adequate case to justify their line of inquiry, and if they cannot, they should consider ceasing research or prohibiting certain applications. While it is not the case that the public will always be right regarding such issues (it is also not the case that scientists will always be right), as members of society, scientists have a responsibility to at least consider and respect the zeitgeist of public morality. Indeed, in Study 2 scientists strongly agreed that 'science should respect and act within the mores of society' (see item D3, Table 7.8, p. 243).

Likewise, regulators must engage with the public and demonstrate that adequate precaution is built into legislation and regulation. Regulators must take technical advice from scientists and they must pay heed to public values. Because the public and scientists expressed strong distrust and concern about how companies will use GE technology, a most important component of social responsibility regarding the development of gene technologies is the role of regulators in controlling the behaviour of companies developing and marketing these technologies. This component increases in importance as science and technology increase in power and effect. Scientists may also have a moral role as corporate watchdogs, alerting the public and the appropriate authorities to unacceptable behaviour by their employing companies. Scientists' moral obligations should prioritise society and public good over their obligations to employers. Data from Study 2 showed that scientists strongly agreed that it is more important 'to put the good of society ahead of commercial profit' (see item J10, Table 7.15, p. 254).

The coming 21st Century Promethean technologies have the potential to be used to create existential catastrophes (as well as much public good). As argued in the first three chapters, such technologies are far too powerful to be left to the vagaries of market forces which have helped create the present social and moral inequities described in Chapter 1, with technologies far less powerful than the Promethean one currently emerging. The crises indentified in Chapter 1, that currently present existential threats to Gaia, are immensely compounded by laissez-faire market approaches to technological development and consumerist economic ideologies (Hall, 2004; Hall & Klitgaard, 2006). The path and consequences of uncontrolled technological development have been clear to many in the science community for the past four to five decades (Daly, 1977, 1996; Erhlich, et al., 1999; Huesemann, 2001; Jonas, 1985; Laurance, 2001; Leakey & Lewin, 1996; Leopold, 1949; Lubchenco, 1998; Marris, 2001; Marris, et al., 2002; Meadows, et al., 1972; Naess, 1973; Potter, 1971; Russell & Einstein, 1955; Serageldin, 2002; Tainter, 1988).

If action had been taken three decades ago, before the planet reached overshoot (the point at which human appropriation of resources exceeded the planet's productive renewal capacity), the approaching crises may have been relatively easy to avert (Meadows, et al., 1972; Wackernage & Rees, 1996). Now, it is unclear whether it is too late to reverse trends and avert existential tipping points (Lovelock, 2006; Sherwood and Huber, 2010). However, it is clear that the best we can hope for, even if immediate global action is taken, is to mitigate some of the more serious consequences and prepare for a vastly different future (Flannery, 2009; Suzuki, 2010). The public should be asking whether scientists have done enough to warn them of the looming crises – this could be considered an area in which science and scientists have not lived up to their moral responsibility to society. It might be argued that scientists have failed to stand up to politicians and the market economy, letting them produce and implement policies, laws and commercial practices which are hastening the crises. Scientists have failed to convince politicians, business people and the general public of the need and urgency for a change to sustainable lifestyles. They are also failing to strongly alert the public to politically ineffectual responses to these crises and politicians' refusal to follow evidence based advice when it it clashes with their ideology.

Although scientists have played an important part in bringing to public and government notice the impacts that human use of technology is having on Gaia, they have tended to be very conservative about their pronouncements to society. As discussed by participants in Study 1, their scientific training encourages them to be sceptical and to want high levels of certainty before they bring issues and problems to public attention. They tend to couch the statements they do make with reservations and discussions of their uncertainty. Indeed, they consider doing so a major scientific social responsibility: in Study 2, scientists very strongly agreed that it was important 'to give the public clear guidance on the reliability and validity of scientific conclusions regarding potential benefits and risks' (see item J3, Table 7.15, p. 254). However, as several scientists in Study 1 noted, dwelling on the issue of uncertainty by scientists may tend to confuse the public, giving them the impression that there is greater uncertainty, less consensus and even legitimate scientific disagreement regarding issues about which the science is actually relatively clear.

This problem is compounded when 'junk science' (false science designed to obfuscate the public on important scientific issues) is added to the mix. Junk science is designed to increase public uncertainty and scepticism of mainstream science's discoveries about human technologically driven impacts on Gaia (Agin, 2006; Erhlich, et al., 1999). It is well documented that companies and political groups, for whom the current consumerist ideologies provide financial lifeblood, make deliberate efforts to spread false science (Oreskes & Conway, 2010). As evidenced by the historians of science, Oreskes and Conway, a handful of ultra right wing scientists and organisations have played a consistent and disproportionate role in challenging scientific consensus on a range of issues from the dangers of tobacco, the effects of acid rain, the hole in the ozone layer and anthropogenic global warming.

According to Oreskes and Conway (2010), the tactics used by these 'renegade' scientists are to discredit real science, and spread false information to create public confusion and doubt. They named three individual scientists (and several organisations that the trio have been involved with) who have been particularly influential in the deliberate obfuscation of public health and public good issues over the past four decades. As stated by one of the interviewees in

Study 1, and evidenced by the scientists who worked for tobacco companies promoting junk science and denigrating legitimate research, "[some] scientists will do ethically irresponsible things for the sake of money" (R12, see Chapter 6, p. 208).

Another perspective may also be taken on the gap in attitudes between scientists and the public to controversial science issues. In the past, public attitudes to new technologies have often been apprehensive for both deontological and teleological reasons (Mills & Williams, 1986). Well-known examples include pasteurised milk, oral contraceptives, heart transplants, in vitro fertilisation, microwave ovens and nuclear power stations.

To some extent scientists are at the 'crest of the wave' in understanding nature and applying its principles to satisfy human needs and desires. At least for some controversial technologies, public thought and attitudes may lag behind those of scientists. Perhaps by examining the gap between scientists' and the public's attitudes we can gain understanding of how public attitudes are likely to change over time. However, it is always possible that public attitudes may harden against a particular line of science (e.g., if a significant national or global technological disaster were to occur creating an associated negative *availability heuristic* [see Tverski & Kahneman, 1974]). In which case, either scientists shift their practices to meet public expectations or the gap between science and society (attitudes, values, beliefs and trust) will increase.

An important application of studies such as the current one is to provide information for the development of policy. Providing an indication of scientists' attitudes regarding social responsibility may help to determine whether or not it is necessary to develop policies that regulate or control scientific research and technological development, the extent to which these activities should be controlled and regulated and the extent to which scientists and science companies should have freedom to operate. Research such as the analysis of scientists' attitudes to social responsibility may also be useful for formulating general policy regarding science governance. Whereas, comparison of scientists' and public attitudes to specific technologies may help to inform policy regarding controversial technologies (such as GE).

Scientists are clearly one stakeholder group whose values, beliefs and, attitudes need to be taken into account when forming science and technology policy. However, because of the power and ubiquity of technological impacts, there are a multitude of publics and other stakeholder groups who also have a legitimate say. Similar sorts of techniques and research methods as used in this thesis could be used with other stakeholders to determine their attitudes, beliefs and values regarding scientific social responsibility and a range of different Promethean technologies.

Post-normal science (Funtowicz & Ravetz, 1993; Ravetz, 2006) is the concept of using extended peer communities, qualitity oriented reference systems, and consideration of extended facts, for decision and policy making, when the issues are urgent, stakes are high, values contested and facts uncertain. From this theoretical background of post-normal science post-normal sustainability technologies have evolved. These include a range of processes and tools for facilitating deliberative events with extended stakeholder groups for developing policy (Frame and Brown, 2007) and assessing the risk of emerging technologies (Kastenhofer, 2011). In such processes, public and stakeholders determine the relative importance of impacted values, scientists/experts provide the relative likelihood of factual events, and decision-makers provide the relative preference for the various outlined alternatives (Fowler & Allison, 2008).

The post-normal science approach treats deliberative events as environments of mutual learning for public/stakeholders, experts/scientists and decision-makers/policy people, developing awareness of the "others" perspectives and knowledge. According to Rowe and Frewer (2005), proposed benefits of deliberative engagement events for science and technology policy making include more satisfactory decisions (through the inclusion of lay knowledge and values), greater trust in decision-makers (due to attention being paid to public concerns) and enhancement of public and institutional knowledge (through mutual learning) (Rowe and Frewer, 2005).

However, little is known about how successful such events are in achieving these proposed benefits, as evaluation of their effectiveness has been rare (Rowe and Frewer, 2005). Currently, evaluation frameworks are being developed to assess the success of deliberative processes and events (e.g., Rowe, Horlick-Jones, Walls, Poortinga & Pidgeon, 2008). However, an evaluation of the 2003 UK: *GM Nation?* debate indicated deliberative engagement is not without its own issues. Problems with deliberative events may include: lack of inclusiveness (the unengaged choose not to participate), lack of representativeness (those who do engage and participate tend not to be demographically representative of the population and to have different beliefs and attitudes to the issue profiles than the general public), upfront cost and time requirements are high (although it is argued that the process may mitigate the cost of expensive public opposition by being seen to address the public's concerns), and appropriate resources need to be provided that illustrate (in a readily comprehensible form) complex scientific scenarios (Horlick-Jones, Walls, Rowe, Pidgeon, Poortinga, & O'Riordan, 2006). One might also question the degree of mandate that participants have to represent the various interested stakeholder groups. It also seems likely that only event participants will experience the mutual learning, and they will be but a fraction of the population. A similar consideration may also be true about the issue of trust.

Empirical ethics approaches (Borry, et al., 2005; Musschenga, 2005; Molewijk, et al., 2004; Small, 2007b; van der Scheer & Widdershoven 2004), which have a focus on the use of social science methodologies (both qualitative and quantitative) and normative ethical analysis for assessing public and stakeholder attitudes, beliefs and values, may be able to complement the post-normal sustainability technologies used in policy development. Such approaches may help to rectify the problem of lack of representativeness and lack of mandate.

Policy can offer scientists guidelines on what is acceptable to the public and what is not. However, as noted by participants in Study 1, policy generally follows behind controversy. The issues that are emerging will be perceived by scientists and concerned and interested members of the public before policy or regulation is developed, often while the science and technology are still in their developmental phase. As advocated by a number of scientists in Study 1, it should be a moral responsibility of scientists to foresight the implications of their technological developments and make this knowledge transparently available to both the public and policy makers so that the debate or dialogue can be taken to public fora (Bunge, 1977; Jonas, 1985).

Where division, dissention and controversy exist, fair and equitable processes need to be put into practice to reach policy decisions that take in to account multiple values perspectives and the likely consequences of the particular science and technology. This needs to be based on a consideration of what the benefits and harms are likely to be, the intensity of benefits and harms, knowledge of who benefits and who will be harmed, and the degree of justice and individual autonomy associated with the technology and various policy options. Consideration of such issues is important to the development of fair and appropriate policy. Post-normal sustainability tools such as the Ethical Matrix (Mepham, 1996, 2001), the Ethical Valence Matrix (Small & Fisher, 2005), and the KerBabel Deliberation Matrix (O'Connor, 2004) can help with this type of analysis and decision process.

Study Strengths, Limitations and Future Research

The primary strengths of the current studies lie in an explication of the under-explored domain of scientists' wider social responsibility to society and the development of four psychometrically sound instruments to measure aspects of, and constructs related to, scientific social responsibility. Other study strengths include the convergence and triangulation of results from the qualitative and quantitative studies, the reasonably successful prediction of multiple hypotheses comprising the nomological network, the embedding of the research constructs and theoretical model in current psychological and philosophical theory and convergence of research results with previous similar empirical studies. The findings appear internally consistent and credible as well as externally valid through location in a 'larger' meta-level ontological network. Taken together these strengths provide evidence and confidence that the data obtained and instruments developed are credible and valid.

Nonetheless, there are numerous limitations to both Study 1 and 2. Most of these limitations are due to methodological issues. Some limitations, such as uncertainty regarding the psychometric properties of the technological optimism scale, the self-enhancement scale, and the attitude to GE scale, have previously been discussed and addressed. Others, such as the inherent subjectivity of the research process used in Study 1, and the statistical uncertainty associated with single quantitative studies, such as conducted in Study 2, have been alluded to in Chapters 5 and 6 and Chapters 7 and 8 respectively, and will be discussed further below. However, limitations to a study provide opportunities for future work to address them. Therefore, in the discussion below, limitations are discussed along with ideas for potential future research in the domain.

One limitation in the study design was the absence of control for social desirability responding, which is a known scale moderator (Paulhus, 1981). It is likely that the issue of scientific social responsibility invites socially desirable responding. However, despite the potential for the data to be distorted by this phenomenon, and the availability of scales to measure it, a social desirability scale was not used in the current study. Therefore, a further topic for research and future study is the relationship between the new research scales and social desirability responding scales such as the Marlowe-Crowne Social Desirability Scale (Crowne & Marlowe, 1960).

Another study limitation is that it only considered attitudes (awareness and judgment) to social responsibility rather than the actual behaviour of scientists. An attitude has been defined as “a psychological tendency that is expressed by evaluating a particular entity with some degree of favour or disfavour” (Eagly & Chaiken, 1993, p. 1). Since the 1930s when Allport claimed that attitudes directly influence behaviour, and LaPiere, asserted that attitudes only weakly predict behaviour, psychologists have debated the degree of influence attitudes exert on behaviour (Johnson & Boynton, 2010). The relationship between attitude to scientific social responsibility and scientists’ behavioural compliance with socially responsible practice could be an area for future research.

The theory of reasoned action which underlies Rest’s theory of moral behaviour (used in the current work) is a deliberative rational model of behaviour. However, some researchers have claimed that much behaviour is spontaneous rather than deliberative (Bargh & Chartrand, 1999; Chen & Bargh, 1997; Greene & Haidt, 2002; Schwartz, 2000). Emotion may affect both conscious attitudes, and hence rational, deliberative behaviour (Damasio, 1994), and spontaneous behaviour, including unconscious or habitual behaviour (Greene & Haidt, 2002). This suggests another area for future study regarding scientific social responsibility: the influence and impact of emotion. Although the philosophical theory of emotivism (Hume, 1957) was briefly discussed in Chapter 3, as were psychological theories of moral behaviour involving emotion (Greene & Haidt, 2002; Greene, et al., 2004; Greene, et al., 2001; Haidt, 2001; Haidt, et al., 1993), emotion was not one of the variables studied in this thesis. However, in more recent, as yet unpublished work, I have collected data to investigate the influence of emotion on attitudes to GE and behavioural intentions regarding GE products. Similar data could be collected and related to attitudes to scientific social responsibility, behavioural intentions and socially responsible behaviour directly – particularly as it relates to the development and application of specific Promethean technologies.

The next methodological issue to address is the subjective nature of Study 1. The author was the sole analyst of the qualitative data in Study 1, except for the previously published work on the democratisation and commercialisation of science, which benefitted from the experience and insight of my co-author Professor Mary Mallon. With two of us analysing the data, a crude estimate of inter-analyst reliability and validity, regarding the themes and sub-themes developed from the data, was arrived at by separate generation of sub-themes and themes followed by discussion and resolution of differences. Divergences in selection of text fragments, themes, sub-themes and interpretation were able to be discussed and consensus found. In the original work presented in Chapter 6, with the author as sole analyst, this was not the case. This represents a potential threat to the validity of Study 1. Personal bias and intellectual fallibility are inherently built in to the design and implementation of Study 1.

The two primary controls to these internal limitations to Study 1 (other than adherence to best practise principles of qualitative research) are awareness of potential biases and fallibilities and the anchoring of themes and constructs in existing research and theory (see Chapters 5 and 6 for discussion of these issues). There were also two primary external controls. The first was subjecting the research to the scrutiny of other researchers and experts in the field (i.e., peer-review – perhaps somewhat ironic given the empirical evidence presented previously on the unfortunately lack of validity of the peer review process - see Chapter 6). Nonetheless, I have deliberately noted throughout this thesis where I have published data, information, and conjectures contained in this thesis. This is designed to achieve two functions: 1) to anchor original elements of this thesis in published research literature and 2) to show evidence that at least some of the thesis constructs and ideas have been submitted to peer-review and published in academic journals. However, this thesis has been deliberately oriented to the presentation of previously unpublished work that was conducted solely by me.

The second external control to researcher bias and fallibility regarding Study 1 is triangulation of findings with Study 2, which used a different methodological approach. The results of the quantitative research support the qualitative research results in a number of ways. First, attitudes reported in the qualitative interviews towards democratisation of science, commercialisation of science, social responsibility and genetic engineering were supported in the quantitative study for the CRI sample of scientists. Second, relationships suggested between constructs or themes emergent in Study 1, such as the relationship between democratisation of science and commercialisation of science, and between democratisation and social responsibility and commercialisation and social responsibility were supported in Study 2. Third, the items derived from themes and sub-themes in Study 1 were able to be constructed into unidimensional and reliable instruments that formed predictable relationships in a nomological network of the topic area in Study 2. If the data from Study 1 which fed into Study 2 had no empirical grounding, the results of Study 2 would also highly likely be inconsistent with reality (the rubbish in, rubbish out principle). However, the results of Study 2 make reasonable sense and confirmed the theoretical relationships predicted between the constructs. This increases confidence that the scales are measuring the constructs they were designed to measure.

Despite the highly subjective nature of Study 1, these internal and external controls provide some reasons for confidence in the validity and credibility of Study 1. Of course, as discussed above regarding quantitative studies and also by participants in Study 1, replication is the key to increasing confidence in scientific results. With regard to Study 1, replication could be performed in multiple ways. One way is for other scientists to independently analyse the field data from the current study – the interview recordings and transcripts. Using this method inter-judge reliability could be analysed and personal bias and fallibility reduced (new sub-themes may also arise for development from different analysts). This procedure is more scientifically rigorous and preferable to the method used in Study 1 of the current work (it is also still possible to do this now or at some future time). Another way is to replicate the study with a different sample from the same population and with samples from different populations of scientists (conducted by either the current researcher and/or by other researchers).

Samples from different populations of scientists, for example, university scientists, industry scientists, scientists in other countries, scientists working with different technologies (i.e., nanotechnology, information technology etc.) rather than gene technology, as in the Study 1 sample, could help test the generalisability of the themes and sub-themes to the population of scientists. Other qualitative methods such as behavioural observation, journal entries by scientists, analysis of past behaviour of scientists regarding controversial technologies, analysis of scientists' publications, analysis of the activities and documents of scientific associations, could be used to collect data about and examine scientists' attitudes to social responsibility. Using different methods may provide new insights or triangulate and confirm old ones.

An issue that lies between Study 1 and Study 2 has to do with the nature of the samples in the two studies. In Study 1, two thirds of the scientists interviewed were genetic engineers. The remaining third came from other scientific disciplines (e.g., soil science, entomology, ecology, economics, animal genetics, and evolutionary biology). However, these latter scientists had all conducted some research on the impacts of GE through their own disciplinary lens. Therefore, the Study 1 sample was quite strongly loaded with scientists who were either genetic engineers or had some association with genetic engineering. Study 2, on the other hand, was composed of a much wider range of scientific disciplines, which while containing a number of genetic engineers, was mostly composed of scientists from other disciplines. Given that the outputs of Study 1 were used as inputs to Study 2, the different sample compositions might be considered a weakness and it might be questioned as to why the sample in Study 1 did not include a wider range of scientific disciplines.

However, these differences might also be considered a strength. It was expected that, because of their experience with GE, the highly politicised nature of GE research and products, and the frequent media exposure in New Zealand, the Study 1 sample would be particularly sensitised to the issue of scientific social responsibility and, consequently, would be able to provide a particularly rich and robust source of data regarding the issue. In effect, because of their enhanced exposure to issues of scientific social responsibility, the Study 1 sample might be viewed as subject matter experts. Thus, it was expected that the Study 1 sample would be particularly suitable for obtaining appropriate data and information for category development and elucidating the construct of scientific social responsibility. Indeed, the Study 1 sample was purposively choosen for this particular attribute. Study 2 simply expanded the scientific disciplinary range to ensure that the data and psychometric instruments would be more generalisable to scientists from a wider range of disciplines.

Some limitations to Study 2 have already been raised and discussed. They included: weaknesses in the technological optimism scale, the self-enhancement scale and the attitude to GE scale; lack of statistical power to fully analyse the nomological network due to insufficient sample size; lack of representativeness of the sample to be able to confidently generalise results to the population of New Zealand scientists, and the fact that any individual quantitative statistical study is subject to the vagaries of chance. Just as replication of Study 1 would help to alleviate the threats to its validity, replication of the quantitative Study 2, using similarly diverse samples, as suggested in the paragraph above regarding further qualitative research, could increase confidence in (or test) Study 2 results and the construct validity of the new instruments. It could also help generalise (or test the generalisability) of the theoretical relationships between the research constructs (and any future additions to the nomological network). Multiple studies of this nature could then be used in meta-analyses to strengthen statistical power while avoiding Type 1 errors at low alpha values, narrowing the confidence intervals around the mean relationship effect sizes and enabling identification of moderating and mediating variables.

Another way of enhancing the credibility of the construct validity of the new instruments and nomological network would be to use Campbell and Fiske's (1959) Multitrait-Multimethod Matrix (MTMM) approach. This approach could be conducted with the new instruments and constructs to confirm or determine convergent and discriminant validity. This would involve using and comparing in the MTMM Matrix different methodological approaches (see p. 310 for some examples, in addition, experimental and quasi-experimental designs could also be used) to studying the issues and a range of constructs some of which are believed to be related (e.g., for scientific social responsibility construct: moral development, moral behaviour, world views, etc.) and some of which are believed to be unrelated (e.g., work stress, job satisfaction, etc.) to the constructs of interest. The use of different methods helps to overcome method variance, while using related and non-related constructs as criterion variables enables divergent and convergent validity to be established.

Consideration of study limitations has led to the above suggestions for a range of future studies designed to test and strengthen the reliability, validity, and credibility of the new scales and the current nomological network and to expand the network's structure. These future research suggestions are the bare outline of a systematic program to check the veracity of the current work's results and interpretations and, if confirmed, to build upon them, empirically and theoretically. The instruments developed in this study provide preliminary tools for examining the construct of scientists' broader responsibilities to society. These instruments could be further used in several ways in future research.

They could be used to track scientists' attitudes over time, or to compare the attitudes of different scientific groups. For example, do scientists who work in the commercial sector have different attitudes to social responsibility than scientists who work in the government sector or the academic sector? The CRI scientists in the current sample had a relatively negative attitude to the commercialisation of science – perhaps those who work for commercial organisations or private companies might have a more positive perspective. The situation in which academic scientists are embedded has traditionally been quite different from both

CRI and commercial science – are these differences in circumstances accompanied by different attitudes to scientific social responsibility? Perhaps scientists with different sets of values are more suited to working in different employment environments. The scientists in the CRI sample were strongly oriented to the value of self-transcendence. Perhaps scientist working in a commercial environment might be more oriented to the value of self-enhancement. Does working in a particular environment influence scientists' values and attitudes to social responsibility or, conversely, do their values and attitude to social responsibility influence the environment that they choose to work in? These questions could be addressed in future research with the help of the newly developed instruments.

Another question for possible future research is: do scientists from different disciplines have different attitudes to social responsibility? It was noted in Chapters 3 and 4 that physicists, physicians and ecologist have been in the lead amongst scientists in their recognition and discussion of the responsibilities of science to society. Prpic (1998) and Sommer's (2010) work (reported in Chapter 4) also suggested differences in attitude to social responsibility amongst different disciplines. Perhaps the nature of knowledge in some disciplines is such that practitioners are more immediately confronted with some of the potential or actual negative effects of science and technology. It might be that scientists working in such disciplines may be more sensitised to science's responsibility to society. The scales developed in the current work may be useful to examine this question systematically.

As noted in Chapter 7, the scientists' sample was over-representative of female scientists in comparison to their proportion in the New Zealand scientists' and CRI scientists' populations. Although purely speculation, it might be that the topic of social responsibility struck a stronger cord with female scientists than male scientists, thus provoking a greater response on their part. If this was the case, then female scientists may have different attitudes to social responsibility than their male counterparts. There is some previous empirical support for this hypothesis. Sommer's (2010) study (reported in Chapter 4) found differences between male and female scientists' responses to statements about scientific social responsibility. In a review of the ethical decision-making literature O'Fallon and Butterfield (2005) reported that the issue of gender was mixed with regard to ethical awareness and judgement. Although 23 studies reported no significant gender differences, 16 studies "found that woman behave more ethically than men, at least in certain situations" (p.377). Similarly, Small, Parminter and Fisher (2005), in their study of New Zealand public attitudes to GE, found that females were significantly more opposed to GE than males. In the current study, females scored significantly higher on both social responsibility scales than did males.

Conclusions

Several scholars have promoted the need for an increased ethic of social responsibility amongst scientists (Jonas, 1985; Lenk, 1983; Lubchenco, 1998; Luppicini, 2008; Russell & Einstein, 1955; Sakharov, 1981; Ziman, 1998, 2001). Perhaps cognizant of their responsibility, numerous groups of scientists have delivered warnings to the public and governments regarding potential crises and the actions that society needs to take to avert them (Nobel Laureates, 2001, 2007; Physicians for Social Responsibility, n.d.; Rockström, et al., 2009; Russell & Einstein, 1955; The World Commission on Environment and Development, 1987; Union of Concerned Scientists, 1992). What more can scientists do to enhance their moral responsibility to society, to ensure that science is used for the greater good of all and that the crises facing Gaia are meaningfully addressed? Raising the level of awareness of moral responsibility for scientists and science students through education programs is one start. Sherwin (2001) contended that moral perception or sensitivity, somewhat like aesthetic perception, is a type of skill that can be trained and honed. Empirical work by psychologists supports Sherwin's contention (Bebeau, et al., 1995). Study 1 developed a framework for scientific social responsibility. Study 2 developed scales to measure levels of moral awareness and judgment. These products from this thesis may be useful tools in the moral education of students and scientists.

Scientists could more proactively orient their research to address the crises facing Gaia. As Lubchenko (1998, pp. 491-497) stated in the excerpt at the end of Chapter 1 "It is time for a re-examination of the agendas and definitions of the 'grand problems' in various scientific disciplines." Because of human activity, sustainable survival is the 'grand problem' that faces all life on Gaia. As the problem is urgent, so too must be the response. There is clearly a *grand agenda* awaiting science - to optimise future outcomes of science and technology the many disciplines of science must contribute to this agenda. It might be that, to enact this agenda for the good of Gaia, scientists have to become a political force.

Although governments claim the need for evidence-based policy, they often only use it when it suits their particular needs, or if it does not conflict with their current ideological agendas. A recent example was the English Government regarding their refusal to accept advice from their chief scientific advisor on drugs, Professor David Nutt. Indeed, rather than listening to the scientific evidence, they sacked him from the position because the science did not support their desired policies and ideological beliefs (Nutt, 2009). However, far more serious, in the USA, was the Bush government's interference and distortion of climate science research (Union of Concerned Scientists, 2004; Council on Foreign Relations, 2007). A report produced by the US Council on Foreign Relations documents extensive political interference in scientific reports:

> White House officials and political appointees in the agencies censored congressional testimony on the causes and impacts of global warming, controlled media access to government climate scientists, and edited federal scientific reports to inject unwarranted uncertainty into discussions of climate change and to minimize the threat to the environment and the economy. (Council on Foreign Relations, 2007, Para. 4)

While in the case of Professor Nutt the consequences are limited to increasing rather than minimising harm for a few million people, in the case of the Bush government's interference, the issue is of existential importance to the entire population of the planet. Even when scientists do take their social responsibility seriously, attempting to create an informed public and giving science based advice to governments, the politicisation of science (the distortion of science for political ends) can thwart their efforts.

What can scientists do when politicians and governments chose to ignore scientific facts and advice – especially when the consequences could mean disaster for Gaia? Perhaps in such cases scientists need to become more politically active. They need to stand up as a unified group and forcefully inform the public about the level of political interference in science and resulting inadequacies of policy making. Perhaps even, they need to get angry regarding the political abuses of the knowledge which they have generated. Scientists need to make it absolutely clear to the public that deliberate political distortion of scientific knowledge is leading to poor policy and bad outcomes for all humans and for the rest of the planet's inhabitants.

Scientists, for the good of the planet, need to become a political force. In a previous paper (Small & Jollands, 2006), my co-author and I argued that life has two competing evolutionary strategies for survival: competitive, hawkish behaviour and cooperative dovish behaviour. We argued for the radical thesis that those who seek personal political power and prestige are, for the most part, the very people whose evolutionary derived hawkish tendencies and self-enhancing values preclude them from acting for the greater good of all. In affluent, technically advanced cultures, this is an unfortunate weakness of the current process of representative democratic governance. Perhaps humans have now become such a potent force of nature that governance should not be entrusted to hawks who hunger for political power.

A new more inclusive and participative democratic political process may be required. Perhaps some emerging information/communication technology may provide a better forum for participative democracy. Or, somewhat antithetically, perhaps it is time to seriously reconsider Plato's (2006) concept of 'philosopher kings' or, in our technological age, perhaps they could be 'scientist guardians'. While such a concept would not sit well with modern society, there is certainly a case to be made for an increase in scientific political activism.

However, as several scientists in Study 1 argued, scientists sometimes find it difficult to advocate for particular causes; it seems to conflict with their traditional Mertonian belief of scientific objectivity. Nonetheless, the consequences of human use of technology have reached such a level of potential existential threat that a number of leading scientist have overcome this reservation, foresighting future scenarios and advocating for Gaia and future generations of humans (e.g., Diamond, 2005; Flannery, 2009, Hansen, 2007; Hansen, et al., 2008; Lovelock, 1979, 2006; Potter & Whitehouse, 1998; Raven, 2002; Smil, 2008, Suzuki, 2010).

We live in an age of scientific miracles and wonders. However, the laissez-faire use and application of 20th century technologies have brought our planet to the brink of crises regarding providing a sustainable environment for the support of human and many other species of life. Given the far greater power and reach of emerging 21st century Promethean technologies it is clear that a new form of governance is required for science and technology and it application and use by society. The scientists who participated in Study 1 asserted the need for foresight in regard to Promethean technological development and governance. The scientific method provides the best-known process for foresight. In the Greek myth, Prometheus gave fire and the technological arts to humanity, but perhaps the true gift was the foresight that this knowledge and skill entails. It is no coincidence that the name Prometheus means forethought. In regard to the role of foresight in the development of our species, David Suzuki had this to say

> Drawing from our experience and knowledge, we dreamed of our place in the world and imagined the future into being. By inventing a future, we could look ahead and see where dangers and opportunities lay and recognise that our actions would have consequences in that future. Foresight gave us a leg up and brought us into a position of dominance. (Suzuki, 2010, p. 11)

Humans are now in such a position of dominance that all of Gaia depends on our foresight. Science and technology now give humans the power to create not just the short-term future, but to create consequences that extend into the far distant future and affect all life on earth. In the past, only the gods had such power over nature. Technology has given humans awesome power over space, time, matter, energy, life and consciousness, and it behoves an equal degree of responsibility. More than ever before, our powerful technologies require foresight and responsibility in their governance. In the myth, Prometheus had a brother, Epimetheus, who despite the warnings of Prometheus, foolishly accepted Zeus' gift of Pandora. From Pandora's jar were released the spites that plague humankind. We must take care not to make the same mistake.

The name Epimetheus means afterthought or hindsight. Because the problems that face us are existential in nature, hindsight, awareness after the event, is a fatal option (Bostrom, 2002). Nonetheless, hindsight and foresight are opposite sides of the same coin, without hindsight there can be no foresight. Hindsight allows us to see and understand what has been, this is how science begins. It is only through our understanding of what has been that we are able to see what is to come. Humans now have 10,000 years of scientific and technological hindsight as a basis for forethought and foresight. The work of scholars such as Tainter (1988) and Diamond (2005) gives us hindsight into the rise and demise of once great civilisations. The parallels to our current situation are clear. The wisdom inherent in hindsight is its translation into foresight. Scientists have a key role to play in the wise use of humanity's godlike technological power: it is time for them to stand up for the future.

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Appendices

Appendix 6.1. Letter requesting permission to interview scientists

Date
CEO
Address

Dear CEO

Request for assistance with FRST funded and Doctoral research

I seek the assistance of your organisation as part of our FRST ethics research programme. Considerable research has been conducted with the general public into their attitudes and values regarding science and technology and in particular gene technology. However, little research has been conducted with members of the science community to examine their values and attitudes regarding these issues. This FRST project, which is also part of my PhD research with the Psychology and Philosophy departments at Waikato University (under the supervision of Prof. Micheal O'Driscoll and Dr Liezl Van Zyl), seeks to examine these questions in the science community.

I have already interviewed a number of scientists in AgResearch. I now need to expand the research into two other organisations. Professor Mary Mallon (of Massey University) and I are seeking permission to conduct interviews with members of the Biology Department at Massey as one of the two further organisations. I am approaching you to seek permission to work with your organisation as the third organisation.

I would like to conduct personal interviews with approximately ten of your science staff. In particular, I want to interview scientists working in the area of gene technology. The personal interviews would take approximately 1-2 hours each and I would like to conduct them on the interviewees "home territory". The interviews are unstructured narrative interviews based around themes of ethics and social responsibility in scientific research (see attached interview schedule). Aggregated results would be made available to your organisation.

Because this research will be used as part of my doctoral thesis, and to ensure and guarantee confidentiality regarding what could be controversial issues, the research has been designed and will be undertaken in compliance with the University of Waikato Psychology Department Ethics Review for Human Research protocol. Among the main principles of this approach are:

- informed consent;
- privacy and confidentiality;
- socially and culturally responsive research goals; and
- the prevention of exploitation of researcher-participant relationships.

The project design has been submitted to and approved by the Waikato University Psychology Department Ethics Committee.

I am interested in the diversity of beliefs and attitudes that scientists hold regarding ethics and social responsibility – particularly in relation to powerful modern technologies. I believe that this sort of approach has the potential to help to (1) understand how scientists see their role in society, (2) understand scientists' attitudes and values regarding their ethical responsibilities to society.

I seek your permission to approach appropriate participants and undertake the interviews. Please contact me if there are any further details that you would like clarified. I look forward to any comments you may have. If you feel that it is necessary, I would be very willing to come and meet you or a representative of your organisation and discuss my research proposal and any requirements that you may have.

Thank you for your consideration.
Yours sincerely,

Bruce Small
Social Research Unit
AgResearch Ltd
Ruakura Research Centre
East St, Private Bag 3123
Hamilton, New Zealand.

Phone 64 7 838 5216
email bruce.small@agresearch.co.nz

Appendix 6.2: Narrative Interview Guide

Narrative interviews will be interactive and guided by questions requiring open ended answers. Interviews will be taped (with the consent of interviewees) and transcribed for analysis. Anonymity and confidentiality of individual responses is guaranteed. Only aggregated data or anonymous will be published.

Broad theme areas of questions to be covered in interview are:

1. **Scientists' attitudes to ethics and social responsibility in scientific research**
    a. What are a scientist's (the science communities) ethical responsibilities regarding her/his research?
    b. What does being social responsibility in scientific research mean to you?
2. **Democratisation of science**
    a. What should be the public's role in the setting of scientific research agendas? Why? How?
3. **Commercialisation of science**
    a. What do you think/feel about the increasing commercialisation of science?
    b. How does commercialisation impact on ethics and social responsibility of scientists and scientific research?
4. **Ethics and social responsibility in gene technology research**
    a. What are the main ethical issues associated with gene technology research?
5. **Demographic questions**

Appendix 6.3. Participant Consent Form

University of Waikato

Psychology Department

CONSENT FORM

Participant / Researchers Copy

Research project: **Scientists views on ethics and social responsibility in scientific research**

Name of Researcher: **Bruce Small**

Name of Supervisors (if applicable): **Prof. Michael O'Driscoll, Liezl Van Zyl**

I have received an information sheet about this research project or the researcher has explained the study to me. I have had the chance to ask any questions and discuss my participation with other people. Any questions have been answered to my satisfaction.

I agree to participate in this research project and I understand that I may withdraw at any time. If I have any concerns about this project, I may contact the convenor of the Research and Ethics Committee.

Participant's Name: ______________________

Signature:______________________

Date:______________________

Appendix 7.1. Scientists' Survey Instrument

Attitudes to Ethics and Social Responsibility in Science[4,5]

In the questions that follow, you are presented with a statement. You are being asked to indicate your level of agreement or disagreement with each statement by indicating whether you: 1 = Strongly disagree, 2 = Disagree, 3 = Neither agree nor disagree (Neutral), 4 = Agree, 5 = Strongly agree.

The democratisation of science

Please rate your level of agreement with the following statements.
(Disagree/Agree - 5 point Likert scale)

D1 The science community has a duty to consult and dialogue with the public regarding the directions of science

D2 The public has a right to influence the amount of funding that is directed to different areas of research

D3 Science should respect and act within the mores of society

D4® The public lack the necessary scientific literacy to properly participate in setting the scientific research agenda

D5® Public participation in setting the science research agenda should be limited to issues regarding culture, spirituality and ethics

D6® Giving the public a significant role in setting the science agenda will impede scientific progress

[4] This word document shows the questions that were transcribed into a web-based survey using SurveyPro software. Only questions used in the current work are included.

[5] Items marked with ® are reverse worded to scale direction

The commercialisation of science

(Disagree/Agree - 5 point Likert scale)

C1 Has had a positive effect on scientific progress

C2® Inhibits the production of public good science

C3 Increases transparency and public participation in science

C4® Reduces public trust in science and scientists

C5® Promotes the profit imperative at the expense of the precautionary principle

C6® Increases the probability of ethical misconduct by scientists

C7 Enhances the free flow of scientific knowledge

C8® Has been detrimental to scientists' working conditions

C9 Increases scientific innovation

Science, society and ethics (moral awareness)

Please indicate your level of agreement with the following statements (Disagree/Agree - 5 point Likert scale).

A1® Science must sometimes push the boundaries of social and ethical acceptability in order to advance knowledge

A2 The science community has a moral obligation to ensure that the products of scientific knowledge do not cause harm (e.g., to humans, animals, environment)

A3® The science community cannot be held ethically responsible for the uses to which scientific discoveries are put

A4 The more powerful a technology is the more important the evaluation of its ethical and social implications becomes

A5 The more powerful a technology is the more important and relevant the precautionary principle becomes

A6 There are some fields of knowledge that are so potentially dangerous that they should not be researched

A7® Science is the value free pursuit of true knowledge

A8 Ethical training should be an integral part of scientific training

A9 The benefits of science and technology should be distributed throughout society in a fair and equitable way

A10® There is no ethical imperative for science to "do good"

Scientists' moral responsibilities to society (moral judgment)

How important are the following principles to you as a scientist living and working within society? (1 = Not at all important, 2 = Of little importance, 3 = Moderately important, 4 = Important, 5 = Very important)

J1 To evaluate possible benefits against possible harms when deciding on research projects

J2 To refrain from exaggerating the potential benefits or minimising the potential risks associated with research

J3 To give the public clear guidance on the reliability and validity of scientific conclusions regarding potential benefits and risks

J4 To refrain from conducting work in areas that you find morally questionable

J5 To ensure that approval for research is gained from the appropriate ethical authorities

J6 To ensure that the process and development of research complies with the precautionary principle

J7 To become informed about what society finds acceptable or unacceptable in scientific research

J8 To consider, and dialogue with the public about, the possible misuses to which knowledge gained from your research could be put

J9 To participate in public debate and dialogue over contentious scientific issues

J10 To put the good of society ahead of commercial profit

Technological optimism/pessimism

(Disagree/agree - 5 point Likert scale)

T1 The human use of the products of science and technology will help bring about a utopian society by the end of the 21st century

T2® The human use of the products of science and technology will most likely cause the collapse of modern civilisation before the end of the 21st century

T3® Science and technology will **not** be able to solve ecological problems such as overpopulation, resource depletion and environmental degradation

T4 Science and technology will enable continuous sustainable economic growth long into the future

T5 The future can take care of itself – we should not be concerned about trying to protect the future, it is more important that we try to provide the highest possible standards of living for current humans

Attitudes to gene technologies

Genetically Engineered Food (GF)

(Disagree/agree - 5 point Likert scale, 6 = Don't Know)

GF1 Genetically engineered food products are safe for human consumption

GF2 I would feel good about eating food from genetically engineered plants

GF3 I would feel good about eating food from genetically engineered animals

Genetic Engineering - Intrinsic (deontological) moral values (GI)

(Disagree/agree - 5 point Likert scale, 6 = Don't Know)

GI1 Using genetic engineering technology fits with my cultural and spiritual beliefs

GI2 Using genetic engineering technology fits with my basic moral principles

GI3 It is acceptable to genetically engineer animals (e.g., cows, sheep) for human benefit

Genetic Engineering – Extrinsic (teleological) beliefs about moral outcomes (GE) (Disagree/agree - 5 point Likert scale, 6 = Don't Know)

GE1 Genetic engineering technology will help cure the world's major diseases

GE2 Genetic engineering technology will help solve the world's food problems

GE3 Genetically engineered products are environmentally friendly

Trust In Responsible Authorities Regarding Genetic Engineering (GT)
(Disagree/agree - 5 point Likert scale, 6 = Don't Know)

GT1 I trust what the regulatory authorities say about genetic engineering technology

GT2 I trust what scientists say about genetic engineering technology

GT3 I trust what companies say about genetic engineering technology

Schwartz values survey

(Short version: following Schultz & Zelezny, 1998, 1999; Stern, Dietz, & Guagnano, 1998)

The following is a list of ideas that are possible *guiding principles in life,* and mean different things to different people. Please rate *how you as an individual feel* about each idea (-1 = Opposed to my values, 0 = Not important, 2 = Important, 4 = Very Important, 5 = Of supreme importance)

1. Helpful, working for the welfare of others

2. Social power; control over others, dominance

3. Successful, achieving goals

4. Creativity, uniqueness, imagination

5. Daring, seeking adventure, risk

6. Pleasure, gratification of desires

7. Devout, holding to religious faith and belief

8. Politeness, courtesy, good manners

9. Clean, neat, tidy

10. Protecting the environment, preserving nature

11. Honest, genuine, sincere

12. Authority, the right to lead or command

13. Capable, competent, effective, efficient

14. Curious, interested in everything, exploring

15. A varied life, filled with challenges, novelty & change

16. Enjoying life, enjoying food, sex, leisure, etc.

17. Respect for tradition, preservation of time-honoured customs

18. Honouring parents & elders, showing respect

19. National security, protection of my nation from enemies

20. Forgiving, willing to pardon others

21. Wealth, material possessions, money

22. Ambitious, hardworking, aspiring

23. Freedom, freedom of action and thought

24. An exciting life, stimulating experience

25. Humble, modest, self-effacing

26. Obedient, dutiful, meeting obligations

27. Social order, stability of society

28. Unity with nature, fitting into nature

29. Loyal, faithful to my friends

30. Preserving my public image protecting my 'face'

31. Influential, having an impact on people & events

32. Choosing own goals, selecting own purpose

33. Moderate, avoiding extremes of feeling and action

34. Self-discipline, self-restraint, resistance to temptations

35. Family security, safety for loved ones

36. Social justice, correcting injustice, care for the weak

37. A world at peace, free of war and conflict

Demographic questions

1. Age ____________

2. Gender: 1= female, 2=male

3. What is your Employing organisation

1. AgR
2. HortR
3. Crop & Food
4. Landcare
5. ESR

4. What is your highest academic qualification and what subject was it in?

1. Certificate or diploma
2. Batchelor’s degree
2. Master’s degree
3. Doctorate
4. Other,

5. Please specify _______________________

6. Subject of highest degree _________________________

7. Ethnicity

1. NZ European
2. Maori
3. Pacific Islander
4. Asian
5. Other,

8. Pease specify ________________________

9. Religion

1. No religion
2. Christian
3. Buddhist
4. Muslim
5. Hindu
6. Jewish
7. Other,

10. Please specify _________________________

11. Which of the following science areas most closely describes your current main scientific research work and interests (please choose only one):

1. Animal science
2. Chemistry
3. Computer science
4. Ecology or environmental science
5. Economics
6. Engineering
7. Entomology
8. Food science
9. Health science
10. Mathematics/statistics
11. Microbiology or molecular biology
12. Physics
13. Plant sciences

14. Social sciences
15. Other,

12. Please specify ___________________

13. In regard to management, which best describes your current role in your employing organisation

1. Member of senior management team
2. Middle manager
3. Line manager
4. No managerial responsibility

14. In regard to science seniority, which best describes your current role in your employing organisation

1. Senior scientist
2. Scientist
3. Science technician
4. Other,

15. Please specify ________________

16. If you are interested in participating in a further survey seeking scientists opinions and attitudes to issues of ethics and social responsibility and towards new technologies please enter your email address:

____

Please do not enter you email address if you wish to remain anonymous to the researcher.

You have the option of not responding to the survey by closing the web browser. Otherwise, please click Send to submit your responses. Clicking on send and submitting your responses will be considered as confirmation of your informed consent to participate in this research.

Thank you for your time and assistance

Appendix 7.2. Letter requesting permission to conduct survey

Dr (CEO)

CEO

(Organisation)

Dear (CEO),

Study of scientists' ethical beliefs regarding research and their attitudes towards GE

As part of an AgResearch FRST funded NSOF programme and my PhD studies, I am investigating 1) scientists' attitudes to ethics and social responsibility in scientific research and 2) scientists' moral attitudes to genetic engineering. Further details of the study are below. I am hoping to conduct the survey in several CRIs by means of a web-based survey. I write to seek your permission to allow and assist me to survey the scientists in your organisation. If you give permission for your organisation to participate I would require your assistance to send an email to all scientists in your company containing a hotlink to the survey web-site and inviting them to participate. I am hoping to conduct the survey at the end of May /beginning of June 05.

Participation would be on an individual voluntary basis and privacy and confidentiality are guaranteed. After data analysis the results of the study will (with permission) be presented to participating organisations in seminars. A one to two page summary of results will be forwarded to the organisations for forwarding on to participants. Results will also be presented at academic and scientific conferences and articles will be submitted to peer reviewed journals. Articles submitted to journals will also be forwarded to participating organisations. Permission is sought to identify participating organisations in my PhD thesis.

I have designed and will undertake the survey using the University of Waikato Psychology Department Ethics Review for Human Research protocol. Among the main principles of this approach are:

- informed consent;
- privacy and confidentiality;
- socially and culturally responsive research goals; and
- the prevention of exploitation of researcher-participant relationships.

Approval for the project has been obtained from the Psychology Research Ethics Committee.

My PhD supervisors are Prof Michael O'Driscoll, of the Psychology Department and Dr Liezl Van Zyl of the Philosophy department of Waikato University. They may be contacted at Waikato University (ph. 07 856 2889, Private Bag 3105, Hamilton) for further information.

Science, ethics and society

The issue of ethics and social responsibility in scientific research is going to continue to increase in importance in the eyes of the public and is strongly related to public trust and confidence in science and the science community. Consequently, this issue will have an increasing impact on both science and members of the scientific community. Scientists' awareness of the issues, attitudes towards them, and the scientific community's responses will be crucial to the building and maintenance of a healthy and productive relationship between science and society.

The issues that will be investigated regarding scientists' attitudes to ethics and social responsibility in research include attitudes to:

- Democratisation of science (public participation in setting the science agenda)
- Commercialisation of science
- The ethical relationship between science and society
- Scientists' moral responsibilities to society
- Scientists' value motivations for science careers
- Technological optimism/pessimism

Scientists' attitudes to Genetic Engineering

Much research has been conducted regarding the public's attitudes and beliefs about GE. I have previously conducted two surveys into public perceptions of GE in New Zealand (at a two year interval) and am conducting a third in the series in May '05. Repeating the same questions at regular intervals enables the measurement and tracking of changes in public attitude. I also intend to compare scientists' attitudes to GE with public attitudes from the latest public survey.

Little research has been conducted looking at what scientists think about GE. Scientists have a "knowledge advantage" over the public - those working in the area of GE have detailed knowledge of the molecular processes involved while scientists working in other fields have an understanding of the scientific process - how knowledge is discovered, what counts as evidence, research methodology, and an understanding of probability. This should, in theory, give them a better understanding of the risks and potentials associated with the technology. What do they believe? How does GE fit with their values and moral perceptions? Their story needs to be told and compared to that of the public.

The issues that will be investigated regarding scientists' attitudes to GE include:

- Intrinsic moral values regarding GE
- Extrinsic beliefs about the moral outcomes of GE
- Trust in authorities responsible for the development, regulation, marketing, and commentating on GE

The research will also investigate the relationship between personal values structures (as measured by the Schwartz Value Survey) and scientists' attitudes to ethics and social responsibility in research and scientists' attitudes to genetic engineering.

Your support for this project will be greatly appreciated.

Yours sincerely

Bruce Small

Social Scientist, AgResearch.

Appendix 7.3. Canvassing email to potential survey participants

Science, Society, Ethics and GE Survey

Dear scientist, research associate or science technician (i.e., all persons with a tertiary science qualification, otherwise please ignore),

I would like to invite you to participate in an online survey investigating scientists' values and attitudes to social responsibility in research in general and to genetic engineering in particular. This questionnaire is being sent to scientists in six CRIs including organisations that conduct GE research and those that do not. The data regarding scientists' attitudes to GE will be compared with matched questions included in a survey of the New Zealand public's attitudes to GE.

The study is part of my PhD research and is funded by FRST through a NSOF (Non-Specific Output Fund) grant from my employer AgResearch. My PhD is being conducted through Waikato University and my supervisors are Prof. Michael O'Driscoll of the Psychology Department and Dr Liezl Van Zyl of the Philosophy Department. The project has been approved by the Waikato University Psychology Research Ethics Committee. If you require further information please contact either myself, my supervisors or the Psychology Research Ethics Committee.

The survey will take approximately 20-25 minutes. To go to the survey please click on the URL link below. Before doing so please read the notes about informed consent and confidentiality below. Note that after completion of the survey submitting your responses will be understood as informed consent. The last day for participation in the survey is Friday June 17th.

Thank you for your help.

URL: http://www.agresearch.co.nz/attitudes

(If the hotlink does not work, please copy the URL address and paste into your web browsers address line)

Informed consent

You have the right to choose not to respond to the survey or any individual questions. You may exit the survey at any time, without sending your responses, by closing the web browser. However, a good response rate helps to increase the external validity of survey data and results. At the end of the survey you may submit your responses by clicking the "Send Answers" button. Submitting will be understood as informed consent.

Privacy and confidentiality

Your privacy and confidentiality are assured. Due to the data collection method, even the researcher will be unable to identify individual participants – unless the participant specifically chooses to include identity or contact details. Only aggregated data will be published. A 1-2 page summary of results will be sent to participating organisations for dissemination on their intranets. With permission, results will be presented in seminars in the participating organisations. Result will also be presented at academic conferences. Papers submitted to journals will also be forwarded to participating CRIs.

Bruce Small

bruce.small@agresearch.co.nz

ph. (07) 838 5216

Appendix 7.4. Question item normality statistics

Table A7.4.1.

Normality Statistics for Proposed Instrument Items (Table continued next page)

Item No.	Kolmogorov-Smirnov Statistic[a]	Skewness[b]		Kurtosis[c]	
		Statistic	Std. Error	Statistic	Std. Error
		Democratisation Items			
D1	.31	**-.98**	.09	**1.18**	.18
D2	.26	**-.24**	.09	**-.83**	.18
D3	.30	**-.86**	.09	**.88**	.18
D4	.29	**-.55**	.09	-.33	.18
D5	.24	.16	.09	**-.91**	.18
D6	.24	**-.34**	.09	**-.63**	.18
		Commercialisation Items			
C1	.21	.11	.09	**-.85**	.18
C2	.28	**-.52**	.09	**-.46**	.18
C3	.26	**.29**	.09	**-.97**	.18
C4	.27	**-.39**	.09	**-.74**	.18
C5	.30	**-.67**	.09	.25	.18
C6	.25	**-.32**	.09	**-.80**	.18
C7	.29	**.99**	.09	.19	.18
C8	.21	**-.19**	.09	**-.72**	.18
C9	.18	.02	.09	**-.73**	.18
		Technological Optimism Items			
T1	.22	**.62**	.09	-.16	.18
T2	.25	**.70**	.09	.13	.18
T3	.23	.13	.09	**-1.05**	.18
T4	.21	**-.34**	.09	**-.69**	.18
T5	.34	**1.97**	.09	**4.34**	.18
		Awareness Items			
A1	.37	**-1.12**	.09	**1.33**	.18
A2	.27	**-1.23**	.09	**1.53**	.18
A3	.24	**-.22**	.09	**-.93**	.18
A4	.30	**-.90**	.09	**1.12**	.18
A5	.29	**-.83**	.09	**.93**	.18
A6	.25	**.41**	.09	**-.73**	.18
A7	.22	-.12	.09	**-.98**	.18
A8	.30	**-.69**	.09	**.60**	.18
A9	.30	**-.75**	.09	**.63**	.18
A10	.24	**.32**	.09	**-.62**	.18

Note. Pairwise deletion of missing cases, *n* ranges from 723 to 732 for individual items.
[a] All Kolmogorov-Smirnov statistics are significant at the .001 level indicating rejection of normality.
[b] Bolded skewness statistics are more than twice their std error indicating rejection of normality.
[c] Bolded kurtosis statistics are more than twice their std error indicating rejection of normality.

Table A7.4.1 continued

Item No.	Kolmogorov-Smirnov Statistic[a]	Skewness[b]		Kurtosis[c]	
		Statistic	Std. Error	Statistic	Std. Error
		Judgment Items			
J1	.31	**-.76**	.09	**.99**	.18
J2	.26	**-.94**	.09	**1.24**	.18
J3	.26	**-.81**	.09	**.95**	.18
J4	.25	**-.84**	.09	**.37**	.18
J5	.24	**-1.06**	.09	**.95**	.18
J6	.29	**-.70**	.09	**.62**	.18
J7	.23	**-.24**	.09	**-.28**	.18
J8	.24	**-.34**	.09	-.34	.18
J9	.23	**-.37**	.09	-.34	.18
J10	.25	**-.91**	.09	**.71**	.18

Note. Pairwise deletion of missing cases, *n* ranges from 723 to 732 for individual items.
[a] All Kolmogorov-Smirnov statistics are significant at the .001 level indicating rejection of normality.
[b] Bolded skewness statistics are more than twice their std error indicating rejection of normality.
[c] Bolded kurtosis statistics are more than twice their std error indicating rejection of normality.