Personality at different levels

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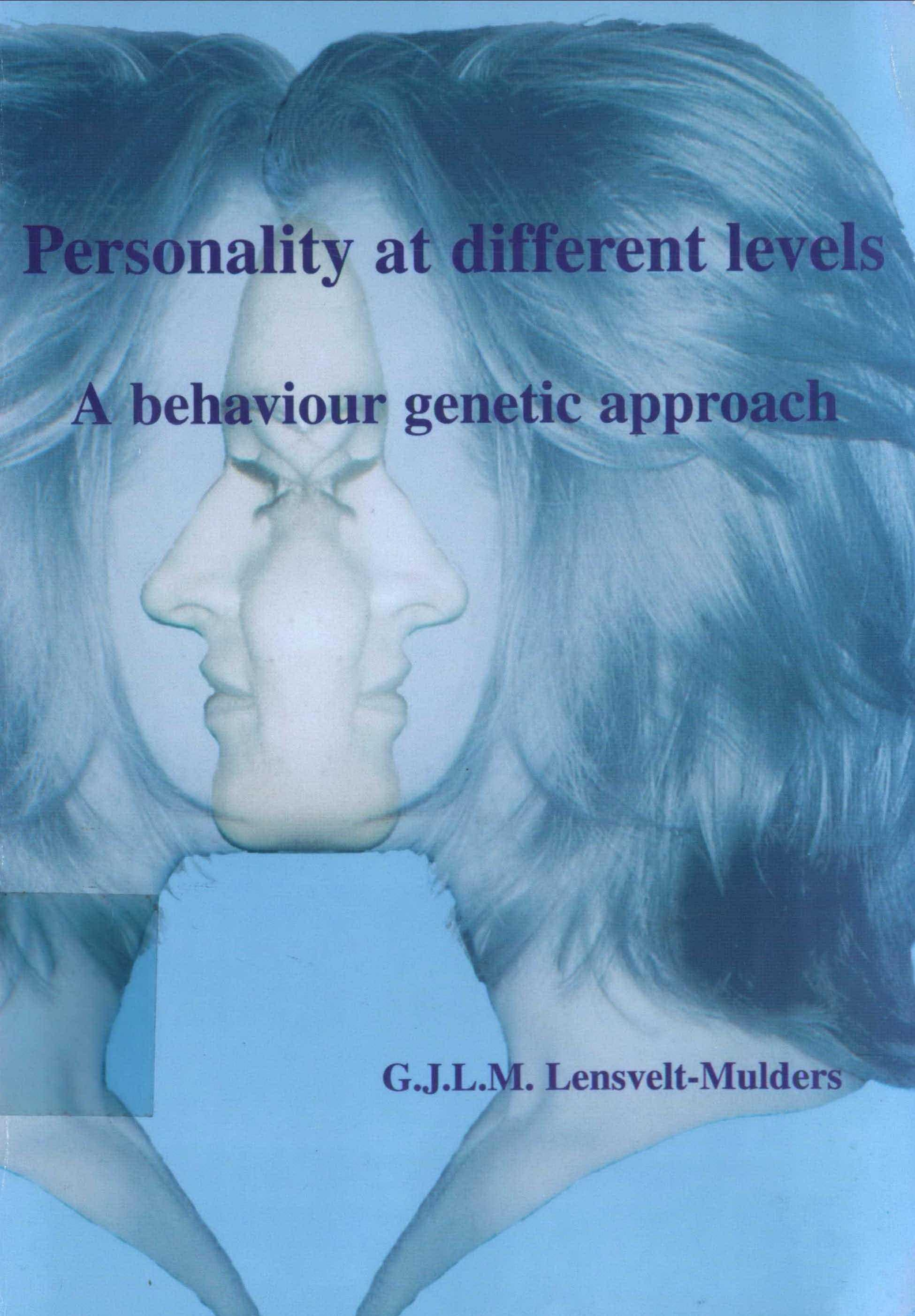
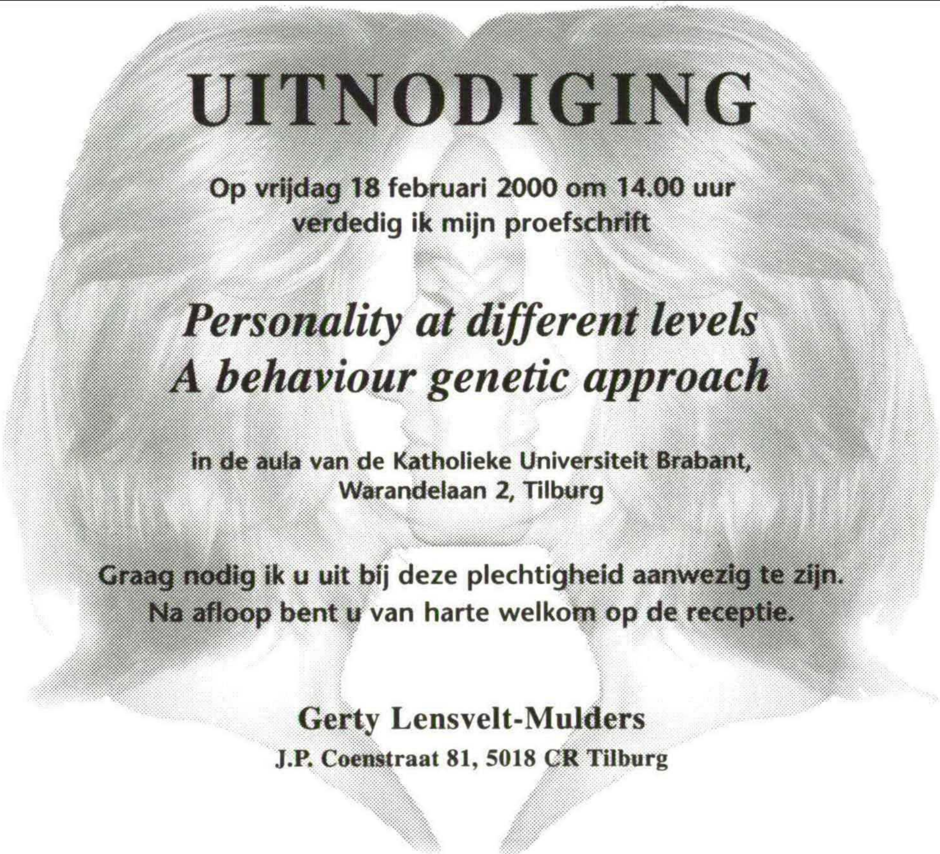


Personality at different levels

A behaviour genetic approach

G.J.L.M. Lensvelt-Mulders



UITNODIGING

Op vrijdag 18 februari 2000 om 14.00 uur
verdedig ik mijn proefschrift

Personality at different levels
A behaviour genetic approach

in de aula van de Katholieke Universiteit Brabant,
Warandelaan 2, Tilburg

Graag nodig ik u uit bij deze plechtigheid aanwezig te zijn.
Na afloop bent u van harte welkom op de receptie.

Gerty Lensvelt-Mulders
J.P. Coenstraat 81, 5018 CR Tilburg

Personality at different levels
A behaviour genetic approach

Proefschrift
ter verkrijging van de graad van doctor
aan de Katholieke Universiteit Brabant,
op gezag van de rector magnificus,
prof.dr. F.A. van der Duyn Schouten,
in het openbaar te verdedigen
ten overstaan van een door het
college voor promoties aangewezen commissie
in de aula van de Universiteit
op vrijdag 18 februari 2000 om 14.15 uur

door

Geertruida Johanna Lucia Maria Lensvelt-Mulders

geboren op 8 november 1957 te Geertruidenberg

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Voorwoord

Op 1 oktober 1994 ben ik aan dit proefschrift begonnen en precies vijf jaar minus één dag later, op 29 september 1999, heb ik het manuscript ingeleverd bij de promotiecommissie. Nu ik terugkijk op de periode die ik aan dit proefschrift gewerkt heb, kan ik alleen maar zeggen dat het een geweldig, formidabel avontuur is geweest. Dit is de plaats om iedereen te bedanken, die heeft bijgedragen aan het feit dat dit avontuur voor mij zo goed is afgelopen.
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Ivan, Jolanda, Herman, Jannemarie, Rinus, Charles, Bert, Susan en Nettie van de KUB en Harold, Willem, Nicole, Irmgard, Iris, Tris, Toon, Frans, Jaco, Gerard, Ellen en John van het IVA, allemaal bedankt voor jullie hulp en collegialiteit. En tenslotte is er nog de groep mensen die niet direct bij het proefschrift of de werkplek betrokken zijn geweest, maar mij op een ander manier door dit avontuur hebben geloodst, dat is mijn familie en vooral mijn gezin. Papa en mama bedankt voor jullie genen en de omgeving die jullie nog altijd zo gul met mij delen. Helmy, bedankt voor je dagelijkse warme space-embrace. Mijn schoonouders, in het bijzonder mijn schoonvader, die altijd apetrots op me is geweest. Hij had de plechtige promotie nog graag bijgewoond, maar is helaas op 3 januari 2000 overleden. Ad, in jouw omgeving heb ik meer facetten van mijn genetisch potentieel ten volle waargemaakt dan ik ooit heb durven dromen, dank je wel daarvoor. Mijn kinderen, Mare, Gertjan en Rens zijn, ieder op hun eigen manier, bezig op te groeien tot geweldige mensen. De afgelopen vijf jaren waren belangrijke jaren in hun eigen proces van volwassenworden. Ik hoop en vrees dat dit proefschrift ook hen deels gevormd heeft.

Ik heb in mijn vrije tijd een voorkeur voor het spelen van spannende adventure games op de computer die eindigen op de naam 'Quest', als Kings-quest, Space-quest, Police-quest, maar er gaat echt niets boven Thesis-quest. Het was geweldig. Het is klaar. Goddank!

Tilburg, februari 2000

Contents

1 Multilevel Models of Personality: Where biology and psychology meet

Every morning, I ride my bike to the university. And almost every morning, I stand there waiting for the red traffic light at the end of my street. And then I do my own little psychological field experiment: I try to describe the personality of the person in the car next to me by his or her behaviour, while he or she is waiting for the red traffic light. I call this my 'red traffic light'-experiment. Sometimes the car next to me makes a distress stop, keeps the motor running like mad, and spurts of just a few moments before the light goes green again. Other drivers will stand there next to me, waiting patiently, hands slapping the rhythm of the radio on the wheel.
At first glance the behaviour of all participants is the same, they see the red light, they stop and wait until the light turns green again. That is what we have learned to do when we were young, and those who have learned this lesson well do have a significantly better chance to survive compared to those who have not.
At second look we can distinguish different ways to stop and stand. Why is it that waiting for the red light for some seems to be an almost unbearable infringement on their mobility and for others just a short interruption of the course of the day? What is this feeling of urge some drivers seem to experience and where does it come from? And when an individual feels this urge waiting for the red traffic light, will he or she experience this feeling in every situation where waiting is involved? And maybe also in situations with no component of waiting at all?
How do the demands of the situation (stop, red light) match with the individual's physiology (feelings of urge), motives (arriving in time, staying in one piece), competences (knowing were to find the break) and personality traits (low or high levels of sensation seeking).
This is the story I told over a hundred times, to explain the goals of the study to 'my' twins, and ultimately these are the kind of questions this thesis is about.

1.1 Introduction

This thesis is about individual differences, and how these differences come about. Not all differences between individuals will be considered, not height and weight, nor hair colour. This thesis is about differences in the psychological phenomena that are studied by personality psychologists to increase our understanding of the roots of human individuality. Personality is extremely complex. There will never be one single approach in terms of reductionistic explanations, that will cover the whole concept. Therefore psychological phenomena have always been approached from several perspectives, e.g. the behavioural perspective, the biological perspective, the cognitive perspective, and the interactional perspective. Each of these approaches to individuality offers a somewhat different explanation of why individuals act as they do, and in doing so, each approach makes a contribution to an integrated conception of the total person. This multiple approach to the phenomena of individuality and personality has its advantage. As they say in the Netherlands; Let 1000 flowers flower, because this will always bring up something good and useful in the end.

But, although all these approaches to personality are contributing to the development and maturation of personality psychology, this fragmentation is also experienced as the major impediment of real progress in understanding individual differences. The lack of an integrative frame of reference stimulates the tendency to restrict ones research to the own field of research, and prohibits a more open multi disciplinary approach to the area of individual differences (Hettema and Deary, 1993; Magnusson, 1981, 1988; Toulmin, 1981). Accordingly, the past decades have witnessed controversy rather than consensus on the basic elements of personality as well as on the methods to study them.

An example of a methodological debate is the clinical versus statistical prediction controversy in the 60's. The main question was how the best understanding of individuality could be obtained. The adherents of the clinical method advocated a subjective and intuitive approach to psychological phenomena. Adherents of the statistical method advocated an objective and mechanical view on personality, to let 'the data speak' (Dawes, Faust, and Meehl, 1989; Murphy and Davidshofer, 1991).

In the 70's Mischel stood on the basis of a major 'elements'-debate, known as the person situation controversy (Mischel, 1968, 1986). After reviewing many studies about the influence of situational aspects on behaviour, Mischel concluded that people's behaviour is very inconsistent across situations. He found that correlations between trait measures and actual behavioural observations were quite low. The paradox that sustained this debate for so long is the fact that we intuitively seem to know that individuals are consistent and that research tells us this is not the case.

Currently a major issue is the genes versus the environment debate (Eaves and Young, 1981; Plomin, DeFries, and McClearn, 1990). Are we a biological or a social creature? Or are we both? This debate is a consequence of a much older debate, a very influential controversy known as the 'nature-nurture debate'. This longstanding discussion is about the relative importance of biological and social factors in the development of individual differences. For a long time, biological and social explanations seemed to be mutually exclusive, and always one approach seemed to be overriding the other, dependent on the zeitgeist. I like to visualise this controversy with the aid of a giant seesaw. At one end there are the biological explanations of personality, like evolutionary theories, the influence of genetic factors, or the results of brain research on behaviour. At the other end are the social explanations of personality, i.e. upbringing, learning and culture. Throughout the history of psychology it seems that always one end of the seesaw is down, a form of equilibrium is never reached. It is not in the scope of this thesis to give a full overview of all movements of the seesaw in time, but a few examples may increase the understanding of this nature-nurture debate.

At the dawn of psychology as a science, about 100 years ago, psychologists had an open mind towards biological explanations of human nature. Biological features as body physique were an accepted basis for personality theorising. The idea that physical conditions and personality are related did not come out of the blue, but was rooted in culture and language. In 400 BC, the Greek philosopher and physician Hippocrates was aware of the differences between individuals and he explained these differences in temperament as differences in concentrations in body fluids (biological approach). People who are extraverted and stable, he called sanguine. Sanguines were thought to have more blood in their veins than other people. People who are introverted and stable were called phlegmatic, indicating high levels of phlegm (mucus). Introverted unstable people were named melancholic, because they had high levels of black bile (chole). Extraverted unstable people were called choleric and they were thought to have high levels of yellow bile (Eysenck and Rachman, 1965). The remains of this theory are still found in our language. In the Netherlands, people who are pessimistic and despondent are called 'zwartgallig' which means 'full of black bile' and in the Dutch and English language we still use the word phlegmatic to indicate a calm and stolid person. Another popular biologically based theory of more recent date was the theory of Sheldon (1954), who reported correlations between bodily physiques - called somatotypes - and temperament. The endomorphic type with round and soft body features correlated with relaxed and sociable behaviour. The mesomorphic type, with muscular and athletic body shape correlated with an energetic and assertive temperament. And finally the ectomorphic type which is tall and thin, correlated with restrained, introverted and artistic behaviour.

The favourable look upon biologically based theories changed when the dominant paradigm in psychology became the social approach to personality, emphasizing social learning and reinforcement as major sources of individual differences. In its most extreme form, the social approach is known as 'social behaviourism', based on a school in psychology associated with John Watson. Behaviourism arose as a protest against all forms of introspective psychology, concerned with consciousness and free will. In doing so psychology was defined as the study of overt behaviour and data collection was usually limited to objective and measurable characteristics. According to Watson and his followers this was the only way psychology could ever become a real science (Endler, 1984, 1993; Watson, 1930). Watson and his followers were not against physiological explanations, but they thought the brain to be a black box. Understanding of its processes was not necessary, nor would it add to a better understanding of social phenomena. This view is still advocated by some current researchers. In 1993 Hofstee asks the question if biology can help personality psychology and his answer is that contributions can be modest at best (Hofstee, 1993). In his article he does not deny the influence of biological processes, he only challenges their importance to the field of personality. In the 1960s-1970s the seesaw really skipped towards the social approach. In those days there was a strong social equality movement and to focus research at individual differences was suspicious at least. To attribute these differences to innate differences seemed against the strong notion that all men are created equal. A restricted view upon the philosophical concept of equality and the lack of understanding how biological

processes contribute to individuality made the biological and social approaches more then ever mutually exclusive.
The contemporary social approach to individual differences, although still very influential, is currently challenged by the biological paradigm stressing genetic and evolutionary mechanisms as the main sources of individual differences (Harris, Williams, and Plomin, 1999). Biological approaches focus on the role of genetic, constitutional, physiological, and biochemical variables of behaviour as basis for individual differences in overt behaviour (Buss, 1990; Bouchard,1993; Hettema and Deary, 1993; Loehlin, 1992; Zuckerman, 1989, 1990b, 1992, 1993). Biologically orientated psychologists look at man as a species, subject to the laws of biology and evolution (Buss, 1990, 1991). Behavioural mechanisms evolve in response to the need of an organism to adapt to the environmental demands. These mechanisms are stored in the genetic make-up of species.
Especially recent results of research in behaviour genetics have convinced many workers in the field of personality psychology that biological mechanisms can no longer be ignored. The strongest evidence for the importance of biological factors in behaviour, is the demonstration that genetic effects are found to explain about half the variance in behavioural traits that have been studied. Genetic effects have been studied in the areas of neurology, physiology, traits, motivation, and attitudes (Eaves, Eysenck, and Martin, 1989).
Although modern biological approaches may provide an alternative explanation for social behaviourism in the explanation of individual differences, current research on individual differences makes it more and more evident that acquired social mechanisms as well as innate biological causes are necessary to explain complex human behaviour at any given time. Man is a biological as well as a social creature, and personality is a biosocial concept (Hettema and Deary, 1993; Plomin, DeFries, and McClearn, 1990). So instead of pushing the seesaw too far towards biological explanations of personality, we have to search for equilibrium. The scientifically relevant question for current personality psychology is: what causes the differences between individuals for a particular behaviour? Then environmental as well as biological determinants leap to mind. Social learning and biological explanations are not mutually exclusive, they are both necessary components for a complete understanding of individual behaviour. Since both approaches have proven fruitful in identifying personality conditions it seems an obvious choice to include biological as well as social conditions into one

integrative framework. This framework should have descriptive and causal elements, it must be subject to prediction and experimental testing of these predictions (Eysenck, 1986). Such a comprehensive framework, that explains rather than merely describes the roots of individual differences is still lacking.
What are the roots of the stable and consistent differences in behaviour among individuals? Which latent determinants underlie overt behaviour as commonly observed in daily life situations. Some theorists restrict the underlying determinants to only two levels. Cattell, for example, assumes surface traits, which are manifested in overt behaviour, to be based on source traits underlying them (Cattell, 1972). However, this can only be seen as a preliminary solution, because other levels seem to be required for the explanation of source traits.
Most current personality theorists assume more than two levels of explanation to be necessary to understand personality. More complex stratified models are a way to conceptualise personality and to give credit to its complexity. Stratified models can include biological as well as social determinants of personality, which could give these models several advantages for psychological theory building as well as practice. They may open the way to improve personality psychology from merely describing to explaining individual differences. These explanations may range from construct validity studies at separate levels, to studies of relations between levels and even studies on the direction of causality, and in doing so stratified models may provide the building blocks for theories of personality development in biosocial terms (Stelmack, 1993).
In this thesis complex stratified models will be referred to as 'multilevel'-models. Here the word 'multilevel' is not referring to the concept of multilevel research in the statistical sense, based upon the multi-stage sampling design, and resulting in a nested data structure. The levels of stratified models are not ordered in units that have an inclusive relation, which means that lower levels are not nested in higher levels (Hox, 1995).

1.2 Multilevel models in contemporary psychology

A classic multilevel approach may be found in Freud's psychoanalytic theory. In his model Freud combined the notions of consciousness, perception and memory with biologically based instincts. From these notions he composed a personality model, defining three major systems within the person, the Es (Id), the Ich (Ego) and the Überich (Superego) (Freud, 1941). A classical problem with Freud's model is its emphasis on inner structures, without the empirical definitions necessary to put it to test. To define the major levels for a multilevel model of personality, more recent developments in the area of personality may provide a better start.

Examples of current multilevel models are the biosocial model of Kenrick, Montello, and MacFarlane (1985; Hettema and Kenrick, 1989), the genetic-cultural transmission model of Poortinga, Kop and Van de Vijver (1990), the P-model of Eysenck (1993a, 1993b), and the most elaborated model, the 'Seven Turtles'-model of Zuckerman (1991, 1992, 1993).

Kenrick et. al. (1985) proposed a multilevel model, according to which behaviour is explained as a consequence of several factors, ranging from distal to proximal. At the most distal level are biological influences including sociobiology, genetics and physiology. At the intermediate level 'Learning' is a major factor. Finally, at the most proximal level cognitions underlie behaviour. Physiological predispositions are in the focus of mainstream biological psychology, environmental events are in the focus of traditional learning theories and the cognitive representations are in the focus of current social learning theories (Hettema and Kenrick, 1989).

Poortinga, Kop, and van de Vijver (1990) proposed a cross cultural model of behaviour, including genetics. Between genes and culture, the model postulates the levels physiology, perception, cognition, personality and social behaviour. Along these levels the genetic transmission of personality features decreases and (cross-)culturally evoked variation increases. Poortinga et al. argue that variation between cultures in physiology is very small, and that it is difficult to bring up an example. Variation between cultures in perception is still small, although there are examples of differences e.g. in the perceptions of colour between people in the tropics and those in milder climates. These differences are related to the way the retina is build, which reflects the need for protection against ultraviolet radiation. Variations in cognitions are ubiquitous, people learn cognitions to adapt to the environment they live in. Personality as a concept is defined in between, rooted in genetics and shaped by the environment. In this model social behaviour reflects the demands of culture. Poortinga and coworkers (1987) claim that it is hard to find an example of genetic effects on social behaviour since most of the characteristics of social behaviour prove to reflect conventions (Poortinga, Van de Vijver, Joe, and Van de Koppel, 1987).

Eysenck (1993a) emphasized the need to identify the roots of personality in a nomological framework, underpinning the construct validity of personality models. Therefore it is important to study the distal and causal effects of behaviour to give meaning and relevance to traits that, in his view, are no more than dictionary based psychometric concepts. His model for psychotism where psychotism is explained from DNA to traits, is an example of this line of research (Eysenck, 1992). After identifying the connections between psychotism as a behavioural trait and DNA, Eysenck proposed the causal chain: DNA - dopaminergic functioning - latent inhibition - over inclusiveness in thinking - psychotism (or creative genius) (Eysenck, 1993a). In terms of a multilevel model Eysenck emphasizes the levels of genes, neurology, cognition, and behavioural traits.

The most elaborate multilevel model is Zuckerman's 'Seven Turtles' model, named after the old story of the guru trying to respond to the student's question about what the world rests on. The world according to the guru rests on a giant turtle. Then the student asked: 'Were does that turtle rest on?', 'An even larger turtle' the guru answered. The student took a deep breath to ask again 'and what does this turtle rest on, oh master?' And the guru said 'Another, even larger turtle'. This scene repeated itself six times, but when the guru came at the seventh turtle he replied ' and there it stops, because seven is the magical number' (after Zuckerman, 1992).

The seven turtles the world of the psychology of personality rests on are:

traits
social behaviour
learning
physiology
biochemistry
neurology
genetics

Variables on these levels are all necessary to explain and completely understand the existence of individual differences '*....from top (traits) to bottom (genes), with stops at every level between*' (Zuckerman 1993, pag 73). This model will be explained in more detail in the next section. At each level some examples of research will be given as illustrations.

1.3 Levels of the 'Seven Turtles' model

Genetics

Genes are the functional units of heredity. They are the turtle's egg. While there is an argument about the direction of causation for the higher levels, the genes are the basis. Genes contain the specific information about a wide variety of human features, ranging from eye colour to social attitude. Some characteristics are controlled by single genes, but most complex traits are controlled by the combined action of several genes. This multiple regulation increases the possibility of individual differences, and makes the variety in human genotypes enormous. Recent research in behaviour genetics suggests that variation in personality depends to a considerably extent on genetic factors. However, genes do not underlie personality in a direct sense. Genes serve as templates or models for the synthesis of proteins (Griffiths, Miller, Suzuki, Lewontin, and Gelbart, 1993; Kalat, 1988; Plomin, DeFries, and McClearn, 1990). These proteins exert profound influence on behavioural structures and processes via the nervous system and the production of behaviourally relevant hormones and neurotransmitters.

At the micro level genetic studies are performed as DNA studies. Aims of this field of research are to increase our understanding of the mechanisms of gene action, to study DNA variation of the human species directly, and to map the human genome.

At the macro level genetic studies are performed as population genetics. Population genetic studies in the field of psychology are better known as behavioural genetic research. The aim of behavioural genetic research is to study the genetic and environmental causes of individual differences. Genetic influences can be studied with the aid of the twin method, where the similarity of monozygotic twin pairs is compared with the similarity of dizygotic twin pairs, to determine the relation between genetic and environmental influences on behaviour (Neale and Cardon, 1992). Zuckerman's multilevel model assumes genetic influences to be found for behaviour at every level.

IRS is the tendency for an individual to emit characteristic responses to most stimuli (Engel, 1972). This tendency may be related to specific consistent personality dispositions like, e.g., temperament or coping styles. IRS may be due either to genetic factors or acquired personality characteristics and competences (Fahrenberg, 1986; Stemmler, Grossman, Schmidt, and Foerster, 1991).
SRS is the tendency of a stimulus or situation to evoke characteristic responses from most individuals (Engel, 1972). SRS assumes that different classes of physical or psychological stimulus characteristics have the capacity to activate specific psychological reactions.
MRS assumes the subjective interpretation and appraisal of a standardized stimulus situation to vary among individuals (Ax, 1964). Rather than the individual or the stimulus situation per se, the meaning an individual gives to the stimulus, underlies responsiveness.
If autonomic responsiveness is studied in daily life situations, MRS accounts for large portions of the total variance. Research in our laboratory with single autonomic variables summoned by motion pictures as stimuli has invariably revealed MRS causes the lion's share of the variance in those conditions. In recent studies almost half of the systematic variance in autonomous responsiveness could be explained by MRS, whereas only one third was due to IRS (Geenen, 1991; Leidelmeijer, 1991; Hettema, Leidelmeijer, and Geenen, 1999).
This view on response specificity is not restricted to physiological measures. IRS is in fact a measure for what is generally referred to as cross-situational consistency, the concept of behavioural traits (P). SRS is referred to as intra situational consistency (S), here the situation is the determinant of behaviour. And MRS refers to stable interactions between persons and situations (P×S), the person ×situation consistency.
Research on D-goals showed the relative importance of P, S, and P×S on D-goals, where P×S accounted for the largest part of the variance (Hol, 1994). Research with the TinSit (see Chapter 2) revealed similar findings for the Big Five personality traits (Van Heck et. al., 1994; Hendriks, 1996), the P×S interaction accounted for the largest part of the total variance.
The inconsistency of behaviour over different measures is usually interpreted as unreliability or error. The different situation descriptions or films can be conceived as different measurement occasions. In our approach the possibility is investigated that the (lack of) generalisation of behaviour over different situations

Biochemistry

On the level of biochemistry Zuckerman studied relations between levels of neurotransmitters in the brain and overt behaviour. Neurotransmitters are chemicals released by a neuron at a synapse to affect the activity of a second neuron. Examples of neurotransmitters are serotonin, dopamine, and noradrenaline. Neurotransmitters are converted into inactive chemicals by enzymes as mono amino oxidases (MAO). Low levels of MAO are associated with sensation seeking and bipolar affective disorders, whereas high levels of MAO are associated with major depressive disorders (Zuckerman, 1993). Levels of neurotransmitters are also genetically affected. Genetic effects on mood disorders explain approximately 25-30 percent of the total variance in depression (Kendler, Kessler, Walters, McLeane, Neale, Heath, and Eaves, 1995).

Eysenck's factor 'Psychotism' (P) is related to low levels of MAO and DBH (Dopamine-beta-hydroxylase) and to high levels of gonadal hormones in Males. More then 80 % of the variance in enzymes correlated with P is determined by heredity (Zuckerman, 1989).

Physiology

At this level the functioning of the autonomic part of the central nervous system (ANS), and the way it influences behaviour, is studied. Within the ANS two separate systems are active, the sympathetic system (SNS) and the parasympathetic or vagal system (PNS). The SNS facilitates activation processes, where the PNS, or vagal branch facilitates restoration and recovery functions. Until recently SNS and PNS were thought of as antagonists: when PNS was active, SNS activity was low, and when SNS was active, PNS activity had to be low (Obrist, 1981). However, although both branches are functionally antagonistic, the activity of SNS and PNS is not linearly related. Both systems can work more or less independently (Grossman, Stemmler, and Meinhardt, 1990). Both branches affect the responsiveness of cardiovascular and electro dermal measures, so the search was for a combination of psychophysiological variables to increase our understanding of the combined working of SNS and PNS. For a more complete overview of the structure and the functions of the cardio-vascular and the electrodermal system I refer to 'Cardiovascular psychophysiology' (Obrist, 1981), 'Principles of Psychophysiology' (Cacioppo and Tassinary, 1990), and 'Psychophysiological Consistency and Personality' (Geenen, 1991).

Hettema and coworkers linked physiological variables to information processing (Hettema, Leidelmeijer, and Geenen, 1999). They conceived different functional patterns of autonomic reactivity to be related to different systems of information processing (this will be treated more extensively in chapter 2). Cardiovascular measures are also related to anger, hostility and type A- behaviour (Mills and Dimsdale, 1992) and to the Big Five personality traits (Kaiser, Beauvale, and Bener, 1997). Research on coronary proneness as a personality trait yielded evidence for the role of genetic dispositions in variation on coronary proneness and a personality subscale called 'cynical hostility' (Rose, 1992).
Cumulative evidence from behaviour genetic studies suggests that the genetic effects on single psychophysiological variables, like heart rate responsiveness, blood pressure, and electrodermal activity are moderate to high. For cardiovascular responsiveness to psychological stressors heritability coefficients ranged from .30 to .70 (Turner and Hewitt, 1992; Ditto, 1993), for respiratory sinus arrhythmia between .28 and .62 (Snieder, 1996; Snieder, Boomsma, van Dooren, and de Geus, 1997) and for EEG measures between .37 and .75 according to the place of the electrodes on the scalp (Van Baal, 1997).

Learning

At the learning level conditioning and observational learning are the most important processes to sculpture personality. Conditioning and other kinds of learning depends on information processing systems and motivational systems in the brains (Gray, 1991; Zuckerman, 1992). Biological mechanisms underlie conditioning mechanisms. One can not be conditioned when physiological arousal is too high or too low, or when physiological attention mechanisms interfere with stimulus intake. Reward and punishment exert their effects on physiological mechanisms like response inhibition, heart rate, and skin conductance during instrumental learning (Gomez and McLaren, 1977).
The relation between traits, conditioning and physiology has been the object of much study (Eysenck, 1967; Stelmack, 1990; Zuckerman, 1990a). Eysenck's theory of optimal level of arousal of the ascending reticular activation system (ARAS) is based on this research. Eysenck suggests that introverts are more auto aroused - their level of arousal is optimal without much stimulation - and are therefore easier to condition than extraverts. This theory has met with much criticism. Especially the fact that Eysenck's concept of arousal is unidimensional

has often been the focus of scientific attack (Brody, 1988; Gray, 1981, 1982, 1991; Matthews and Gilliland, 1999; Stelmack, 1990).

The literature on social disorders suggest that there are individual differences in sensitivity to punishment and reward, and that these differences have a genetic basis (Martens, 1997; Robinson, Kagan, Reznick, and Corley, 1992). For instance it is demonstrated that delinquent people have a lower galvanic skin response (GSR) and a longer recovery period than non delinquents. And that this autonomic reaction plays an important role in the unlearning of undesired behaviour (Mednick and Christiansen, 1977).

Social behaviour

Social behaviour is conceived here as everyday behaviour, a person in interaction with his environment. Social behaviour is learned through stimulus response contingencies, where stimulus refers to all possible antecedent conditions and response to all possible behaviours and behavioural products. People learn to know situational contingencies, making it possible to generalize learned behaviour over different situations. Major processes involved are operant conditioning, social learning, modelling, and social cognition. Social learning studies the effects of reward and punishment that other people receive as important motivators of an individual's behaviour. Thus, social learning is conceived as a special case of operant conditioning (Bandura, 1977, 1986). Modelling is the process of observing and imitating others, by which a person learns social and cognitive behaviours (Atkinson, Atkinson, Smith, Bem, and Hilgard, 1990). The social approach to behaviour is no longer restricted to behaviour that can be observed externally. Social cognition scientists have challenged the assumption of behaviourism that behaviour can be understood only by studying external and environmental factors. People can also represent the world mentally and operate on these mental representations. Social cognition is a field of research that studies how people give meaning to their world and to the self. Cognitive processes related to people, social attribution, and social perception are in the focus of social cognitive research. But they are not studied in relation to biological factors like the way the brain functions.

Which social behaviours can be learned depends on an individual's biological make-up, defined by Zuckerman as physiology, biochemistry of the brain, neurology and genetics.

Traits

Traits are the basic dimensions of individual differences along which an individual may be located. To meet the criterion of 'basic dimensions' traits have to be reliably measurable across methods, gender, ages, and cultures (Costa and McCrae, 1992).

Traits can be conceived as a summary label for aggregated social behaviour. A person is labelled according to his observed social behaviour. If the same type of behaviour is observed regularly and consistently over situations and time, that person will be labelled accordingly. For instance, an individual that is often involved in social and physical active behaviours, will be labelled 'extravert'. A person who acts friendly in different occasions is labelled a friendly person (Van Heck, Perugini, Caprara, and Fröger, 1994). In Zuckerman's model traits are conceived as the ultimate products of behavioural processes at all other levels. Traits are based on genetics and obtain their shape during a lifetime of development based on physiological processes, a history of learning, and the role of overt behaviour.

Traits are heritable and therefore rooted in the genotype. The total variance of a large variety of personality traits explained by genetic effects is approximately 40 to 50% (Loehlin, 1992; Bouchard, 1993; Lang, Livesley, and Vernon, 1996).

1.4 Connections between levels

Zuckerman postulates relations between the seven levels. Behaviour at all levels is rooted in the genotype. Genes exert their influence on a personality trait indirectly, mediated by the other levels. But genes can only exert their influence in an environment.

The environment exerts its effect at every level. These effects are thought to increase with increasing level. The effects of a specific environment upon personality varies from one individual to the other, depending on their genotype (Loehlin, 1992). Within Zuckerman's model, adaptation of the individual to the environment plays a major role. Different genotypes seem to prefer different environments (Bouchard, 1993, 1994; Eysenck, 1990; Loehlin, 1992). When people are given the opportunity to attend selectively to, and make their choice from, various situations they will choose the situation that matches best with their

stable dispositions. In similar situations identical genotypes can be expected to make similar choices and behave in a similar way (Scarr and McCartney, 1983). Phenotypic variance may be due to genotype/environment correlations and genotype/environment interactions. Genotype-environment correlation describes the extent to which individuals are exposed to environments as a function of their genetic propensities. Plomin et. al. (1977) mention three kinds of genotype/ environment correlations, the passive, the reactive and the active one. Passive correlation occurs because children share genes as well as environment with their family and can thus passively 'inherit' environments that match their genetic structure. Reactive or evocative correlation refers to the experiences that a child has from the reactions of other people to the child's genetic propensities. Active correlation occurs when children (and adults) actively seek the environment that fits their genetic dispositions. Interaction between environment and genotype refers to the effect of environmental factors dependent on genotype. This is interaction in the statistical sense (Plomin, DeFries, and Loehlin, 1977).
Genes 'prefer' environments that are beneficial for the development of traits according to the genotype. A person will develop behavioural competencies necessary to adapt to these environments, dependent on main effects of genotype and environment, the genotype/environment correlation and the genotype/ environment interactions. As an example the autonomic arousal theory of Eysenck can be used here to show this process. According to the theory, people with low auto arousal of the ARAS prefer situations with much sensoric input, and people with high auto arousal will prefer situations with much sensoric input. Eysenck found evidence for this hypotheses (Eysenck, 1993a). If one wants to study genetic effects at the higher levels it is necessary to study behaviour within specific situations.

1.5 Assumptions underlying Zuckerman's model

Biosocially stratified models have four important assumptions that will help to generate research (Hettema and Deary, 1993).
First, these models claim to have a *conditional ordering of levels*, where processes at the distal biological levels provide necessary but not sufficient conditions for the more proximal social levels to materialize. Neurological features like the quality

and quantity of dendritic branches and connections are necessary conditions for the occurrence of learning processes and social behaviour, but they are not sufficient. Input from the environment is also needed for learning and social behaviour to occur.

Secondly, the model knows an *order assumption*. The order assumption emphasizes the relative positions of higher levels versus lower levels. Biological conditions like neurology, biochemistry and physiology are assumed to be more closely linked to genes than social behaviour and traits. It is hypothesized that with increasing level, the genetic effects on behaviour will decrease and the effects of the environment on behaviour will increase. This assumption is under a lot of criticism, and there is a lot of argument about the relative positions of the different levels, especially about the relative positions of the biological levels, like physiology and biochemistry (Zuckerman, 1992, 1993). But also about the relative position of traits versus learning and social behaviour. Traits could be more basic then learning and social behaviour, and in being so they could restrain what is learned and what behaviour is performed in different situations.

Thirdly, multilevel models can be viewed as *developmental as well as current state* models. Development of a trait is mediated by physiological and learning processes. An example of this developmental view, can be found, as we saw before, in Eysenck's arousal theory (Eysenck, 1967; Stelmack, 1990). Individual's who have an innate tendency to have a low activated ARAS will not very easily become physiologically aroused. They will reach their optimal level of arousal only in an environment with sufficient sensory stimulation. This is the environment that 'feels good', so the individual will become motivated to seek these environments by a process of classical conditioning and will learn the competencies necessary to deal with that environment by vicarious and instrumental learning processes. In the example of a low activated ARAS others will label that individual as extravert, because of his preference to be in highly stimulating environments. One of the underexposed features of the Seven Turtles model is the developmental transition between biological and social processes at the learning level. Multilevel models are also current state models, because every level can be measured at a specific moment in time. In this study the Seven Turtles model is considered a current state model: every level of behaviour is measured at the same time, within the same respondent group, and within different situations.

Fourth and last, every level represents an *existing approach* within personality psychology, and as such, much and varied research is done at every level. However, these results are usually reported without reference to other levels. Therefore multilevel models are difficult to be tested. For every level choices have to made from a·very wide range of psychological variables. In chapter 2 we will enter at length to this subject.

1.6 Goal of this thesis

Research on the 'Seven Turtles'-model and related models has been done by different researchers, using different methods, at different moments in time, under different circumstances, with different groups of subjects. We could not find any research that included all levels of the model at once, using one group of subjects. Accordingly, differences in findings and conflicting evidence is often found (Matthews and Gilliland, 1999).
The purpose of this study is to test some major hypotheses derived from Zuckerman's multilevel model. The best way to test a multilevel model, that includes genetics, seems to us to test *all levels within one group of participants*, using the twin method. This will allow personality psychologists to declare upon the connections between the levels of the model (Eysenck, 1993a, 1993b), and to declare upon the differential genetic and environmental effects at every level (Hettema and Deary, 1993). The design of this study will be explained in chapter two.

1.7 Hypotheses and outline of the thesis

From the assumptions for biosocial models we can derive testable hypotheses, about the genetic and environmental effects on the singular levels, about the connections between the levels and their causes, and about the genetic and environmental interaction between levels and situations. Many hypotheses can be derived from the assumptions of such a complex model, but only six of them will be put to test in this study.

1 *Variables at the higher levels can be predicted by variables on lower levels.* This hypothesis can be put to the test with the aid of multiple regression analysis (chapter 3).

2. *Variables at the adjacent levels are better predictors than variables at more remote levels.*
This hypothesis can be derived from the fact that the levels are ordered according to a simplex model, in which adjacent levels correlate more than the levels that are further apart (chapter 3).

3. *Behaviour at all levels will reveal genetic effects.*
This hypothesis follows logically from the fact that genotype is postulated on the basis of the model (chapter 4).

4. *Genetic effects are largest at the lower levels and will decrease with level. At every level the environment has its own effects and these effects will increase with increasing level.*
Because of the cumulative effects of environment the effects of genotype will decrease with every level (chapter 4).

5. *There are correlated genetic components on the basis of behaviour at all levels.*
This is the strongest hypothesis, predicting one to one relations of genetic nature between variables at different levels. The same gene pool is thought to innervate more than one variable. This can be measured with the aid of multivariate genetic analysis (Neale and Cardon, 1992) (chapter 5).

6. *Genotype-environment interactions will become stronger with increasing level of the Zuckerman model.*
This is a further elaboration of the second hypothesis. Plomin et. al. (1977) make it very explicit that environmental effects do not work in isolation, but are always mediated by the genotype. An example of these genotype-environment interaction effects is found in the depression model of Kenddler, Kessler, Walters, Neal, Heath, and Eaves (1995). Here they clarify the interactions between genetic liability and major life events on the etiology of

major depression. Genetically controlled sensitivity for the depression inducing effects of stressful life events was the best predictor for onset of depression. Not the events per se, nor genetic effects per se, but an interaction of situations and genetic liability proved to be the best fitting model (chapter 6).

This thesis will be concluded with a general discussion and an overview of the conclusions in chapter 7.

2 Testing the Zuckerman model: A research design

2.1 The choice of levels

There are several ways to test Zuckerman's model. The different approaches have in common that data on more than one level of the model are collected and compared. An ideal test of the model would include evidence on all seven levels. However, it is rather unlikely that such a design will ever be materialized. To collect data on the genetic, neurological, biochemical, physiological, learning, social behaviour and trait levels in the context of one single study is currently practically impossible. Fortunately, all the hypotheses derived from the model are relative hypotheses, i.e. emphasizing the relative positions of higher levels versus lower levels (cf. Chapter 1). Thus, studies representing less than all seven levels may provide important although partial tests of the model. Needless to say, to the extent that more levels are represented the study becomes more important. In addition to the number, the nature of the levels studied is relevant.
For the present study, instead of all seven levels, five levels were selected. Care was taken to include levels that can be considered crucial from the point of view of the model. To study the most extreme levels seems to be a logical choice. Thus, genes and traits were included. And, subsequently, the levels marking the transition from biological to social effects deserve our special attention. Thus, the levels physiology, learning and social behaviour were included as well.

2.2 The choice of variables

2.2.1 Introduction

Zuckerman's multilevel model postulates relationships between several levels of a biological and/or social nature. To provide evidence on the model, variables have to be selected at the different levels. To qualify as elements of the model the variables at each level should answer some important specifications. Those variables cannot be chosen at random, they have to fulfil some major conditions. First of all, the classification of a variable at a given level must be unequivocal. With traits this may be obvious, because the Big Five model has achieved prominence because of the identification of the factors in different cultures, but at the other levels there is room for debate. For instance, at the 'social' levels it is not always clear whether a variable belongs to the learning level or social behaviour level.

Besides these considerations with respect to content the selection of variables should take into account major methodological considerations. The present study is a comparative study designed to demonstrate differences among variables at different levels. However, the differences obtained should unequivocally reflect the level at which the variables are located. All other factors affecting the outcomes are to be considered disturbing factors causing error. An important disturbing factor may be differences in cross-situational consistency among the variables. As is well known from previous research, personality variables differ in the amount to which they reveal consistency across different situations. Although systematic research on this issue is still lacking, it is to be expected that cross situational consistency is moderated by genetic effects. In addition, one of the hypotheses to be tested in this study is directly concerned with the genetic basis of person $\times$ situation interactions. Thus, it seems important at the different levels to select variables that are comparable with regards to cross-situational consistency.

2.2.2 Genetic level

At the level of genes no choice of variables was required. As we saw before genes are templates or blue prints for protein syntheses. Current research on genes tries to unravel the gene substrate in behaviour, and the way genes exert their influences. In this study the genetic and environmental influence on the variation in behaviour at different levels will be studied with the aid of quantitative genetic analysis techniques. Measures at every level will be analysed according to the twin design. This method involves the analysis of differences in covariation between monozygotic and dizygotic twin pairs (Neale and Cardon, 1992).

2.2.3 Physiology

In the area of personality research, physiological processes are studied predominantly to reflect individual differences in information processing (Changeux and DeHaene, 1989; Donchin, Karis, Bashore, Coles, and Cratton, 1986; Eysenck and Keane, 1990). Classic work in this area are the studies of Eysenck on the relation between cortical arousal and introversion/extraversion. This theory about the activation of the Ascending Reticular Activation System (ARAS) underlying extraversion/introversion has been the target of many studies, and is both admired and abused. As often as not results have supported the theory (Stelmack, 1990; Matthews and Gilliland, 1999). At this moment the most severe criticism raised against Eysenck's model is his unidimensional conception of arousal (Brody, 1988; Gray, 1982). Related with this criticism is Lacey's (1967) advice to search for multivariate patterns of psychophysiological reactivity rather than single variables. More recently, Brody (1988) argued that an unidimensional theory of activation is too simplistic: functional physiological behaviour related to information processing and learning cannot be found in simple unidimensional patterns. An example of research in line with the multiple arousal dimensions view is the classical work of Pribram and McGuiness (1975). They identified three separate information processing systems, connected with input, output, and internal processing of stimuli from the environment. In their more recent work these systems are called the Familiarisation, Readiness and Effort systems (Pribram and McGuiness, 1992).

In our laboratory methods have been developed to measure the physiological dimensions reflecting reactivity of these three systems. The dimensions have been identified in subjects watching films (Hettema, 1994; Hettema, Van Heck, and Brandt, 1989; Hettema, Leidelmeijer, and Geenen, 1999). The dimensions are based on seven physiological measures: heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), pulse transit time (PTT), T-wave amplitude (TWA), finger tip temperature (FTT) and galvanic skin level (GSL) (Geenen, 1991; Hettema, 1989; Leidelmeijer, 1991). With the aid of pharmacologically induced changes in autonomic responsiveness the differential innervation of these seven measures by SNS and PNS can be shown (Weiss, DelBo, Reichek, and Engelman, 1980).

Because of the differential influence of SNS and PNS on autonomic measures, different patterns of covariance/dissociation can be distinguished. Hettema, et. al. (1999) identified three major dimensions. The first dimension is based on the covariation of heart rate, blood pressure and galvanic skin response. The second dimension shows heart rate versus blood pressure reactivity as a major feature. The third dimension reflects cardiovascular versus galvanic skin response. These dimensions showed a remarkable fit with the information processing model proposed by Pribram and McGuiness (1975, 1992). The first dimension was interpreted as Readiness, the second dimension as Effort and the third dimension as Familiarisation. Hettema, Leidelmeijer and Geenen (1999) provided evidence supporting this interpretation. They confirmed Pribram and McGuiness' claims that Familiarisation reflects 'Stop' processes to register input. The major function of Readiness is output regulation reflecting 'Go' processes. Effort is a process under voluntary control with the capacity to break up the connection between Familiarisation and Readiness. The three dimensions are highly consistent across different situations as demonstrated with intraclass correlations exceeding .80 for each dimension (Hettema et al., 1999).

2.2.4 Learning

At the higher 'social' levels research has produced a number of so-called middle level units (Buss and Cantor, 1989). Examples are expectations, plans, values, competencies, strategies, tactics, control mechanisms, goals, life tasks and personal projects. A first major consideration to select one type of variables or another is whether these units reflect conditioning or social learning processes. It has to be noted here that the transition from one level to the other is rather fluent. Conditioning is primarily concerned with smaller, more operational units. Social learning primarily involves cognitive units, placing more emphasis on mental events. Thus, short term tactics to obtain immediate situational control reflect conditioning while long term strategies and life tasks belong to the level of social behaviour. Zuckerman (1993) refers to the latter type of variables as 'cognitive traits'. The units selected here for the learning level are concerned with control, identified earlier as a major factor involved in conditioning (Mayer and Seligman, 1976). People have a basic need to exert control over their environment, i.e. to produce behaviour-event contingencies (Rothbaum, Weisz, and Snyder, 1982; Heckhausen and Schulz, 1995; Skinner, 1996). If the environment does not match the needs and desires of a person, the person will try to gain control. There are two major ways to gain control: primary control or secondary control. With primary control, the person acts upon the situation and changes the situation in a desired direction. Secondary control occurs if no possibilities to change the environment are available. With secondary control, the person changes his or her cognitions about the environment. The targets of secondary control are cognitive processes, to be located at the level of social behaviour. At the level of learning variables representing primary control are the main categories to be included. By their very nature, those variables have the character of operants. In evolutionary psychology operants have been proposed as tactics to manipulate and exploit situations to one's own benefit (Buss, Gomes, Higgins, and Lauterbach, 1987; Van Heck, Hettema, and Leidelmeijer, 1990). Earlier work has shown that operants generally reveal high consistencies across situations (Funder and Colvin, 1991).

As major representatives of primary control Hettema and Hol (1989, 1998; Hol, 1994) proposed Delta-goals as behavioural categories. Originally introduced by Schank and Abelson (1977), Delta-goals (further indicated as D-goals) represent goal concepts people use in every day situations. The word Delta is used to indicate 'difference', the intended change of an existing situation into a wanted situation.

D-goals include the intention to gain power or authority (D-social control), the intention to gain control over resources (D-control), the intention to become close to others (D- proximity), the intention to increase knowledge (D-knowlegde), the

intention to get someone else to help you reach one's goals (D-agency), and the intention to prepare oneself for the attainment of other goals (D-preparation).
Clearly, D-goals have the character of operants. Schank and Abelson (1977) argued that, initially, D-goals are pursued deliberately, but when they prove successful in gaining control they become automatic. In the end they become a stable element of personality. D-goals are consistent across situations. Hettema and Hol (1998) found intraclass correlations reflecting consistency ranging from .70 to .81. Stability coefficients for D-goals over a period of 18 months ranged from .74 to .79, indicating a good deal of stability for D-goals (Hettema, 1996).

2.2.5 Social behaviour

The social learning theory emphasizes social learning and cognitive processes and the active interaction between the individual and his environment (Mischel, 1986; Wagner and Sternberg, 1986; Cantor and Kihlstrom, 1987). An important feature of this theory is that personality develops in enduring interaction between individual and environment. Through exercise and use of its various sensomotor and symbolic organizations the adult personality comes to development (McVicker-Hunt, 1981). The individual is able to make adaptive modifications in his behaviour in order to cope with the demands of the environments encountered. Some environments do not allow or reward particular behaviour (Bandura, 1986). That is why people learn strategies to transform or modify the environment, when it does not match their own motivational goals (Hettema, 1989; Hettema and Kenrick, 1989).
Social learning processes leave behind products in persons reflecting the environments to which they have been exposed. Mischel (1973) proposed 'cognitive social learning person variables' as major classes of variables to conceptualize these products. Those variables were primarily meant to take the place of traits in accounting for human behaviour (Mischel, 1973, 1986; Mischel and Wright, 1982; Shoda and Mischel, 1993; Shoda, Mischel, and Wright, 1994). Cognitive social learning variables include different layers of behaviour, like e.g., competences, encoding strategies and personal constructs, stimulus-outcome and behaviour-outcome expectancies, subjective values and self-regulatory systems and plans.

In the present study competences were selected to represent major variables at the level of social behaviour. Competences include potential behaviours and scripts that one can carry out. Increasing competences give an increasing sense of control and may be a positive factor in the development of self-esteem (Coopersmith, 1967) and self efficacy (Bandura, 1982). Competences include crystallized knowledge, cognitions about behavioural rules, scripts and concepts. Competences stand for what people *can* do rather than what they actually do (Wallace, 1966 in Atkinson, 1990).

The behavioural skills and competences to deal with social environments belong to the domain of social intelligence (Buss, et. al., 1987; Cantor and Kihlstrom, 1987). In the present study, we distinguish four different behavioural competences: intellectual or mental competences, social or interpersonal competences, physical competences, and instrumental competences. These competences are operationalized by means of primitive actions (Schank and Abelson, 1977; Hettema, 1989; Hol, 1994, see also instruments).

Primitive actions account for the concepts underlying an action that people talk about and they serve to organize the inferences that can be made about the results of an action. Competence is an example of such an inference. Mental competence is defined as the competence to construct new information from old information. Social competence is the ability to transfer information between individuals. Physical competence includes all competences involving the body. Hugging, kissing, and slapping each others shoulder are positive examples of physical competences, whereas fighting, and kicking are negative forms. Instrumental competences include the many small, complete actions of people with respect to objects, like lighting a match, or typing a paper in Word Perfect. Regrettably, no information is available on the consistency of these competences across different situations.

2.2.6 Traits

Trait theory has developed from attempts to define a taxonomic structure that would represent the structure of personality in a common framework. Evidence has mounted up that the factors identified by Tupes and Christal in 1961, underlie most of the numerous dimensions that have been proposed earlier to study

personality. Currently, there is broad agreement that five orthogonal factors, known as the Big Five give a fairly exhaustive account (Costa and McCrae, 1992). These five dimensions are: Extraversion, Conscientiousness, Agreeableness, Neuroticism, and Openness to experience (also named Culture or Intellect). Although not everyone agrees, large groups of trait psychologists are convinced of the predictive power of these five dimensions (Costa and McCrae, 1992; Jang, Livesley, and Vernon, 1996; McCrae and Costa, 1989). Contrary to most trait psychologists, Zuckerman places traits at the top of his Seven Turtle model. Accordingly, traits are treated as summary labels rather than causal factors. Following this view, if a certain kind of behaviour is frequently observed, the person is labelled according to this behaviour. A person who acts friendly in different situations is labelled a friendly person. Cross-situational consistency of the Big Five (intraclass correlations) ranged from .54 to .82 in one sample and from .58 to .73 in a second sample (Van Heck, Perugini, Caprara, and Froger, 1994). However, a replication study yielded much higher values ranging from .74 to .90 (Hendriks, 1996).
Behavioural genetic research indicates that approximately 50% of the variance in trait scores can be explained by genetic effects (Lang, Livesley, and Vernon, 1996; Loehlin, 1992; Loehlin, McCrae, Costa, and John, 1998; Pedersen, Plomin, McClearn, and Friberg, 1988).

2.3 The choice of situations

2.3.1 Introduction

The person variables mentioned thus far allow for a test of the multilevel model because, according to the model, behaviour at all levels will reveal genetic effects (Hypothesis 4). However, in addition to those effects the model expects effects of the environment at all levels. How can these expectancies be reconciled? The answer is simple. In addition to straightforward genetic effects the model assumes interactions between genes and the environment. Those interactions will become stronger with increasing level (Hypothesis 6). To study interactions a design is needed that differs from most classical behaviour genetic studies. In addition to person variables we included environmental variables, i.e. situations in which the different personality variables could be observed. At every level all personality variables were studied in different situations.

2.3.2 Situations based on consensual prototypes

To test the effects of the environment on observable behaviour separately or in combination with the genotype, subjects have to be confronted with a wide range of relevant situations. Although situations are an important concept in research on individual differences, the heterogeneity among the constructs used by different investigators is striking. There appears to be minimal agreement on the terms one should use as well as on the constructs they stand for. Terms like situation, scene, episode, and setting are all used to point to the same construct (Argyle, 1981; Pervin, 1981). Situations are defined according to different cues, social versus physical (Cantor and Kihlstrom, 1987), objective versus subjective (Endler, 1989). The objective situation does not have to be the same as the situation perceived by different individuals. Different (sub)cultures can give different meanings to the same situation (Magnusson, 1981; Hol, 1994).
Currently, within the field of behaviour genetics there is a debate on the question if an objective environment can even exist (Plomin and Daniels, 1987; Hoffman, 1991). Life events that seem to be part of a common environment at first sight, like e.g. divorce or unemployment of the parents, can have very different impact on the development of complex personality traits in siblings, resulting in making them more different from one another instead of making them more alike. For situation-response studies an important requirement is that different individuals perceive situations in the same way. A situation may have different connotations or values for different individuals, but there has to be agreement on what kind of situation we are dealing with. Situations have to be realistic and many persons have to share their denotative meaning. Therefore in this study we have adopted the approach of the situation concept proposed by Van Heck (Van Heck, 1984, 1989; Forgas and Van Heck, 1992). Van Heck developed a taxonomy of situations based on consensual prototypes generated by a large number of subjects. In the taxonomy, 248 situations are defined in terms of cues like locations, actors, actions, objects typically present in each. A factor analysis of the situations revealed ten factors or domains of situations: Interpersonal conflict, Cooperation, Interpersonal relations, Recreation, Traveling, Rituals, Sport, Excesses, Serving,

and Trading. For our study the situations were derived from the domains Conflict, Cooperation, and Interpersonal relations. Situations can also be categorized according to their invitational character regarding specific actions. Situations show considerable differences in this respect. For instance, talking is invited especially in a discussion, while fighting is called for in a quarrel. A major requirement of the present study is sufficient opportunity for a number of different actions to become visible in the situations offered. Accordingly, situations were selected with the aim to provide a broad and balanced set of situations regarding the invitational nature for different actions. D-goals were used as the basis for selection. Based on Van Heck's original data, the actions in each situation were categorized according to the two D-goals emphasized most. With six D-goals and taking the order of the first two goals into account, 30 different situation categories can be distinguished. From each category a situation was selected to act as a stimulus for the present study. Table 2.1 gives the situation labels together with the dominant D-goals (Hettema, 1979, 1989).

Table 2.1: Situation labels and (prototypical) D-goal packages.

Situation	D-goals	Situation	D-goals	Situation	D-goals
panic	S/C	failure	K/S	diner	A/P
intrigue	C/S	visit	I/S	rapprochement	P/I
teasing	S/P	exam	K/C	encounter	I/P
quarrel	P/S	training	C/A	expectation	K/A
appointment	S/K	job application	A/C	instruction	A/K
accident	S/A	bureaucracy	C/I	investigation	K/I
interruption	S/I	assembly	I/C	survey	I/K
love play	C/P	love declaration	P/K	punishment	I/A
divorce	P/C	job interruption	K/P	cooperation	A/I
gossip	C/K	flirt	P/A	disturbance	A/S

Abbreviations: S = D-social control, C = D-control, P = D-proximity, K = D-knowledge, A = D-agency, I = D-general preparation.

2.4 Method

2.4.1 Subjects

A group of 100 adult female twin pairs (age 18-47, mean 31.5) participated in the study. There were two reasons to include only female twin pairs. One was very pragmatic: it is easier to find women, who are willing to spend a whole day at the university, than men. The second reason was more important, we wanted the experimental group to be homogeneous. This was thought to be important because quantitative genetic analysis is very sensitive to differences in numbers.
Twins were recruited with the aid of the media and the Dutch Twin Association. A small number of twins were recommended by friends and colleagues. Eligible twins received a letter in which we explained the aim of our research and asked for their participation. A short time later they could contact us, or we contacted them by phone, to make the arrangements.
Participants were divided into two groups of 57 monozygotic (MZ) and 43 dizygotic (DZ) twins. All participants finished the questionnaires, but, due to higher error susceptibility of physiological research, 56 MZ and 37 DZ twin pairs finished the physiological measurements. One MZ twin pair and three DZ twin pairs had to be discarded from the physiological analysis because of apparatus failure. Two DZ twin pairs had to be discarded because one of the participants had a serious ventricular sinus arrhythmia. One twin pair had to be discarded because one of them became ill during measurement.
For 12 twin pairs zygosity was determined before they came to our laboratory by blood- and DNA typing. The other twin pairs completed a questionnaire to determine zygosity. The questionnaire consisted of items about physical similarity, and frequency of confusion by significant others. Agreement between zygosity based on blood typing versus questionnaires is approximately 95% (Loehlin, 1992).
Twenty-three twin pairs participated in scientific research before, the other 77 pairs were unacquainted with scientific experimenting.

2.4.2 Design

All subjects were tested at each level. Contrary to most behaviour genetic analyses, behaviour was studied here in the context of different situations.
The research design at the different levels is:

$$T \times t \times S \times B$$

in which T are twin pairs, t are twin halves, S is the situation and B is behaviour at different levels.

2.4.3 Procedure

Twins came to the laboratory in pairs, one pair each day. An experimental session started at 9.30 AM and took until approximately 4.00 PM. All subjects were paid FL 80.- ($40) and a free lunch for their help. Subjects were asked to abstain from drinking alcohol and excessive amounts of coffee and tea after 11.00 PM on the day before they came to the laboratory.
Subjects were requested to check in at the desk of P-building, Tilburg University, at 9.30 AM, where they met the investigator.
After a brief introduction, subjects were brought to the experimentation rooms, where the project was explained. The introduction consisted of three issues. First the multilevel model of personality was explained by means of a short story called 'the red traffic light' (cf. Chapter 1). Then the apparatus was shown to the subject and the course of the day was explained in chronological order. Finally, we tossed up to allocate twin A to the morning session including the physiological measurement, and twin B to the morning session completing the questionnaires. At 12.30 AM there was a joint lunch. Subjects were not allowed to talk about films or questionnaires during lunch. At 1.30 PM we restarted the experimental session, where twin A had to complete the questionnaires and twin B was subjected to physiological measurement. The end of the second session was at approximately 4.30 PM. If necessary, both participants were given extra time to finish their questionnaires.

2.4.4 Instruments

The development of instruments was a substantial part of this study. Measurement at different levels requires the development of specific instruments for each level. In addition, situations had to be represented with the proper medium for the physiological, learning, social behaviour and trait levels.

2.4.4.1 Measurement at the physiological level

Situations represented with films
To study physiological responding in daily life situations we used a film technique developed by Hettema and coworkers (1989). The films were developed in what is called an ecologically valid fashion (Hettema, Van Heck, Brandt, 1989). This means that they are not, like feature films, supported by music and/or camera effects to evoke the desired emotions. Films were made from the observer's point of view, where the camera is taking over the spectator's eye movements.
To present different situations to the subjects in this study nine films were used including one buffer film. The eight experimental films are a sample from the 30 situations mentioned earlier. Practically it was not possible to use the whole set of situations. However, the reduction does not present a great loss of information in view of the high values for cross-situational consistency obtained with this technique.
First the film '*Party*' was shown as a buffer film to relax the participants and to give them the opportunity to become familiar with the physiological apparatus. The content of the eight experimental films can be briefly described as follows.

- *Divorce:*

After the quarrel on the night before Mr A tells his wife that he is going to see a lawyer. He wants a divorce. Her bitter reply is that she will do the same. They both tell their story to their lawyers. At the end Mr A picks up his belongings, kisses the children, and drives away.

- *Failure:*

M has to do an oral examination, but on almost every question she fails to give the correct answer. On top of that the examiners conduct makes her very nervous. After a while she is sent away.

- *Rapprochement/Advances:*

Mr M works in a building opposite the music school. Looking out of the window he falls in love with a cello teacher. He approaches her by telling her that he wants to go on with his cello lessons. He borrows an instrument of his friend and tries to draw some acceptable sounds out of it, which is very annoying for the neighbours. When he shows up at her place he has to make two confessions: the first that he never played the cello before, and the second, that he has fallen in love with her.

- *Intrigue*:

One evening Mr S is told that the manager of his department will be promoted, so there will be a vacancy to fill. His wife suggests that he will take some actions against his competitors.

- *Quarrel:*

When Mr and Mrs F return from an office-party she is very angry because her husband spent too much time entertaining his secretary. On top of that she is furious about his boss bold behaviour and she blames her husband for a spoiled evening. He blames her for being narrow-minded

- *Interruption:*

Garage owner R wants his mechanic to mend Mr W's car first of all. He himself has an appointment and cannot help. The mechanic starts working on the car but he is often interrupted by customers, telephone calls, tools that do not fit and so on. When hours later his boss returns and he is told that Mr W does not need his car anymore, he nearly explodes.

- *Gossip:*

At about four o'clock, Mr K a high school teacher, walks to his car. There he is welcomed by an attractive young girl, who kisses him. Two of his colleagues watch this scene. That day Mr K and the girl are seen in several public places. The next morning Mr K is told that the headmaster wants to see him right away, because an intimate relation between teacher and pupil is still taboo.

- *Love-play:*

A young man with a cut out ad for a tent in his hand, rings at a door. He looks very surprised when the door is opened by a girl he already knows. She has just moved in and he helps her placing the furniture. Then they talk about the tent. He needs it for his holidays in Greece. After a while he suggests she should come with him. She is delighted and accepts his offer. He accepts her invitation to stay with her that night.

Films were projected by means of an Ernemann VIII film projector, on a large screen (3.14 x 1.8 m). Sound was amplified with a Sansui AU-66-audio amplifier. To maximize the impact of the films, participants were seated in a comfortable chair in a one person cinema. Music and sound came from two Phillips speakers, type 22RH497, aside the film screen. Temperature in the cinema was kept constant at 22 ^{o}C. All instruments were placed in the measurement room, next to the cinema, and cables were inserted through the wall. The investigator could observe the participants through a one-way screen, and the participant could contact the investigator by means of an intercom. During the whole session autonomic reactions were monitored continuously.
The films were presented to all subjects in the same sequence as given above. They were alternated with four minutes rest periods, in which relaxing music was played. This was done for two reasons. First it was necessary to give the autonomic arousal, elicited by the film, time to return to baseline level. Secondly, the data sampled during the rest periods are used to correct for time trends (Geenen, 1991).

Autonomic measures

Physiological measures were chosen to reflect the information processing dimensions identified earlier (Pribram and McGuiness, 1992; Hettema, et. al., 1999). The set of measures included:

- Inter Beat Interval (IBI), as a measure for heart rate
- Pulse Transit Time (PTT)
- T-wave amplitude (TWA)
- Systolic Blood Pressure (SBP)
- Diastolic Blood Pressure (DBP)
- Finger Tip Temperature (FTT)
- Galvanic Skin Level (GSL)

For ECG recording two Ag-AgCl-electrodes were placed on the left side of the abdomen and the right clavicle and one, the ground electrode, was placed on the left under arm. The signal was amplified with a Beckman HP 396a amplifier, high pass filter 0.3 RC, low pass 30 Hz, sample frequency 1000 Hz. From the ECG-signal the IBI and the T-wave amplitude were taken.

The T-wave was defined as the maximum amplitude between 150 and 300 msec after the R-top, minus the extrapolated zero level of the ECG signal, determined as iso-electric midpoint of the PQ interval (Geenen, 1991; Melis, 1997).
Pulse Transit Time (PTT) was measured with the aid of a Hewlett and Packard photo electric densitograph, placed at the left ear-lobe. Signals were amplified with a plesmythogram amplifier (NIM). PTT was defined as the time between R-top and maximum blood pulse in the left ear lobe.
Blood pressure was measured with the aid of an Ohmeda 2300 Fin-a-press blood pressure monitor. This monitor provides continuous measurement of arterial blood pressure. The finger cuff was placed on the left phalanx finger. From this signal SBP and DBP were derived as the maximum and the minimum reading of the monitor.
The galvanic skin response (GSL) was measured with the aid of an GSL-coupler (Wuppertal, 1995), LP 15 Hz, HP 1 HZ (RC=0.15). The output signal was amplified to 2.5 Volt. Ag-AgCl electrodes were placed at the right foot (Boucsein, 1992).
The FTT was recorded with the aid of a thermocouple, the Tempcontrol, P550, with standardised output. The transducer was placed at the right middle finger.

Physiological measures were sampled continuously, at 1000 Hz, during films and rest periods. A computer program was written to make the data ready for analysis. This program conversed the data into the desired units of measurement, mmHg for blood pressure, IBI and PTT in msec, GSL in μohm, TWA in μVolt and FTT in ^{0}C.
The program also recognised and recomputed the servo self adjustment of the Ohmeda fin-a-press. If SBP minus DBP was less than 40 mmHg this measure would be replaced by the mean of the foregoing and next value.
A distinction is made between measures dependent on heart rate; IBI, TWA, PTT, SBP, and DBP, and the 'real time' measures, FTT and GSL. Therefore we created two time axis for the duration of the entire experiment. The time axis for the heart rate dependent variables is created as a cumulative axis of the Inter Beat Interval measures. This axis is compared with the real time axis to bring both kinds of measurements in agreement.
At the end we were left with a data file containing the physiological variables, IBI, SBP, DBP, GSL, TWA, and PTT, per second, per subject.

Scoring

As we saw before, data were sampled at 1000 Hz, over 7 canals and during 5400 seconds, providing us with 37,8 MB data per subject. First *data reduction* was necessary to change the raw data into reactivity scores. Our data were corrected with a three steps curve fitting procedure that is derivated from a procedure by Geenen (1991), correcting for base levels as well as for time trends. The main assumption of this procedure is that time trends are monotonically increasing or decreasing functions. For each physiological measure average scores were computed for each subject, for successive periods of 30 seconds. In addition average scores per subject were obtained for each third minute of the four minute resting condition between films. Subsequently time curves were fitted on the average scores for each subject during rest periods. Deviation scores were deviations from those curves for each film episode. Deviation scores were divided by individual standard deviations of the values during the resting periods to yield reactivity scores (Geenen, 1991; Hettema, et. al., 1999, in press).

To obtain *dimension scores* for the three information processing dimensions Familiarisation, Readiness, and Effort, we used regression equations derived earlier by Hettema, et. al. (1999). In their study they derived dimension scores in a four steps analysis. First, patterns of reactivity were computed and differentiated from patterns of non reactivity. Secondly, the number of patterns was reduced to 100 pattern clusters. Thirdly these pattern clusters were then submitted to Alscal for multidimensional scaling. This analysis produced the three dimensions Familiarisation, Readiness and Effort. Finally, for each dimension a regression equation was derived:

Familiarisation:

$$-.22 + .15\ \mathrm{IBI} + .05\ \mathrm{PTT} + .37\ \mathrm{GSL} + .17\ \mathrm{FTT} - .05\ \mathrm{DBP} - .05\ \mathrm{SBP}$$

Effort:

$$-.15 + .17\ \mathrm{IBI} + .17\ \mathrm{TWA} - .15\ \mathrm{PTT} - .09\ \mathrm{FTT} + .23\ \mathrm{DBP} + .21\ \mathrm{SBP}$$

Readiness:

$$.51 + .17\ \mathrm{IBI} + .14\ \mathrm{TWA} + .22\ \mathrm{PTT} - .16\ \mathrm{GSL} + .04\ \mathrm{FTT} - .19\ \mathrm{DBP} - .18\ \mathrm{SBP}$$

These equations were applied to our data to obtain dimension scores.

2.4.4.2 Measurement at the levels of Learning and Social Behaviour

The SR inventory for goal-directed behaviour

Situation specific measurement with questionnaires has obtained emphasis especially in the interactional approach to personality. A major example is the SR inventory developed originally by Endler, McVicker-Hunt and Rosenstein (1962). An SR inventory consists of situation descriptions in short stories followed by behavioural alternatives. Subjects are asked to estimate on a Likert scale the chance that they would act according to the given response alternative in the situation described. So the SR inventory does not give actual behaviour but the possibilities and the preferences subjects see for themselves in that particular situation (Hol, 1994).

In the present study the response alternatives were presented to the participants on a 5-point-Likert scale, labelled:

1: I certainly would act like this
2: I probably would act like that
3: Maybe I would act like that
4: I probably would not act like that
5: I certainly would not act like that

From this response set it can be concluded that lower scores are a measure for high levels of the D-goals and competences. To synchronize the meaning of these scores with scores at the physiological level and the trait level, scores were recoded. Higher scores are now indicating higher levels of D-goals and competences.

SR inventories allow to decompose the total score variance into different components, due to the person (V_p), to the situation (V_s), to the response alternatives (V_r), and due to the different interaction effects (V_{ps}, V_{pr}, V_{rs}, $V_{prs,e}$). SR inventories were developed originally to study social emotional variables like anxiety, hostility, and the like. However, in current personality psychology attention has switched to goal directed behaviour aimed at transforming situations rather than merely reacting to situations. As a derivative of the SR inventory, Hettema and Hol (1989) proposed the SRS questionnaire as a format to study goal directed behaviour. The SRS questionnaire emphasizes the transformation products as well as the reactions. SRS questionnaires have been successfully applied to study the consistency across situations of goal directed behaviours reflecting primary control (Hettema & Hol, 1998). For the present study an SR inventory was developed to study competences as well as D-goals. Special attention was paid to the minimal psychometric requirements of SR inventories: ecological validity of the situations and response alternatives, and internal consistency of the responses.

Situation descriptions as stimuli

Thirty situations listed earlier in this chapter acted as stimuli in the SR inventory of D-goals and competences. To picture the situations in short stories, the method of minimal cues (Hettema and Hol, 1989) was used. Only the cues emphasized in the situation prototypes were included in the situation descriptions. All situations were described as slightly problematic. The descriptions followed a standardized pattern. In each situation the acts take place between an 'I' figure and an 'other' figure. Each situation description contains a brief introduction followed by an action of the 'I' figure, that is followed by an action of the 'other' figure. The intentions of the 'I' and 'other' figures are different, expressed as different delta goals. As mentioned before, six D-goals crossed leaves us with 30 situations. Several other aspects were kept in mind to generate an optimal set of experimental situations. Examples are an approximately equal distribution of situations over the home environment, work or school and public life. Although our subjects were all females, an attempt was made to use gender neutral formulations for the 'I' figure, so the same descriptions might be used in future research with male subjects. For the same reason the sex of the 'other' figure was balanced. All situation descriptions are given in Appendix 1.

Response alternatives reflecting D-goals and competences

Thus far, the development of the SR inventory does not differ much from recent SRS questionnaires (Hol, 1994; Hettema and Hol, 1998; Riteco, 1998). However, in the earlier studies D-goals were always presented within a single competence category (usually MTRANS assuming social competence). For the present study the response alternatives had to include different competences as well as different D-goals. Thus, the 6 D-goals were systematically combined with the 4 competences to yield 24 response alternatives. Every response alternative was meant to express the intention to attain the D-goal using the competence as a major tool.

To develop a set of responses alternatives answering the specifications, we started with the 425 verbs derived from the Dutch dictionary by Van Heck (1984). Based on primitive actions emphasized the verbs were classified according to physical, mental, social and instrumental competences. Subsequently the verbs were compared with the verbs representing D-goals in earlier SRS studies (Hol, 1994; Riteco, 1998). This comparison made it possible to fill in the cells of the D-goal by competences matrix and define 24 D-goal/competence prototypes. Like with the situations we wanted consensual prototypes. Thus, the matrix was presented to 12 judges, all high-school teachers. They judged if the verbs were classified correctly. If they did not agree with the classified verb, they had to give an example of a verb that in their opinion better fitted the description. As a result of this pilot study, two verbs had to be changed.

Based on these results a preliminary SR inventory including 24 response alternatives was developed.

This inventory was used to test the generality of the response alternatives, i.e. their applicability to many different types of situations. Thirty psychology students (age 18-26) were asked to rate the degree to which each response alternative was applicable in the given situations. As a result we obtained 24 consensual response alternatives combining D-goals and competences that can be used as standard alternatives in many different situations (Table 2.2).

Unconfounding D-goals and competences

A major advantage of crossing D-goals and competences is that both levels can be measured simultaneously with the aid of only one questionnaire. The questionnaire consisted of 1270 responses, which was considered a maximal number without being cruel to our subjects. By crossing the competences and D-goals we obtained 24 response alternatives per situation, with every goal formulated four times and every competence six times.

Crossing D-goals and competences confronts us with a psychometric difficulty. D-goals and competences should be independent measures. After all, they are variables at different levels, and the aim of the study is to examine the connection between the different variables on the levels of the multilevel model. Independence is demonstrated among other things if variables at one level generalize over variables of the other level. Thus, D-goal scores should generalize over competences, and competence scores should generalize over D-goals. To test the

two sets of variables for independence an analysis of variance was carried out. In this analysis a twin pair was treated as two persons, so N = 200.
The factor Persons (P), Situations (S), D-goals (D), and items (C) were crossed, according to a P×S×D×C-design. All variables were conceived as random facets. Mean squares and variance components are represented in Table 2.3.

Table 2.2: Overview of the standard response alternatives.

D-goal/competences	Response alternative
S/mental	I dislike *my friends* behaviour
S/social	I openly criticise *my friends* behaviour
S/physical	I am going to kick a row
S/instrumental	I push over *my friend* and solve the problem myself
C/mental	I think about what to do now
C/social	I negotiate with *my friend*
C/physical	I grab *my friend's* arm
C/instrumental	I repair the broken object
P/mental	I think about something nice to say
P/social	I make a little joke to ease up the situation
P/physical	I friendly touch *my friend*
P/instrumental	I offer *my friend* a cup of coffee
K/mental	I think about the situation
K/social	I ask my friend what I shall do
K/physical	I try to use the object
K/instrumental	I figure out how *the object* works
A/mental	I think about what *my friend* can do for me
A/social	I tell *my friend* to solve the problem for me
A/physical	I look at *my friend* with a firm look
A/instrumental	I provide *my friend* with the materials to fix the object
I/mental	I go through the problem once again
I/social	I am going to consult *someone*
I/physical	I wait and see what happens
I/instrumental	I just play along with the object

Note: The words in italics can change depending on the situation
Abbreviations: S = D-social control, C = D-control, P = D-proximity, K = D-knowledge, A = D-agency, I = D-general preparation.

Table 2.3: Analysis of variance for independency of D-goals and Competences.

var comp	df	MS	σ^2
P	199	70.2	.0789
PD	995	8.5	.0290
PC	597	8.7	.0217
PDC	2985	4.7	.1283

Abbreviations: Var comp = components of variance, D = D-goals, C = Competences, P = subjects.

First, the generalizability coefficient was computed for D-goals over competences. The generalizability coefficient was computed with the aid of Equation 1:

Equation 1

$$\rho^2_{(P+PD)} = \frac{\sigma^2_P + \sigma^2_{PD}}{\sigma^2_P + \sigma^2_{PD} + \frac{1}{N_C}(\sigma^2_{PC} + \sigma^2_{PDC})}$$

The $\rho^2_{(P+PD)}$ is .75. This is a satisfying generalizability coefficient, therefore D-goals can be treated independently from competences.

This argument also applies to competences. The competence profile of a person should generalize over D-goals. This hypothesis is tested with Equation 2.

Equation 2

$$\rho^2_{(P+PC)} = \frac{\sigma^2_P + \sigma^2_{PC}}{\sigma^2_P + \sigma^2_{PC} + \frac{1}{N_D}(\sigma^2_{PD} + \sigma^2_{PDC})}$$

The $\rho^2_{(P+PC)}$ is .79, this is also a satisfying generalizability coefficient. Thus, also competences can be treated apart from D-goals. We may conclude that the manipulation to cross D-goals with competences in the response items has been successful. Following from these generalizability coefficients we can continue our analyses, treating D-goals and competences independently from one another.

2.4.4.3 Instruments at the trait level

The TinSit: Measuring tendencies in situations

In this study, contrary to common practice in trait measurement, we were interested in trait scores of individuals in different situations. To measure the Big Five personality traits in specific situations a TinSit questionnaire was constructed according to the rules provided by Van Heck, Perrugini, Caprara and Fröger (1994; Hendriks, 1996). TinSit stands for tendencies in situations. The TinSit is a questionnaire in SR format, in which short situation stories are followed by 15 bipolar adjective scales measuring the Big Five personality traits.

For the development of the present TinSit scale we used the same 30 situation stories used earlier to measure D-goals and competences.

Every Big Five dimension was measured by three markers, arranged on bipolar scales (see Table 2.4).

Thus, the total test included $30 \times 5 \times 3 = 450$ responses. The labels were primarily based on the work of Goldberg on standard markers of the Big Five factor structure (see Goldberg, 1989; Van Heck, Perugini, Caprara and Fröger, 1994; Hendriks, 1996).

Like before, the situations offered were slightly problematic. Subjects were asked to respond to the question ' How would you describe your approach to this problem?', The subjects rated their answers on a nine point Likert scale. This scale ranged from 1, 'My behaviour in this situation would be extremely passive', via 5, 'My behaviour is neither *passive* nor *active*', to 9 'My behaviour in this situation would be extremely *active*'.

If necessary scores were recoded, individuals with the higher scores were labelled as more extravert, agreeable, conscientious, neurotic and open to experiences.

Table 2.4: Bipolar item scales to measure Big Five personality traits.

trait	**bipolar scales**
Extraversion	passive - active quiet - talkative inhibited - impulsive
Agreeableness	unfriendly - friendly boastful - modest selfish - unselfish
Conscientiousness	negligent - conscientious frivolous - serious disorganized - organized
Neuroticism	nervous - at ease emotional - unemotional insecure - secure
Openness to experience	imperceptive - perceptive uncreative - creative uninquisitive - curious

Internal consistency

To study the reliability of the TinSit, analysis of variance was done for every personality trait separately, with all variables crossed: P × S × I.
Here P stands for single persons or twin halves (N = 200), S for situations (S = 30) and I for response items (I = 3). Variance components were estimated according to an all random model. Table 2.5 presents the results.

Internal consistency can be compared with a reliability coefficient in the classical sense (Shavelson and Webb, 1991; McGraw and Wong, 1996; O'Brien, 1995). Accordingly, as a measure for internal consistency a coefficient was computed for the generalization of persons and person × situation interactions over response items according to Equation 3.

Equation 3

$$\rho^2_{(ps)} = \frac{\sigma^2_P + \sigma^2_{PS}}{\sigma^2_P + \sigma^2_{PS} + \frac{1}{N_i}(\sigma^2_{PSI})}$$

Table 2.5 gives the coefficients for each of the Big Five. The internal consistencies (ρ^2PS) range from .67-.76, which was considered acceptable.

Table 2.5: Variance components ANOVA in BMDP-V8 (P × S × I-design).

Trait	**P**	**S**	**I**	**PS**	**PI**	**IS**	**PSI,e**	**ρ^2PS**
Extraversion	.525	.319	.145	1.413	.395	.070	1.855	.76
Conscientiousness	.441	.169	.248	.8372	.408	.091	1.508	.72
Agreeableness	.302	.267	.542	.9502	.523	.1433	1.628	.70
Neuroticism	.598	.338	.348	1.368	.580	.213	1.909	.76
Openness	.308	.029	.086	.6501	.326	.138	1.348	.67

Abbreviations: P= single persons (N = 200), S = situations (30), I = items (3).

3 Prediction of higher level variables on the basis of lower level variables

3.1 Introduction

In this chapter we will occupy ourselves with the issues of ordering and predictive value of the Zuckerman model. Behavioural processes at the lower levels of Zuckerman's model are assumed to be conditional for behaviour at the higher levels to occur. Without physiological processes no learning can occur, learning processes reveal themselves in social behaviour, and traits are conceived of as the ultimate products of processes at all lower levels. According to this assumption, the levels of the Zuckerman model do have a conditional ordering in which the more distal level variables provide the necessary but not sufficient conditions for the more proximal level variables to materialize. As a consequence the adjacent levels will be more closely related to one another then levels further away.
Two hypotheses will be tested. Hypothesis 1, *variables at the higher levels can be predicted by variables at the lower levels*. Hypothesis 2, *variables at the adjacent levels are better predictors than variables at more remote levels*.
These hypotheses will be put to the test with the aid of a multiple regression analysis.

3.2 Conditional ordering of the Levels

At every level variables are chosen that are currently important, empirically based, and reliably measurable constructs. At the highest level, personality traits are defined as the basic units of personality as appearing in daily life. The Big Five personality traits are chosen because in their field of research, these variables are the most widely used, best studied and most reliable measures of personality at current (Costa and McCrae, 1992; Digman, 1990; John, 1990; Loehlin, 1992). According to the multilevel model people differ on these traits according to their genotype, but this relation is an indirect one, modulated by physiological processes, learning processes and social behaviour. According to this assumption it should be possible to predict traits on the basis of behaviour on these lower levels.

Because of the predicted conditional ordering of the multilevel model, variables at the level of social behaviour should be the best predictors of personality traits, since social behaviour is defined as the level most adjacent to the trait level. Physiological dimensions should be the worst predictors, because the physiological level is the most remote level. Variables at the learning level should be positioned in between. Restrictions in our data do not allow to study genotype as predictor of overt behaviour with regression analysis. The role of the genotype will be studied exhaustively in the following chapters.

3.3 Multiple regression analysis

3.3.1 Regression analysis and prediction

Regression analysis is an excellent tool for the estimation of linear relations and the evaluation of predictive relationships (Hagenaars, 1990). Problems that can be solved with the aid of regression analysis are:

- Is there a statistical relation between variables at the different levels, affording some predictability?
- How strong is this relation, how strong is the predictive value?
- Can we formulate a simple linear rule for predicting the variables at the trait level, based on scores on variables at the lower levels? (Hays, 1988)

In Zuckerman's model a trait is assumed to be a function of behaviour at different levels of the model, that can be functionally described as:

$$F_{(trait)} = B(P + D + C)$$

were P is behaviour at the physiological level, D is behaviour at the learning level, and C is behaviour at the level of social behaviour.

When a trait is a complex cluster of behaviour, there is no theoretical basis to look for one to one relations between variables at the higher levels and variables at the lower levels. The multilevel models mentioned in chapter 1, all suggest that more then one variable at each lower levels is necessary to make behaviour at the higher levels possible. As an example we can look at the trait 'Extraversion'. At the level of social behaviour, Extraversion can be decomposed into the behavioural dimensions activation, impulsiveness and sociability (Zuckerman, 1993). At the physiological level, Extraversion covers more physiological aspects than low cortical arousability alone. A whole group of functionally related physiological processes are thought to contribute to the trait of Extraversion (Stelmack, 1981; Brody, 1988; Derryberry and Rothbart, 1988; Eysenck, 1993).

According to Hettema and Deary (1993) the Zuckerman model assumes that processes at the lower levels are necessary but not sufficient for behaviour at the higher levels to occur. In the light of the above we conclude that it is better to take all variables into account when predicting trait scores from scores on the level of social behaviour, learning and physiology. The primary objective of this chapter is to illustrate the assumption of conditionality. A multiple regression analysis (method enter) will be used to provide a test of hypotheses 1. The predictive value of the lower level variables for the higher level variables will be computed. Variables at different levels are entered as blocks, in the same order as defined in Zuckerman's multilevel model. The advantage of entering variables in blocks is that we are able to understand the extra predictive value that comes with each level, shown in a significant change of the multiple correlation coefficient (R). A disadvantage of this method is that the value of R, and thus the explained proportion of variance (R^2), depends on the ordering in which levels are entered. The first level entered is known to take away most of the variance. This is especially true when levels are mutually dependent (Sen and Srivastava, 1990). So the increase in explained variance per level is not a correct measure to study hypothesis 2. To correct for this restriction a regression analysis was performed on every level.

3.3.2 The model

The basic multiple regression model for the analysis of our data is:

$$Y = a + b_p P_p + b_d D_d + b_c C_c + e$$

where Y is a person's predicted score on a variable at the trait level, 'a' is the regression constant, P is an individual's score for variables on the physiological level, D is an individual's score at variables on the conditioning level (D-goals), and C is an individual's score for the variables at the level of social behaviour (competences), and e is the error component. The b's are the regression coefficients of an individual's score on different variables. The relationship between trait scores and scores on the other levels is assumed to be monotonic, and linear (McKay, Schofield, and Whiteley, 1983; Fox, 1997).

When applying multiple regression analyses there are at least two important issues that should be considered.

1. The issue of multicollinearity
2. The issue of 'capatalising on error'

Multicollinearity

Multicollinearity is the occurence of correlations between the independent variables, as a result of a high degree of linear relationship between these variables. For example, when relating household consumption to income and education, income and education are mutually related. When entering 'income' first into a regression analyses, part of the variance explained by 'income' will incorporate variance that is indirectly related to 'education'.

Therefore sometimes it is assumed that independent variables should be mutually uncorrelated. Since the Zuckerman model does assume relationships between all levels, a certain amount of correlation between variables at different levels is expected. According to Freund and Minton (1979, pag 117) the absence of multicollinearity is not an underlying assumption of regression analyses. Its existence does not invalidate the regression analyses itself. Multicollinearity however may introduce some rather serious problems when the goal of the analysis is to mutually compare the effects of the independent variables. As an effect of multicollinearity the confidence intervals are broadend, which makes the regression coefficients overlapping and inexact (Tacq, 1991). For the test of the first hypothesis the effects of multicollinearity could be rather limited, since we are only interested in the multiple correlation coefficients. Multicollinearity does however invalidate the partial regression coefficients. Therefore comparing the standardised partial regressioncoeffients (β) from a multiple regression analysis including all variables at all levels is not the correct way to study hypothesis 2. Hypothesis 2 is studied with the aid of separated regression analyses on every level.

Capitalising on chance (or error)

When using explorative techniques like multiple regression analysis, the role of coincidence should not be underestimated. The best strategy to diminish the role of chance is to randomly divide the sample into two independend subsamples. This way a replication study can be done, the similarity of results is used as a measure for robustness of the results (Van der Heijden, 1994; Seegers and Hagenaars, 1990).

3.4 Analysis

3.4.1 Hypotheses

Hypothesis 1 and 2 are concerned with the conditional ordering of the model, without taking different situations into account. The scores in this study are situation specific. To test hypothesis 1 and 2 scores were aggregated across situations because, ideally, trait scores are a measure for aggregated behaviour across a representative sample of situations (Blalock, 1982; Van Heck, Perrugini, Caprara, and Fröger, 1994). The 30 situation descriptions are conceived of as a representative sample of every day situations. An extra advantage of aggregation is the increase in reliability of the test scores, because test reliability increases when the correlation between items increases and/or when the number of items increases (Murphy and Davidshofer, 1988).

According to the model, traits are predicted by variables at the level of social behaviour in step one, in step two by variables at the physiological and learning level, and in step three by physiological dimensions, learning variables and competences.

When the R's are ordered according to the model, they should significantly increase with every extra level taken into analysis. When this is true a conditional relation between traits and variables at the lower levels can be assumed.

A second analysis was done to test the ordering assumption of the model. Three regression analysis were done, comparissing traits with competences, traits with D-goals and traits with physiological dimensions. β's were inspected to increase insight in how traits are related to other variables in so-called trait profiles.

3.4.2 Subjects

For an extensive description of subjects, procedures and preliminary data-analysis on every single level the reader is referred to chapter two. The regression-analyses is used to study the predictive value of behaviour at lower levels tobehaviour at higher levels. Twinship is not included in these analyses, and twins are regarded as two persons (N=200). To prevent for chance capitalising the sample was divided into two subsamples of n=100, according to an odd-even splithalf method on respondents.

3.5 Results

3.5.1 Descriptives

The mean scores and standard deviations of the variables on different levels are displayed in Table 3.1.

Table 3.1: descriptives of variables at each level, means and standard deviations.

level	variables	Mean scores	SD	n
Physiology	Familiarisation	.1259	.380	171
	Effort	.1348	.352	171
	Readiness	.7478	.613	171
Learning	D-social control	3.633	.329	200
	D-control	2.756	.391	200
	D-agency	3.148	.390	200
	D-proximity	3.534	.424	200
	D-knowledge	2.557	.424	200
	D-preparation	2.956	.428	200
Social behaviour	C-mental	2.500	.429	200
	C-social	3.029	.352	200
	C-physical	3.429	.350	200
	C-instrumental	3.423	.325	200
Traits	Extraversion	5.743	.693	200
	Agreeableness	5.122	.390	200
	Neuroticism	4.827	.730	200
	Conscientiousness	6.144	.644	200
	Openness to Experience	5.855	.552	200

Abbreviation: D=delta goal, C=competences.

3.5.2 Prediction of traits

Table 3.2 shows the results of the multiple regression analyses, with traits as criterion and variables at the other levels as the predictor variables.

Table 3.2: Regression coefficients for every step in the analysis.

Variable	Level	multiple R	R^2	Fchange
Extraversion	C	.425 (.225)	.180 (.095)	4.507**
	C+D	.531 (.549)	.302 (.282)	2.202*
	C+D+P	.550 (.573)	.328 (.303)	.960
Neuroticism	C	.275 (.279)	.075 (.078)	1.671*
	C+D	.523 (.441)	.273 (.195)	3.443**
	C+D+P	.524 (.452)	.275 (.204)	.064
Agreeableness	C	.366 (.243)	.134 (.059)	3.175**
	C+D	.521 (.567)	.271 (.322)	2.381*
	C+D+P	.531 (.605)	.282 (.366)	.380
Conscientiousness	C	.427 (.400)	.183 (.160)	4.584**
	C+D	.535 (.513)	.286 (.264)	1.828
	C+D+P	.562 (.566)	.316 (.320)	1.079
Openness	C	.380 (.381)	.144 (.145)	7.000**
	C+D	.474 (.464)	.224 (.215)	2.685**
	C+D+P	.501 (.498)	.251 (.248)	1.981

Abbreviations: C= competences, D = Delta-goals, and P = physiological dimensions
R^2 is a measure for the proportion of variance explained by levels entered. Numbers between parentheses are the results of the replication study.
F-change is mean change in F when next block is entered. * = $p<.05$, and ** = $p<.01$.

All multiple R's are significant. R's increase with every new step, but this is partially intrinsic to the method of multiple regression. When extra variables are included in the regression analysis, the explained variance is expected to increase. A significant increase in R can be counted as an indication for a significant increase of predictive value. All trait scores can be explained on the basis of scores on the level of social behaviour. With the exception of the variable 'Conscientiousness' this prediction increases significantly when D-goals are entered. According to a not significant change in F, the predictive value does not increase significantly when physiological dimensions are added.

Conclusion

These results indicate that traits can be explained on the basis of variables at the lower levels. Between 25% and 33% of the variance in trait scores can be explained on the basis of an individual's behaviour at all levels. These results partly corroborate the first hypothesis; variables at the higher levels can be predicted by variables at the lower levels. Entering a new level to the regression analysis contributes significantly to a better prediction of the trait scores, except for variables at the physiological level.

3.5.3 Are variables at the more adjacent levels better trait predictors than variables at more remote levels?

A regression analysis is performed on every level to test the second hypothesis, variables at the adjacent levels are better predictors than variables at the more remote levels. The results of these analyses are displayed in Table 3.3.

The multiple correlation coefficients, R, are lowest for the physiological dimensions. Only the R's for Extraversion and Openness are significant. At the learning level the multiple correlation coefficients are significant for all traits. And at the level of social behaviour the multiple correlation coefficients are also significant. The average R on the learning level is higher than the average R on the level of competences. This could be the result of the strong interdependence of D-goals and competences. In chapter 2 it was demonstrated that D-goals and competences were independently measured. This is not equal to not being correlated. Correlations between D-goals and competences varied between .34 for D-social control and Mental competence and .81 for D-control and Mental competence.

The multiple correlation coeffients obtained per level do not confirm hypothesis 2. Variables at the level of physiology contribute least to the total variance in trait scores, which is according to the second hypothesis. Variables at the learning level contribute more to the total variance, which means that they are more linearily associated with traits than competences.

Table 3.3: Three regression analyses with personality traits as dependent and physiological dimensions, D-goals, and competences as independent variables.

variables	Extraversion		Neuroticism		Conscientiousness		Agreeableness		Openness	
	β	R	β	R	β	R	β	R	β	R
Famil	.307**	.30**	-.104	.14	.171*	.18	-.052	.19	.164	.22*
Effort	.051		.038		.052		.009		.031	
Readiness	-.060		.122		.064		.092		.134	
D-A	.040	.38**	.190	.46**	-.120	.37**	-.148	.36**	-.016	.44**
D-C	.542**		.311**		.310**		-.023		-.334**	
D-IPREP	-.378**		.285**		-.268**		.071		-.228	
D-K	-.226		-.154		.325*		.096		.147*	
D-P	.002		-.257**		-.132		.163**		.166*	
D-S	.022		-.244**		-.115		-.307**		.072	
C-F	.027	.31**	.272*	.29**	-.180	.33**	-.156	.23*	.065	.39**
C-I	-.361*		.019		.051		.255**		-.026	
C-M	.040		-.129		.472**		.121		.227*	
C-S	.238**		.091		-.232**		-.272*		.162	

Abbreviations: C-M = mental competences, C-S = social competences, C-F = physical competences, C-I = instrumental competences, D-S = delta social control, D-C = delta control, D-A = delta agency, D-P = delta proximity, D-K = delta knowledge, D-Iprep = delta general preparation, T-E = Extraversion, T-N = Neuroticism, T-A = Agreeableness, T-C = Conscientiousness, and T-O = Openness to experience. R= multiple correlation coefficient per level. Tolerance for variables per level was acceptable. * is significant at $p \leq .05$ and ** $p \leq .01$

Trait profiles

Extraversion

Inspection of the β's at the physiological level reveal a high and significant β-weight for Familiarisation. Extraverts express more Familiarisation than introverts. On the learning level general preparation and D-control contribute the most to the explained variance of Extraversion. Higher levels of Extraversion are associated with higher levels of D-control and lower levels of D-preparation. The instrumental and social compentences contribute the most to Extraversion. Higher levels of Extraversion are associated with lower levels of instrumental competence and higher levels of social competence.

Neuroticism
Higher levels of Neuroticism are associated with higher levels of D-control and general preparation and with lower levels of D-proximity and D-social control. Neuroticism is positively associated with physical competences, people who express higher levels of Neuroticism also express more physical compentence.

Conscientiousness
The only other significant β-weight on the physiological level is for Familiarisation on Conscientiousness. More conscientious people express higher rates of Familiarisation. Furthermore conscientiousness is positively associated with D-knowledge and with D-control. It is negatively associated with D-preparation. Conscientiousness is associated with higher scores on Mental competence, and with lower scores on Social competence.

Openness
Openness is negatively associated with D-control, and positively with D-knowledge and D-proximity. Openess is associated with higher scores on mental competence, which is according to the definition of Openness as intellect.

Agreeableness
Higher levels of the trait Agreeableness are associated with higher levels of D-proximity and lower levels of D-social control. Agreeableness is associated with higher scores on instrumental competence and social competence.

3.6 Discussion

The first hypothesis, variables at the higher levels can be predicted by variables at the lower levels, is partly confirmed by our data. Trait scores can be predicted on the basis of scores at the levels of social behaviour and learning, and, to a smaller extent, on the basis of the physiological dimension variables. The physiological dimension scores contribute significantly to the trait scores Extraversion and Openness.
The second hypothesis, variables at the adjacent levels are better predictors than variables at more remote levels, is not confirmed by our data. According to this hypothesis variables at the most remote level, physiology, contribute least to the

prediction of trait scores. Variables at the learning level are better predictors of trait scores then variables at the level of social behaviour.

Lack of coherence between physiological dimensions and traits

The lack of coherence between phsyiological variables and variables at the trait level can be a serious problem.

The results on the physiological level are rather disappointing. On the basis of these results it can not be concluded that there is a relation between variables at the trait level and variables at the physiological level above chance level. This is not conform prediction, and calls for an explanation. Reactivity of the autonomic nervous system has been widely associated with information processing and learning through habituation processes (Gruzeliers and Mecacci, 1994; Hettema, Leidelmeijer, and Geenen, 1999). The question that comes to the mind is: Is a linear relation between physiological dimensions and other variables to be expected? The relation between physiology, learning and personality has been the object of many studies, especially since Eysenck published 'The biological basis of personality' (Eysenck, 1967, 1990, 1993; Geenen, 1991; Zuckerman, 1991). The literature on biological systems that underlie the expression of personality traits is not very helpful in this. Different and contradicting results are legion (Cattel and Kline, 1977; Eysenck 1993; Stelmack, 1991). Some scientist are radical optimists, where others are less positive in their search for highly reliable and valid physiological indices for personality (Buss and Plomin, 1984; Stemmler and Meinhardt, 1990). But a linear relationship seems not a necessary requisite. Different forms of information processing can lead to different types of output processes (Hettema, Leidelmeijer, and Geenen, 1999). In that case no linear coherence will be found and a linear regression model is not the appropriate way to explore the relationship between the physiological versus the other levels.

Then there is the difference in measurement modes between levels. Levels are studied with different assessment techniques. Where traits, D-goals and competences are assessed with self report measures, dimension scores are obtained in a direct confrontation with concrete every day life situations in the form of films. Although both forms of assessment are highly reliable it remains possible that they trigger different processes.

Finally there is the problem of generalizability of personality aspects over different situations. Maybe different situations trigger different dimensions of information processing. Personality traits assessed with questionnaires will not be manifested in differences in autonomic reactivity at all dimensions, during all situations and all time. For instance one of the defining features of Extraversion is the fact that persons scoring high or low on this trait show different responsiveness in different situations, dependent on the intensity, content and number of previous exposures (Eysenck and Eysenck, 1985; Geenen, 1991; Stelmack, 1981).

The social learning theory emphasizes social learning, cognitive processes and the active interaction between the individual and its environment. An important feature of this theory is that personality develops in enduring interaction between individual and environment. The environment does not have a direct influence on personality development (Buss, Gomes, Higgins, and Lauterbach, 1987; Cantor and Kihlstrom, 1987; Mischel, 1984; Wagner and Sternberg, 1986). D-goals, the variables that define the learning level, are operants learned by conditioning processes. Conditioning occurs only when behaviour is rewarding, and not every situation triggers every D-goal behaviour, some environments do not allow or reward particular behaviour at all (Bandura, 1986). For instance people with an innate tendency for Readiness will express more controlled reactions concerned with output behaviour and oriented on the environment. But during development they come across situations that are not rewarding Readiness, so behavioural differentiation over situations will develop. When behaviour is aggregated over situations this important source of behavioural variance is lost, which could be an explanation for the lack of relationship found between the physiological variables and variables on the other levels. When there is a relation between variables at the physiological level and variables at the learning levels these relations could well be situation dependent. Situations that trigger certain D-goals, should also trigger the related physiological variables.

To study this assumption, 6 situation clusters were made. Situations where clustered according to their first D-goal loading (chapter 2), following the assumption that behaviour according to the first D-goal is the kind of behaviour that is most rewarding in the topical situation. Mean scores were computed for these 6 clusters and the relation between physiology, situation cluster and behaviour on the learning level was established by means of a MANOVA, with scores on D-goal variables as dependent variables, and situation clusters and physiological dimensions scores as independent variables. Situation clusters were entered as repeated measures, because the same behaviour is measured more than once in one respondent. It was expected that the extent to which physiology and situation show consistent interactions is a measure for the effect of physiology on learning. The results did not confirm the assumption. Behaviour on the D-goal level depended on the situation at hand, but not on the interaction between situation cluster and physiological variables. Only one significant interaction was found, between D-preparation and Effort. The results are given in Table 3.4.

Table 3.4: Results of the MANOVA with repeated measures for cluster D-preparation.

Wilks Lambda	Value	F	df	error df	significance
factor 1	.132	144.627*	4	88	.000
factor 1 × Effort	.877	3.077*	4	88	.020

Abbreviations: * = exact statistic. Factor 1 = within factor, all situations that have D-preparation as dominant D-goal

3.7 Conclusions

Hypothesis 1, variables at the higher levels can be predicted by variables on the lower levels, and hypothesis 2, variables at the adjacent levels contribute more to the predictive power then variables at the levels, were put to the test in this chapter.

Hypothesis 1 was partly confirmed, variables at the trait level can be predicted on the basis of variables at the levels of social behaviour and learning. At the physiological level Familiarisation explained a significant part of the total variance in the scores for Extraversion and Openness.

The results did not confirme hypothesis 2, variables at the physiological level were the worst predictors, but variables at the learning level were better predictors then variables at the level of social competences. This could be the result of the strong interdependence of D-goals and Competences. In the remaining of this thesis we will examine these levels from a genetic perspective to obtain a better understanding of the way the different levels of Zuckerman's model are related.

4 Quantitative Genetic Analysis: Effects at different levels

4.1 Introduction

The focus of behavioural genetic research is on differences between individuals and the genetic and environmental causes of these differences.
In fact behavioural genetics touches on the essence of the nature-nurture debate, not pitting nature against nurture, as if behaviour is influenced solely by one or the other, but focussing on the effects of nature and nurture, in an attempt to understand how genes 'nature', and environments 'nurture', play a role in shaping complex social behaviour (Plomin, DeFries, and Loehlin, 1977; Loehlin, 1992; McCartney, 1992).
'Nature' influences behaviour by way of the genotype, the individual's genetic constellation. Genes are the functional units of heredity, and part of the DNA-molecule (desoxyribonucleic-acid) in the cell nucleus. They serve as templates or models for the synthesis of proteins (Kalat, 1988). Genes contain the specific information about a wide variety of human features, ranging from eye colour to social attitudes. Some characteristics are controlled by single genes, i.e. the wellknown neural disorder Huntington's Chorea. Most complex traits however are controlled by the combined action of several genes, the gene pool. This multiple regulation increases the chances that individual differences will occur, and makes the variety in human genotypes almost infinite.

'Nurture', or the environment, covers the total of the external input to the behavioural process. As such it is a very broad concept, including biochemical factors like nutrition, physical factors like sound and colour, and family factors

like child raising practices and rank order of siblings (Hoffman, 1991; Loehlin, 1992; Plomin, DeFries, and McClearn, 1990).
Proceeding from the genotype, under influence of experiences and (social) learning processes, an individual develops the phenotype, including the observable characteristics and traits of a person (Beijsterveldt, 1996).

The way genes cause complex social behaviour is still quite unknown, although with the aid of linkage techniques and DNA-analyses some of the mysteries are solved, and it is believed that others will probably be solved in the near future. Happily for behaviour geneticists it is not necessary to wait until all the mysteries of heritability are unravelled before we can pass a judgement on the causation of behaviour. To understand complex behavioural systems, it is not necessary to understand every step in the process. It is possible to attribute the causes of behaviour to broad categories, like genotype and environment, without understanding all the details (Loehlin, 1992; Rose, 1995). One can be perfectly able to drive a car, without understanding the way the engine works.

In this chapter we will test the effects of genetic and environmental influences at different levels of our multilevel model with the aid of quantitative genetic analysis. Hypothesis 3; *behaviour at all levels will reveal genetic effects*, and hypothesis 4, *genetic effects are largest at the lower levels and will decrease with increasing level*, will be put to the test.
In section 4.2 we will explain the classic twin approach, and the underlying assumptions of twin modelling. In section 4.3 we will explain the ins and outs of model fitting, as method for genetic analysis. In section 4.4 the different steps taken in analysing the different levels of the model will be explained. In section 4.5 results of the quantitative genetic analysis will be given. In section 4.6 the results are discussed in the light of the hypotheses, and this chapter is concluded with section 4.7, recommendations for further research.

4.2 The classic twin approach

The basic assumption in twin research is that the phenotypic variance that is found for a behavioural trait within a population is caused partly by variation in individual genotypes and partly by variation in the individual's environments.

4.2.1 Genotypic effects on the phenotype

Phenotypic variance can be due to different sorts of genetic effects. Within genetic science three kinds of genetic effects are distinguished, the additive genetic effects, dominance effects and effects of epistasis.
Genetic effects are additive in as far as they are augmenting, as far as they add up to one another. Complex behavioural traits are thought to be poly-genetic, a pool of genes causes the trait. An additive genetic effect is the sum of the average effects of the individual alleles. Dominance is the non-additive interaction of alleles at a single locus, dominance stands for intra-locus interaction. Epistasis is the interaction of an allele with alleles on other loci, called inter-locus interaction[1] (Beijsterveldt, 1996; Neale and Cardon, 1992; Plomin, DeFries, and McClearn, 1990).

4.2.2 Environmental effects on the phenotype

The environment can exercise its influence in two ways. The environment can make individuals of different genotypes more alike. Culture and parental upbringing practices are instances of such influences. They make genotypically different individuals behave in a uniform way. The greater the extent to which the environment is shared, the more individuals will become alike. This is called the shared, common, or between family environment.
The environment can also have opposite effects, it can make individuals with the same genotype more different from one another. Unique experiences, things that happen in every day life, which are not shared by individuals with the same

1 Explanation of some genetic terms: locus (pl loci) is the side of a gene on a chromosome and allele (pl alleles) the alternative form of a gene that occupy the same place on a chromosome.

genotype, have an individualizing effect on the phenotype, making individual differences between twins more pronounced than could be expected on the basis of their genotypical similarity. This effect of the environment is called the effect of the unique, idiosyncratic, or within family environment.

4.2.3 Twin analysis

To analyse the differential impact of genotype and environment on individual differences, data are needed from genetically informative individuals. The comparative study of complex behaviour within monozygotic and dizygotic twin pairs affords an informative approach to this question and has become by far the most popular design in behaviour genetic research (Boomsma, 1992; Bouchard, 1993; Loehlin, 1992; Plomin, DeFries, and McClearn, 1990; Turner and Hewitt, 1992).

The twin design is based on the notion that there are two kinds of twins, the monozygotic (MZ) or identical twins and the dizygotic (DZ) or fraternal twins. Identical twins share 100% of their genes, they are of the same genotype. All differences between them are assumed to be environmental in origin. Fraternal twins share an average of 50% of their genes. They are genetically related as first degree relatives, but they share the family environment to a greater extent than 'normal' siblings do. Differences between the members of a DZ twin pair can be genetic as well as environmental in origin. By comparing the phenotypic similarity of identical twins with that of fraternal twins, we conduct a natural experiment to investigate the effects of heredity and environment. If identical twins are twice as similar on a trait than fraternal twins, this is a strong indication that an observed trait is influenced by genetic factors.

In the classic twin method the difference between intraclass correlations of the MZ and DZ twin pairs is doubled to estimate the heritability coefficient (h^2).

$$h^2 = 2\,(r_{MZ} - r_{DZ})$$

The heritability coefficient times 100 is a measure for the part of the total population variance that is due to genetic effects. The influence of the unique environment can be roughly computed as 1 - h^2, and the effects of the shared environment as $2r_{DZ} - r_{MZ}$ (Falconer, 1989; Van Baal, 1997).

4.2.4 Heritability coefficients and the inheritance of traits

Behaviour genetics is about causes of differences between individuals, not about the processes that caused these differences. Culture can be a powerful source of environmental influence. For instance, social attitudes differ in different cultures, as a result of socialisation processes (Petty and Cacioppo, 1981). Conversely, it is possible that differences on social attitudes between individuals of the same cultural population are the result of mere genetic differences (Bouchard, Lykken, McGue, and Segal, 1991; Posner, Baker, Heath, and Martin, 1996; Truett, Eaves, Meyer, and Heath, 1992). So it can not be stated that a trait is 'caused' by genes, as in the saying: 'social attitudes are inherited'. What one really means to say is 'individual differences in social attitudes, in that particular population, are mainly genetic in origin'.

4.3 Quantitative Genetic Analysis: Model Fitting

4.3.1 An introduction to genetic model fitting

The classical twin method does have some major disadvantages. Estimates based on intraclass correlations have large standard errors and low power, the influence of non additive genetic effects can not be incorporated, and subjects at different levels of relatedness can not be studied simultaneously (Boomsma, 1992; Neale and Cardon, 1992).

Nowadays a method called 'Quantitative Genetic Analysis' has become the standard procedure to analyse twin data (Boomsma and Gabrielli, 1985; Heath, Neale, Hewitt, Eaves and Fulker, 1989; Neale and Cardon, 1992). Quantitative genetic analysis works with path models, expressing the relations between observed and latent (theoretical) variables in the form of path diagrams. Contrary to the classical twin method, that uses the intraclass correlation (ICC) as a measure of genetic and environmental relationship, QGA makes use of the variance and covariance matrices. The most important advantages of this method are:

- the models make the assumptions more explicit,
- the goodness of fit is tested,
- estimates of the genetic parameters are given as well as their standard errors,
- alternative models can be compared,
- one can analyse more than two groups of genetically informative individuals simultaneously,
- complex models as those incorporating family and adoption studies can be tested,
- generalization from univariate to multivariate models is not difficult,
- longitudinal design analysis becomes possible (van Baal, 1997; Beijsterveldt, 1996; Boomsma, 1992; Snieder, 1996).

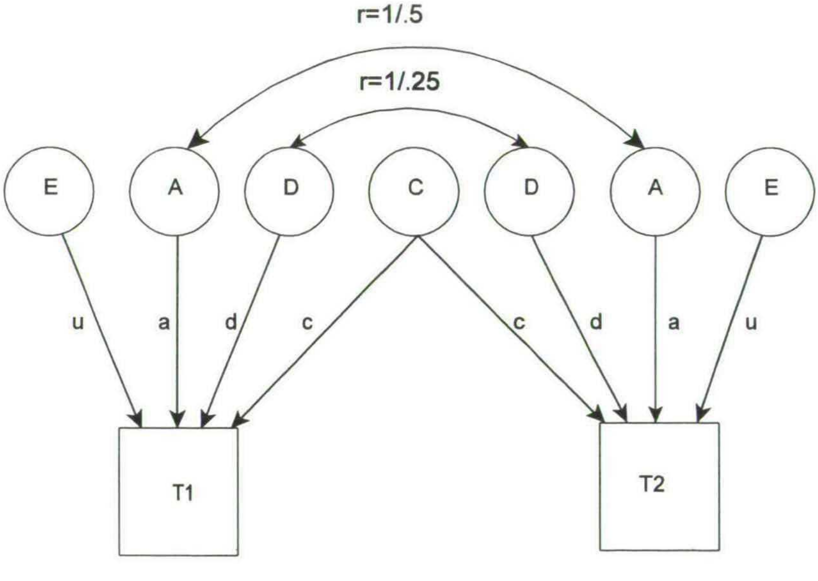

Figure 1: Path model for MZ and DZ twin pairs, where T1 and T2 are the members of a twin pair, E = Unique environment effect, A =Additive genetic effect, D = Dominance, and C = Common environment effect. The paths u, a, d, and c are the effects of E, A, D, and C on the trait.

Figure 1 presents the simple path model for twins reared together, the theoretical decomposition of genetic, and environmental influences of the phenotype

(Boomsma, 1992; Loehlin, 1992). The squares represent the observed variables, the phenotypic variance, where T1 and T2 are members of a twin pair. The variables in the circles are latent, not observable variables, they are defined on theoretical notions. 'A' stands for the part of the variance due to additive genetic influences, ' D' for variance due to dominance and epistasis effects, 'C' for the part of the total phenotypic variance due to the effects of the shared environment, and 'E' for the part of the variance due to effects of the unique environment, where random errors are by definition incorporated in 'E' (Loehlin, 1992).

The genetic model is defined by the structural equations:

$$P_i = hA_i + dD_i + cC_i + eE_i$$
$$V_p = a^2 + d^2 + c^2 + u^2$$

where P is the phenotype of individual i, A is additive genetic influence, D is the influence of dominance effects, C is the influence of the common environment, and E is the influence of the unique environment. A, D, C and E are conceived of as latent factors with zero mean, and a, d, c, and u are the factor loadings of the observed variable on the latent factors (Boomsma, 1992; Neale and Cardon, 1992; Snieder, 1996).

In the classical twin study, with twins reared together, C and D are confounded, making it impossible to test a full ACDE-model. Therefore the models tested in the present study are:

- the E-model: the data do not indicate any family resemblance,
- the AE-model: family resemblance is caused by additive genetic effects,
- the CE-model: family resemblance is caused by shared environmental effects,
- the ACE-model: family resemblance is caused by additive genetic and shared environment effects,
- the ADE-model: stating that family resemblance is caused by additive genetic and dominance effects.

As a rule of thumb the ACE-model is tested when the (intraclass) correlation of MZ twin pairs (r_{MZ}) is less than twice the (intraclass) correlation between DZ twin pairs (r_{DZ}), i.e. when DZ twins are more alike then could be expected on the basis of their genetic relationship. When r_{MZ} is more than twice r_{DZ} the ADE-model will

be tested, i.e. DZ-twins are less alike then could be expected on a 50% genetic relationship.
A model with only genetic D effects (DE, DCE) is not expected on theoretical grounds, and therefore not tested (Neale and Cardon, 1992).

Before applying this method to our data, three assumptions have to be made.
It is assumed that gene-environment correlations and interactions are zero and that there is no assortative mating for the observed trait.
The model also assumes equality of trait relevant environmental experiences among MZ and DZ twins, i.e. the so called equal environment assumption (Loehlin, 1992; Plomin, DeFries, and McClearn, 1990; Rose, Koskenvuo, Kaprio, Sarna, and Langinvainio, 1988). We tested the equal environment assumption (EEA) on our data, and although we found significant differences between MZ-twin pairs with regard to shared environment, these differences did not seem to influence the traits under study. There were no demonstrable effects of the degree of shared environment on the magnitude of the intra class correlation, meaning that a more extensive sharing of environment did not make the twin pairs significantly more equal on significant traits (Lensvelt-Mulders and Hettema, 1996).

4.3.2 Genetic analysis of the Zuckerman model

Zuckerman's model is based on the assumption that a conditional ordering underlies the different personality determinants. Lower ranking determinants are conditional for higher ranking determinants to materialize but they are not sufficient. Input from the environment is also a necessary condition. For instance, genes are conditional for physiological processes to occur. However without proper nutrition, or without any physical input from the environment, physiological processes will not develop up to expectancy. The development from genotype to traits occurs indirectly, and is mediated by determinants at different levels (Eysenck, 1993; Hettema and Deary, 1993; Zuckerman, 1991, 1992, and 1993).
Because of this conditional ordering it is hypothesized that genetic effects upon personality will differ as a function of the level. Genetic effects will decrease with

increasing level, based on the conditional nature of the levels regarding personality development (Hettema and Deary, 1993; Zuckerman, 1991, 1992, 1993).
At the lower levels of the Zuckerman model individual differences will be caused predominantly by genetic factors, where at the higher levels of the model individual behaviour will be more affected by environmental variables.
Behaviour genetics supplies us with a tool to study the differential input of genes and environment at every level. For every level heritability coefficients are computed for each variable, together with coefficients for the effects of shared and unique environment. These estimates will be used to test hypothesis 4, on the conditional ordering of the personality model.

4.3.3 Environment and Situation

The behaviour geneticists concept of 'environment' is not equal to the concept of situations as used in the present study (see chapter 2). In behaviour genetic studies, the environment is conceived of as a much broader concept. In fact it incorporates all the demands of the topical situation (i.e. the laboratory conditions, the questionnaire the respondent is filling out, the test that is administered), as well as the effects of past experiences.
Hypothesis 3 and 4 are concerned with the genetic effects on the model at every level, without involving situations. Our scores are situation specific, and it is possible to compute heritability estimates for every situation. But since our variables are thought to be sufficiently consistent over situations, it was decided not to include situations in this analysis.
To test hypothesis 3 and 4 we left situations out, and estimated the genetic and environmental effects at different levels of the model with the aid of univariate genetic model fitting. To do so we aggregated all scores across situations. Ideally, trait measures are aggregated across a representative sample of situations (Blalock, 1982; Van Heck, Perrugini, Caprara, and Fröger, 1994). An extra advantage of aggregation is the increase in reliability of the test scores, i.e. test reliability increases when the correlation between items increases and/or when the number of items increases (Murphy and Davidshofer, 1991).

4.4 Method

For an extensive description of subjects, procedures and preliminary data-analysis on every single level the reader is referred to chapter two.

4.4.1 Score aggregation

For each variable, we aggregated the scores across situations, obtaining one mean score per subject, for every variable, on every level. At the physiological level scores were computed for IBI, SBP, DBP, GSL and the autonomic dimensions Familiarisation, Effort, and Readiness. At the level of Delta-goals scores were computed for D-social control, D-control, D-agency, D-proximity, D-knowledge, and D-preparation. On the level of competences, Mental, Social, Physical and Instrumental competences were computed. On the trait level we computed scores for the Big Five dimensions.

4.4.2 Statistic analysis

Variance-covariance matrices were computed for MZ and DZ twins with the aid of SPSS 7.5, and univariate genetic structural equation models were fitted to these variance-covariance matrices. To fit the models we used the statistical package Mx, a model fitting program especially created for use in genetic research. Mx provides parameter estimates, a Chi-square test of the overall goodness of fit of the model, and Akaike's information criterion (AIC). AIC, calculated as χ^2 - 2df, is a measure to evaluate the goodness of fit of a model. The model with the lowest AIC can be considered the most parsimonious model. Neale and Cardon warn against the unqualified use of AIC. The best fit by AIC is not the same as the best fit by the χ^2 statistic. Models with different parameters should be tested with the aid of a $\Delta\ \chi^2$ test and models with the same number of parameters with the aid of AIC (Neale and Cardon, 1992).

4.5 Results

4.5.1 Intraclass correlations

The statistical package BMDP-V8 was used to calculate the intraclass correlations for MZ and DZ twin pairs, according to:

$$ICC = \frac{MS_{betw} - MS_{within}}{MS_{betw} + MS_{within}}$$

Intraclass correlations (ICC) were used for a first examination of the data. From differences in ICC between MZ and DZ twins, we can conclude if genetic effects are apparent and if dominance effects can be expected (Falconer 1989; McGraw and Wong, 1996).
Intraclass correlations (ICC) between twin halves are presented in Table 4.1, for MZ and DZ twin pairs separately. All MZ correlations exceed the DZ correlations. On the Physiological level the ICC of MZ twins exceeds the ICC of DZ more than twice for 'Familiarisation', 'Effort' and 'Readiness' indicating the possibility of dominance effects on those dimensions (ADE-model). On the trait level the ICC for MZ twins exceeds the DZ twin's ICC more than twice for 'Agreeableness' and 'Openness', indicating dominance effects and thus the possibility of an ADE-model.
For most measures DZ twin ICC's are larger than half the MZ twin ICC, indicating the possibility of influences of the shared environment.

4.5.2 Level 2: Physiology

In Table 4.2 the results of the model fitting procedures are reported, for single variables and dimension scores on the physiological level.
E, AE, CE and ADE or ACE-models were tested with the aid of the maximum likelihood method. Depending on the magnitude of the difference between MZ-ICC and DZ-ICC, an ACE or an ADE model was tested. Competing models were tested with 1 df against the overall model (Boomsma, 1992).

Table 4.1: Intra Class Correlations for MZ and DZ twins, situations at every level collapsed.

Physiology	IBI	SBP	DBP	GSL	Familiar	Effort	Readiness
MZ	0.54	0.44	0.27	0.12	0.65	0.79	0.81
DZ	0.32	0.27	0.23	0.07	0.08	0.20	0.37
D-goal	D-soccont	D-cont	D-agency	D-prox	D-know	D-iprep	
MZ	0.54	0.57	0.57	0.47	0.55	0.37	
DZ	0.4	0.52	0.49	0.41	0.42	0.27	
Competence	C-mental	C-social	C-physical	C-instrumental			
MZ	0.51	0.42	0.53	0.52			
DZ	0.38	0.39	0.46	0.49			
Trait	Extraversion	Agreeableness	Neuroticism	Conscientious	Openness		
MZ	0.50	0.51	0.50	0.38	0.43		
DZ	0.39	0.12	0.26	0.10	0.27		

Abbreviations: Familiar = Familiarisation, D-soccont = social control, D-cont = control, D-agency = agency, D-prox = proximity, D-know = knowledge, D-iprep = general preparation. IBI = Interbeat Interval, SBP = Systolic Blood Pressure DBP = Diastolic Blood Pressure, GSL = Galvanic Skin Level

For most variables the AE-model was the best fitting model when tested against other models with the chi-square difference test. Only for Familiarisation the χ^2 difference test yielded a score above 3.841 (F by 1 df), indicating ADE to be the better model.

The heritability coefficients are reported in the lower part of Table 4.2. For the single variables they are in the 'normal' range, between .28 for GSL and .42 for SBP (Turner and Hewitt, 1992; Rose, 1992). The heritability coefficients for the dimensions are unexpectedly high, for Familiarisation .79 (.40+.39), for Effort .81 and for Readiness .82.

Table 4.2: Model fitting results for physiological variables.

Variable	IBI	SBP	DBP	GSL	Familiarisation	Effort	Readiness
Best Fit	AE	AE	AE	AE	ADE	AE	AE
χ^2	4.455	3.316	2.647	1.079	3.465	3.368	2.342
DF	4	4	4	4	3	4	4
P	0.348	0.506	0.618	0.898	0.325	0.498	0.676
$\Delta \chi^2$	0.29	0.012	0.949	0	4.425	0.498	0.108
Estimates							
h^2	0.41	0.42	0.32	0.38	0.40	0.81	0.82
d^2					0.39		
e^2	0.59	0.58	0.68	0.62	0.21	0.19	0.18

Abbreviations: χ^2 values, df and p-value testing for the best fitting model. $\Delta \chi^2$ is the difference between the full and restricted model, with 1 df. When $\Delta \chi^2 > 3.84$ the more restricted model has the best fit. The parameter estimates for additive heritability (h^2), dominance heritability (d^2), and environmentality (e^2) are given. IBI = Interbeat Interval, SBP = Systolic Blood Pressure DBP = Diastolic Blood Pressure, GSL = Galvanic Skin Level

4.5.3 Level 3: Learning

In Table 4.3 the results of the model fitting procedure for D-goals are presented. In all cases the AE-model was the best fitting model. Chi-squares were low, as was AIC, yielding high p-values. The heritability coefficients range between .36 for D-social control and .56 for D-preparation.

Table 4.3: Model fitting results for Delta goals.

Variable	D-soccont	D-contr	D-agen	D-prox	D-know	D-prep
Best model	AE	AE	AE	AE	AE	AE
χ^2	7.723	2.868	1.74	1.272	7.103	4.305
df	4	4	4	4	4	4
p	0.102	0.580	0.946	0.866	0.131	0.366
$\Delta\chi^2$	0.523	2.281	0.619	0	2.254	2.17
Estimates						
h^2	0.36	0.44	0.39	0.43	0.51	0.56
d^2						
e^2	0.64	0.56	0.61	0.57	0.49	0.44

Abbreviations: see Table 4.2

4.5.4 Level 4: Social behaviour

In Table 4.4 the results are shown of the model fitting procedure for competences. The AE-model was the best fitting model on the data and the h^2 ranged from .37 for Physical competences to .55 for Mental competences.

Table 4.4: Model fitting results for competences.

Variable	C-mental	C-social	C-physical	C-instrumental
Best model	AE	AE	AE	AE
χ^2	3.183	6.429	1.593	4.969
df	4	4	4	4
p	0.528	0.169	0.810	0.291
$\Delta\chi^2$	0.042	1.504	1.002	3.446
Estimates				
h^2	0.55	0.54	0.37	0.50
d^2				
e^2	0.45	0.46	0.63	0.50

Abbreviations: see Table 4.2

4.5.5 Level 5: Traits

Table 4.5 presents the results of the model fitting procedure for personality traits. The AE-model proved to be the best fitting model, except for 'Agreeableness', where the ADE-model had a significantly better fit. The h^2 ranged from .39 for 'Neuroticism' to .63 for 'Openness'.

Table 4.5: Model fitting results for the big five personality traits.

Variable	Extraversion	Agreeableness	Neuroticism	Conscientiousness	Openness
Best model	AE	ADE	AE	AE	AE
χ^2	3.863	6.596	1.468	11.857	5.968
df	4	3	4	4	4
p	0.425	0.08	0.832	0.018	0.200
$\Delta\ \chi^2$	0.467	4.325	0.56	1.035	2.686
Estimates					
h^2	0.47	0.37	0.39	0.48	0.63
d^2		0.11			
e^2	0.53	0.52	0.61	0.52	0.37

Abbreviations: see Table 4.2

4.5.6 Comparing genetic effects between levels

To understand the differential effects of genes and environment on the different levels of the Zuckerman model, we tested the mean difference for h^2-estimates with the aid of an ANOVA (Table 4.6). The results indicated that the only differentiation on genetic influences between levels is between the physiological variables and variables at the other levels. The proportion of the systematic variance explained by genetic influences is largest at the physiological level, especially when we concentrate on the physiological dimensions, instead of the single variables. Between the other levels, no difference in genetic influence on variables was found.

Table 4.6: One-way ANOVA with contrasting groups (LSD).

Source	df	Sum of Squares	Mean Squares	F ratio	F prob
Between groups	3	0.279	0.0928	16.420	0.000
Within groups	14	0.079	0.0056		
Total	17	0.358			
pair wise comparisons	std error	Sign			
physiology-Learning	.053	.000			
physiology-Social behaviour	.057	.000			
physiology-Traits	.055	.000			
Learning-Social behaviour	.049	.405			
Learning-Traits	.046	.376			
Social behaviour-Traits	.050	.099			

Summarizing the results of the univariate genetic analysis of the Zuckerman model:

1. The results confirm the third hypothesis. We found heritability coefficients for all variables at every level, indicating genetic effects to be profound.
2. Hypothesis 4 is partly confirmed. Variables at the physiological level reveal much higher heritability estimates than the other levels. Between the other levels no significant differences were found.
3. We found extraordinarily strong genetic effects on the population variance of the autonomic dimension scores.
4. The results do not indicate significant effects of the shared environment on any of our measures.

4.6 Discussion

The third hypothesis was confirmed, at all levels we found significant genetic effects on the variance of every variable investigated. Hypothesis 4 was partly confirmed. The autonomic dimension variables at the physiological level reveals much higher heritability estimates than the other levels. For the variables at the other levels no significant differences could be found.

When the heritability coefficient is defined as a measure for the hierarchical order of the model, the physiological variables are at the second level, directly after the

genetic level. It is not possible to draw conclusions on the ordering of the other levels, because the differences in h^2 are not significant.
In the remainder of this section we will discuss the following results to a greater extent:

1. The very high heritability coefficients of the physiological dimensions as compared to those of the single variables.
2. The lack of differentiation between the learning- , social behaviour-, and trait levels.
3. The fact that the effects of the shared environment seems nill for all variables, at all levels.

The most remarkable finding of this exploration of the Zuckerman model is not the split we found between the physiological variables on one hand and the other levels on the other. Rather it is the fact that on the physiological level the heritability coefficients for the physiological dimension scores, Familiarisation, Effort, and Readiness, are so much higher than those of the single variables, IBI, BP, and GSL.
For the single cardiovascular variables moderate heritability coefficients where found, consistent with earlier research results: about .25 for GSL (Ditto, 1993), between .40 and .70 for cardiovascular measures (Turner and Hewitt, 1992), between .41 and .68 for blood pressure (Snieder, 1996, pag. 63-64). Research on cardiovascular reactivity is done with single variables as measures for reactivity. Turner and Hewitt (1992) recommend a different approach to the study of cardiovascular reactivity, including more then one variable to define functional physiological processes that could be used as measures for cardiovascular reactivity. In this study aggregated dimension scores where used, based on the work of Pribram and McGuiness (1975, 1992), and identified unequivocally by Hettema and coworkers (1999). For these dimensions, Familiarisation, Effort and Readiness, very large heritability coefficients were found.
Familiarisation has a heritability coefficient of .40 for A and .39 for D, which indicates that 79% of the total variance in the population for this dimension can be explained by broad genetic influences. For Effort 81% of the variance in the population can be explained by genetic effects, and for Readiness this is 82%. Although hypothesis 4, stating that the genetic contribution to the variance in a variable will be highest at lower levels of the model and will decrease with

increasing level, is not completely confirmed by the data, these are very tantalising results.

Many researchers are convinced that physiological reactivity should be highly heritable (Stelmack, personal conversation), but little empirical evidence for this hypothesis could be found. Heritability estimates for blood pressure reactivity are found between zero and .80, results that are far less consistent than estimates for basic blood pressure levels (Snieder, 1996).

First, the question can be raised why the h^2's for dimensions are so large. Although we could not find any genetic research on physiological response profiles, 79-82% of the total variance of a trait in the population explained by genetic effects is uncommonly large and calls for an explanation (Plomin, DeFries, and McClearn, 1990).

Is this an artefact of data collection, or the way we compute the dimensions, or are we really on to something here? If we answer this question we are confronted with a second question, namely why this split between heritability coefficients of variables at the physiological level and variables at the other levels?

First it is possible that the large differences between response profile scores and single variables are the results of a higher reliability of the response profiles. After all, reliability has a tendency to increase when more items are taken into account (Murphy and Davidshofer, 1991). However, computation of Cronbach's alpha for single variables and dimensions revealed no differences large enough to explain the difference in heritability. For the single variables Cronbach's alpha varied between .80 and .93 (IBI .93, SBP .84, GSL .80) and for dimensions between .80 and .87 (Familiarisation .80, Readiness .87 and Effort .86).

This leaves us with the explanation that autonomic dimensions are indeed more meaningful concepts than single variables. This idea is not new. Several functional covariations between heart rate and blood pressure are described (Lacey and Lacey, 1978; Mulder and Mulder, 1981). An example may elucidate the difference. Suppose that during a scene, in a film, a person has a heart rate deceleration, while this same person has a heart rate acceleration in a comparable scene in the next film. When computations are made on single variables, this person's scores will be averaged out, when we aggregate across films. In the case of response profiles, the direction of the response is not very informative, the combination of the directions of the different single variables is what counts (see Table 4.7). An increase or decrease of HR, BP or GSL in different films can be interpreted either as the opposite poles of the same dimension or as different dimensions.

Table 4.7: Dimensions of autonomic responsiveness.

measures	Familiarisation	Effort	Readiness
HR	+/-	+/-	+/-
BP	+/-	-/+	+/-
GSL	-/+	0/0	+/-

Abbreviations: HR: Heart Rate, BP: Blood Pressure, GSL: Galvanic skin level.

Estimates of heritability at the other levels do not differ significantly from one another. At the level of traits the heritability coefficient ranged between .39 for Neuroticism and .63 for Openness. These findings are in line with earlier research on the heritability of the big five personality variables for twins raised together (Loehlin, 1992; Bouchard, 1993, 1994; Lang, Livesley, and Vernon, 1996).

The other two levels, learning and social behaviour reveal heritability estimates that do not differ from the h^2 's of the trait level. This was the first time those variables were used in a genetic study, so regrettably no comparison can be made between heritability coefficients of different studies. However, the fact that hypothesis three, behaviour at all levels will reveal genetic effects, is confirmed for these variables is a satisfying development. On the other hand it is unfortunate that no significant difference was found between the heritability coefficients between the levels.

What does this mean for our model? Maybe we should have taken a different approach to measure the variables at some of the levels, e.g. learning. A questionnaire is a very restrictive way to measure learning. Observational studies could have revealed different heritability coefficients.

From genetic studies we know that substantial contrast effects are often found in parental and twin ratings, especially when twins are of known zygosity. MZ twins are perceived as much more concordant than DZ twins, resulting in larger differences between the ICC, and higher heritability estimates. According to Hoffman (1991), and Rose (1995) greater siblings similarity is expected for observable behaviours, than for inventory based research. On the other hand, in a topical situation behaviour can become more uniform. If this is the case, heritability coefficients will be smaller, when studied in observable situations. This is in line with recent research. Riemann and coworkers found the EC-model, with

no genetic effects accounting for familiar resemblance to be the best fitting model for emotional behaviour observed in a laboratory situation (Riemann, Angleitner, Borkenau, and Eid, 1998).
An other reason why we do not find any differentiation in genetic effects between the three highest levels can be that we did not measure behaviour, but cognitions. When behaviour is studied with the aid of a questionnaire it are the cognitions of a person about the situation that are studied, not behaviour itself.

Finally, we have tried to understand the third finding, the lack of significant shared environment effects in our data, a common finding in behaviour genetic research (Plomin and Daniels, 1987; Hoffman, 1991; Scarr, 1992).
An explanation for these (lack of) results is the notion that a common environment can not exist. Even important social and familial events as parental divorce, thought to be an important developmental influence, do not exercise the same effects on every child in a family (Hoffman, 1991; Bouchard, 1993, 1994). People are differentially susceptible to life events because the perception of the situation is as important as the objective event itself in establishing behaviour (Rose, 1995). Behavioural traits develop in interaction with the environment, and a trait that develops in one environment, does not have to develop in an other environment. Research shows that the environment has a tendency to make people more unique and to enhance individuality. I will explain this with an example. Two siblings can have an innate tendency for Neuroticism, sibling A has a score of 3 and sibling B has a score of 4 on a 10-point scale at the age of 5. Important life events are important in the development of this trait. Such a life event is the divorce of parents. When parents divorce, the perception of this situation can be slightly different for both siblings, the more neurotic sib being more confused and feeling more guilt than the slightly less neurotic sibling. This will make sibling B become more and more neurotic and gradually the siblings will grow apart on this trait. Thus, an event that seems to be important and shared by members of the family, can turn out to be a major differentiator, making siblings more different from one another. This reasoning is in line with Caprara and Zimbardo's concept of marginal deviations as important causes of individual differences (Caprara and Zimbardo, 1996). This tendency of the genotype to interact with the environment is called genotype-environment interaction (Scarr, 1992; Plomin, and Daniels, 1987).

Furthermore, the effects of the common environment seem to decline with age. When twins tend to share less of the environment, they grow apart, and the effects of the within family experiences become less important (McCartney, Harris, and Bernieri, 1990). In our study the average age of the respondents was 32 and most of them lived in the circle of their own family for some time, not with each other. There can also be a statistical explanation for the lack of common environmental effects in our data, the power needed to detect a significant C-effect. We can measure the multiple fit option in effect. With N=100 the power to detect a significant level with 1 df is .1246. To reject the hypothesis, on a .050 level (reasonable fit) we would have needed at least 611 subjects (Boomsma, personal conversation).

4.7 Further research

As a result of the preliminary unigenetic analyses of the Zuckerman model two interesting new lines of research readily present themselves.
First we may try to shed some new light on the role of autonomic responsiveness as mediator between genotype and behaviour on the higher levels of the model. In chapter 5 we will test a multivariate model for correlated genetic effects between autonomic responsiveness and the variables on the other levels.
Secondly research can be directed at the interaction between genotype and situations. As a result of aggregation across situations we omitted an important source of behavioural variance. The results of the quantitative genetic analysis revealed the possibility of genotype×environment interactions. People make choices not only from behavioural possibilities but also from situations that present themselves to them. If they have a choice they will choose the environmental niches within which the behavioural expression of their genotype is optimal (Scarr and McCartney, 1983; Rose, 1995).

5 Genetic correlations between variables at different levels

5.1 Introduction

In chapter 3 behavioural processes at the lower levels were introduced as conditional but not sufficient for behaviour at the highest level to occur. Traits could be predicted with the aid of competences, D-goals, and, to a lesser extent, physiological dimensions.
In chapter 4 the relevant sources of genetic and environmental variation in single variables, at every level, were estimated. Variance in all variables could be explained by genetic and environmental factors that differed between individuals.
In this chapter the genetic and environmental effects on interlevel relations will be the object of study. The main question will be to what extent the correlation between variables at different levels, is genetic correlation.
Hypothesis 5, *the same genetic and environmental components are at the basis of behaviour at all levels*, will be put to the test. This is the strongest, most stringent hypothesis. It predicts that variables at different levels share to some extent genetic and environmental factors, that mediate their relationships. To put this hypothesis to the test independent pathway analyses are computed to estimate the degree to which the phenotypic correlation between variables at all levels can be attributed to common genetic and/or environmental factors (Neale and Cardon, 1992). The results of these analyses are used to shed some preliminary light on the extent to which genetic and environmental influences mediate the predictive value of variables at lower levels for variables at higher levels.
In section 5.2 the meaning of genetic correlation of variables at different levels will be explained. In section 5.3, the method section, the multivariate genetic approach will be explained and the models will be given. In section 5.4 the

research method is displayed. The results will be shown in section 5.5 and this chapter will end with conclusions and a discussion in section 5.6.

5.2 Relationships between different levels of the multilevel model

A major goal of designing multilevel models is to explain personality variables on the basis of variables at the other levels. Processes at the lower levels are necessary, but not sufficient, for behaviour at the higher levels to occur. For Zuckerman's model this means that learning processes can not occur without physiological processes underlying them. Without learning processes there can be no social behaviour, and social behaviour is a prerequisite for traits to be established (Zuckerman, 1992, 1993). According to the Zuckerman model biological variables underlie variables at the social levels. So learning is partly determined by physiological dimensions, as are social behaviour and personality traits (Eysenck, 1967, 1993; Hettema and Deary, 1993; Stelmack, 1990; Zuckerman, 1991, 1992, 1993).

A multiple regression analysis was done to support the assumption that traits can be explained on the basis of behaviour at the lower levels (chapter 3). The results indicated that caution has to be taken with the interpretation of the results at the physiological level. Autonomic dimension scores did not contribute significantly to the explanation of variance in trait- or D-goal scores. This means that no direct linear relation could be established between variables at the levels 'physiology' and 'traits', nor between variables at the levels 'physiology' and 'learning'.

Results of the univariate genetic analysis of all variables supported the assumption that variables at all levels are rooted in the genotype (chapter 4). Twin data support the existence of strong genetic influences on the physiological dimensions Familiarisation, Effort and Readiness, where approximately 80% of the variance is explained by genetic effects. On the other levels moderate to considerable genetic effects on the total variance were found. For traits these effects varied between 39% for Neuroticism and 63% for Openness. For social behaviour the genetic effects on the total variance varied between 37% for physical competences and 55% for mental competences. At the learning level part of the total variance explained by genetic effects varied between 36% for D-social control and 56% for D-preparation. As Zuckerman says, 'genes are the eggs, where all turtles come from' (Zuckerman, 1992).

The connection between level variables can have social as well as biological grounds. The environment as well as genetic effects may play a role in the relations we found. This is a logical consequence of the theoretical background of the model. When all levels form a conditional chain, with genes on the basis, then the same genes should at least partly influence all variables. Genetic variance on the trait level may be partly the result of genetic variance on the physiological level, the learning level, or the level of social behaviour, or all three of them. For example: A possitive correlation is found between Agreeableness and D-proximity, people who are more agreeable express more behaviour with the intention to reduce distance to other people, defined as making a joke to ease up the situation, offering someone a cup of coffee, touching someone friendly, and thinking about something nice to do or say to someone. Variance in both variables can be partly explained by genetic effects, Agreeableness for 48% and proximity for 43%. The association between both variables is thought to be effected to some extent by the same genes and the same environmental niches.
The relevant question is to which extent the genetic and environmental variation in traits stems from the same source as genetic and environmental variation in variables at the other levels?
In the remainder of this chapter we will examine the genetic contributions to the observed correlations between variables at different levels, based on the data of adult female twins.

5.3 Multivariate genetic analysis: Models

Multivariate genetic analysis provides us with a tool to unravel the genetic and environmental correlations between sets of variables from different levels. In Chapter 4 variance in single variables was partitioned into genetic and environmental components. When using a multivariate approach it can be determined to what extend the covariation between variables at different levels is due to shared genetic and environmental factors (Neale and Cardon, 1992). Three multivariate approaches are to our disposal. The Choleski factorisation or triangular decomposition, the independent pathway analysis and the common pathway analysis. When the objective of the study is to fit data to a model the Choleski factorisation is not indicated (Loehlin, 1996). The indepent and common pathway analyses are more restrictive. When each of the common factors has its own path to the obeserved, phenotypic variables, this is called an independent pathway (figure 5.1). When the covariation between variables at different levels is detemined by a single phenotypic latent variable then a common pathway analysis is indicated. The common pathway analysis is more restrictive then the independent pathway analysis, making the latter more suitable for a first test of the model.

Figure 5.1 displays the independent pathway model. The correlation between variables at different levels can be partly explained by correlated genes and environments. Each observed measure, the phenotype, is a function of a subject's underlying common additive genetic factor (A), a common specific environmental factor (E), and common shared environmental trait factor (C). These factors are common factors, because they excert their influence at each of the four levels. The factor loadings can vary between levels, the same genetic processes influence variables at different levels, but to a different degree. In addition to these common factors, each variable has its own unique factors, an additive genetic factor A_x and a unique environmental factor E_x (x = P, D, C, T), explaining the variance specific to that variable. The correlations between the unique A_x's are 1 for MZ and .5 for DZ twins (Neale and Cardon, 1992; Neale, 1995).

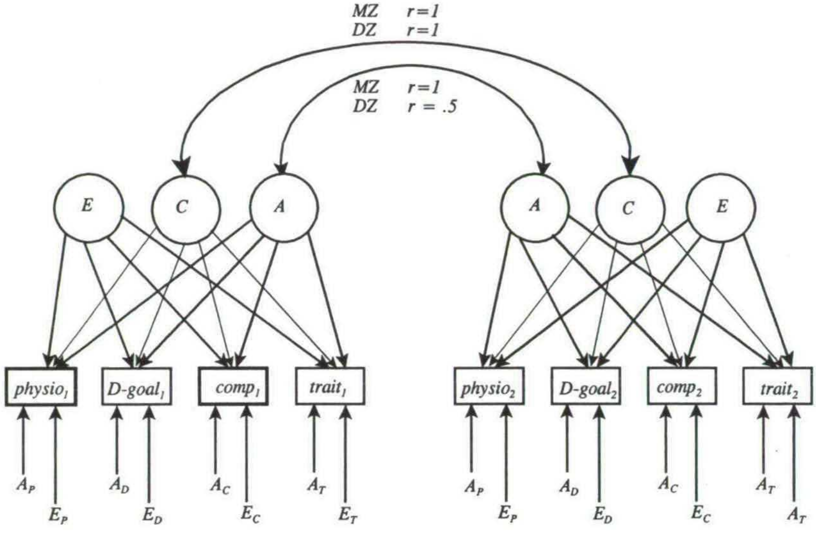

Figure 5.1: Independent pathway model for physiological dimensions, D-goals, competences and traits. All labels for path-coefficients have been ommited. All unique genetic correlations are fixed to 1 for MZ and .5 for DZ twins (after Neale and Cardon, 1992, pag 255).

5.4 Methods

For an extensive description of subjects, methods and first data-analyses we refer the reader to Chapter 2. Data are aggregated over situations.

The independent pathway analysis restricts the numbers of variables that can be compared. In an ideal world it should be possible to relate many different patterns of genetic and environmental causation to particular physiological, learning, social behaviour and trait systems. In doing so we can hope to find the different biological and social processes that are involved in consistent patterns of differences between individuals (Eaves and Young, 1994). Since this is not an ideal world not all variables can be taken into one big analysis, for instance the number of observations (MZ twin pairs =57 and DZ twin pairs =43) forbids.

For every trait a promissing submodel, with one to one relations is searched for. Therefore correlation-cross-correlation matrices are computed for monozygotic (MZ) and dizygotic (DZ) twins seperately. Inspection of these matrices revealed the covariation between variables at different levels. If crosscorrelations are higher for MZ twin pairs then for DZ twin pairs, this is an indication for the prevelance of common genetic effects. In addition, if the phenotypic correlation is small this could be due to a cancelling effect of the genetic and environmental correlations. This is the case with a positive genetic correlation and a negative environmental correlation (Plomin, DeFries, and McClearn, 1990).

Although we rejected one to one relations in Chapter 2, for a preliminary test of Zuckerman's model it was decided, it was opportune to follow a one to one variable line of reasoning. Only single relations between variables at different levels will be considered in this analysis. Clearly the result in section 5.4 must be regarded as preliminary.
Only pathways that included variables at all levels of the multilevel model were tested. No relevant submodel for the trait 'Extraversion' could be found so the analysis is restricted to the other four Big Five variables (Table 5.1).

Table 5.1: Different submodels chosen on the basis of cross-correlation matrices.

	submodel 1	submodel 2	submodel 3	submodel 4
Traits	Agreeableness	Neurotocism	Conscientiousness	Openness
Social behaviour	Mental	Social	Physical	Mental
Learning	D-agency	D-proximity	D-agency	D-control
Physiology	Readiness	Readiness	Readiness	Familiarisation
abbreviations	RAMA	RPSN	RAPC	FCMO

We used a maximum likelihood fitting procedure, model independent pathway, to the 8×8 variance-covariance matrix, four levels crossed with two twins halves. These matrices consisted of the covariances among the four level measures between twinhalves, and the 4×4 cross-covariance of measures between twins. The variance of variables at each levels is decomposed into variance explained by three (A, C, and E) common factors and two specific factors (A_x and E_x). The common factors influence each of the level variables. Factor loadings are estimated. Loadings can vary between variables, indicating that the same genetic or environmental processes influence variables at different levels to a different degree.

5.5 Results

The independent pathway analysis was used for modelling the relations between physiological, learning, social behaviour, and trait variables. Quantitative genetic model fitting was conducted on the variance-covariance matrices to decompose the total phenotypic variance, according to the independent pathway analysis (Neale and Cardon, 1992; Neale, 1995).
Four models were tested, the full common ACE model (see figure 1), a reduced model with only AE as common factors, a reduced model without an additive genetic trait factor (CE), and a model with only specific additive genetic (A_x) and specific environmental (E_x) factors. The best fitting model was chosen on the basis of the $\Delta\ \chi^2$ test, comparing the reduced models with the full model, or by comparing the values of AIC if df were equal. No submodel fitted an only specific factors genetic model or a model without common genetic factors (CE). Table 5.2 summarizes the goodness of fit statistics for the best fitting independent pathway models.

Table 5.2: Goodness of fit for the best fitting independent pathway genetic models.

Submodel	model common	χ^2	df	p	AIC
RAMA	ACE	69.592	52	.052	-34.408
RPSN	AE	70.500	56	.007	-17.500
RAPC	AE	89.341	56	.003	-22.659
FCMO	AE	180.301	56	<.001	92.301

<u>Abbreviations:</u> RAMA = P-Readiness, D-agency, C-mental, T-Agreeableness. RPSN = Readiness, D-proximity, C-social, T-Neuroticism. RAPC = P-Readiness, D-agency, C-physical, T-conscientiousness. FCMO = Familiarisation, D-control, C-mental, Openness. AIC=Akaiki's information criterion.

For the submodel 'Readiness, D-agency, C-mental, Agreeableness' the ACE model was the best fitting, most parsimonious model. For the other submodels the common AE-model was the best fitting model.

The independent pathway analysis yielded a reasonable fit to the data for three submodels. The fit of the FCMO submodel is disputable. Factor loadings for the best fitting models are listed in Table 5.3. Squared factor loadings are an estimate for the relative influence of each factor on a level variable. The total variance is split into common and specific variance. Common variance (V_C) is computed as $A_C^2 + C_C^2 + E_C^2$. Specific variance (V_S) is computed as $A_S^2 + E_S^2$. The V_C is divided into an additive genetic component, a shared enviromental component, and a unique environmental component, by dividing the squared factor loadings by V_C. Likewise V_S is divided into a genetic and environmental component (table 5.4) (Riemann, Angleitner, Borkenau, and Eid, 1998).

Table 5.3: Mx factor loadings for the best fitting models.

Models	A_C	C_C	E_C	A_L	E_L
RAMA					
Readiness	.173	.153	.150	.426	.718
D-agency	.174	.218	.277	.000	.000
C-mental	.139	.309	.174	.000	.000
Agreeable	.210	.010	.193	.258	.385
RAPC					
Readiness	.234		.137	.423	.721
D-agency	.280		.275	.000	.000
C-physical	.322		.192	.000	.350
Conscientiousness	.090		.021	.513	.410
RPSN					
Readiness	.191		.033	.323	.385
D-proximity	.236		.139	.040	.211
C-social	.208		.291	.229	.001
Neuroticism	.156		.343	.343	.487
FCMO					
Familiarisation	.220		.107	.311	.377
D-control	.248		.325	.117	.000
C-mental	.269		.205	.154	.000
Openness	.050		.068	.214	.214

Abbreviations: A_C = correlated genetic factor loading, C_C= correlated shared environment factor loading, E_C =correlated unique environmental factor loading, A_L = variable specific additive genetic factor loading, and E_L = variable specific environmental and error factor loading.

The estimated factor loadings on common and level specific factors inform us about the interdependence of the variables at different levels. Mx presents estimates for the relative influence of the common and specific factors on each variable of the model. The overall estimates for genetic and environmental factors were comparable with the heritability and environmentability coefficients of the univariate analysis.

Table 5.4: The proportion of variance explained by different components of the independent pathway model.

RAMA	V_c	V_s	a^2_c	c^2_c	e^2_c	a^2_s	e^2_s
Readiness	.076	.697	.39	.31	.30	.26	.74
D-agency	.154	.000	.19	.31	.50	.00	.00
C-mental.	.145	.000	.13	.65	.22	.00	.00
T-agreeable	.081	.215	.54	.01	.45	.30	.70
RAPC							
Readiness	.073	.698	.75		.25	.26	.74
D-agency	.154	.000	.51		.50	.00	.00
C-physical	.141	.123	.73		.27	.00	1.00
Conscientiousness	.009	.431	.85		.05	.61	.39
RPSN							
Readiness	.038	.252	.96		.04	.41	.59
D-proximity	.075	.046	.74		.36	.03	.97
C-social	.127	.052	.34		.66	1.00	.00
Neuroticism	.142	.354	.17		.83	.33	.67
FCMO							
Familiarisation	.059	.238	.81		.19	.41	.59
D-control	.167	.014	.36		.64	.00	1.00
C-mental	.129	.024	.56		.44	.00	1.00
Openness	.008	.091	.31		.69	.50	.50

Abbreviations: V_c = total of correlated parameter estimates. V_s = total of specific parameter estimates, a^2_c= the standardised correlated a^2, e^2_c= the standardised correlated c^2, e^2_c= the standardised correlated e^2, a^2_s= the standardised specific a^2, and e^2_s= the standardised specific e^2.

Table 5.4 displays the proportion of variance explained by different genetic and environmental factors. The proportion of common variance is smaller then the proportion of specific variance for physiological dimensions and traits. For the dimensions this was expected, because no strong relations between variables at the physiological level and variables at the other levels were found. However the variance of physiological dimensions that is common, is to a great extent common genetic variance. This means that the relation between physiological dimensions and the other levels is genetically mediated.

Delta goals and competences have a large proportion of common variance. This common variance can be divided into common genetic and common unique environmental variance. For the submodel RAMA also common shared environmental factors are important (ACE model). The lack of specific variance for these variables is calling for an explanation. When reasoning very straightforward this should mean that D-goal and competences are 'the same concept'. These results could be a consequence of the method used to measure both levels. D-goals and competences were measured with the aid of one questionnaire. Although D-goals and competences are measured independently, according to generalization analyses (chapter 2), these results indicate strong relations between both variables.

5.6 Conclusions and discussion

The strong indication that scores at the trait level could be predicted by behaviour at the other levels combined with the genetic contribution to all variables at all levels raised the possibility that associations between levels might be mediated by common genetic and/or environmental factors. In chapter 5 hypothesis 5, *the same genetic and environmental components are at the basis of behaviour at all levels,* is put to the test. This hypothesis was confirmed.
A better understanding is obtained of the Zuckerman model, especially in the submodels 'RAMA', 'RAPC', 'RPSN', and 'FCMO'. For the trait Extraversion no promising submodel could be found.
The connections between the physiological dimensions Readiness and Familiarisation and the other levels are small, but the common variance is to a large extent mediated by common genetic factors. The association between the D-goals and competences is almost completely mediated by the same genetic and environmental factors, rendering them suspect to problems with the modes of measurement.
Behavioural genetic research has a tradition of repeating studies and drawing conclusions from multiple research. One study on the genetic and environmental effects on interlevel associations is to limited to draw ultimate conclusions about Zuckerman's model. However the independent pathway analyses apeared to be a relevant method to study the genetic and environmental relations between the different levels of explanation of the Zuckerman model. Although this study is

only a preliminary test, it gave an indication that the important issue of the etiology of personality and individual differences can be studied with the aid of multivariate genetic analysis. The biological as well as the social influences shared by all variables of the multilevel model, as well as biological and social influences specific to every variable can be estimated for all levels of the multilevel model.

6 Genotype × Situation: interaction effects at different levels

6.1 Introduction

Compared to the person, the situation has received little attention in personality theorizing and research (Endler, 1989; Magnusson, 1981). This is also true in genetic research. The study of the interplay between the individual and his environment has begun only recently (Plomin, 1994). Recent genetic research has shown that genes have their effects on situations. There are strong indications that subjective measures of the situation are mediated by innate personality characteristics (Rowe, 1994). These findings agree with the results of research on person × situation interactions. In the interactionist's view neither situations, nor enduring dispositions are the most important source of variance in behaviour. The most important feature of behaviour is the interaction between a person and the environment. But does this interaction of individuals with the situation have enough predictive utility to justify their study, or is it enough to study cross situational consistency as defined in general behavioural traits?

Individuals do not passively react to the topical situation, they actively select, modify and transform situations to their own demands (Diemer, Larsen, and Emmons, 1984; Hettema and Kenrick, 1989). Individual differences in Psychotism, Neuroticism, and Extraversion (Eysenck, 1993), sensation seeking (Zuckerman, 1992), the Big Five personality traits (Bouchard, 1993; Jang, Livesley, and Vernon, 1996), and D-goal preferences (Hol, 1994) influence to some extent the type of situations people seek and avoid and the way people function in daily life situations. Different genotypes seem to prefer different environments (Bouchard, 1993; Eysenck, 1990), making the effects of the environment upon personality vary over individuals (Loehlin, 1992). Genetic make-up seems to play a major role in this selective processing of the environment, it directs the experiences one can have (Scarr and McCartney, 1983).

The occurrence of specific behaviour in daily life situations is governed by many different factors. Factors at the individual level include the individual's repertoire of competences and skills (Bandura, 1986), the subjective evaluation of the situation (Cantor, 1981; Cantor and Kihlstrom, 1987; Wagner and Sternberg, 1986), and the person's personality characteristics (Hendriks, 1996; Loehlin, McCrae, Costa, and John, 1998; McCrae and Costa, 1992; Van Heck, Perugini, Caprara, and Fröger, 1994; Hendriks, 1996).

In addition there are factors in the immediate situation the person has to act in or react to (Mischel, 1968). The immediate environment exerts a strong influence on individual behaviour and should therefore be considered in a model of individual functioning.

In this study the organism and its internal (genes) and external (topical situation) environments are considered a functional unit. Both genetic make-up and demands of the environment confine overt behaviour. In chapter 6 heredity and environment are studied as a functional unit, with emphasis on the extent to which differences in genotypes and the demands of the environment interact to lead to differences in overt behaviour.

Chapter 6 presents a test of hypothesis 6: *Genotype environment interactions will become stronger with increasing level of the Zuckerman model.* This hypothesis is about the effects of nature and nurture on consistencies and inconsistencies of behaviour in different situations.

In this chapter we want to elaborate a statistical approach to study genotype-environment interactions, integrating the behavioural genetic approach and the person × situation interactional approach [1].

In section 6.2 hypothesis 6 will be explained. In section 6.3 the statistical method is explained, in 6.4 the method is described, in section 6.5 results of the analysis are given, and we conclude this chapter with a discussion of results and conclusions for further research in 6.6.

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1 I want to thank Lyndon Eaves for his helpfull comments on this subject. Without his article (with Hans Eysenck) and helpfull comments, I would still be in the woods today.

6.2 The assumption of conditional ordering

The first assumption of multilevel models is the assumption of conditional ordering, couched in terms of hypothesis 4; Genetic effects are largest at the lower levels and will decrease with level.
Regrettably, this hypothesis was only partly confirmed by the data (see chapter 4). Individual differences at the physiological level could be explained by differences in individual genotypes up to 80%. Conversely, genetic effects explained individual differences at the other levels for approximately 50%. No differential effect on the main effects on genotype and environment was found on these levels. These results cause a serious problem to the model, because the main argument is on the ordering of the higher turtles. Where genetics are at the basis, 'the egg from which the turtles emerge...', the place of the other levels is disputable (Zuckerman, 1992).
In previous chapters features of the model were studied without the incorporation of specific situations. Behaviour was aggregated across situations (Blalock, 1982; Van Heck, Perrugini, Caprara, and Fröger, 1994). In the light of the above, this could be a problem. Situations are an important concept in the study of individual behaviour.
According to Plomin and coworkers (1987), in addition to the genetic and environmental main effects, phenotypic variance can also be explained by gene × environment interaction effects (Plomin, deFries, and Loehlin, 1977; Plomin and Daniels, 1987). Plomin and coworkers (1977) defined genotype-environment interaction as due to the nonlinear combination of genetic and environmental effects. Interaction is used here in the statistical sense of a conditional relationship. However, interaction connotes something more than statistical interaction. In the interactionistic view a person is looked upon as an active agent. This definition of the person × situation interaction is better conveyed by the concept of genotype-environment correlations. Especially the active gene-environment correlation defines the interactionist's point of view. This correlation occurs as a result of the fact that an organism is not the passive recipient of the situation. An organism contributes to the environment and actively seeks one that is related to its genetic propensities (Plomin, et. al., 1977). When the environment does not match the genetic propensities, then a person will transform the situation to match its own goals and motives (Hettema, 1989).

According to the Zuckerman model the effects of the environment will increase with increasing level. Although this could not be demonstrated for main effects, it is possible that, at the higher levels, genes and environment exert their influence in a different way. Not directly, and measurable as a main effect of the environment on individual differences, but indirectly, by way of interaction. When this is the case the differential effects of genotype and environment at different levels are not linearly additive. In behaviour genetic research on the effects of the environment is often conceived of as research on the effects of the 'sum of past environments' (Anastasi, 1958, in Plomin and Daniels, 1987). Here the environment is a topical concept, in this way the situation is a restriction of the behaviour genetic concept of environment (Wachs, 1983, 1993).
Hypothesis 6 states that with increasing level, the genotype × environment interactions will become stronger. We should find increasing interaction effects between genotype and environment with every level.

6.3 The genetics of interaction effects

6.3.1 Introduction

In the following section we will describe the method of analysis chosen to explore the combined effects of environments and genes. What we will try to demonstrate is that the effects of interaction between person and situation can be viewed as personality variables in their own right.

6.3.2 Genetics of Person by Situation interactions

In research on physiological measures one has to account for a characteristic of measures; the 'autonomic response specificity'. Originated in the field of physiology, this concept can be easily extended to other levels of personality research involving subjects and situations. Physiological reactions are governed by three types of response specificity: the individual response specificity (IRS), the stimulus response specificity (SRS) and the motivational response specificity (MRS).

IRS is the tendency for an individual to emit characteristic responses to most stimuli (Engel, 1972). This tendency may be related to specific consistent personality dispositions like, e.g., temperament or coping styles. IRS may be due either to genetic factors or acquired personality characteristics and competences (Fahrenberg, 1986; Stemmler, Grossman, Schmidt, and Foerster, 1991).
SRS is the tendency of a stimulus or situation to evoke characteristic responses from most individuals (Engel, 1972). SRS assumes that different classes of physical or psychological stimulus characteristics have the capacity to activate specific psychological reactions.
MRS assumes the subjective interpretation and appraisal of a standardized stimulus situation to vary among individuals (Ax, 1964). Rather than the individual or the stimulus situation per se, the meaning an individual gives to the stimulus, underlies responsiveness.
If autonomic responsiveness is studied in daily life situations, MRS accounts for large portions of the total variance. Research in our laboratory with single autonomic variables summoned by motion pictures as stimuli has invariably revealed MRS causes the lion's share of the variance in those conditions. In recent studies almost half of the systematic variance in autonomous responsiveness could be explained by MRS, whereas only one third was due to IRS (Geenen, 1991; Leidelmeijer, 1991; Hettema, Leidelmeijer, and Geenen, 1999).
This view on response specificity is not restricted to physiological measures. IRS is in fact a measure for what is generally referred to as cross-situational consistency, the concept of behavioural traits (P). SRS is referred to as intra situational consistency (S), here the situation is the determinant of behaviour. And MRS refers to stable interactions between persons and situations (P×S), the person ×situation consistency.
Research on D-goals showed the relative importance of P, S, and P×S on D-goals, where P×S accounted for the largest part of the variance (Hol, 1994). Research with the TinSit (see Chapter 2) revealed similar findings for the Big Five personality traits (Van Heck et. al., 1994; Hendriks, 1996), the P×S interaction accounted for the largest part of the total variance.
The inconsistency of behaviour over different measures is usually interpreted as unreliability or error. The different situation descriptions or films can be conceived as different measurement occasions. In our approach the possibility is investigated that the (lack of) generalisation of behaviour over different situations

is a trait in its own right, as suggested by Eaves and Eysenck (1976; Eaves and Young, 1981). To test this line of reasoning we had to find a way to integrate the behavioural genetic approach, where the total variance is decomposed into a genetic and an environmental part, with the ANOVA approach, where the total variance is decomposed into a part for P, S, and P×S.

6.3.3 Decomposition of explained variance

Both the straightforward analysis of variance (ANOVA) and the quantitative genetic analysis approach decompose the observed variance into latent components.

Quantitative genetic analysis is based on the decomposition of the observed phenotypic variance into four components, additive genetic (A), and dominance (D) effects, and shared- (C) and unique (E) environmental effects. In person ×situation studies, the regular ANOVA decomposes the total observed variance into three components, a part explained by effects of the person (P), effects of the situation (S), and effects of the person by situation interaction (P×S).

If P is defined as all the effects of the person, including genetic as well as learning factors, then it can be expected that genetic as well as environmental influences will become apparent in the P×S interaction. And since, in previous research, P×S interactions took a significant part of the total variance, it can be assumed that the genetic effects on P×S interaction will explain an important part of the total phenotypic variance as well.

6.4 Method

For an extensive description of subjects, procedures and preliminary data-analyses on every single level the reader is referred to chapter two.

To test hypothesis 6 the data were analysed with ANOVA on both zygosity groups with response profiles as dependent variables and twin pair (T), twin halve (t), situation (S=situation description in questionnaires or film) and response (I=item in questionnaires, or in films the different scenes) as independent variables.

Although t is sometimes defined as nested within T, an all variables crossed approach is chosen, because twin 1 and twin 2 are mutually exchangeable. The difference in results between a crossed and nested approach is almost neglectable, as demonstrated by Eaves and Eysenck (1976; Eaves and Young, 1981).
There are 4 independent mean squares involving the triple interaction of subjects, situations and items. These are the mean squares $S \times T \times I$ (between twins) and $S \times t \times I$ (within twins), for each group of twins (MZ and DZ). In our model measurement error is confounded with the triple interaction term. These triple interactions will therefore be regarded as error terms in the strict sense. Can we do this? Yes, because no significant differences between the within and between interactions for MZ and DZ twin groups are found. This means that no strong genetic effects influence the triple interactions. So it is safe to conclude that the triple interaction term can be regarded as error. The triple interactions $S \times T \times I$ (between twins) and $S \times t \times I$ (within twins) are pooled over twin groups and further treated as a measure of error in the strict sense.
It is possible to fit a genetic model according to the classic approach, by computing the ICC (McGraw and Wong, 1996) according to:

$$ICC = \frac{MS_{betw} - MS_{within}}{MS_{betw} + MS_{within}}$$

However, it is better to reparametrise the expectation of the mean squares in terms of a simple genetic model (Eaves and Eysenck, 1976; Eaves and Young, 1981). This model has the advantage that it makes the assumptions of genetic models more explicit, and the theoretical relations between components of variance become more apparent. Accordingly, two genetic parameters can be specified, one for the main effect of the person (G_P), and one for the $P \times S$-interaction ($G_{P\times S}$). Environmental parameters will be specified for the main effects on the person (E_P), the $P \times S$-interaction ($E_{P\times S}$) for the $P \times I$-interaction ($E_{P\times I}$) and error (the triple interaction pooled).
We are interested in three types of response specifity: the tendency of a person to behave in a similar way over different situations (Individual Response Specifity), the behavioural effects evoked by the situation (Situational Response Specificity),

and the tendency of a person to engage in systematic interactions with the environment (Motivational Response Specificity).
In ANOVA the main effect for P can be regarded as a measure for IRS, and will be decomposed into genetic and environmental effects. The P×S-interaction effect is a measure for MRS, and will also be decomposed into genetic and environmental effects. The main effect of S is a measure for SRS, and will not be decomposed into genetic and environmental effects.
In Table 6.1 a simple genetic model (AE) for P and P× S interactions is defined (Eaves and Eysenck, 1976; Eaves and Young, 1981)

Table 6.1: Simple genetic model for Variance Components, ANOVA for MZ and DZ twin groups.

Component	D_P	E_P	D_{PS}	E_{PS}	E_{PI}	E
σ^2	0	0	0	0	0	1
σ^2_{RI}	0	0	0	0	1	0
$\sigma^2_{S\times MZw}$	0	0	0	1	0	0
$\sigma^2_{S\times MZb}$	0	0	.5	0	0	0
σ^2_{MZw}	0	1	0	0	0	0
σ^2_{MZb}	.5	0	0	0	0	0
$\sigma^2_{S\times DZw}$	0	0	.25	1	0	0
$\sigma^2_{S\times DZb}$	0	0	.25	0	0	0
σ^2_{DZw}	.25	1	0	0	0	0
σ^2_{DZb}	.25	0	0	0	0	0

D_P: Additive genetical variation, $D_p = \frac{1}{2}V_A$ (Matter and Jinks, 1971)
E_P: Environmental effects on trait scores
D_{PS}: Additive genetical variation effects on the person×situation interaction for trait scores
E_{PS}: Environmental effects on the person×situation interaction for trait scores
E_{PI}: Environmental effects on the person×item interaction for trait scores
E: P×S×I;error effects.

The expected mean squares are reparametrised according to this model into genetic and environmental parameters.
The parameters for the genetic and environmental components (θ) can then be estimated with the aid of a weighted least squares regression analysis. There are two reasons for adopting the weighted least squares method: statistics based on relatively few observations play a smaller part in determining the final solution, and the method provides a statistical basis for deciding which discrepancies in the data are to be taken seriously and which are the result of sampling variation (Hays, 1988).

From the parameters for the genetic and environmental component we can estimate any desired reliability coefficient to obtain the value of the heritability of the variable as:

$$h^2_P = \frac{1}{2} D_P / (\frac{1}{2} D_P + E_P)$$

where P stands for person. The heritability of individual differences in interactions between the person and the situation can be computed as:

$$h^2_{PS} = \frac{1}{2} D_{PS} / (\frac{1}{2} D_{PS} + E_{PS})$$

(Eaves and Eysenck, 1976; Ozer, 1986; Hettema, 1989; McGraw and Wong, 1996).

6.5 Results

In this section we will present the results of the analyses. Because of the fact that the expectations of MS depend on the number of persons and observations, we will present four tables at every level of the model. The first Table will present the expectations of the mean squares for the model, the second Table will present the expectations of the relevant MS on basis of the ANOVA, the third Table presents reparametrised expectations, the combination from Table 1 and the first Table per level. The fourth Table presents the results of the regression analysis, the genetic and environmental components, and the heritability coefficient for dimensions and interactions. This order will persist over levels.

6.5.1 On the physiological level

ANOVA: Twinpairs × twinhalves × situations × scenes (N × 2 × 8 × 2).
In Table 6.2 the expectations of means squares are given.

Table 6.2: Expectations of MS in BMDP-V8 analysis, for physiological dimensions.

Films (S)	σ^2		$+2n\sigma^2_{SI}$	$+2\sigma^2_{St}$	$+4\sigma^2_{SP}$	$+4n\sigma^2_{S}$		
Twinpair (P)	σ^2	$+16\sigma^2_{PI}$		$+2\sigma^2_{St}$	$+4\sigma^2_{SP}$	$+16\sigma^2_{P}$	$+32\sigma^2_{t}$	
Twinhalve (t)	σ^2			$+2\sigma^2_{St}$				$+16\sigma^2_{t}$
Scenes (I)	σ^2	$+16\sigma^2_{PI}$	$+2n\sigma^2_{SI}$					$+16n^2_{i}$
S×P	σ^2			$+2\sigma^2_{St}$	$+4\sigma^2_{SP}$			
S×t	σ^2			$+2\sigma^2_{St}$				
S×I	σ^2		$+2n\sigma^2_{SI}$					
pooled P×I	σ^2	$+16\sigma^2_{PI}$						
pooled S×P×I	σ^2							

Components come from BMDP-V8 analysis of variance.

Table 6.3 presents results of the ANOVA in BMDP-V8, for the physiological dimensions, Familiarisation, Effort and Readiness. As expected most of the MS_{within} are larger for DZ than for MZ twins, and most of the $MS_{between}$ is larger for MZ than for DZ twins. This will result in a larger ICC for MZ then for DZ twins, which could be an indication for genetic effects. These results are found for the main effects as well as for the P×S-interaction effects.

Table 6.3: Mean squares of analysis of variance in BMDP-V8, for physiological dimensions.

source	df		Readiness		Effort		Familiarisation	
	MZ	DZ	MZ	DZ	MZ	DZ	MZ	DZ
Film (S)	7	7	4.334	4.506	8.368	5.198	4.135	2.582
Twinpairs (P)	55	36	8.732	7.352	3.817	1.809	3.220	3.037
Twinhalves(t)	56	37	4.152	3.791	1.625	2.159	1.652	1.788
Scene (I)	1	1	1.264	0.035	0.343	0.812	0.085	0.169
S×P	385	252	1.001	0.879	0.585	0.506	0.523	0.261
S×t	392	259	0.672	0.836	0.425	0.459	0.432	0.251
S×I	7	7	1.517	0.766	0.282	0.121	1.252	0.275
P×I	55	36	0.284	0.106	0.084	0.073	0.102	0.031
I×t	56	37	0.245	0.142	0.094	0.068	0.128	0.044
S×I×P	385	252	0.285	0.145	0.090	0.072	0.184	0.051
S×I×t	392	259	0.227	0.121	0.086	0.075	0.193	0.046
PI pooled	184		0.209		0.095		0.091	
SPI pooled	1288		0.201		0.081		0.013	

Table 6.4 represents the reparametrised expectations of the MS, used in the regression procedure to obtain the estimates (θ) from Table 6.3.

Table 6.4: Reparametrized expectations of the relevant Mean Squares for a simple genetic AE model.

MS	E	E_{PI}	E_{PS}	D_{PS}	E_P	D_P
MZB	1	16	2	2	16	16
DZB	1	16	2	1.5	16	12
MZW	1		2		16	
DZW	1		2	.5	16	4
S×MZB	1		2	2		
S×DZB	1		2	1.5		
S×MZW	1		2			
S×DZW	1		2	.5		
P×S	1	16				
P×F×S	1					

Abbreviations: P = person, F = film

Genetic parameters were specified for variation in Familiarisation (D_{Fam}), Effort (D_{Effort}) and Readiness (D_{Read}) and the person×film interactions (D_{PSF}, D_{PSE} , D_{PSRead}). Environmental parameters were specified for the variation in Familiarisation (E_{Fam}), Effort (E_{Effort}), and Readiness (E_{Read}) and the interaction of person×film (E_{PSF}, E_{PSE}, E_{PSRead}), person × scene (E_{PRF}, E_{PRE} , E_{PRRead}) and error E.

From these components, the heritability coefficient of the dimensions is computed as

$$\frac{1}{2} D_P \,/\, (\frac{1}{2} D_P + E_P)$$

for Familiarisation, Effort and Readiness. The heritability of individual differences in person-situation interactions is computed as

$$\frac{1}{2} D_{PS} \,/ (\frac{1}{2} D_{PS} + E_{PS})$$

Table 6.5: Estimates of genetic and environmental components (θ), for physiological dimensions.

Parameter	θReadiness	θEffort	θFamiliarisation
D_P	.572	.212	.106
E_P	.183	.073	.071
$D_{p\times s}$	.148	.015	.075
$E_{p\times s}$	.252	.141	.166
$E_{p\times i}$	.044	.011	.033
E	.193	.129	.089
h^2 P	.61	.59	.43
h^2 interaction	.23	.05	.19

6.5.2 The learning level

ANOVA: Twins × twin halves × situations × items (N×2×30×4)
The expected means squares are given in Table 6.6

Table 6.6: Expectations of MS in BMDP-V8 analysis, for Delta-goals.

Films (S)	σ^2		$+2n\sigma^2_{SI}$	$+4\sigma^2_{ST}$	$+8^2_{SP}$	$+8n\sigma^2_S$		
Twinpair (P)	σ^2	$+60\sigma^2_{PI}$		$+4\sigma^2_{ST}$	$+8\sigma^2_{SP}$	$+120\sigma^2_T$	$+240\sigma^2_P$	
Twinhalve (t)	σ^2			$+4\sigma^2_{ST}$		$+120\sigma^2_T$		
Items (I)	σ^2	$+60\sigma^2_{PI}$	$+2n\sigma^2_{SI}$					$+60n\sigma^2_I$
S×P	σ^2			$+4\sigma^2_{ST}$	$+8\sigma^2_{SP}$			
S×t	σ^2			$+4\sigma^2_{ST}$				
S×I	σ^2		$+2n\sigma^2_{SI}$					
pooled P×I	σ^2	$+60\sigma^2_{PI}$						
pooled S×P×I	σ^2							

Components come from BMDP-V8 analysis of variance.

The mean squares for D-soccont, D-control, D-agency, D-proximity, D-know, and D-preparation are given in Table 6.7.

Table 6.7: MS for delta-goals.

source	df		D-S		D-C		D-A		D-P		D-K		D-iP	
	mz	dz	mz	dz	mz	dz	mz	dz	mz	dz	mz	dz	mz	dz
Situation (S)	29	29	90.84	82.73	61.86	41.31	77.51	52.09	157.72	102.7	79.09	56.43	22.55	18.63
Twinpairs (P)	56	42	17.43	16.87	24.35	21.91	23.79	22.30	37.12	26.84	31.43	27.86	34.45	26.25
Twinhalves(t)	57	43	8.99	8.25	9.23	13.49	11.39	12.50	10.43	15.40	12.42	12.71	12.06	14.95
Item (I)	3	3	906.35	831.57	812.62	626.29	419.13	216.2	402.88	289.7	753.67	747.6	390.64	388.78
S×P	1624	1218	1.96	1.78	1.40	1.32	1.45	1.35	2.06	1.75	1.66	1.53	1.17	1.02
S×t	1653	1247	1.17	1.19	1.06	1.11	1.08	0.96	1.28	1.22	1.09	1.17	0.96	1.06
S×I	87	87	18.94	13.04	34.62	22.20	56.72	39.48	23.08	16.39	36.03	26.81	78.15	67.23
P×I	168	126	3.97	3.92	8.10	6.64	6.42	5.58	6.52	6.62	5.59	6.25	4.21	4.11
I×t	171	129	2.39	3.22	4.23	4.94	2.73	3.87	3.46	3.71	3.25	3.75	2.50	2.14
S×I×P	4872	3654	0.78	0.73	1.21	1.12	1.25	1.20	0.75	0.72	0.99	0.94	1.12	0.99
S×I×t	4959	3741	0.64	0.63	0.91	0.93	.96	0.96	0.60	0.64	0.78	0.82	0.87	0.89
PI pooled	594		3.37		5.97		4.65		5.07		4.71		3.24	
SPI pooled	17226		6.7		10.4		1.09		.67		.88		.96	

The results of reparametrising mean squares in terms of the genetic model are presented in Table 6.8.

Table 6.8: Reparametrized Expectations of the relevant Mean Squares for a simple genetic AE model.

MS	E	E_{PS}	E_{PR}	D_{PS}	E_P	D_P
MZP	1	60	4	4	120	120
DZP	1	60	4	3	120	90
MZT	1		4		120	
DZT	1		4	1	120	40
S×MZP	1		4	4		
S×DZP	1		4	3		
S×MZT	1		4			
S×DZT	1		4	1		
P×S	1	60				
P×I×S	1					

Abbreviations: I=items, see Table 6.4

The results of the regression analysis to obtain the parameters for θ are given in Table 6.9.

Table 6.9: Estimates of genetic and environmental components for delta goals (θ).

Parameter	D-socc	D-control	D-agency	D-prox	D-know	D-general
D_P	.051	.052	.075	.140	.131	.165
E_P	.059	.092	.082	.092	.082	.080
$D_{p\times s}$	.021	.097	.162	.162	.152	.043
$E_{p\times s}$	.018	.023	.112	.112	.047	.022
$E_{p\times i}$	.041	.081	.075	.075	.068	.038
E	1.038	1.088	1.088	.667	.877	.959
h^2 P	.29	.26	.32	.43	.45	.49
h^2 interaction	.36	.67	.42	.42	.62	.49

Abbreviations: D-socc = D-social control, D-prox = D-proximity, D-know = D-knowledge and D-genral = D-general preparation

6.5.3 The competence level

ANOVA: twin × twin halve × situation × items (N×2×8×6)
The expected mean squares are given in Table 6.10.

Table 6.10: Expectations of MS in BMDP-V8 analysis, for competences.

Films (S)	σ^2		$+2n\sigma^2_{SI}$	$+6\sigma^2_{ST}$	$+12\sigma^2_{SP}$	$+516\sigma^2_{S}$		
Twinpair (P)	σ^2	$+60\sigma^2_{PI}$		$+6\sigma^2_{ST}$	$+12\sigma^2_{SP}$	$+180\sigma^2_{T}$	$+12N\sigma^2_{P}$	
Twinhalve (t)	σ^2			$+6\sigma^2_{ST}$		$+180\sigma^2_{T}$		
Items (I)	σ^2	$+60\sigma^2_{PI}$	$+2n\sigma^2_{SI}$					$+60n\sigma^2_{I}$
S×P	σ^2			$+6\sigma^2_{ST}$	$+12\sigma^2_{SP}$			
S×T	σ^2			$+6\sigma^2_{ST}$				
S×I	σ^2		$+2n\sigma^2_{SI}$					
pooled P×I	σ^2	$+60\sigma^2_{PI}$						
pooled P×S×I	σ^2							

Components come from BMDP-V8 analysis of variance.

The mean squares for mental, social, physical and instrumental competences are given in Table 6.11.

Table 6.11: Expected mean squares for competences, according to BMDP-V8.

source	df		C-S		C-F		C-M		C-I	
	mz	dz	mz	dz	mz	dz	mz	dz	mz	dz
Situation (S)	29	29	29.54	41.96	39.72	25.76	58.48	32.81	73.03	56.21
Twinpairs (P)	56	42	36.13	26.74	34.04	29.14	35.68	27.50	27.12	19.81
Twinhalves(t)	57	43	14.82	14.43	12.49	12.63	11.88	21.26	11.70	10.57
Item (I)	5	5	399.66	256.89	912.67	1171.69	348.64	589.67	639.36	929.17
S×P	1624	1218	1.67	1.49	1.01	0.97	2.01	1.39	1.38	1.23
S×t	1653	1247	1.18	1.47	.79	0.82	1.43	1.08	1.15	1.05
S×I	145	145	19.56	33.55	42.28	28.71	44.23	20.17	42.78	30.74
P×I	280	210	12.77	8.05	13.85	12.27	8.82	6.60	5.15	4.54
I×t	285	215	6.01	4.20	5.84	5.79	3.37	5.81	3.39	3.28
S×I×P	8120	6090	1.02	1.04	1.02	.95	1.13	.89	1.12	1.04
S×I×t	8265	6235	.73	.87	.75	.75	.85	.71	.83	.87
PI pooled	985		7.71		9.43		6.15		4.09	
SPI pooled	28710		.88		.87		0.89		.96	

The results of reparametrising mean squares in terms of the genetic model are presented in Table 6.12.

Table 6.12: Reparametrized expectations of the relevant Mean Squares for a simple genetic AE model, for competences.

MS	E	E_{PS}	E_{PR}	D_{PS}	E_P	D_P
MZP	1	60	6	6	180	180
DZP	1	60	6	4.5	180	135
MZT	1		6		180	
DZT	1		6	.5	180	45
S×MZP	1		6	6		
S×DZP	1		6	4.5		
S×MZT	1		6			
S×DZT	1		6	.5		
P×S	1	60				
P×I×S	1					

The results of the regression analysis to obtain the parameters for θ are given in Table 6.13.

Table 6.13: Estimates of genetic and environmental components for competences (θ).

Parameter	C-mental	C-social	C-physical	C-instrumental
D_P	.086	.077	.073	.067
E_P	.068	.065	.058	.058
$D_{p\times s}$	.095	.063	.095	.095
$E_{p\times s}$	.059	.065	.059	.059
$E_{p\times i}$	.086	.114	.143	.143
E	.893	.880	.870	.870
h^2 P	.37	.39	.38	.40
h^2 interaction	.32	.44	.37	.51

6.5.4 The trait level

ANOVA: twin × twin halve × situation × item (N×2×30×3)
The expected means squares for traits at given in Table 6.14

Table 6.14: Expectations of MS in BMDP-V8 analysis, for Personality traits.

Films (S)	σ^2		$+2n\sigma^2_{SI}$	$+3\sigma^2_{ST}$	$+6\sigma^2_{SP}$	$+342\sigma^2_{S}$		
Twinpair (P)	σ^2	$+60\sigma^2_{PI}$		$+3\sigma^2_{ST}$	$+6\sigma^2_{SP}$	$+90\sigma^2_{T}$	$+180\sigma^2_{P}$	
Twinhalve (T)	σ^2			$+3\sigma^2_{ST}$		$+90\sigma^2_{T}$		
Items (I)	σ^2	$+60\sigma^2_{PI}$	$+2n\sigma^2_{SI}$					$+60n\sigma^2_{I}$
S×P	σ^2			$+3\sigma^2_{ST}$	$+6\sigma^2_{SP}$			
S×T	σ^2			$+3\sigma^2_{ST}$				
S×I	σ^2		$+2n\sigma^2_{SI}$					
pooled P×I	σ^2	$+60\sigma^2_{PI}$						
pooled P×S×I	σ^2							

Components come from BMDP-V8 analysis of variance.

The mean squares for Extraversion, Neuroticism, Agreeableness, Conscientiousness, and Openness to experience are given in Table 6.15.

Table 6.15: Expected mean squares for personality traits.

source	df		T-E		T-A		T-C		T-N		T-O	
	mz	dz	mz	dz	mz	dz	mz	dz	mz	dz	mz	dz
Situation (S)	29	29	120.26	83.56	105.68	84.66	57.73	48.42	132.0	87.8	11.00	8.71
Twinpairs (P)	56	42	83.11	48.87	45.80	29.60	65.38	48.02	82.3	71.6	47.39	32.17
Twinhalves(t)	57	43	29.46	30.31	15.98	16.25	16.38	29.28	33.0	39.5	15.26	15.38
Item (I)	2	2	414.84	487.80	690.05	627.12	933.22	564.44	652.3	584.6	259.11	206.15
S×P	1624	1218	4.72	4.21	3.83	3.00	2.83	2.71	4.8	4.3	1.93	1.86
S×t	1653	1247	3.70	3.54	2.19	2.25	2.21	2.20	3.6	3.7	1.59	1.64
S×I	58	58	14.16	8.51	25.01	19.04	10.73	9.06	33.4	19.9	19.19	12.45
P×I	112	84	17.89	11.07	19.71	18.95	14.74	14.39	22.7	18.4	17.02	16.99
I×t	114	86	8.01	9.06	10.84	8.95	9.56	8.92	11.9	12.1	7.21	6.60
S×I×P	3248	2436	2.07	2.07	1.98	1.83	1.70	1.54	2.1	2.0	1.65	1.40
S×I×t	3306	2494	1.70	1.71	1.42	1.42	1.41	1.35	1.6	1.6	1.25	1.13
PI pooled	396		11.50		14.61		12.23		16.23		11.88	
SPI pooled	11880		1.89		1.66		1.50		1.83		1.35	

The results of reparametrizing mean squares in terms of the genetic model are presented in Table 6.16.

Table 6.16: Reparametrized expectations of the relevant Mean Squares for a simple genetic AE model, for personality traits.

MS	E	E_{RI}	E_{RS}	D_{RS}	E_{TREK}	D_{TREK}
MZR	1	60	3	3	90	90
DZR	1	60	3	2.25	90	67.5
MZT	1		3		90	
DZT	1		3	.75	90	22.5
S×MZR	1		3	3		
S×DZR	1		3	2.25		
S×MZT	1		3			
S×DZT	1		3	.75		
P×I	1	60				
P×S×I	1					

The results of the regression analysis to obtain the parameters for θ are given in Table 6.17.

Table 6.17: Estimates of Genetic and Environmental Components for personality traits (θ).

Parameter	Extraversion	Agreeableness	Neuroticism	Conscientiousness	Openness
D_P	.438	.143	.375	.382	.221
E_P	.230	.131	.317	.167	.124
$D_{p\times s}$	.325	.539	.400	.226	.119
$E_{p\times s}$	.581	.123	.562	.217	.076
$E_{p\times i}$	.155	.175	.240	.175	.174
E	1.90	1.66	1.83	1.51	1.35
h^2 P	.49	.37	.53	.36	.48
h^2 interaction	.41	.26	.34	.34	.33

6.6 Discussion

6.6.1 Genetic and environmental effects on P and P×S-interactions

One of the assumptions of quantitative genetic research is the demand of absense of gene-environment interactions and correlations (Plomin, DeFries, and McClearn, 1990; Loehlin, 1992). However, recent evidence of behavioural genetic studies have raised important questions about the relationship between genes and environment (Barinaga, 1994). There are strong indications that genetic individuality renders people differentially sensitive to the effects of life events. It leads individuals to seek environmental niches within which to behaviourally express their genetic dispositions. The question behaviour genetics will have to study in future research will not be wether genes matter, but how genetic effects and the environment interact (Rose, 1995). According to Rose about half the variance of every trait under study can be explained by genetic effects. But genes do not excert their influence directly but largely indirectly through gene-environment interactions and correlations. In this chapter the nature of the relation between genetic effects on behaviour and the demands of the environment is studied.

To understand the nature of behavioural inconsistency over situations we used a statistical method originally used by Eaves and Eysenck (1976), and extended the method to our data and the response specificity approach. The two-way P×S-interaction is treated as influenced by genetic effects, and therefore not as a form of error, but as a personality variable in its own right.

The relation between MRS and IRS on the one hand and genetic and environmental effects on the other is explained by reparametrising the expected mean squares for MZ and DZ groups from the ANOVA in parameters of a simple genetic model.

The data indicate genetic influences explaining a large part of the systematic variance of all main effects for P. Since we used the main effect on P as a measure for IRS, we can say that IRS is partly influenced by genetic factors (Fahrenberg, 1986; Stemmler, Grossman, Schmidt, and Foerster, 1991). This finding is not new or very exciting because IRS is a measure for behavioural traits in the classical view of a persisting characteristic of dimension of personality that can be used as an explanation of observed regularities and consistencies in behaviour (Reber, 1989). And as stated above, between 40 and 50% of the variance of every trait under study can be explained by genetic effects (Loehlin, 1992; Rose, 1995).

For MRS, the subjective interpretation and appraisal of a standardized stimulus situation, rather than the individual or the stimulus situation per se (Ax, 1964), we found significant genetic effects in our data. The part of the systematic variance of P×S interactions, explained by genetic influences varies between 10% for Effort and 67% for D-control. These results provide evidence of genetic influences on the person × situation interaction.The results presented here indicate that there is not a simple general personality factor structure, that reflects a nomothetic organisation of traits. The results indicate that at least part of individuality is idiosyncratic, making the person, not the trait, the object of study. At each level of the model individuals have a uniquely structured behavioural repertoire for responding to several kinds of situations.

The idiosyncratic way people react to the situation can be explained by features of the situation and features of the person, which depend on a person's genotype. Genetic individuality renders people differentially sensitive to the effects of life events. It leads individuals to seek environmental niches within which to behaviourally express their genetic dispositions (Barinaga, 1994; Scarr and McCartney, 1983).

As P×S-interactions reflect genetic influences they are a behavioural class of their own. The results of this study indicate that there are at least two ways to relate genetic effects to situations. First people choose the situation that fits their needs best, as according to the theory of McVicker-Hunt (1981) and Scarr and McCartney (1983). This is the case when people actively seek an environment (as when applying for a job) and a case of active gene-environment correlations. Secondly when there is no choice of situation, which is a much found phenomenon in daily life, some situations trigger behaviour that is 'genetically relevant' more then other situations, as shown in the person-situation interaction effects. People search for environments that do credit to their innate needs, but not all environments trigger the preferred behaviour.

6.6.2 Conclusions

Our results yielded strong support for a genetic basis for individual differences in situation specific responding for all variables at all levels of the Zuckerman model. Furthermore the results support the view of Phillips and Matheny (1997) when they assume that the existence of genetically based situation specific behaviour along with the unequivocal indication of gentically based individual differences in general traits suggest that variable organisations of personality are distinct possibilities.

What do these findings learn about the Zuckerman model?
A distinction between the physiological dimensions and variables at the other levels is found. The interaction between a person and the environment on the physiological level is only to a small extent influenced by genetic effects. At the other levels, the interaction effects reveal the largest genetic effects, the heritability coefficients of the interaction trait generally exceed the heritability coefficients of the general traits. But no difference was found between the heritabiltiy coefficients on the so-called 'social' levels.
Hypothesis 6 is only partly confirmed. The results are in line with earlier results, the differentiation between heritability coefficients is found between the physiological level and the other levels, learning, social behaviour and traits.

7 Summary and general discussion

7.1 Introduction

Personality psychology is a diverse field: Different paradigms exist next to each other. Two major approaches to personality are the biological versus the social approach. The use of the word versus is a reflection of the fact that, until very recently, the biological and social study of personality seemed to be mutually exclusive. And although throughout the history of psychology many distinctive personality psychologists have argued for the integration of both forms of psychology, the study of both approaches within one paradigm is still not common practice.

Integration of theories and research paradigms, known as scientific pluralism, can be very problematic, but restricting the search for explanations of personality to one paradigm is like voluntarily putting blinkers on. In the end it will only hamper the progression of the field of personality research. Only if more fields of research are combined one can start to integrate theories and take new and different coherences into consideration. This is always a difficult exercise. It is very hard to do full credit to every field of research that is employed in a new model. This kind of multi-field research is prone to criticism and mistakes. But it also makes scientific life very exciting.

This thesis deals with Zuckerman's 'Seven Turtles'-personality model (Zuckerman, 1992, 1993). This model integrates biological and social aspects of personality within one framework by introducing a series of levels between genes on the basis of personality and traits at the top. Jumping directly from genes to personality traits was assumed to be inappropriate. Zuckerman followed a different strategy, he introduced a series of levels between genes and traits. Traits were defined as the ultimate product of processes on the levels of genetics, neurology, biochemistry, physiology, learning, and social behaviour. In this thesis the results of a test of this model are described. Not all levels were taken into account, neurology and biochemistry were not included in the study. Because every level represents an extensive field of research within psychology, choices had to be made about which variables should be taken to represent different levels.

Traits

The Big Five personality traits were taken as variables to represent the trait level. Traits are labelled 'Extraversion', 'Neuroticism', 'Agreeableness', 'Conscientiousness' and 'Openness to experience' (sometimes called culture or intellect) (Costa and McCrae, 1992).

Social behaviour

Behavioural competences were chosen as variables to represent the level of social behaviour. Competences are a person's potentials for behaviour, including crystallized knowledge. Competences stand for what people can do rather than what they actually do (Mischel, 1973). Mental, social, physical, and instrumental competences were taken as variables to measure the level of social behaviour.

Learning

On the learning level operants were chosen. Operants are behavioural aspects that can be characterised in terms of effects of topical behaviour on the environment. Operants are associated with primary control. Hettema and Hol (1998) proposed Delta-goals as behavioural categories to represent operants. D-goals used to operationalize the learning level were D-social control, D-control, D-knowledge, D-agency, D-proximity and D-preparation.

Physiology

At the physiological level functional dimensions of autonomic measures (heart rate and related cardiac measures, blood pressure, and galvanic skin level) were introduced as representatives of information processing systems (Hettema, Leidelmeijer, and Geenen, 1999; Pribram and McGuiness, 1975, 1992). These dimensions were:

Familiarisation, associated with input control and a dissociation of the cardiovascular measures and the galvanic skin level.

Effort, is a process under voluntary control with the capacity to break up the connection between Familiarisation and Readiness. Effort is characterised by a dissociation of heart rate and blood pressure.
Readiness, associated with output control, is characterised by a covariation of cardio-vascular and galvanic skin level measures.

Genetics

When Zuckerman's model is put to the test different approaches are possible all having their pros and cons. One possibility is to put emphasis on the multilevel characteristics of the model. An other approach is to put emphasis on the genetic characteristics of the model. Because the first aim of this project was to integrate biological and social aspects into one personality model, we had a strong preference for the genetic approach.
A twin study was designed that included measures at every level, within one group of subjects. Within this twin approach different genetic analyses were done. Univariate analyses were carried out to measure the genetic and environmental effects on single variables at every level. This was necessary because no literature was available about these effects on variables at the levels social behaviour and learning. At the physiological level the single cardiovascular measures are well studied, but the functional dimensions derived from these single variables have never been subject of a genetic study before. Results of univariate genetic analyses on single variables revealed heritability coefficients that support the results of previous research (Turner and Hewitt, 1989). The heritability coefficient of the functional dimension scores were much higher, 80% of the variance could be attributed to additive genetic effects.
Results of the quantitative genetic analysis on the trait level revealed heritability coefficients that are in agreement with other studies (Loehlin, 1992).
The fact that genetic factors contribute to the variance of variables at all levels raises the possibility that the association between levels might be mediated by the same genetic factors (Plomin, 1994). A multivariate genetic approach was used to study the common genetic and common environmental basis of interlevel relationships. And finally a person-situation interactional approach was chosen to study the genetic and environmental effects on situation specific measures. Here attention is paid to the processes by which the environment is translated into development. The interactional model emphasizes the active selection,

modification and structuration of the environment. Plomin and coworkers defined the genetically based interactive relation between the actor and the environment as gene-environment correlations (Plomin, DeFries, and Loehlin, 1977).
In the next section the results of the study will be summarised on the basis of the six hypotheses derived from Zuckerman's model.

7.2 Overview of the main results of the study

1. Variables at the higher levels can be predicted by variables on lower levels.

To test hypothesis 1 a multivariate regression analysis was carried out. When the more distal levels are necessary for behaviour at the more proximal levels to occur, then it should be possible to predict behaviour at these proximal levels from scores of behaviour at the more distal levels. Significant multiple correlation coefficients (R) indicated that traits could be predicted on the basis of social behaviour, learning and physiology. Not all single variables contributed significantly to the predictive value of lower level variables on trait scores. No single variable contributed significantly to a person's score on Neuroticism.

2. Variables at the adjacent levels do contribute more to this predictive value than variables at the more remote levels.

The results of the multivariate regression analysis did not confirm this hypothesis. A regression analysis at every level apart did not reveal that behaviour at more adjacent levels contributed more to variability in trait behaviour than variables at the more remote levels. D-goals and competences were highly related, although they are measured independently, variables at both levels were highly correlated.

3. Behaviour at all levels will reveal genetic effects.

One of the basic assumptions of the model is the genetic basis of personality. Behaviour on all levels should be rooted in the genotype. In chapter 4 this genetic basis was studied. At all levels genetic effects were found. The heritability coefficients for the physiological dimensions were high. Approximately 80% of the variance could be attributed to differences in individual genotypes. For D-goals a mean heritability coefficient of .45 was found. The D-goal concept has never been object of genetic studies yet, so it is not possible to compare this result with other studies. But 45% of the total variance due to genetic effects is not extraordinary for personality measures. For competences a mean heritability coefficient of .49 was found, almost half the variance can be attributed to individual differences in genotypes. For traits also a mean heritability coefficient of .49 was found, almost half the variance can be explained by differences in the genotype. This is in agreement with earlier findings (Loehlin, 1992; Bouchard, 1993).

4. Genetic effects are largest at the lower levels and will decrease with level. At every level the environment has its own effects and these effects will increase with increasing level.

Our data could only partly confirm this hypothesis. The heritability coefficients were high for the physiological variables. The heritability coefficients of variables at the other levels were all in the same range. This could be an effect of the measurement mode. Physiological variables were measured directly, while subjects were watching a film. The other variables were measured with the aid of SR-questionnaires. Questionnaire based research is more prone to social desirability effects and other inferences. On the other hand no strong linkage between the physiological dimensions and variables at the other levels was found before. So it is also possible that this split can be explained by the lack of coherence between the concepts we used to operationalize the different levels of the model. Finally there are reasons to assume that the relation between levels are not only linear. On the basis of information processing theory it can be reasoned that distinct forms of information processing, as revealed by different autonomic dimensions, lead to distinct types of output processes and in doing so it violates the assumption of linearity. From a genetic point of view it is argued that genetic and environmental effects at all levels are not direct, but mediated by different genotype-environment processes. The occurrence of correlations and interactions between genotype and environment violate the assumption that relations between levels are linear (Plomin, 1994; Riemann, Angleitner, Borkenau, and Eid, 1998).

5. The same genetic components are at the basis of behaviour at all levels.

This hypothesis was confirmed. With the aid of a multivariate genetic analysis the genetic and environmental relations between all levels can be studied. Testing this hypothesis, we found strong indications of the usefulness of this approach to gain a better understanding of the etiology of individual differences in behaviour. Four submodels of Zuckerman's model were studied with the aid of an independent pathway genetic model. This model demonstrates that variables at different levels load on the same genetic and environmental factor(s) and are influenced, every variable apart, by unique genetic and environmental factors. For three out of four submodels a common genetic and environmental basis for variables at all levels could be demonstrated. Variables on the physiological level did not share much common variance. This is in agreement with the results of chapter 3, where we did not find a strong relation between the physiological and other levels. But the part of the variance that was shared could to a large extent be explained as common genetic variance. The variables at the levels learning (D-goals) and social behaviour (competences) were almost completely defined by common variance. This could be (partly) the result of the measurement method. Both variables were measured with the same questionnaire. Traits were effected by common genetic and environmental factors as well as specific genetic and environmental factors.

6. Genotype-environment interactions will become stronger with increasing level.

This hypothesis is also partly confirmed. For variables at the physiological level the proportion variance explained by genetic effects is larger for main effects then for person × situation interaction effects. Variables at the other levels showed larger proportions genetically based variance on the interaction effects than on the main effects. Otherwise we could not differentiate between these levels.

7.3 Implications of these results for Zuckerman's model and future research

7.3.1 Test everything and hold fast to what is good

Zuckerman's model could not be confirmed in the most restrictive sense. Then according to good scientific practice there are two possible strategies, the model can be rejected, or the model can be modified.

Should Zuckerman's model be rejected at the basis of our research or should it be modified to stimulate future research? From the above (section 7.2) it can be concluded that too many hypothesis are confirmed or partly confirmed to justify the unsparing rejection of the model. Multilevel models can be used as an integrative framework for personality psychology. Although not all hypotheses could be confirmed, some strong indications were found to justify this conclusion. The coherence between variables at different levels of the multilevel model and the biological basis of the different levels is demonstrated in multiple ways. Different statistical approaches to the data revealed to a great extent consistent results.

Biological and social processes at different levels revealed to be important and interrelated features of personality. The importance of the role of genotype-environment relations in the integration of biological and social processes is elucidated. These results are in line with new and promising research paradigms. Current environmental and interactional theories are moving towards a nature-nurture approach and behaviour genetics. Bronnenfenner and Ceci (1993) propose new environmental theories that include genetic and physiological factors. The basic assumption of their theory is that human development is based on the complex, reciprocal interaction between bio-psychological processes and objects and symbols in the immediate environment, referred to as proximal processes. Behaviour genetics are moving to a new, more situation specific approach of the environment, where research on the effects of global past and present environmental influences is extended with research where the emphasis is on more specific environments (Plomin, 1994). The development of more extended multivariate statistical models, and the greater accessibility of the relevant statistical packages, makes this kind of research more accessible for scientists in different fields of personality research. The last years, an increase of multivariate research on genetics of environmental measures can be observed (Kendler,

Kessler, Walters, McCleane, Neale, Heath, and Eaves, 1995; Neale and Cardon, 1992; Petrill and Thompson, 1993; Plomin, 1994; Riemann, Angleitner, Borkenau, and Eid, 1998; Spinath, Riemann, Hempel, Schlangen, Weiß, Borkenau, and Angleitner, 1998). A multilevel approach to personality that includes aspects of the environment fits in this new research line. The study of Zuckerman's model is an attempt to study personality in this new evolving tradition. As a first test it is without doubt too successful to reject the model.
When the model is not to be rejected on the basis of the above, then it should be modified to stimulate future research. Two important outcomes have to be taken into consideration. First there is the apparent lack of linear connections between the physiological level variables and variables at the other levels. The consequences of this result for Zuckerman's model will be discussed in section 7.3.2. Second the levels of learning, social behaviour and traits do not differentiate as predicted. Genetic and environmental effects on the trait as well as on the interaction between person and situation are all in the same range. The implications of these results for future research on multilevel models of personality will be discussed in section 7.3.3.

7.3.2 Redefinition of interlevel connections

At every level variables are chosen that relate to an important paradigm, or theory, within psychology. At the physiological level functional dimensions, related to information processing systems, are computed with the aid of single autonomic variables. Individual differences in these dimensions, Familiarisation, Effort and Readiness, proved to a high degree heritable (Chapter 5). The fact that dimension scores reveal higher heritability coefficients than single variables can be taken as a hint for the physiological functionality of the different covariations and dissociations of autonomic processes. These results second again the old advise of Lacey (1967) to take functional units instead of single variables as object of measurement. The results also fall in with the assumption of Turner and Hewitt (1992) that functional units are better candidates for a genetic approach then single physiological variables. From the above it can be concluded that autonomic dimension scores are fit to represent the physiological level.

Yet, physiological dimension scores could only be connected to variables on the other levels to a very small extent, although this association itself was to a large extent genetically based.

In most personality models that include physiological processes, a linear connection is assumed between physiology and traits (Eysenck, 1993; Eysenck, 1982; Gray, 1991; Zuckerman, 1992). Zuckerman himself related levels of neural enzymes on levels of depression in a unidimensional linear way. For instance, high levels of mono amino oxidases (MAO) are linearly related to major depressive disorder. Eysenck's theory on the association between arousability and the development of Extraversion, and Gray's theory on arousability and emotions also assume linear relations between traits variables and physiological measures. However, the classical models are not without problems. A review of different studies on both theories did not impressively support one of them (Matthews and Gilliland, 1999).

More recent research gives some useful indications of non linear relations between genotype, biological processes and social behaviour. Hettema and coworkers (Hettema, Leidelmeijer, and Geenen, 1999) emphasise information processing systems as functional features of autonomic processes. They argue that information processing dimensions mediate between the genotype and the environment by moderating the influence of the environment. Learning and information processing are intimately connected. Not all environmental aspects have a profound influence on behaviour or learning. Not every individual learns the same things from a given situation (Scarr and McCartney, 1983). People with a preference for Familiarisation will learn different things from a situation than people with a preference for Effort or Readiness. This means that the process of learning is a complex interaction between genotype, physiology and the environment. These processes are to be conceived as too complex to be reflected in a simple linear relationship between the physiological and learning level.

A second indication comes from research on Eysenck's arousal theory. According to Eysenck's theory, arousal is inversely related to levels of Extraversion. Experimental research on performance reveals a curvelinear relation between performance and arousal, whether the performance is on a sensory, motor or cognitive level. Moreover the link between arousal, personality and performance depends on environmental external conditions, making the relation between

biological variables and social behaviour non-linear (Gruzelier and Mecacci, 1992).
In future research it would be considered opportune to take into account different non-linear relationships to study interlevel relations.

7.3.3 Modification of the research methods

Earlier we explored the idea that the lack of differentiation in genetic and environmental influences between variables at the social levels should be the consequence of different measurement modalities. At the physiological level all variables are measured directly. Subjects are watching motion pictures, and their autonomic reactivity to different situations is measured simultaneously.
Variables at the other levels are studied with the aid of an S-R-questionnaire and consequently by self ratings. The fact that learning, social behaviour and traits are measured within just one modality, the S-R questionnaire, can be the reason that no differentiation between genetic and environmental effects at different levels is found. When questionnaires are used to measure D-goals, competences and traits, what is really measured are cognitions and attitudes of the subject towards behaviour in certain situations. From psychological research on cognitions and attitudes, it is known that they are not reliable predictors of real life behaviour (Petty and Cacioppo, 1981). For instance how many women will admit that they will physically attack someone in a situation that only exists in a questionnaire? When it is concluded that not behaviour per se but cognitions about behaviour are measured, this must have implication for research.
In future research measurement modes that fit the behavioural level should be taken into account. When traits are measured, peer ratings and parental ratings could be compared to selfratings (Bouchard, 1993; Hoffman, 1991; Riemann, Angleitner, and Strelau, 1996). D-goals and Competences could be measured with an observational study design (Hol, 1994). Hettema and Hol (1998) compared the results of a self report and an observational study design on D-goals, and found that D-goals could be measured very reliable with an observational study design. Spinath and coworkers (1998) also used an observational design to study the sources of individual differences in temperament and personality. Twins were

separately confronted with identical tasks. The first results of this study are very promising (Riemann, et. al., 1998).

7.4 Epilogue

The starting point of this research was the notion that man is a biosocial creature. The biological and social approach have long been two separate and mutually exclusive ways to study personality and individual differences. Knowledge of the biological causes of behaviour is growing fast. Research results from different fields like medicine, neurology, physiology, and behavioural genetics, contribute to our knowledge of the biological basis of personality. Time seems right for the giant seesaw of Chapter 1 to skip to the biological side. The study of multilevel personality models that include biological as well as social aspects of behaviour into one integrated framework of personality is a strategy to keep the seesaw in equilibrium and to integrate biological as well as social causes of personality and individual differences. Zuckerman's multilevel model is a prommissing approach in that direction.

Samenvatting

Een van de oudste en meest persistente debatten in de geschiedenis van de psychologie is het nature-nurture debat. In dit debat gaat het om de discussie met betrekking tot de relatieve bijdrage van biologische- versus omgevingsfactoren aan het ontstaan van eigenschappen van het individu (Reber, 1988). Lange tijd zijn biologische verklaringen voor persoonlijkheid en het ontstaan van individuele verschillen afgezet tegen sociale verklaringen. Binnen de nature-nurture discussie worden biologische en sociale theorieën vaak benaderd alsof het om elkaar wederzijds uitsluitende verklaringen voor individuele verschillen gaat. Hoewel de verklaringsgronden van beide benaderingen sterk verschillen proberen beiden hetzelfde object te verklaren, namelijk de persoonlijkheid. Het feit dat beide wetenschappelijke stromingen met verschillende verklaringen voor gedrag komen, wil niet zeggen dat slechts een van beide verklaringen de enige juiste kan zijn. Daarvoor is persoonlijkheid een te complex fenomeen; er dient zich niet direct een eenduidige benadering aan in de vorm van een simpel reductionistisch model. Waar persoonlijkheidspsychologen wel naar streven is om te komen tot modellen waarmee de complexiteit van het fenomeen 'Persoonlijkheid' zo goed mogelijk wordt verklaard. Op dit moment ontstaat er bij persoonlijkheidsonderzoekers dan ook steeds meer behoefte aan geïntegreerde theorieën die recht doen aan het feit dat de mens zowel een biologisch als een sociaal wezen is. Geïntegreerde theorieën formuleren persoonlijkheidsmodellen die uitgaan van de assumptie dat menselijk gedrag meervoudig gedetemineerd is, waarbij zowel biologische als sociale factoren ten grondslag liggen aan persoonlijkheid en gedrag. Persoonlijkheidsmodellen die zowel sociale als biologische theorieën in zich verenigen worden ook wel biosociale persoonlijkheidsmodellen genoemd.
In hoofdstuk 1 wordt tegen de achtergrond van de nature-nurture discussie het biosociaal persoonlijkheidsmodel van Zuckerman (1992, 1993) uiteen gezet. In dit model wordt persoonlijkheid gedefinieerd op meerdere lagen of verklarings-

niveaus. Zuckerman positioneert genen aan het ene eind van het persoonlijkheidsspectrum en persoonlijkheidstrekken aan het andere eind. Daartussen definieert hij vijf noodzakelijke persoonlijkheidsniveaus, te weten neurologie, biochemie, fysiologie, leerprocessen en sociaal gedrag.
Het doel van dit proefschrift is om de mogelijkheden te onderzoeken van Zuckerman's model als framework voor onderzoek naar biosociale modellen. In voorliggend onderzoek zijn de volgende lagen van het Zuckerman model onderzocht:

Trekken
Sociaal gedrag
Leren
Fysiologische processen
Genotype

Tijdens het opzetten van het onderzoek blijkt het niet mogelijk te zijn alle niveaus in één onderzoeksdesign te operationaliseren. De biologische niveaus neurologie en biochemie zijn daarom niet in het onderzoek opgenomen.
In hoofdstuk 1 wordt op beknopte wijze inzicht gegeven in het Zuckerman-model. Vier assumpties van het model worden nader beschreven.

- De volgorde van de niveaus is zo gekozen dat processen op de lager gelegen niveaus conditioneel zijn voor het tot stand komen van gedrag op de hoger gelegen niveaus. Dat wil zeggen dat processen of gedrag op de lagere niveaus noodzakelijk, maar niet voldoende zijn om gedrag op de hogere niveaus te veroorzaken.
- Het model kan benaderd worden als een ontwikkelingsmodel en als een in de tijd gefixeerd model. In dit onderzoek is voor de laatste opzet gekozen; gedrag op alle niveaus wordt eenmalig gemeten om de biologische en sociale relaties tussen de niveaus te kunnen onderzoeken.
- Elk niveau vertegenwoordigt een discipline in de persoonlijkheidspsychologie, met eigen theorieën, paradigma's, concepten en onderzoeksmethoden. Dat betekent voor het voorliggende onderzoek dat op elke niveau reeds veel kennis bestaat. Doel van het onderzoek is het integreren van de theorieën uit verschillende disiplines in één toetsbaar persoonlijkheidsmodel.

- Het model kan bestudeerd worden vanuit een multilevelbenadering (met de daarbij horende technieken en analysemethoden) en vanuit het gedragsgenetisch perspectief. In dit proefschrift willen we de nadruk leggen op de manier waarop biologische en sociale aspecten van de persoonlijkheid samen tot gedrag leiden. Daarom is dit onderzoek opgezet met de nadruk op de gedragsgenetische benadering.

Het Zuckermanmodel is gebruikt om de volgende onderzoeksvragen te beantwoorden:

1. Kan gedrag op het trekniveau voorspeld worden door gedrag op de lager gelegen niveaus?
2. Zijn variabelen op de naast gelegen niveaus betere voorspellers van gedrag dan variabelen op de verder af gelegen niveaus?
3. Wordt het gedrag op alle niveaus beïnvloed door het genotype?
4. Neemt de invloed van het genotype af met het stijgen van de niveaus en neemt de invloed van sociale processen omgekeerd evenredig toe?
5. Liggen gecorreleerde genetische- en omgevingsfactoren aan de basis van gedrag op alle niveaus?
6. Zijn er aanwijzingen voor het voorkomen van gen-omgevingscorrelaties op alle lagen van het model?

Deze onderzoeksvragen worden in **hoofdstuk 1** vertaald naar toetsbare hypothesen.

Hoofdstuk 2 heeft een introducerende functie. De eisen die gesteld worden aan de keuze van de variabelen op de verschillende verklaringsniveaus worden toegelicht. De variabelen die gekozen zijn om het model te operationaliseren op de verschillende levels worden beschreven.
Het eerste niveau, genotype, is geoperationaliseerd met behulp van tweelingonderzoek.
Een belangrijke voorwaarde voor het Zuckerman model is de aanname dat biologische processen noodzakelijke voorwaarden zijn voor het onstaan van leerprocessen en tenslotte gedrag. Zonder biologische basis is leren niet mogelijk en zonder leerprocessen is sociaal gedrag niet mogelijk. Daarom hebben we om het fysiologische niveau te definiëren gekozen voor fysiologische variabelen die

geassocieerd worden met informatieverwerkingsprocessen. Familiarisation, Effort en Readiness zijn oorspronkelijk benoemd door Pribram en McGuiness (1975, 1992). Hettema, Geenen en Leidelmeijer (1999) toonden aan dat deze fysiologische dimensies functionele autonome systemen vertegenwoordigen, die samenhangen met informatieverwerkingsprocessen. Familiarisation staat voor inputprocessen en wordt op fysiologisch niveau gekarakteriseerd door een dissociatie van hartmaten en bloeddruk enerzijds en de huidweerstand anderzijds. Effort staat voor verwerkingsprocessen en de ontkoppeling van input en output. Op fysiologisch niveau wordt Effort gekarakteriseerd door een dissociatie van hartmaten en bloeddruk. Readiness wordt in verband gebracht met outputprocessen en motorische preparatie. Op fysiologisch niveau is Readiness geassocieerd met een covariantie van hartmaten, bloeddruk en huidweerstand. Deze drie fysiologische dimensies representeren processen op het fysiologische verklaringsniveau.

Op het leerniveau is gekozen voor een operationalisatie met behulp van D-doelen (Hol, 1994, Hettema en Hol, 1998). D-doelen zijn operanten. Operanten kunnen worden gekarakteriseerd in termen van hun situatiegebonden gedragseffecten en zijn daardoor geassocieerd met primaire controle.

Op het derde niveau, sociaal gedrag, zijn vier competentievariabelen gedefinieerd: mentaal, sociaal, fysiek en instrumenteel. Een competentie is een gedragsmodule die geleerd is door operante conditionering, dan wel sociale leerprocessen. Als zodanig vertegenwoordigen competenties het repertoire van gedrag dat een individu tot zijn beschikking heeft (Bandura, 1986).

Op het hoogste verklaringsniveau heeft Zuckerman de trekken gepositioneerd. Trekken zijn volgens hem de meest basale concepten van de persoonlijkheid (Zuckerman, 1992). Trekken worden in het model opgevat als het uiteindelijke produkt van processen die zich afspelen op de lager gelegen niveaus. Op het trekniveau zijn de 'Grote Vijf' gekozen om het niveau te operationaliseren. De Grote Vijf zijn extraversie, aardigheid, neuroticisme, stiptheid en openheid of intellect (Costa en McCrae, 1992). De relatie tussen het laagste verklaringsniveau, het genotype, en de trekken op het hoogste verklaringsniveau is al door veel onderzoek bevestigd. Gemiddeld kan bijna de helft van de variante in trekken binnen de populatie verklaard worden door genetische effecten.

Van Zuckerman's model zijn zes hypotheses afgeleid die in dit proefschrift worden getoetst. In het navolgende zijn de belangrijkste resultaten beschreven aan de hand van deze hypotheses.

In **hoofdstuk 3** worden de eerste twee onderzoeksvragen besproken.

1. Variabelen op de hoger gelegen niveaus kunnen worden voorspeld op basis van variabelen op de lagere niveaus.

Deze hypothese is onderzocht met behulp van een multivariate regressie analyse. Als gedrag op de onderliggende niveaus noodzakelijk is voor gedrag op de hogere niveaus, dan moet het gedrag op het trekniveau kunnen worden voorspeld met behulp van gedrag op de lagere niveaus. De data bevestigen deels hypothese 1. Significante multiple correlatie coëfficiënten (R) waren een aanwijzing voor het feit dat trekken kunnen worden voorspeld door gedragsuitkomsten op het leerniveau en het sociaal gedragsniveau. Variabelen op het fysiologisch niveau droegen minder bij aan de totale verklaarde variantie.

2 Variabelen op de nabij gelegen niveaus zijn betere voorspellers dan variabelen op de niveaus die verder weg liggen.

Deze hypothese wordt niet bevestigd. De correlatie coefficienten op het niveau van competencies en D-doelen verschillen niet signifikant van elkaar. Competencies en D-doelen blijken wel sterk te correleren, wat waarschijnlijk het gevolg is van de manier waarop variabelen op beide niveaus gemeten zijn.

In **hoofdstuk 4** wordt de gedragsgenetische benadering uiteengezet. Aan de hand van de klassieke gedragsgenetica worden de onderliggende assumpties verduidelijkt. De op dit moment meest gebruikte methode voor gedragsgenetisch onderzoek, de model-analyse, wordt uitgelegd (Falconer, 1989; Neale en Cardon, 1992). Twee hypotheses worden getoetst en de resultaten beschreven.

3. Genen hebben effect op gedrag op alle niveaus.

Een van de basisassumpties van het Zuckermanmodel is dat genen een noodzakelijke voorwaarde zijn voor alle gedrag. Gedrag op elk niveau is geworteld in het genotype. In hoofdstuk 4 is deze assumptie onderzocht. Voor alle variabelen worden effecten van het genotype op het fenotype gevonden. De erfelijkheidscoëfficiënten voor de fysiologische variabelen zijn hoog. Ongeveer 80% van de variantie in het gedrag op de fysiologische dimensies kan worden verklaard door genetische factoren. Niet alleen voor de fysiologische dimensies zijn erfelijkheidscoëfficiënten berekend, maar ook voor de enkelvoudige variabelen die aan de dimensies ten grondslag liggen. De erfelijkheidscoëfficiënten voor hartslag, bloeddruk en huidweerstand zijn vergelijkbaar met die uit eerder gedragsgenetisch onderzoek naar fysiologische maten (Ditto, 1993; Turner and Hewitt, 1992)

Voor D-doelen wordt ongeveer 45% van de variantie verklaard door genetische factoren en 55% door unieke omgevingsfactoren. D-doelen zijn niet eerder met behulp van tweelingonderzoek bestudeerd, daardoor is het niet mogelijk deze resultaten te vergelijken met die van eerdere onderzoeken. Voor gedrag op het verklaringsniveau 'sociaal gedrag' wordt een gemiddelde erfelijkheidscoëfficiënt van .49 gevonden, dat betekent dat ongeveer 49% van de totale variantie in sociaal gedrag (competenties) kan worden verklaard door genetische factoren en 51% door unieke omgevingsinvloeden. Ook competenties zijn niet eerder onderwerp van gedragsgenetische studies geweest, daardoor is het ook nu niet mogelijk de eigen resultaten te toetsen aan resultaten uit bestaande literatuur. Ook voor trekken wordt een erfelijkheidscoëfficiënt van .49 gevonden, bijna de helft van de variantie in trekken wordt verklaard door genetische factoren. Dit is vergelijkbaar met wat gewoonlijk gevonden wordt in gedragsgenetisch onderzoek naar trekken (Loehlin, 1992; Bouchard, 1993).

4. *Geneffecten zijn het grootst op de lagere niveaus en nemen af met het stijgen van de niveaus. Omgevingseffecten zijn het kleinst op de lagere niveaus en nemen toe met het stijgen van de niveaus.*

Deze hypothese wordt deels bevestigd. De erfelijkheidscoëfficiënten voor de fysiologische dimensies zijn zeer hoog in vergelijking met die op de andere niveaus. Maar de erfelijkheidscoëfficiënten op de verklaringsniveaus die met behulp van een vragenlijst werden ondervraagd, differentieerden niet van elkaar. Hier komen we later op terug.

In **hoofdstuk 5** wordt de meest stringente hypothese onderzocht. Hier gaan we uit van een 1:1 benadering, waarbij per verklaringsniveau 1 variabele wordt gekozen om de andere variabelen te voorspellen op grond van gecorreleerde genen.

5. *Gecorreleerde genetische factoren liggen aan de basis van gecorreleerd gedrag op alle niveaus.*

Met behulp van multivariate genetische analyses zijn de genetische en omgevingscorrelaties tussen de niveaus onderzocht. Er worden sterke aanwijzingen gevonden voor de bruikbaarheid van multivariate genetische analyse technieken om de biologische en sociale relaties tussen de verschillende verklaringsniveaus uit Zuckerman's model te onderzoeken. Inzicht in deze relaties draagt bij aan een beter begrip van de manier waarop individuele verschillen in gedrag tot stand komen. Vier submodellen zijn getoetst met behulp van een 'independend pathway model' (Neale en Cardon, 1992). Op deze manier kon worden aangetoond dat variabelen op verschillende niveaus laden op dezelfde gecorreleerde genetische- en omgevingsfactoren. Variabelen op het fysiologische niveau hadden weinig variantie gemeen met variabelen op de andere niveaus, maar de variantie die gemeenschappelijk was kon voor een groot deel worden toegeschreven aan gedeelde genetische factoren.
De variabelen op het leerniveau en variabelen op het niveau van sociaal gedrag deelden bijna alle variantie die deels aan genetische en deels aan unieke omgevingsfactoren is toegeschreven. Waarschijnlijk is dit het resultaat van de manier waarop beide variabelen gemeten zijn, namelijk met behulp van één vragenlijst en gedeelde items.

In **hoofdstuk 6** wordt de laatste onderzoeksvraag beantwoord, namelijk die naar de mate waarin biologische en sociale processen een rol spelen bij het tot stand komen van persoon-situatie interacties op de verschillende niveaus.

6. *Genotype-omgevingsinteracties zullen toenemen met het toenemen van de niveaus van het Zuckerman model.*

Deze hypothese wordt deels bevestigd. Voor de fysiologisch dimensies wordt vooral genetische invloed op het hoofdeffect gevonden. De genetische invloed op de interactie tussen persoon en omgeving is op het fysiologische niveau altijd kleiner dan de genetische invloed op het hoofdeffect voor personen. Voor alle andere variabelen geldt dat de genetische invloed op de persoon-situatie interactie groter of gelijk is aan de genetische effecten op de hoofdeffecten voor personen.

In **hoofdstuk 7** worden de resultaten van het onderzoek eerst kort samengevat. In de daarop volgende discussie worden de resultaten geïntegreerd. Tenslotte worden een aantal conclusies ten aanzien van het onderzoek getrokken.
Concluderend kan worden gesteld dat de resultaten van het onderzoek gedeeltelijk het model van Zuckerman bevestigen. De resultaten zijn consistent over alle gebruikte benaderingen en analysemethoden heen. Teveel hypothesen worden (deels) bevestigd om het model volledig te verwerpen. Betekent dit dat toekomstige onderzoekers zich moeten beraden over de onderzoeksopzet? Of betekent dit dat het model van Zuckerman bijgesteld moet worden?
Beide redenaties worden in hoofdstuk 7 nader uitgewerkt.
Moet het onderzoeksdesign worden veranderd? De verwachte veranderingen in genetische en omgevingsinvloeden op de verschillende verklaringsniveaus worden niet gevonden. Volgens Hettema en Deary (1993) is een van de kenmerken van het model dat de invloed van de omgeving toeneemt met elk level. De invloed van de omgeving zou het kleinst zijn op het fysiologisch verklaringsniveau en toenemen omdat de sociale invloeden toenemen met de niveaus. Dit wordt niet gevonden; de fysiologische dimensies zijn veel meer erfelijk dan de andere variabelen, maar D-goals, competenties en trekken worden gelijkelijk verklaard door omgevings- en geneffecten. De vraag die gesteld wordt is dan ook of vragenlijstonderzoek de beste manier is om gedrag op meerdere niveaus te onderzoeken. Alle variabelen op het leerniveau, het niveau van sociaal gedrag en het trekniveau zijn onderzocht met behulp van SR-vragenlijsten. Dit laatste heeft twee nadelen. Vragenlijsten zijn gevoelig voor sociaalwenselijke beantwoording. Proefpersonen krijgen een vragenlijst voorgelegd waarin situaties worden beschreven en gecombineerd met een aantal mogelijke gedragingen. De kans is aanwezig dat men zichzelf die gedragingen toeschrijft die sociaal het meest wenselijk zijn, maar die niet zouden worden uitgevoerd in de realiteit van alledag. Ten tweede kan men zich in gerede afvragen of het mogelijk is om met behulp van vragenlijsten gedrag op verschillende niveaus te onderzoeken. Een verklaring voor het gebrek differentiatie tussen de 'sociale' niveaus van genetische- en omgevingsinvloeden, kan zijn dat uiteindelijk misschien slechts één gedragsniveau is onderzocht, namelijk cognities, meer precies, cognities over het eigen gedrag. Bij vervolg-onderzoek is het van belang om gedrag op elk verklaringsniveau te onderzoeken op een manier die beter aansluit bij dat niveau. Zo kan men trekken onderzoeken met behulp van zelfrapportages aangevuld met ouder- en peerrapportages. D-goals

en competenties kunnen betrouwbaar worden onderzocht met behulp van observatiestudies (Hettema en Hol, 1998; Hol, 1994; Rieman, Angleitner, Borkenau en Eid, 1998). Het onderzoek zou in ieder geval de niveaus 'sociaal gedrag' en leerprocessen' beter uit elkaar moeten trekken, om versmelding van beide levels te voorkomen.

Moet Zuckerman's model worden bijgesteld? Er wordt geen (lineaire) relatie gevonden tussen fysiologische variabelen enerzijds en de sociale variabelen anderzijds. De meeste psychobiologische modellen veronderstellen een lineaire relatie tussen fysiologische variabelen en trekken (Eysenck, 1993; Gray, 1981, 1982, 1991; Zuckerman 1992). De klassieke modellen zijn echter aan veel kritiek onderhevig. De lineaire relatie tussen fysiologische processen en trekken (bijvoorbeeld de relatie tussen de spiegels van neurotransmitters in de hersenen en de trek Extraversie) wordt net zo vaak wel, als niet gevonden. In de toekomst zouden ook andere dan lineaire relaties kunnen worden onderzocht. Daarvoor worden twee argumenten gegeven. Op alle sociale niveaus vinden we substantiële genetische effecten op de interactie tussen persoon en omgeving, niet echter op het fysiologische niveau. Het is mogelijk dat het genotype via fysiologische processen de impact van de omgeving modelleert. Een aangeboren voorkeur voor Familiarisation, Effort of Readiness maakt dat in dezelfde omgeving door verschillende individuen verschillende dingen worden geleerd. Nader onderzoek zou kunnen uitwijzen dat bij informatieverwerkingsprocessen niet-lineaire relaties tussen fysiologie en leren een grote rol spelen. Volgens Eysenck's theorie, is het arousalniveau van een individu omgekeerd evenredig aan het niveau van de trek extraversie. Grotere autonome arousal leidt tot minder extravert gedrag. Experimenteel onderzoek naar performance wijst uit dat de relatie tussen arousal en performance curve-lineair is. Dit geldt voor performance op elk onderzocht gebied, sensorisch, motorisch en cognitief. Daarbij wordt benadrukt dat de vorm van de relatie tussen arousal, persoonlijkheid en performance afhankelijk is van omgevingscondities. De relatie tussen biologische variabelen (zoals arousal) en persoonlijkheidsvariabelen (zoals trekken) is volgens Gruzelier and Mecacci (1992) waarschijnlijk niet-lineair. In de toekomst is aan te raden om bij het onderzoek naar de biologische en sociale relaties tussen de verschillende niveaus van het Zuckermanmodel ook niet lineaire relaties te betrekken.

Nawoord

Het voorliggend onderzoek heeft aangetoond dat het Zuckermanmodel kan worden gebruikt om meer inzicht te krijgen in de biologische en sociale aspecten van gedrag en de manier waarop beide aspecten samenhangen. Nu er in deze tijd weer een voorkeur voor biologische verklaringen van gedrag lijkt te ontstaan is onderzoek naar biosociale modellen een goede manier om recht te doen aan nature én nurture en daarmee aan de complexiteit van gedrag. Meerlagige modellen die biologische en sociale persoonlijkheidstheorieën integreren kunnen door de toegenomen kennis van fysiologische processen die ten grondslag liggen aan gedrag en door de vooruitgang in statistische analyses steeds beter worden onderzocht. Het is belangrijk dat de verschillende verklaringsniveau in de toekomst worden onderzocht op een manier die recht doet aan het verklaringsniveau. Daarnaast zou onderzoek zich in de toekomst kunnen richten op niet-lineaire verbanden tussen de verschillende verklaringsniveaus.

Descriptions of situations as used in the SR- inventory and the TinSit

1. Dinner

You are having diner with your family in the livingroom. You have prepared an extra nice diner. To create a romantic atmosphere you have put some candles on the table. As you bring in the main course your partner asks if everybody can eat rapidly, because in fifteen minutes a soccer game will start on television.

2. Intrigue

You have got a friend who is married, but very much in love with an other man. She wants to go away with this man for the weekend. To avoid problems at home she wants to tell her partner that she is spending the weekend with you. You accuse her of trying to take advantage of you. Your friend picks up your phone to call her husband.

3. Interruption

You are a reporter and have an article due before the end of the day. You start collecting everything you need. Unfortunately the day does not go by as you had hoped it would. You are interrupted over and over again, so that your article is bound to be late. At the end of the day your colleague comes in to collect the article, but you haven't finished yet. Your colleague pushes you away from your PC to finish the article himself.

4. Panic

You enter the elevator to go to the 11th floor. With you a young woman enters. On the way up the lights start blinking. Suddenly the elevator stops between the fifth and sixth floor. You push every possible button but the elevator does not move. The young woman starts to sweat and feels oppressed. She panics and starts pushing you.

5. Tease

Together with some friends you spend a weekend at the see sight. The mood is great. A few of your friends have spend the afternoon building a beautiful sandcastle. You walk towards them meaning to tease them a little. Then accidentally you step on there castle. One of them is really angry with you.

6. Appointment

Because your car needs to be checked, you make an appointment with your garage. You have agreed to bring the car in the morning and to pick it up after work. When you arrive to pick up your car, the mechanic presents you with a 400 dollar bill. You want this bill to be better specified. The mechanic answers that you should not rack your brains over it: you should leave the technical business to those who know about technique.

7. Quarrel

When you and your partner have returned from a office-party, you feel very angry because you have been bored to death, while your partner spent too much time entertaining his young female colleagues. You feel your temper rise. Before you know it you are calling your partner names and blaming him for a spoiled evening. Your partner reacts surprised and offers you a drink.

8. Visit

One day you asked a friend who you did not see for a long time, to visit you. You drink coffee together and have a really good time, laughing and telling stories about the old times. After an hour your friend wants to go home. You insist on staying for lunch, but your friend wants to go.

9. Test

You are taking a driving test. On the day of the test you are nervous. You fill out some forms and go to the car with the examiner. You take the keys and start the car. On the road you drive as well and as careful as possible. When you return to the place where you started, you feel like you have driven well. As you are about to leave the car the examiner asks you to repeat a special skill, because he did not pay enough attention the first time.

10. Failure

You took a first aid course. To get a certificate you have to take an exam. The practical part went very well but you have probably failed the written part. Afterwards you talk some more with your fellow course members. You have a lot of criticism towards the faculty. One of the other course members asks if you have ever opened your reader?

11. Anticipation

At your work you use a copier. One day the machine is broken. You phone for the technical service and ask if they could come and repair the copier. They promise to send some-one over to see what is wrong. After three days some-one finally comes by.

12. Disturbance

You are a member of a sports club and you are playing an important game today. One of the opponents has pushed you quite hard for a few times now. The referee does not seem to see it. Just as you get a chance to score the opponent walks into you and you trip. You get angry and throw the ball to your opponent. The referee warns you not to make another contravention, if it happens again you will be expelled from the game.

13. Love making

One morning you enter the bathroom to brush your teeth. Your partner just gets out of the shower. You smile at your partner and make a compliment. Your partner hold on to you and start making love to you. You are in a hurry because you are late, but your partner wants to continue the love making.

14. Application

You are writing to a job offer on a newspaper. You are called in for an interview. You try to convince the personnel manager of the fact that you are the best men for the job. He tells you that it is very important that you are able to work with the computer. He asks you to prove your competence with making a presentation of yourself in Power Point. Unfortunately, this is not your program.

15. Red tape

Just before you are going on a trip abroad you have to let your passport and some documents made. With your photo's you arrive at the town hall. The civil servant behind the counter tells you to come back for your documents in five days, and that the opening hours are between 10 am en 12 am and between 1 pm and 4 pm. You are at work at that time. Perhaps the passport can be layed out for you? The civil servants says that the counter is only open at the indicated time.

16. Divorce

You and your partner are having major difficulties for some time. You decide that a divorce will be the best solution to your problems. You are negotiating with your partner about how to divide the furniture. You tell your partner that you want the painting that you bought at the start of your marriage. Suddenly your partner puts his arms around you.

17. Meeting

A coffee-shop will be opened at your neighbourhood. According to the police this is the best way to keep dealing and using of soft drugs under control. You are very much against this coffeeshop in your street. Tonight you and the other suburbanites are going to a meeting of the city board. You have written down your arguments. During the meeting you make an important remark, but the chairman ignores you and continues the discussion.

18. Punishment

You and your family are going to the mall at Saturday afternoon. You park your car on the car park, and pay enough to stay for one hour. You make sure everybody hurries, so you will be ready and done in one hour. Just as you come back to the car, you see a police officer writing you a parking ticket.

19. Gossip

You are talking to a colleague. You bring up an other colleague who is not at work. You ask if the rumour that your colleague is not sick, but that her husband has beaten her up is true? Your colleague tells you that she hates to gossip and pours herself a cup of coffee.

20. Job interruption

You are hard at work. A colleague asks you if you have time to sort out 500 envelopes. You tell your colleague that you won't have the time this week. You apologize for it. Your colleague telles you that the job is very important and wants to know what is so important for you that you should not help.

21. Declaration of love

You have known a nice guy for a while. One night you have accepted his invitation to come to the cinema with him. Afterwards you go for a drink in a pub. When the drinks are on the table you talk about the movie. Then he suddenly takes your hand. He tells you that he has been in love with you for some time. In the middle of the pub he wants to hug you, but you do not like him that much.

22. Instructions

You have bought a new VCR. You do not know anything about VCR's so you have the recorder installed at your house. You ask the one who installed the VCR to instruct you about how to program it. He replies he has no time for that, and that you should read the manual thoroughly.

23. Flirt

You have a problem that keeps you from going on with your work. Because your colleague is more experienced you ask him to look at the problem. Your colleague takes the things from you. He looks at you, winks, and says he cannot refuse anything to such a charming lady.

24. Inquiry

You are working for an advertising agency. You have received a set of questionnaires for a door to door survey, on the consumption behaviour of your target group. When you read the questionnaire you think it is extemely bad.

According to you some questionnes cannot pas muster. You ask why this list was in such a bad condition, your colleagues tells you there was not enough preparation time.

25. Advances

Tonight you are going out with some friends. You dress up and make sure that you look your best. In the pub you notice a man looking at you. He makes eye contact, he smiles at you, he winks at you. Finally he comes up and introduces himself. Then he takes a chair and seats himself between you and your friends.

26. Cooperation

Your sport club enters a contest for the benefit of a third world project. The profit depends on the number of kilometres you run. All the members of the club have decided to run for 10 kilometres. You practice as hard as you can and you hope to make it through the game. Then your trainer asks you to run for 5 more kilometres because of the important goal of the contest.

27. Accident

You are talking to an inmate when somebody next to you gets her fingers stuck between the doors. It hurts terribly and her hand is bleeding severely. The victim turns white and starts screaming. You run to the victim and shout to the inmate to get the first aid kit. Your inmate also runs to the victim, and slaps her face to calm her down.

28. Training

Because you lack condition you have decided to go sporting. As a start you become a member of a gym in your neighbourhood. You make your choice from all the appliances and start working out. Next to you some-one else is also working out and looking at his muscles you conclude that this is not his first time. You ask him to show you how the equipment works. He hangs some weights in it and start pulling. Helas, it does not seem to work.

29. Research

You are preparing a large research project. For this you have to set the equipment right. After you connected the electrical circuits it appears that a part of the machinery does not work. You push and pull, you poke it with a screwdriver, and hope the thing will start working. As you are trying to master the device a colleague enters and starts looking over your shoulders.

30. Meeting

During the weekend you are shopping. In the store you recognise one of the sales woman as an old classmate. You go up to her and greet her cordially. She is happily surprised and asks you to come and visit her. This is not what you had in mind for the evening, but she is very persistent about it.

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