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Children's Perception and Interpretation of Robots and Robot Behaviour

Sajida Bhamjee

A thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy in Social Studies

University of Warwick

School of Health and Social Studies

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Declaration

I confirm that this thesis is my own work. It has not been submitted for examination at any other university for any other award. Aspects of the work have been reported in:

Bhamjee, S., Griffiths, F.E. and Palmer, J., 'Children's perception and interpretation of robots and robot behaviour', in Proc. 3rd Int. Conf. on Human-Robot Personal Relationships (HRPR 2010), June 2010, Leiden University, Netherlands.

Abstract

The world of robotics, like that of all technology is changing rapidly (Melson, et al., 2009). As part of an inter-disciplinary project investigating the emergence of artificial culture in robot societies, this study set out to examine children's perception of robots and interpretation of robot behaviour. This thesis is situated in an interdisciplinary field of human–robot interactions, drawing on research from the disciplines of sociology and psychology as well as the fields of engineering and ethics. The study was divided into four phases: phase one involved children from two primary schools drawing a picture and writing a story about their robot. In phase two, children observed e-puck robots interacting. Children were asked questions regarding the function and purpose of the robots' actions. Phase three entailed data collection at a public event: Manchester Science Festival. Three activities at the festival: 'X-Ray Art Under Your Skin', 'Swarm Robots' and 'Build-a-Bugbot' formed the focus of this phase. In the first activity, children were asked to draw the components of a robot and were then asked questions about their drawings. During the second exercise, children's comments were noted as they watched e-puck robot demonstrations. In the third exercise, children were shown images and asked whether these images were a robot or a 'no-bot'. They were then prompted to provide explanations for their answers.

Phase 4 of the research involved children identifying patterns of behaviour amongst e-pucks. This phase of the project was undertaken as a pilot for the 'open science' approach to research to be used by the wider project within which this PhD was nested. Consistent with existing literature, children endowed robots with animate and inanimate characteristics holding multiple understandings of robots simultaneously. The notion of control appeared to be important in children's conception of animacy. The results indicated children's perceptions of the location of the locus of control plays an important role in whether they view robots as autonomous agents or controllable entities. The ways in which children perceive robots and robot behaviour, in particular the ways in which children give meaning to robots and robot behaviour will potentially come to characterise a particular generation. Therefore, research should not only concentrate on the impact of these technologies on children but should focus on capturing children's perceptions and viewpoints to better understand the impact of the changing technological world on the lives of children.

Chapter 1: Introduction

1.1. Starting the Journey

The concepts of culture and emergence have generated extensive inter-disciplinary interest. As Winfield and colleagues note, ‘a profound question that transcends disciplinary boundaries is “how can culture emerge and evolve as a novel property in a group of social animals?”’(Winfield, et al., 2007:no pagination). One way to study the emergence of culture is to examine the emergence of artificial culture in a society of embodied intelligent agents or robots.

1.1.1. ‘The Emergence of Artificial Culture in Robot Societies’

This thesis is part of a wider, inter-disciplinary project on complexity and emergence called *The Emergence of Artificial Culture in Robot Societies* funded by the Engineering and Physical Sciences Research Council (EPSRC). The senior members of the project team attended an annual EPSRC ‘sandpit’ where they were required to produce an innovative research project on emergence as part of the research program on complexity sciences. It was proposed that an artificial society of embodied intelligent agents (real robots) be built and an environment (artificial ecosystem) created together with the appropriate primitive behaviours for those robots in a free-running artificial society. The primary focus was ‘...on the very early stages of the emergence and evolution of simple cultural artefacts...the transition...from nothing recognisable as culture, to something (let us call this proto-culture)' (Winfield, et al., 2007: no pagination). In sum, the team aimed to build a working model of cultural evolution, hoping to further our knowledge of culture by looking at the processes and mechanisms by which culture has emerged amongst robots.

This interdisciplinary project includes academics from swarm robotics, systems biology, cognitive modelling, philosophy, art and social science. There are four PhD students and one research assistant each working within their own disciplines at different universities across the UK all with a distinct role in the project. I am the social scientist on the project; the three other PhD students are from the disciplines of philosophy, robotics and the computer sciences.

It was initially proposed that 70 small (10cm diameter x 5cm high), relatively simple robots would be free-running in the robot laboratory at the University of the West of England, Bristol. These simple robots called e-pucks (Figure 1) can move, see, hear and communicate by radio and flash lights, and can interact in a number of ways. For example, one robot can signal another through movement, light or sound, and robots are programmed to react to signals by imitating behaviour. However, due to the quality of the sensors and variations in the environment e.g. light levels, this imitation may be performed imperfectly.

The research team anticipated that within a short period of time, there would be a number of interactions between the physical e-puck robots. The use of real robots instead of simulated robots is pertinent to the methodology of the artificial culture project as real robots will have more possibilities for emergence in their interactions. Due to a combination of physical obstacles and environmental conditions, each experimental run will have different outcomes. Similarly, when one robot copies another's behaviour it will be slightly different from the original, thus producing unexpected differences. Importantly, it is suggested that through observing the interactions of these swarm robots it may be possible to identify emergent patterns of behaviour. The concept of emergence is explored in the following section.

The team also decided that computer simulation experiments should be employed to allow a wide range of experiments to be run, in order to identify interesting experiments that could be executed with the physical robots. Computer simulation experiments also allow the robots to run on 'evolutionary time', permitting the simulation of multiple generations of robots.

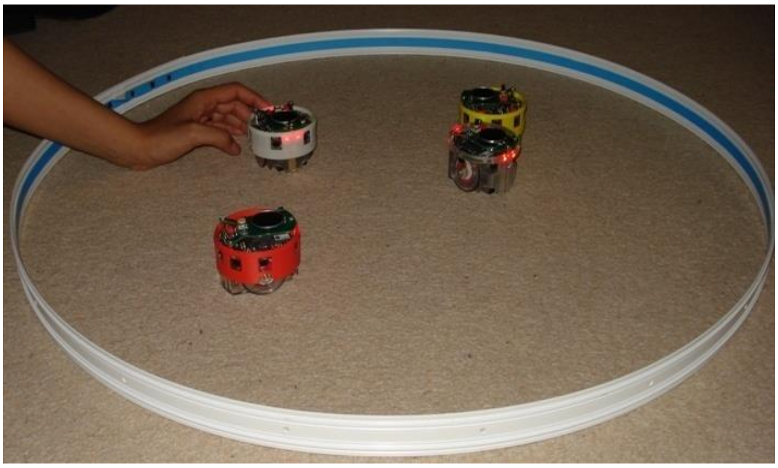

Figure 1 E-pucks - Swiss designed, miniature wheeled robots that can run around on their wheels powered by their own motors; they include a camera and lights and can detect objects and obstructions.

1.2. Emergence

Emergence is a central theme in this research and is a term used in complexity sciences to describe the way complex systems and patterns arise out of numerous simple interactions (Cilliers, 2002). A fairly standard definition of 'complex systems' that suits my purpose here is a system comprised of elements or parts that are interconnected in order to produce a behaviour or number of behaviours that cannot be achieved from any part individually. These systems can be biological, mechanical, organisational or social.

Emergence can be categorised as bottom-up or top-down. For example, much of the past work of roboticists employed a top-down approach in the field of robot research, whereby they sought to replicate human intelligence in a machine (Harding, 2009). After establishing a number of possible robot capabilities, the roboticist would engineer an elaborate programme for robots to perform the prerequisite behaviours. In contrast, current robotics research can be categorised as bottom-up. It is influenced by evolution and biology and similar to biological organisms involves a simple programme that allows for multiple, simple actions to produce remarkably complex behaviours.

The idea of bottom-up emergence is illustrated in an artificial life programme known as 'boids' developed by Craig Reynolds in 1986 to simulate the flocking behaviour of birds. Reynolds explored whether the flocking behaviour of animals (such as fish and birds) and insects was a result of a flock leader's instructions or an intention to flock. The computer programme written by Reynolds involved each digital bird acting 'solely on the basis of its local perception of the world' (Reynolds, 1987:27) . Reynolds called these digital birds 'boids', although a boid was not necessarily limited to bird species and could potentially represent any flocking creature. The flocking behaviour of boids in the computer simulation arose from three simple rules that Reynolds developed: "'separation': steer to avoid crowding local flockmates, 'alignment': steer towards the average heading of local flockmates and 'cohesion': steer to move toward the average position of local flockmates" (Reynolds, 2001:no pagination). By making each bird following these three simple rules, the bird flocking pattern is formed (Reynolds, 2001). The boids programme poses an interesting question: if animals follow simple rules that lead to complex behaviour, could the complex behaviour of humans be the result of following a few simple rules?

Similarly, Resnick (1992) developed a 'StarLogo' computer programme that allowed children to direct the actions of various 'creatures'. Creatures were issued with instructions or rules and it was possible for creatures to follow numerous instructions at the same time. When creatures adhered to these simple rules complex behaviours emerged. One such creature was the termite and its programme consisted of artificial termites and digital woodchips. At the beginning of the programme, woodchips were arbitrarily dispersed all over the termites' world and the task was to make the termites cluster the woodchips into stacks. In order to do so, the termites were given two rules: 'if you're not carrying anything and you bump into a woodchip, pick it up; if you're carrying a woodchip and you bump into another wood chip, put down the chip you're carrying'(Resnick, 1997:234) . By following these two rules together, the screen termites made woodchip piles even though children did not specifically direct them to do so (Resnick, 1992). The StarLogo computer programme highlights that the outcomes of individualized actions based on simple rules cannot be easily predicted; and the emergent phenomena and 'decentralized control' (Davis-Floyd and Dumit, 1998:322) evident in the programme's outcomes are both indicative of bottom-up emergence.

Even though boids and the StarLogo programme are simple examples of emergence, they differ considerably from the form of emergence that team members anticipated with e-pucks. The boids and StarLogo programme are 'rule-based', i.e. each agent follows a simple set number of rules in order for a pattern of behaviour to emerge. In the current project, we did not aim for the emergence of a certain set of behaviours among e-pucks, instead e-pucks were programmed with the capacity to interact (discussed later in section 1.4). Whether the interactions between robots constituted emergent behaviours was left to the interpretation of observers.

In the artificial culture project, all the actions and interactions of e-pucks can be recorded and stored for future data-mining. If emergent patterns of behaviour are observed, then it is possible to examine the recorded data prior to the emergent pattern of behaviour to further our understanding of how emergent patterns develop among e-pucks (Winfield and Griffiths, 2010). However, the key problem the project team faced was recognising and interpreting patterns of emergent behaviour. My role in this project was to introduce children to assist in interpreting the data collated whilst searching for emergent patterns. Further detail of this is provided in the next sections.

1.3. My Research and Role in the Project

I was motivated to embark on this research project as it provided me with an opportunity to fuse the empirical and theoretical basis of my background in sociology and psychology with my interest in technology. Technological advancement is often viewed as having a profound influence on our daily lives, and as playing an important role in the formation of various cultures and traditions (Wajcman, 1999; Haraway, 1997). In addition, I also have an interest in culture and the evolution of culture within society.

To assist in identifying emergent patterns and cultures, expert and non-expert audiences were identified as needed. One identified group of 'non-experts' was children. Children play an important part in influencing generational norms and in the development of cultures (Corsaro, 1997). The role of this project was to design a research methodology to gather and analyse data about how children understand robots and interpret robot activity. The proposal of children as a non-expert audience was due to the belief that they may have fewer preconceived ideas about robots and may therefore see patterns that adults may overlook. It was further intended that the expert audience members would assist in observation and interpretation through an open source Internet platform whilst the non-expert audience (such as groups of school children) would observe the robots through Internet 'streaming'[1] methods. This would ensure that members of the public would engage with and support the project in the interpretation of the results.

1.4. Culture and the Influence of Imitation in the Role of Culture

The project summary states that 'Robots...will be able to copy each other's behaviours and select which behaviours to copy... behaviours (memes) will mutate because of the noise and uncertainty in the real robots' sensors and actuators, and successful memes will undergo multiple cycles of copying (heredity), selection and variation (mutation)' (Winfield, et al., 2007:no pagination) . The term 'meme' will be explored later. By implementing this over several months, robots will learn and copy behaviours many times. The project team anticipated that this would eventually produce a set of proto-cultural memes in the robot society that are 'qualitatively and quantitatively' different from the behaviours at the start of the experiment and which can be likened to an emerging 'robot culture' (Winfield, et al., 2007:no pagination).

Throughout the wider project, 'culture' is used as an abstract model to refer to a general rather than a human phenomenon, but this begs the question: what is culture?

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[1] Due to various tracking and logging equipment only accessible at the robot lab, it was not feasible to take the e-pucks to the audiences.

> 'Culture is one of the two or three most complicated words in the English language...mainly because it has now come to be used for important concepts in several distinct intellectual disciplines and in several distinct and incompatible systems of thought' (Williams, 1983:87) .

Williams' statement effectively highlights the difficulty in defining the word 'culture'. Its meaning and use varies from discipline to discipline. Dictionaries provide many definitions of human culture but there is nothing documented here about species culture. Similarly, Whiten states that cultures are 'defined by multiple traditions' (Whiten, et al., 2007) or to put it simply 'the ways in which things are done'. The use of the term 'culture' within the artificial culture project differs from my use of the term throughout this thesis as my focus is on one aspect of children's lived culture: how robots are perceived. This is explored further in Section 1.7.

The project team made a significant assumption about the essential pre-requisites for the emergence of culture. Inspired by Nehaniv and Dautenhahn's (2007) book *'Imitation and Social Learning in Robots, Humans and Animals'*, the project team viewed imitation as crucial for the development of culture between agents within either a biological, computational or robotic autonomous system (Nehaniv and Dautenhahn, 2007). Therefore in order for a culture to emerge amongst the swarm of e-pucks, they will be required to copy each other's behaviour. Additionally, as the programming allows for a certain level of autonomy, the e-pucks will also determine which of these behaviours to copy, much like human culture and biological evolution. Throughout the project this imitated behaviour is referred to as a 'meme'.

The term ‘meme’ was coined by Richard Dawkins in his book ‘The Selfish Gene’ in 1976.

> ‘When you imitate something else, something is passed on. This ‘something’ can then be passed on again, and again, and so takes on a life of its own. We might call this thing an idea, an instruction, a behaviour, a piece of information... but if we are going to study it we shall need to give it a name...it is a meme’ (Blackmore, 1999:4).

However, it is worth noting that team members, including myself, were hesitant to use ‘meme’ as a term or concept as it is very controversial. Critics of the term question whether one can meaningfully categorise culture into discrete units. It is also argued that memetic evolution has no predictive or explanatory power. Nevertheless, this term was initially employed in order to stimulate conversation and ideas.

‘The Emergence of Artificial Culture in Robot Societies’ project draws on Blakemore’s example of the *Copybot*. She suggests that a group of simple robots called ‘copybots’ have a memory system that can imitate the sounds they hear through their microphones. After a short period, they will be copying each other’s noises. Depending on the copybots’ perception and how well they imitate, some sounds will inevitably be adopted whilst others will be ignored. Therefore ‘some sounds will have higher fidelity, longevity, and fecundity (depending on the characteristics of the copybots) and these should be copied more and more accurately, and patterns begin to appear’ (Blackmore, 1999:106).

Blakemore discusses the meme as an ‘evolutionary replicator’, where data is copied by individuals or agents through the process of imitation. She suggests that memes were apparent in human evolution when people became capable of imitating behaviour and from this time on in human evolution there were two replicators: memes and genes. ‘Successful memes changed the selective environment, favouring genes for the ability to copy them’ (Blackmore, 2001:225). This project therefore relies on the assumption that this meme-gene co-evolution is ‘a key underlying mechanism in the transition from no culture to proto-culture’ (Winfield and Griffiths, 2010:10).

A key problem that was anticipated by the project team was how to interpret emergent behaviour. A senior member of the project team describes this difficulty in the following way: “In a sense we will be using robots like a microscope to study the evolution of culture. The possibility that genuinely novel, non-human, culture may emerge within the robot lab is both exciting and challenging. How will we be able to be sure that we are really witnessing the emergence of novel cultural behaviours, rather than simply projecting our own human concepts of culture on to the robots?” To this end, children were recruited as a non-expert audience in order to assist in the interpretation of novel cultural behaviours by robots.

1.5. The Involvement of Children within the Project

1.5.1. Children as Novice Scientists

As mentioned previously, my role was to involve children in order to explore their interpretations and understanding of robot behaviour. In this project, children were viewed as novice scientists who adopt a rational approach to the physical world without knowledge of the physical world and the experimental methodology accumulated by the institution of science. However, the novice scientist concept is contentious. Whilst some in the cognitive and developmental psychology field argue that children construct theories that are in many ways similar to those constructed by scientists (Gopnik, 1996; Brewer, Chinn and Samarapungavan, 1998; Carey, 1985), other researchers have countered this, suggesting that children's theories are conversely very different from scientific theories (Nelson, 2007; Overton, 2006; diSessa, 1988; Inhelder, et al., 1958). In addition, findings from the pilot fieldwork indicated very early on in the research that children held many preconceived ideas about robots.

Since the late 1980s, there has been increasing acknowledgement that children can make important contributions to the world of research. Children are seen as 'co-creators' (Freeman and Mathison, 2009:4) who can construct themselves in several social contexts. Children's perceptions and experiences can offer a deeper understanding of the world from their point of view. However, even though it is generally agreed that children provide explanations of the world from their viewpoint, what is less clear is the extent to which these viewpoints correspond to the process of explaining and understanding in scientific theories. Whilst the idea of children as novice scientists has been adopted, it has not been assumed that children would come to the research without knowledge or pre-conceptions of robots and their behaviour.

Research methodologies exploring whether children are like scientists are often confined to asking children questions about the 'natural world' such as light and heat (Brewer, Chinn and Samarapungavan, 1998; Samarapungavan and Wiers 1997; Vosniadou and Brewer, 1994). These questions are used to explore children's theories and explanations about a specific phenomenon. Brewer et al. (1998) suggested that there are three types of explanations used by children. The first, called causal/mechanical, suggests that children often provide causal explanations when asked about the natural world. The example given by Brewer is 'Why did the light not come on? - Because it was not plugged in' (Brewer, Chinn and Samarapungavan, 1998:125). The second category is functional explanations. This category explains a phenomenon in terms of functional factors instead of mechanical or physical elements. Samarapungavan and Wiers (1997) found in their study that children use a broad range of functional explanations in accounting for phenomenon. For example, one child was asked: 'Penguins have wings but they cannot fly. Why do they have wings? The child replied that "they use the wings to steer- in swimming"' (Brewer, Chinn Samarapungavan, 1998:132).

The third type of explanation is intentional explanations. There are numerous studies indicating that children apply intentional explanations which refer to intentional states such as beliefs and desires of human behaviour to inanimate objects (Wellman, 1990) , e.g. ‘balloons go up because they want to fly away’ (Piaget, 1960:110) . Brewer et al. (1998) conclude that children use the same forms of explanatory framework as scientists. However, they argue that scientists also use formal or mathematical accounts to explain natural phenomena. So for example, ‘why does this emission line of hydrogen have this frequency? - Because of Balmer’s formula’ (Brewer, Chinn and Samarapungavan, 1998:125).

Researchers report that, like scientists’, children’s theories are empirically-based; however, children’s views are also obtained from adults. A study conducted to explore children’s views of astronomy showed that children attempted to come up with theories of the world which were empirically-based and also contained information that was received from adults (Vosniadou and Brewer, 1994). Another study also conducted by Vosniadou and Brewer (1992) about children’s models of the earth’s shape asked first, third and fifth grade (ages 6-11) children a series of questions relating to the shape of the earth. Children identified five different models of the earth’s shape: rectangular earth, disc earth, dual earth, hollow sphere and flattened sphere. Children’s responses showed considerable inconsistencies. Many children stated that the earth was round while others stated it had an edge or was flat and people could fall off. The researchers report that children obtain these ideas from everyday experiences of shapes and make presumptions about the shape of the earth based on these experiences. Therefore, children’s understanding of the earth’s shape develops with age and further learning and exposure to shapes (Vosniadou and Brewer, 1992).

While children's theories of the world may be empirically-based, researchers suggest that children also gain information from adults. This implies that children may simply be 'copying' what has been heard and not necessarily formulating their own viewpoint in a scientific manner (Vosniadou and Brewer, 1992).

There are other researchers who adopt the 'child as a scientist' view whilst recognising differences between scientists and children, as a consequence of the social institution of science (Brewer and Samarapungavan, 1991). Brewer et al. (1991) argue that a person may develop into a scientist later into adulthood but may never develop without the explicit training that is required in order to be a member of the scientific community (Brewer, Chinn and Samarapungavan, 1998). However, scientists, it is argued, are supposed to be consciously reflective when they formulate theories. But science is structured within an institutional setting where interactions with other scientists occur, and are thereby likely to be influenced by the social institution of science. Similarly, changes in scientific theory may take years to occur; however, the same cannot however be said for children who develop and replace theories relatively quickly; in the space of a few months or years (Gopnik, 1996).

Critics such as Schollum and Osborne (1985) state:

> ‘[children] are limited in the extent to which they can reason in the abstract …tend to view things from a self-centred or human centred point of view ...they tend to endow inanimate objects with the characteristics of humans…they will accept more than one explanation for a specific event and are not too concerned if some of these explanations are self-contradictory’ (Schollum and Osborne, 1985:55-56).

Similarly, Wiser (1988) conducted research on children’s conceptions of heat and temperature and he also concluded that children’s theories are inconsistent. Wiser argued that children did not take into account volume and gave contradictory responses to problems. While children accurately predicted that a bigger vessel would take longer to boil than a smaller one on identical burners, they inaccurately believed that it would not take more heat to boil a larger vessel. Children therefore thought of heat as a temperature that is measured in degrees without taking volume into account in the way an expert might have done.

Piaget, a famous child psychologist, adopted the ‘child as scientist’ view describing children as ‘little scientists’ (Piaget, 1929). The Piagetian approach states that children use the same cognitive processes that scientists use to construct scientific theories and like scientists they are constantly experimenting and trying to make sense of the world. Piaget, however, suggests that children’s worldviews are still developing. For example, they cannot understand how one action may lead to an occurring reaction because they do not possess the logical operations to do so.

Piaget proposed a staged sequence of child development, identifying the following four stages: the Sensorimotor (0-2 years), Preoperational (2-7 years), Concrete Operational (7-11 years) and Formal Operational (11- adulthood). In the 'Sensorimotor' stage, children can differentiate between self and object and are aware of their senses (hear, feel, touch, and smell). In the 'Pre-operational' stage, children learn to use language, are egocentric and are able to classify objects by a single feature (e.g. the child can collate all the red blocks disregarding the shape of the blocks). In the 'Concrete operational' stage, children can think logically about objects and events and can classify objects according to several features such as shape and size. In the last of Piaget's stages, the 'Formal operational', children can think logically about abstract propositions and test hypotheses systematically and are capable of thinking of issues that may arise in the future. Piaget believed that these cognitive changes occurred due to two main factors: maturation of the brain, where the growth of the brain results in more complex thoughts and allows higher levels of thinking to occur; and the child's interaction with the environment, as the child develops by intrinsically exploring and experimenting in their environment (Piaget, 1929).

In contrast to Piaget, other researchers claim that children's theories are more concrete than scientific theories. This stems from a position in child development that children are 'perceptually bound' in comparison to adults (Brown, 1989). Brown argues that children appear 'perceptually bound' because they lack abstract knowledge and use physical similarities that have been experienced in order to respond to questions about the natural world.

Piaget's theories have been subject to numerous criticisms. Firstly, his methodology has come under scrutiny with critics suggesting the instructions posed to children were difficult to understand and thus were usually misunderstood (Nolen-Hoeksema, Fredrickson and Loftus, 2009). Secondly, many argue that even though a sequence of children's development does exist, this sequence does not occur in such discrete stages. Additionally, Piaget has also been criticised for underestimating children's abilities.

For my research, it was critical that children were at a stage of development where they have accumulated reasoning about the world. Piaget's theory of cognitive development was taken into consideration when choosing the specific age of the children to participate in the current study. The children involved in this study were mainly in the concrete operational stage where children are expected to have the ability to sort objects according to various characteristics such as appearance, size, colour, and shape. They are also expected to name and identify sets of objects and are no longer subject to the idea of animism (all objects are alive and thus have feeling). Children at this stage should also be able to take into account multiple aspects of a problem to solve it and, most importantly to this research; children should have the qualities of egocentrism: the ability to view things from different perspectives (Piaget, 1929). In accordance with Piaget's theory, these characteristics therefore appear to be ideal for the interpretation of emergent behaviours.

Despite the criticisms of Piaget's stages of development, they were still taken into consideration when choosing the ages of children for the current research due to the applicability of his framework. Even though Piaget's theories were established several decades ago, his pioneering work has been supported by many studies. Many contemporary researchers and psychologists have implemented similar age boundaries distinguishing the different stages in children's life reflecting the notions put forward by Piaget (e.g. Avan and Kirkwood, 2010; Goddard, Hoy and Woolfolk Hoy, 2004). In this study, Piaget's stages of development were therefore only used as a guide to investigate children's perceptions of robots and robot activity.

In assessing whether children are novice scientists, the evidence suggests that even though children may share similar characteristics with scientists, they do not engage in similar processes of logic, as the Piagetian approach suggests. Also, children's worldviews are not primitive adult versions, but are qualitatively different from those of adults (Nelson, 2007). Comparable to scientists, children gain ideas about concepts and notions from past experiences. However, unlike scientists, children are typically portrayed as gullible (Dawkins, 1993) and are easily influenced by the media. Thus, children may have more preconceived notions than adults. As it is possible that children may have more predetermined ideas about robots, it was questionable whether they could adopt a rational approach to conceptualizing the patterns of behaviour amongst robots. Consequently, it is important to examine children's assumptions about and knowledge of robots as well as their understanding of the emergent behaviour patterns of e-pucks. Nevertheless, putting the novice scientist debate to one side, the current research project views children as active participants in society who are capable of making an important contribution to social research.

1.6. Stumbling Blocks/Research Impediments

Working as part of an interdisciplinary project has many benefits as greater collaboration and networking assists in solving complex problems when researchers from many disciplines combine their expertise. However, there were also setbacks in this study. In robotics research, there are several difficulties that robot engineers face even with the most sophisticated technology, such as achieving stability and fluency of movement in robots (Nehaniv and Dautenhahn, 2007). Along with these issues, the technical team faced many unexpected setbacks during the course of the research. Table 1 provides more detail of the main obstacles and successes experienced throughout the project.

Key Events	Bristol Robotics Laboratory	Computer Science- University of Abertay-Dundee	Computer Simulation- University of Manchester	Philosophy- University of Exeter
Obstacles				
2008	• PhD student leaves. New student recruited. • E-pucks did not have sufficient built-in memory. • Working with embodied robots was problematic. Even though the e-pucks were able to move, see, hear and communicate through flashing lights, these devices were not as sensitive as the research team anticipated therefore reducing clarity. • Further limitations include problems with the hardware. The amount of data involved from all the different sensors was greater than the team could process. This meant that, by necessity, the raw data needed to be simplified but, in doing so, detail was lost such as the camera's resolution and the clarity in the e-pucks' movements. • The team could not estimate the number of limitations for the imitation algorithm – the calculations made on paper or on a simulation may not apply to the real hardware. They then have to be tested and corrected if needed.	• PhD supervisor leaves- new supervisor recruited. • The team did not have an existing robot simulator.	• Post-doctorate research fellow leaves.	
2009	• Correspondence and synchronisation problems. That is, the problems associated with when the robot sees something and has to translate it into an action.	• Even though player stage was devised, there was no sound simulation built into it.	• Not much data set from the robots in Bristol. • Post-doctorate research fellow leaves.	
2010	• Problems with communication between the linux board and the e-pucks. The imitation algorithm was running in the linux board (high-level program) and simple programs (such as turn left, right) were running in the e-pucks.	• The e-pucks were not designed to hear each other. To ensure they hear each other consistently requires very contrived set-ups that are not suitable for actual experiments.		• PhD student leaves.
2011	• When a single robot is added to e-pucks interacting, the data became harder to analyse. The team did not want to add more robots without fully understanding what was going on between these two initial e-pucks.			

Successes				
2008	• First version of imitation 90 degree turns – The robots were allowed to turn multiples of 90 degrees (i.e. 90, 180). • Linux board was developed to compensate for insufficient memory in the e-pucks	• Due to the problems with the e-pucks, it was decided that the team in Bristol would focus on the imitation of movement whilst the team in Abertay would focus on the imitation of sound.	• Developed work on language modelling. • Published papers looking at the evolution of vowels and frequency in language.	• Workshop organised in Exeter. • The reaction from academics from other disciplines was favourable.
2009	• Due to correspondence and synchronisation problems, a protocol was made- each command the linux board sends has an index. Upon receiving the command, the e-puck acknowledges the command. This prompts the linux board to send another command. • Player Stage was devised.	• A simulator was built that incorporates the e-puck features/quirks and can show meme transmission and evolution.	• New researcher recruited. Developed some data mining visualisation strategies.	• Conducted interviews with the aim of philosophically understanding the cultural ethnography of the project.
2010	• The team decided to remove the limitations. The 2nd version of imitation allowed any kind of turns. In the previous versions there was less variance. The newer version has more variances which makes it more interesting.	• A simulator was developed that can show the same new meme emerging more than once, so not every meme has a single origin (convergent evolution) and can show the effects of different factors on a population of imitating e-pucks (i.e. the effects of population size, difference in starting memes, movement speed, memory strategy, selection strategy).	• New research fellow recruited.	
2011	• Imitation experiments being carried out.		• Numerous mathematical models simulating robots singing and listening produced.	

Table 1 Project key events.

Due to the technical problems in developing programs for the robots, I could not engage children in interpreting emergent patterns of behaviour until the later stages of my research. Nevertheless, corresponding with the technical progress of the other team members, I decided to explore children's perceptions of autonomous robots (e-pucks). The only programming developed at the time of my fieldwork involved robots following each other in lines. They did this by following the illuminated tail lights on the back of another robot. These lights were programmed to blink at a specific frequency which another robot could detect using a filtering algorithm, allowing robots to see the tail lights of another robot. Their behaviour was self-organised; it looked as though the robot at the front was leading but it was programmed for another robot to follow, unaware that it was being followed by a line of robots. The key to robots forming long lines is that each robot cannot see its own tail lights. Due to both external and internal influences, such as other lighting in the room and the level of charge in each robot's battery, variation in robots' behaviour occurs. Interestingly, this can appear to be a spontaneous variation in the behaviour of robots as factors that bring about this variation might not be apparent to an observer. Many autonomous robots in today's society portray unpredictable behaviours due to their ability to learn and adapt (Chapter 2 explores this further). Entities that are endowed with illusions of autonomy are essential if children are to perceive robot interactions as indicative of an emerging culture. In addition, by exploring children's perceptions of robots, significant contextual knowledge is attained before immersing children in identifying emerging patterns of behaviour.

Earlier in this chapter, I discussed 'culture' within the context of this research project. As one of the project's aims is to 'shed some light generally on how culture emerges' (UWE Bristol: News, 2007), I decided to focus on one aspect of children's cultures: how they perceive robots. The use of the term 'culture' in this thesis differs from the use of the term culture within the wider, interdisciplinary project as the wider project refers to memes as a unit of information, while this thesis focuses on human culture -- specifically the lived culture of children. How the term culture is used within this thesis is further examined in the following section.

1.7. Lived Culture

Williams proposes three broad definitions of culture. Firstly, culture is 'a general process of intellectual, spiritual and aesthetic development' as represented by the work of influential poets and artists. Secondly, culture comprises 'the works and practices of intellectual and especially artistic activity'. Comparable to the first definition, these are texts and practices that allow us to speak of a culture; such as the 'pop music culture' or the 'soap culture'. Thirdly, and the most relevant to this thesis, culture is defined as 'a particular way of life, whether of a people, a period or of a group' (Williams, 1983:90). This definition of culture encompasses 'youth subcultures' for example and is 'referred to as lived cultures or cultural practices' (Storey, 1993:2). Technology today is recognised as part of children's cultures and it is argued that the pervasiveness of technological artefacts such as robots will not only alter children's lives in practical ways but will also alter their fundamental beliefs and concepts such as what it means to be alive (Turkle, 2005). It is possible that children are forming cultural ideas and expectations of their own that are enriched by robots and their cultural representations. My findings contribute to the larger project providing an insight into how children perceive robots which is vitally important for future research when engaging children in identifying patterns of robot behaviour. In the following section, my rationale for studying children's perceptions of robots will be explored further.

1.8. Rationale for Researching Children's Perceptions of Robots

In recent years, computers, consoles and various other technologies have become the leading leisure activity for children today (Wartella, O'Keefe and Scantlin, 2000). Many predict that in years ahead technology will play a central role in all aspects of children's lives (Dautenhahn, Fong and Nourbakhsh, 2003). The pervasiveness of technology has led to many researchers and academics to suggest that children growing up now belong to a 'digital generation', that is 'a generation defined in and through its experience of digital technology' (Buckingham and Willet, 2006:1). Buckingham and colleagues argue that the popularity of the term is evident in its use in many sectors such as education, entertainment and government. For example, Mehlman (2003) noted that Panasonic is advertising its e-wear MP3 players as providing 'digital music for the digital generation'. Mehlman (2003) also discusses the US Department of Commerce discussing the 'preparation of the digital generation for the age of innovation'. There are also various labels such as 'cyberkids' (Holloway and Valentine, 2003) and 'cyborg babies' (Davis-Floyd and Dumit, 1998). Brooke (2002) discusses the 'thumb generation' – young people in Japan who have apparently developed a new agility in their thumbs as a result of their use of game consoles and mobile phones (in Buckingham and Willet, 2006:1).

Robots are one form of technology that are not only increasing in number but are also becoming more interactive (Chapter 2 explores this in more detail). What does this mean for the generation of children growing up surrounded by robots? It is possible that children's identities are increasingly shaped by technology and a new form of childhood is being created that in many ways fundamentally differs from the one children had just a generation ago. Are children forming new identities as their relationship with technology changes whereby they are prepared to overstep the traditional distinction between animate and inanimate qualities in an attempt to formulate explanations about the capabilities of technological artefacts? (Turkle, 2005) This is typified in computer games where children adopt characters and identities. As children are immersed in these advanced technologies, their views and perceptions will become increasingly important to social research.

In an attempt to explore and further build on these notions, the main research question: **'How do children perceive robots?'** was developed. The following objectives of the study were:

Overall Research Objective:

To understand how children perceive robots.

The overall research objective can be divided into the following three sub-objectives:

1. To investigate children's perceptions and understandings of robots prior to any researcher-led prompts involving robots.
2. To understand children's perceptions of e-pucks.
3. To explore how children interpret robots interacting with each other.

1.9. Outline of the Thesis

This thesis consists of five chapters. Chapter 2, the literature review, situates this thesis within an interdisciplinary field of human–robot interactions and draws on research from the disciplines of sociology and psychology and also extends to the fields of engineering and ethics. As a result, the literature review is based on a wide range of theories on children's relationships with technology. The chapter introduces the concept of social constructivism, the theory adopted as the framework for this study, as well as providing an overview of the definitional problems associated with the word 'robot'. Key debates situated within sociology of technology studies such as technological determinism are explored along with the importance of technology in people's lives. Research within the field of child-robot interaction is then outlined and theoretical perspectives on child-robot interaction are presented. This chapter also explores the role of imagination in children's play. In addition, the tendency of humans to anthropomorphise technological artefacts is discussed in relation to sociological and psychological theories. Finally, I argue that it is imperative to combine both sociological and psychological theories when investigating children's perception of robots.

Chapter 3 is divided into two sections: Methodology and Methods. The methodology section discusses Clark's (2004) mosaic approach, which proposes a multi-method, participatory framework. Within this framework, this thesis draws upon aspects of phenomenology, visual methodologies, semiotics, observation and group interviews. The advantages and drawbacks of a multi-method approach are presented, followed by the ethical implications of the study.

In section two, the method of study used for each phase of the research is outlined. Data from Phases 1, 2 and 3 were collated from schools whereas data from Phase 4 was gathered from a public science event. Throughout this chapter I have provided the method of analysis for each of the four phases. Issues such as negotiating access and the selection of participants are also explored.

Chapter 4 reports the results generated from all four phases of research and explores the results obtained from triangulating the data. In the drawing activity in phase 1, children mainly depicted humanoid robots. When they were requested to write a story about their robots, children attributed agency to their robots. Robots were generally viewed as positive although a few stories also portrayed robots negatively. The children's drawings and stories depicted many of the robot stereotypes present in the media. Findings from phase 2 showed that children mainly attributed intention to the robots' actions. However, when these children were asked about the robots' functioning, some reported that 'people' controlled the robots whilst others suggested that the locus of control is located within the robot itself. From the data collected from phase 3 of the research, the theme of 'control' and 'the locus of control' featured in many of the children's statements. Some children stressed that robots are 'controllable' whereas others suggest that the locus of control is located within the robot itself contributing to the robots' autonomous movements. The technological mechanisms played an important role in the robots' functioning as they were used to 'control' the robot; sometimes by the robots themselves and most often by the user. In the pilot study engaging children in spotting patterns of behaviour (phase 4), children suggested that the robots were 'playing a game'. This was interpreted as the children identifying a pattern of behaviour, albeit expressed within language that they are familiar with.

Chapter 5, the final chapter of this thesis, sets out the conclusions of this study. The findings of the research presented in Chapter 4 are discussed in relation to existing literature in this area. Consistent with many human –robot interaction findings, children appear to endow robots with animate as well as inanimate characteristics. However, I suggest that the notion of control is important in children's conception of animacy. The second part of this chapter provides an overview and reflection of the methodological approach used. This is followed by the implications of this study for the wider artificial culture project. The limitations of the study are also acknowledged followed by recommendations for further research in this field.

Chapter 2: Literature Review

2.1. Introduction

During the past century, the rapid rate of technological advancement has resulted in the pervasiveness of technology[2] across all aspects of society. As the nature of technologies change, such as robotic artefacts, various authors and researchers have adopted the view that the technological revolution will produce substantial, on-going changes to the way individuals perceive themselves and the technologies that surround them (Papert, 1980; Pesce, 2000; Turkle, 1984; Turkle, 2005).

The presence of intelligent robots that appear to have autonomy and control over their own actions, raise questions such as: what does it mean to be alive? (Turkle, 2005) and who or what is in control? Researchers have demonstrated that children have a propensity to attribute animate characteristics to robots, possibly because of this perceived control and autonomy (Bumby and Dautenhahn, 1999; Melson, et al., 2009). It is therefore likely that the way in which children perceive these increasingly interactive, autonomous robots will affect their relationship with robots and may influence the development and integration of robots within society.

[2] Throughout this thesis, technology is referred to any tools and machines created to achieve some value.

This thesis is situated in an interdisciplinary field of human–robot interactions. Drawing on research from the disciplines of sociology and psychology as well as the fields of engineering and ethics, this chapter examines a wide range of theories on children's relationships with technology. The concept of social constructivism has been adopted as the framework for this study, guided by the belief that the formation and development of children's views of robots are a result of an interaction between biological predisposition, cognitive sophistication, and socialisation. In the next section, an overview of the key theories and concepts within social constructivism is provided to explore why social constructivism is best suited in the current project to investigate the complex interaction of biological and social factors in children's perceptions of robots.

This chapter also reviews the development of robots in the context of everyday life, including robots in the media. Subsequently, the definitional difficulties of the word 'robot' are explored, followed by an overview of the popular debates surrounding technologies. Next, consideration is given to existing studies relating to children and robots. After highlighting the dearth of research exploring children's interactions with robots, a trajectory of the interactivity levels of robotic artefacts is presented as well as how robots' interactive capabilities affect robots' perceived locus of control. Studies reporting children's relationships with highly interactive robotic entities are then presented, followed by the theoretical discourse surrounding the relationship between humans and machines. This chapter then highlights the possible reasons for the relationship between children and robots drawing on psychological and sociological theories. Finally, the conclusion examines, in line with social constructivism, the need to move beyond a solitary theoretical perspective by combining psychological and sociological approaches when investigating children's relationships with and perceptions of robots.

2.2. Social Constructivism

The term social constructivism is derived from concepts of 'constructivism' and 'constructionism'. 'Constructivism' and 'constructionism' are very similar terms and are often used interchangeably (Freeman and Mathison, 2009). Both terms are used for:

> 'the view that all knowledge, and therefore all meaningful reality as such, is contingent upon human practices, being constructed in and out of interaction between human beings and their world, and developed and transmitted within an essentially social context' (Crotty, 1998:12).

Constructivism unlike constructionism is rooted in philosophy and psychology and focuses on the individual's engagement with his/her environment. In interaction with the environment, meaning is constructed in the mind of the individual. Many of the early empirical studies of childhood utilise this concept[3]. Influential psychologists such as Jean Piaget and Lev Vygotsky emphasise the importance of a child's individual development on their perception of the world. Thus, research in this area has centred on children's activities at particular stages of development. It was generally agreed that children perceive the world in substantially different ways

[3] For example, Piaget's conservation tests assess whether children can discern that changes in the shape or size of a container will not affect the quantity of the liquid contained therein.

from adults and at different ages throughout childhood (Gelman and Gottfried, 1996; Piaget, 1929).

Constructivism as applied in the study of children has generated considerable debate. Within constructivism there is a notion that an individual's development ends when a child becomes an adult. Freeman and Mathison (2009) reject the notion that childhood connotes immaturity and only in adulthood will an individual display full competency in their thinking patterns (Freeman and Mathison, 2009). Critics of the constructivist perspective also argue that 'constructivism offers an active but somewhat lonely view of children' (Corsaro, 2005:16). Even though constructivists recognise that the relations between the child, parents, teachers, and peers can be influential in shaping individual children's views, they do not take into account how children become part of cultural systems through interpersonal relations, and thus how cultural norms and practices are reproduced collectively.

Social constructionists, on the other hand, suggest that 'all social reality is constructed, or created, by social actors' (Esterberg, 2002:15). Their focus therefore is more on society and how it is created, rather than the interaction of individuals with their environment and its impact on the individual. Social constructionists consider it unproductive to speak only of the development within an individual's mind, as society and culture influence the way things are perceived by individuals. Social constructionist theory stems from interpretive sociology, which emphasises the social construction of meaning through mediums such as language, norms and social relationships (Freeman and Mathison, 2009). Approaches such as interpretive sociology and social constructionism are linked to the theoretical tradition of 'symbolic interactionism'. Symbolic interactionism is located within three premises (Blumer, 1969:2). Firstly, an individual's conduct towards an object is related to the meaning he/she has for this object. Esterberg uses the example of chopsticks, stating that an American or European individual might perceive a bundle of bamboo sticks as simply sticks whereas an individual living in China might relate to the same bundle of sticks as chopsticks (Esterberg, 2002). Secondly, through social interaction, meaning is established. Again, using Esterberg's example, chopsticks in China are familiar eating utensils present in restaurants and homes. However, a child from another culture who had never seen chopsticks used would be unaware of their purpose. Thirdly, meaning is constructed and constantly changes through interpretation. Esterberg states that the form of chopsticks does not indicate their purpose; however, their meaning is 'understood through a process of interpretation' (Esterberg, 2002:15). For instance, if chopsticks are placed on the dinner table, one might infer that they are some form of eating utensil. A child on the other hand, may assume that they are placed on the table as a toy. At that point, the child has constructed a meaning. However, after the child sees an adult eating with chopsticks, their interpretation may change.

Social constructionism places considerable emphasis on the influence of culture, experience and interaction in the shaping of an individual's views and perspectives. This differs from the constructivist viewpoint that individual psychological development is paramount in addressing children's perceptions. The difference between the construction of knowledge from an individual level (constructivism) and a societal level (social constructionism) has generated 'substantial cross-criticism between the two camps' (Gergen, 1999). As a result, the social constructivism perspective has attracted those who uphold both concepts in equal measure (Freeman and Mathison, 2009).

By integrating the two perspectives, social constructivists propose that individuals interact in a socially-constructed environment and these interactions shape their experiences.

> 'Constructivism…points out the unique experience of each of us. It suggests that each one's way of making sense of the world is as valid and worthy of respect as any other, thereby tending to scotch any hint of a critical spirit. On the other hand, social constructionism emphasizes the hold our culture has on us: it shapes the way in which we see things (even in the way in which we feel things) and gives us a quite definite view of the world' (Crotty, 1998:58).

Consistent with social constructivism, Corsaro (2005) states:

> 'Children do not simply imitate or internalize the world around them. They strive to interpret or make sense of their culture and to participate in it. In attempting to make sense of the adult world, children come to collectively produce their own peer worlds and culture' (Corsaro, 2005:24).

This assumption rejects the notion that children have a universal experience of life. Instead, it is argued that experiences of childhood vary between societies, and factors such as socio-economic status, gender and ethnicity play an important role in this variation (Jefferis et. al, 2002).

Social constructivists argue that children's experiences shape their perceptions of themselves and their surroundings. The views held by each child are important whilst still recognising the influence of culture on these views (Freeman and Mathison, 2009). Adopting a social constructivist perspective in this way enables the individual's experiences and meanings to be understood in the context of their social world. Thus, individuals are to be understood as embedded within the society they experience. This thesis explores children's perceptions and interpretation of robots and robot behaviour, but in doing so it takes account of how this may be influenced by the social context of children. However, this thesis also considers how children's interactions with robots are currently shaping children's social context and how this may influence the character of their society in the future.

Before exploring the existing literature on children's interactions and relationships with robots, a brief overview of the development of robots and their uses in society is provided. Robots as featured in media such as film is also discussed as well as definitions of robots. This is followed by a section on the sociological issues surrounding technology.

2.3. The Development of Robots

The world of robotics, like that of all technology is changing rapidly (Melson, et al., 2009). Over two decades ago, robots were usually only found in automotive assembly plants and a few university laboratories (Druin and Hendler, 2000). Predications are that between 2010 and 2013 about 80,000 units of professional service robots will be sold, including military and surveillance robots, robots assisting in transportation, medical robots together with millions of vacuum cleaner and entertainment robots (World Robotics, n.d.). Indeed, we have already witnessed drastic growth, from 4.5 million in 2006 to 8.6 million in 2008 (Guizzo, 2010). These sales figures indicate the gradual permeation of robots within society, providing individuals with entertainment, domestic assistance and health care (Coeckelbergh, 2010b). Lin et al. (2011) present an overview of the robots that are presently in use in society:

- Domestic robots – Robots such as 'Roomba' vacuum cleaners make up almost 50 per cent of the world's service robots. Others include robots that do the washing, mowing and ironing.
- Entertainment and companionship robots – Toys that include AIBO (discussed later), Pleo, PaPeRo and Robosapien were manufactured to provide entertainment (much like a pet) for adults and children alike.
- Medical and healthcare – Robotic dolls such as Kaspar are designed to improve communication and socialisation among autistic children.
- Research and education – NASA's Mars Exploration Rover is designed to explore the planet Mars, offering just one example of robots being used to conduct experiments in naturalistic settings. Similarly, robots are also being employed in classroom settings to deliver lectures and assist in educational activities such as counting and vocabulary.
- Military and security – These robots include Predator, Reaper and Crusher, which are designed to attack targets, defuse bombs, issue warnings and much more. A growing market also exists for robot security in the home whereby

robots have the ability to transmit photos of suspicious activities to their owner's mobile phone.

- Environment – Robots in this area are manufactured to identify toxins, clean polluted areas and even collect information on climate change (Lin, Abney and Bekey, 2011:944).

New developments in the field of robotics research have generated extensive attention. Academics and designers alike are interested in people's expectations and perceptions of robots when developing and designing robotic artefacts to assist in education, therapy and entertainment (Brezeal, 2002; Lin, et al., 2009; Okita, et al., 2005; Woods, Dautenhahn and Schulz, 2007). For instance, in the field of education, Lin et al. (2009) found that children aged 10 to 11 years viewed robots positively and would like to see robots in the classroom. Researchers, in investigating the therapeutic use of robots, were interested in how the elderly viewed robots as aids to perform tasks that were difficult to carry out or as company for the elderly with mobility issues (Monk and Baxter, 2002). Similarly, Dautenhahn et al. (2005) investigated individuals' views towards a robot companion in the home. They found that the majority of their participants were in favour of a robot companion to be their servant, assistant or machine.

This brief summary of the development and use of robots illustrates the increasing prevalence of advanced robots in society. Sophisticated humanoid robots have long featured in the science fiction genre (Bradshaw, et al., 2008). Many people, when asked about robots, refer to science fiction films rather than their personal experience of robots (Khan, 1998; Ray, Mondada and Siegwart, 2008; Scopelliti, Giuliani and Fornara, 2005). Thus, the following section explores how robots feature in the media, with a particular focus on robots in fictional film.

2.3.1. Robots in the media

Robots are widely represented in popular culture, particularly in the media. Robots first entered public discourse following Karel Capek's play 'Rossum's Universal Robots' which was performed in 1921 (Bradshaw, et al., 2008). This somewhat cautionary tale depicts the dangerous effects of issues relating to insufficient programming. Since then, robots have featured as the main protagonist in many best-selling films. Robots are used in science fiction across many cultures; India has just released its first 'robot' film, deviating from the typical 'Bollywood' love story. It is allegedly the most expensive Indian film ever made (Tilak, 2010).

According to social constructivism, children are exposed to a multiplicity of ideas through various forms of media that could influence their perceptions of robots. Society that is saturated by the mass media and for many in the Western world, film, radio, music, television and the Internet are part of daily life. It is therefore no surprise that people often refer to popular culture when asked about robots (Khan, 1998; Ray, Mondada and Siegwart, 2008; Scopelliti, Giuliani and Fornara, 2005).

The media and the media's representation of topics and concepts play an important role in the shaping of people's ideas (Hall, 1997). Giroux (1999), in his study analysing the effects of Disney media on children and adolescents states that popular culture 'is the primary way in which youth learn about themselves, their relationship to others and the larger world' (Giroux, 1999:2). Murdock (1998) argues that media permeates life in two different ways. Primarily, media contact provides the population with their primary leisure activity. However, Murdock agrees with Giroux in suggesting that for many people, the media provides social and political explanations, images and general lifestyle suggestions. The mass media also provides individuals with access to information about which they have no prior experience. For example, Wineburg (2001) reports that inmates entering prison for the first time are likely to use events seen on television/film to anticipate what might occur in their new environment. Therefore, the media is not just entertainment but it exerts a powerful influence on people's ideas, perceptions and even actions. This was an important consideration of the research design undertaken for this thesis, to understand children's pre-existing perceptions of robots before observing their interaction with actual robots.

Researchers and theorists have argued that the mass media serves as a powerful socialising agent (see, for example, Croteau and Hoynes, 1997). Socialisation refers to the process by which we learn and internalise the values, beliefs and norms of our culture and in doing so develop a sense of identity (Graber, 1997). According to Huntemann and Morgan, the media may lead to 'the cultivation of a child's values, beliefs, dreams, and expectations, which shape the adult identity a child will carry and modify through his or her life' (Huntemann and Morgan, 2001:311). This issue is explored further in Chapter 5 where consideration is given to how the experience of children now, both through the media and direct interaction with robots, might establish certain characteristics of future generations of adults.

Critics of the theories concerning the powerful influence of the media suggest that humans are rational and critical subjects who are adept at interpreting and critiquing media representations, rather than passively absorbing them. Coinciding with the social constructivist view, Gauntlett (1996) argues that researchers have sometimes focused too closely on the effects of media ignoring other influential factors that may shape people's ideas and thinking. As demonstrated in Chapter 4, children's perceptions of robots appear to be strongly influenced by the media, although other aspects of socialisation such as gender have a modulating effect.

Given the powerful influence of film on perceptions of robots in society, the next section explores how robots are represented in popular film.

2.3.2 Robots in popular film

Typically, the genre of science fiction films has 'committed itself to certain kinds of narratives, conflicts and closures' (Bukatman, 1993:12), lending itself to the portrayal of robots within a particular set of discourses. The fictional narratives usually represent robots as autonomous, technologically-advanced entities that provide hope for a better future, for example, by relieving humans of menial tasks.

However, a further narrative portrayed in the media also evokes the fear of robots taking over.

Telotte (1995) argues that within science fiction films there is a blurring of the distinction between hope and destruction. Early science fiction films have commonly depicted robots as destructive beings that would ultimately obliterate their creator. Asimov coined the term the ‘Frankenstein complex’ to describe the ‘part of an anti-scientific tradition which treats science as a violation of nature and a dangerous act of human pride’ (Portelli, 1980:150). Asimov suggests that science should be seen as progress for humankind, rather than a threat. However, Susan Sontag (1966) in her essay on science fiction films states otherwise: they are ‘not about science’, she says, ‘they are about disaster’ (Sontag, 1966:215). She argues that science fiction is concerned with the aesthetics of destruction. Additionally, it is the imagery of havoc and destruction caused by robots that is the core of a good science fiction film (Sontag, 1965).

Robots can, however, be represented as a positive development for human society, as providing a service to humans. This service would result in our lives being easier, less complicated and free from work. However, Bates (2004) argues that individuals are not only looking for another domestic machine such as a vacuum cleaner but that they want these characters to be more natural and lifelike. In science fiction films robots are seldomly seen only as machines but often feature human-like characteristics, motivations and a personality (Khan, 1998). Thus, science fiction films, although often prompting fear about what the world would be like with robots, have also instigated and reflected hope for a world with robots.

The roboticist Professor Alan Winfield, principal investigator of the wider project[4], which this research is nested, has suggested that ‘real robotics is a science born out of fiction’ (Winfield, 2011:32). Many film theorists and academics assert that expectations of robots in real life stem from robot depictions in the media (Bukatman, 1993; Telotte, 1995; Khan, 1998).

Until now, references to and usage of the term robot/s have implied that the meaning of the term was both obvious and shared by the reader. Given that robots have been featured in films for a number of years, one would assume that establishing the accepted definition of a robot should be a simple task. However, when Joseph Engelberger[5] was asked to define a robot, he stated: ‘I can’t define a robot, but I know one when I see one’ (Poslad, 2009:205). In the next section further consideration will therefore be given to the definition of ‘robot’.

2.4. Definitions of ‘Robot’

Engelberger’s response to the question Define a robot? indicates the difficulty of providing a single definition for ‘robot’. The Merriam-Webster Dictionary defines a robot as ‘a machine that looks like a human being and performs various complex acts

[4] ‘The emergence of artificial culture in robot societies’ project.
[5] Joseph Engelberger has been called the father of robotics. The American engineer and entrepreneur helped create the first industrial robot. See Poslad, S. (2009) Ubiquitous computing: smart devices, environments and interactions. Chichester, Wiley.

(such as walking or talking) of a human being' (Merriam-Webster Online Dictionary, 2010). In contrast, the Encyclopaedia Britannica lists a **robot** as 'any automatically operated machine that replaces human effort, though it may not resemble human beings in appearance or perform functions in a humanlike manner' (Encyclopedia Britannica, 2010).

There is possibly no single definition of a robot that works for all audiences and academic disciplines. Throughout this thesis I do not espouse Merriam-Webster's definition, as many robots produced for research purposes do not necessarily resemble humanoid figures. In fact, only a small minority of robots that are manufactured are humanoid. From my experience working on this research, those in the technical field tend to favour the Encyclopaedia Britannica's definition although not in its entirety, as robots are not all engineered to replace human efforts.

The robots used in this project: e-pucks (described in Chapter 1) do not fit with either definition, as they do not bear a resemblance to the human morphology nor were they created as human labour substitutes. The roboticist Professor Alan Winfield, principal investigator on the wider project[6] provides a precise definition. He states: 'A robot is a self-contained artificial machine that is able to sense its environment and purposefully act within or upon that environment' (Winfield, 2006:no pagination).

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[6] 'The emergence of artificial culture in robot societies' project.

Professor Winfield's definition may be indicative of the nature of robots used in this project and also in most of his other work. Because of my involvement with the wider project and experience with e-pucks, Winfield's definition is implemented throughout this thesis. Various mechanisms such as motors, sensors, and batteries constitute robots and provide the capacity for them to interact with the environment (Robertson, 2010) and their interaction with the environment can be autonomous or semi-autonomous. Bekey (2005) defines an autonomous machine as a machine with 'the capacity to operate in the real-world environment without any form of external control, once the machine is activated and at least in some areas of operation, for extended periods of time' (in Lin, Abney and Bekey, 2011:943). Autonomous machines are typically endowed with the ability to 'think'. This 'thinking' by a machine has been defined as the ability to 'process information from sensors and other sources, such as an internal set of rules either programmed or learned, and to make some decisions autonomously' (Lin, Abney and Bekey, 2011:943).

Robots can be broadly classified as either biomimetic or non-bio-mimetic. Bio-mimetic robots bear a resemblance to human or animal morphology, whereas non-bio-mimetic robots do not resemble animate entities, e.g., industrial robots. The e-pucks used in this study can be classified as non-biomimetic.

The varying definitions used by individuals result from their perceptions of robots or their interactions with artefacts they identify as robots. A young child may assume a simple robot doll is a robot, whilst for an engineer, adaptive behaviour (artificial intelligence) might be an essential requirement for a robot.

Throughout this thesis, Professor Winfield's definition will be used because the overall project and my own research use the e-puck robots. However, as a social scientist, this definition may not be the obvious choice. Other academics within my discipline who have studied children interacting with robots characterise robots as autonomous objects presenting themselves as having 'states of mind' (Turkle, Brezeal and Scassellati, 2006). A review of the literature on childhood and robots will be presented more fully in section 2.7. However, first, an overview of the literature on the sociology of technology more generally, and the sociology of childhood and technology is provided, as this literature provides the theoretical frameworks within which the specific issue of children's interactions with robots fits.

2.5. Sociology of Technology

MacKenzie and Wajcman (1999) argue that technology has become an integral part of our everyday lives; that regardless of ethnicity, gender, socioeconomic status or geographical location, our lives are intertwined with technology on various levels as it is ubiquitous, providing us with food, shelter, transportation and entertainment. Public debates about the impact of technology have centred on its benefits and its detrimental consequences. Thus, technology is often viewed as infiltrating 'our most intense fears and fantasies' (Buckingham, 2004:108). The view that technology has positive and negative impacts on society has led to notions of technological determinism. The next section explores this in greater detail.

2.5.1 Technological Determinism

The phrase 'technological determinism' was arguably coined by the sociologist and economist Thorstein Veblen (1857–1929), who proposed that technology determines the structure, values and norms of a society (Chandler, 1995). Technological determinists argue that technology has an impact on society and is independent of its social context. Consistent with this view is the notion that technologies such as television and computers, for example, have altered society by determining societal and individual interactions. Thus, instead of technology being a product and an important part of society, it is seen as independent, influential and self-determining. Across some cultural narratives, technology is often discussed as an autonomous agent (Joyce, 2008) beyond the will of society. Joyce, in discussing MRI scans, quotes a reporter who stated 'MRI scans found cancer in her brain' (Joyce, 2008:56). This is consistent with Haraway's (1997) view that when discussing the effects of technology on society, non-human actors are often assigned agency[7].

Isaac Asimov, in commenting on the issue of technological determinism stated:

> 'The whole trend in technology has been to devise machines that are less and less under direct control and more and more seem to have the beginning of a will of their own…The clear progression away from direct and immediate control made it possible for human beings, even in primitive times, to slide

[7] In Social Sciences, 'agency' is referred to an individual having the capacity to act independently and thus are in control of their actions

> forward into extrapolation, and to picture devices still less controllable, still more independent than anything of which they had direct experience' (Asimov, 1981:130).

Social constructivists, however, argue that human action shapes technology rather than technology being the catalyst for determining human action. They suggest that many factors influence new technological devices, including the perceived needs of a society, the human imagination, marketing, the advancement of science and the need for diversity (Webster, 2002).

Social constructivists emphasise the importance of social groups' contribution through expressing their ideals and concerns to the design process (Pannabecker, 1991). Social groups are 'identified empirically as the actors that participate in negotiations or controversies around specific technology' (Wajcman, 2000:451). This is illustrated by Bijker, Hughes and Pinch (1987), who suggest that social groups were influential in the design and evolution of the bicycle. They argue that the bicycle evolved from its original inception as a high wheeler to today's safety bicycle (in Pannabecker, 1991) because of varying influence from different social groups. For instance, women cyclists were concerned about dress and social approval. Young men were concerned about their 'macho image'; the elderly were concerned about their safety whereas sports cyclists were more concerned with speed. Similarly, manufacturers were concerned about economics and the technologists were concerned about materials and the processes involved. This all led to the evolution of the safety bicycle design. Bijker et al. (1987) report that bicycle designs could have taken a completely different route in a context where different social groups had different degrees of influence (in Pannabecker, 1991).

The determinist argument that technology shapes society implies that individuals in society are vulnerable to the positive and negative effects of technology. Buckingham (2004) argues that technology can be dangerous and threatening but can also offer a form of empowerment. In the sub-sections that follow, examples of the impact of technology on three aspects of society are presented: work, domestic life and entertainment. Although by no means exhaustive these examples serve to highlight the repertoire of ideas and debates surrounding the pervasiveness of technology.

2.5.1.1. Technology in the Workplace

Beynon (1992) observes that advances in technology have led to a decline in manual work in industrialised countries with drastic shifts in employment from factory to office work. The development of technology on the one hand is viewed as the key force that positively drives the transformation of society as production is revolutionised with new machinery. On the other hand, critics suggest that technology de-skills the workforce because operating machinery requires relatively unskilled labour. Similarly, the emergence of new technologies may lead to unemployment because manual labour is no longer required. Nevertheless, there has been a shift in work patterns due to the effects of technology; evident with both bluecollar and white-collar occupations (Grint and Woolgar, 1997; Lewis, 1996).

2.5.1.2. Domestic Technology

Household labour is persistently divided along traditionally gendered lines where women assume the larger portion of household chores (Lachance-Grzela and Bouchard, 2010). Many aspects of domestic technology such as the vacuum cleaner and the washing machine have greatly affected the lives of women, given traditional gender roles in the home. At the advent of these technologies, many researchers and academics discussed the impact that this may have. Talcott Parsons (1956) argued that as women spent most of their time engaging in household tasks, they did not have time to engage in paid work. The introduction of domestic technologies no longer required the woman's presence in the home so she was therefore free to enter the labour market. In highlighting the impact of the washing machine, Vanek (1974) states 'probably no aspect of housework has been lightened so much by technological change as laundry' (Vanek, 1974:117). However, research has shown that domestic technologies usually do not reduce the level of women's domestic labour but surprisingly at times increases it (Bittman, Rice and Wajcman, 2004; Cowan, 1985). Reasons for this may include rising standards of cleanliness (Wajcman, 1991) and 'people have more clothes now than they did in the past and they wash them more often' (Vanek, 1974:117). The greater availability of clothes is in part also due to technology, as technological advancement has resulted in the mass production of clothing thereby making it more affordable for the consumer. Thus, the addition of these new tasks may have neutralised any time saved by these new technologies.

This sub-section presumes subscribed gender roles and focuses on the effects of domestic technologies on women in particular, as domestic work has traditionally been associated with women. ‘The male “family breadwinner” mentality became as ingrained in the masculine identity as did the female “homemaker” mentality in the feminine thus doing housework came to be seen as part of enacting women’s natural role’ (Kimmel and Aronson, 2003:408). It is also worth noting that some of the material cited here is somewhat dated, as the work of these authors pioneered the debates about the impact of technology and women’s involvement with the paid labour force.

2.5.1.3. Entertainment technology

Entertainment technology covers a broad range of products and services such as recorded music, movies, television, computer and video games, consoles, the Internet (chat room, social networking websites such as ‘Facebook’, board and card games) and entertainment robots.   The effects of these technologies especially concerning children’s development have prompted extensive debate in recent times, (Götz, 2005; Marshall et al., 2006; Zimmerman, 2007) and this is explored in the section on the sociology of childhood and technology (Section 2.6). One such effect that many researchers have studied is the social impact of television. Studies have found that television leads to sleep problems (Mistry et al., 2007; Johnson et al., 2004), attention problems (Christakis et al. 2004; Obel et al, 2004) and social emotional problems such as depression (Primack et al., 2009). Other studies have investigated the effects of television on issues such as race and gender stereotypes, violence, the portrayal of family life, as well as its educational content (e.g. Huston, et al., 1992). In contrast, there have been numerous empirical studies suggesting that watching television enhances learning and brain development (e.g. Wright et al., 2001; Barr et al., 2008).

The examples explored above have illustrated both the positive and negative influences of technology on society – that is, if one accepts the notion that technology is responsible for these societal changes. The research suggests that the effect of technology is much more complex than the rather two-dimensional idea of social technological determinism. The next section explores the sociological issues surrounding children and technology.

2.6. Sociology of Childhood and Technology

The argument that childhood is a socially-constructed phenomenon has been widely debated in the disciplines of history and sociology. At its heart lies the premise that the 'child' is not a natural category that is simply determined by biology and therefore has one fixed meaning. Instead, the concept of childhood is shaped by historical, cultural, social and political change. Thus, children have been viewed in various ways across time, culture and social grouping (Buckingham, 2004). Many academics do not disregard the fact that 'children' are biologically different from adults, but argue that 'childhood' is defined with 'characteristics and limitations' by various people including children themselves, parents, teachers, policy makers, researchers and the media (Buckingham, 2004; James and Prout, 1990). As a result, the notion of childhood is composed socially through various images and codes (James and Prout, 1990; Jenks, 1992). Children are not only depicted as physiologically immature, but they connote dependency and powerlessness (Gittins, 2004).

The pervasiveness of technology has led to many debates about its function and impact upon the lives of children. These debates usually focus upon technologies such as television, consoles (video games) and computers, as these forms of technology are most prominent in children's lives and are often considered to be potentially the most detrimental to children. The 'technological deterministic' stance that technology is an autonomous discrete force that negatively impacts children's lives implies that children are vulnerable and must be protected from the influential power of technology. This stance underpins much research in the area of children and technology (Buckingham, 2004).

There is speculation that technologies such as television and video games inevitably lead to negative effects on children's 'socio-cultural development, cognitive development and general wellbeing' (Plowman, McPake and Stephen, 2010:65). Children's sociocultural development is considered at risk because technologies promote the decline of children's social interaction with family members and peers because their leisure time is spent with technology instead of engaging in face-to-face interactions and physical activity. Similar determinist arguments emphasise that children's cognitive development is in danger, as technology curbs the child's imagination and linguistic development (Palmer, 2006). Technology may also affect children's physical wellbeing and may lead to complications such as obesity, as children are not physically active because the majority of leisure time is spent indoors with technology (Plowman, McPake and Stephen, 2010). 'The Alliance of Childhood', promoting similar negative views of technology, reports:

> 'The damage being done by immersing children in electronic technologies is becoming clearer. Increasing numbers of them spend hours each day sitting in front of screens instead of playing out-doors, reading, and getting much needed physical exercise and face-to-face social interaction – all of which, it turns out, also provide essential stimulation to the growing mind and intellect' (Alliance for Childhood, 2004:1).

Children's mental stimulation is also seen to be at risk through the use of electronic toys because they threaten creative and imaginative play (Levin and Rosenquest, 2001). It has been debated that play things such as sand and water have a variety of purposes and there is more opportunity for children to create their own play activities and exercise their imaginations. Many psychologists are of the opinion that imaginative play is integral to children's social and cognitive development (Barnes, 1995). The influential child psychologist Vygotsky states 'play contains all developmental tendencies in a condensed form and is itself a major source of development' (Vygotsky, 1978:102). Researchers in this field observe that children's play has changed significantly in recent decades. In the past, children often took their dolls, puppets, and toy cars outdoors and transformed them using their imagination into animate beings (Taylor, 1999). There is a dramatic shift away from exploratory play outdoors, with the majority of children's leisure time now consumed indoors with their technological devices (Beran and Ramirez-Serrano, 2010).

Many critics of ‘technological determinism’, however, contend that children are active users rather than passive consumers of technology (e.g., Buckingham, 2004; Christensen and James, 2000; James, Jenks and Prout, 1998; Plowman, McPake and Stephen, 2010). For example, Tobin (2000) presented two films and two television advertisements to 162 children between the ages of six and twelve years. The children were then interviewed and asked questions about the screenings. Tobin reported that children did not take what they saw at face value but interpreted it within the context of their lives and experiences.

The impact of technology on children’s activities more generally has also been explored. Plowman et al. conducted an 18-month empirical investigation of technology in the home with children aged three and four. This was based on a survey of 346 families and 24 case studies. They reported that all the families in their study participated in various non-technology-related activities: ‘nearly all children played outside in the street or garden and more than half liked to go swimming’ (Plowman, McPake and Stephen, 2010:68). However, the researchers did not state the frequency with which children engaged in these activities in relation to the time spent on technology. Nevertheless, Plowman and colleagues stressed that the number of technologies in the home was not influential in determining whether children spent time interacting with their family members and peers or playing outdoors. However, the cultural practices and values of a household influenced technology use because children were often supervised and given time restrictions. Finally, the researchers concluded that there was ‘no evidence to suggest that the childhoods of these children could be described as toxic or that family life was being undermined’ (Plowman, McPake and Stephen, 2010:71).

Consistent with Plowman et al.’s study, Marsh reported that children’s lives were well-balanced and that technologies such as consoles and televisions played ‘an important, but not overwhelming, role in their leisure activities’ (Marsh, 2005:5). In their report addressing children’s use of popular culture, media and new technologies, Marsh et al. (2005) administered questionnaires to 524 early years practitioners followed by interviews from 12 early years practitioners about their views on the impact of technology on children’s wellbeing. The early years practitioners in their study suggested that technologies such as television and video games positively influenced children’s speaking, listening and literacy, but also voiced concerns about the amount of time children spent using these technologies.

As suggested earlier, those adopting the technological deterministic stance assert that technologies can increase social isolation among children. Nonetheless, children and teenagers are increasingly using computers to access social networking sites, an expression of their development and socialisation that is not very different from that in previous generations (Santrock, 1993). Santrock suggests that in the 1950s–1970s, children and teenagers would quite often spend their free time in shopping centres or at the local ‘hamburger joint’. However, many shopping centres have now imposed a ban on unsupervised youngsters; thus, this may encourage the further use of technologies for socialising (Santrock, 1993). In effect, children are creating their own cultures and communities by using technological tools to suit their needs.

Research suggests that children are competent members of society, capable of actively rather than passively using technology. However, children are granted little or no agency by influential social groups such as policy makers and researchers (Buckingham, 2000). The next section reviews the exisiting, although fairly limited, research literature on children and robots.

2.7. Childhood and Robots

There is extensive design-led research being pursued in the field or robotics (Levy and Mioduser, 2008). For example, researchers have been interested in developing robots to assist children with autism (Bumby and Dautenhahn, 1999). However, very little reseach has been done on children's perceptions of robots and how this perception may influence future generations (Turkle, 1984; Turkle, 2005). One exception is the work of the socio-psychoanalyst Sherry Turkle who has explored children's relationship with technology, particularly computer toys and humanoid/animaloid robots. Turkle is interested in the conceptual perspectives that guide children's thinking about these artefacts. She conducted ethnographic studies in the 1980s and also more recently (Turkle, 1984; Turkle, 2005). In both time periods, she engaged with over 200 children aged 4 to14 years, observing (watching and also playing with children), interviewing and conducting psychological tests to measure the locus of control. These children were chosen at random in a number of naturalistic settings such as schools, day care centres as well as from informal play groups. She collated notes on children's responses to programming, to the animate characteristics that these toys may display as well as their expectations of these artefacts. Turkle's interest resides in children's notion of 'aliveness' and the ideals that constitute consciousness and intelligence. She noted that children in the 1980s were the first generation to be exposed to computer games and toys, and this presented many philosophical questions about aliveness. Because computers were a new phenomenon, there was little discourse about how they should be responded to, and when faced with these machines, children debated their animacy. However, 20 years later, some children easily adopt the adult ready-made response that robots or computers are simply machines and cannot be alive. Nevertheless, she also reports that many children today are so accustomed to interactive machines that they no longer think about whether machines are alive because they are aware that they are not. Yet they are still addressed as though they are animate entities (Turkle, 2005).

Against this background, and building on Turkle's work, this thesis aims to explore how children in the UK perceive robots by conducting a similar study that utilises a mosaic of methods for data collection. In Turkle's study, she focuses on computer games and bio-mimetic robots. In contrast my study uses e-pucks, which are non-bio-mimetic robots.

Children of today are the first generation to grow up at a time when the use of robots is significantly increasing. Throughout this thesis, I suggest that one of the key characteristics of the current generation of children might be how they engage with robots. As robots become increasingly sophisticated and interactive, children may come to understand them in qualitatively different ways from previous generations. The generational characteristics of children today are likely to influence the development and integration of robots within society as this generation of children become adults, and for future generations.

There has been much debate about children's interaction with adaptive robots – robots that 'learn' and 'think' (e.g. Melson, et al., 2009; Lund, 2003; Mioduser and Levi, 2010). Discussions enter the territory of the ethics of deception and illusion where vulnerable user groups are concerned (Lin et al. 2010; Anderson and Anderson, 2011; Wallach and Allen, 2010). Numerous debates have questioned whether it is ethically acceptable to create a robot that dupes individuals, particularly the young and old, into thinking that robots have mental states and sentience. Critics argue that a child's false relationship with robots may be psychologically and emotionally damaging, especially if robots are exclusively used for all childcare needs (Sharkey and Sharkey, 2010).

However, I only briefly touch upon the ethical debates within this thesis as my emphasis is on children's interaction with robots, their interpretation of robot functioning and behaviour and how they perceive the robot's locus of control. During fieldwork, it became apparent that children's interpretation of the robot's locus of control was particularly related to the increasing sophistication of robots and their ability to interact with their environment. The following section therefore explores this further using a range of robotic artefacts as examples.

2.8. Children's Interaction and Locus of Control in Robots

Children perhaps more than adults are exposed to many robotic artefacts, especially in the form of toys. Even though robotic toys have been around for years, the nature of these toys has changed: they are more interactive now than ever before. This section considers robotic toys and their differing forms of interactivity, and argues that robots with high interactivity levels provide the illusion of animacy. Interactivity plays a vital role in creating a sense of reality because the user finds that his/her actions influence the robots' actions. According to social constructivism, individuals construct knowledge internally based on their experiences. Pritchard (2009) suggests that most experience and knowledge are gained from social interaction. Most often, discussion is an important feature in this process. However, in this section I argue that the degree of unpredictability exhibited by these robotic toys provides the user with the illusion of robot autonomy and animacy (Kusahara, 2001) even though language may not necessarily be present. Moreover, this illusion of animacy is heightened at increased interactivity levels and can lead to the illusion that the locus of control is located purely within the robotic toy.

In providing a case for this argument, the next sub-section considers four robotic toys with different levels of interactivity. I chose these particular toys because of their popularity at the time they were launched.

2.8.1. Interactivity levels of robotic toys

Fleming (1996) categorises late 20th century toys into four main themes: (1) 'the theme of a machine' usually found in construction toys such as toy trucks and diggers, (2) 'the theme of young womanhood embodied by a doll' such as the iconic Barbie dolls, (3) 'the theme of animality raised in hard plastic or soft plastic' such as stuffed teddy bears or farm animal figurines, and (4) 'the imaginary play space inside the computer's video chip' such as video games (Fleming, 1996:40–41). I have modified Fleming's categories to include examples of toys that fall within four broad categories of robotic artefacts (children's toys) based on their level of interactivity, as toys available to children today do not conform to this model.

The first of the four categories that I propose includes toys such as dolls and figures that are robot-like in appearance but which are similar to traditional dolls that children played with before robotics became popular via various media such as film. The second category includes animate toys such as clockwork and remote control toys. These toys are manufactured to move and may or may not look like a 'typical' robot. Even though there is movement, they are either unchanging in what they do (clockwork) or directly controlled by their user (remote control). The third category includes toys that are governed solely by computer software. The toys in this category are usually classed as 'Finite State Machines'; that is, the toy exhibits a finite set of states or event categories that follow a certain path (Bruce and Meggitt, 1999). Finite state machines have:

- ' An initial state or record of something stored someplace
- A set of possible input events

- A set of new states that may result from the input
- A set of possible actions or output events that result from a new state'

(SearchCIO-Midmarket.com, n.d.:no pagination).

Finally, in the fourth category, there are toys that have learning capabilities and some level of adaptive behaviour. According to the definition provided earlier**: 'a robot is a self-contained artificial machine that is able to sense its environment and purposefully act within or upon that environment'**; objects in this category are 'robots', whereas those in the first three categories are simply toys with some level of computational behaviour.

Adaptive robots learn through recognising that particular behaviours result in particular results and store this information for future use. For example, if the robot moves its arms to the right and avoids collision, the robot will store this information and use it when it encounters a similar situation. There is a range of levels of interactivity among robotic artefacts. Throughout this section, interactivity is used to indicate a reflexive relationship between the robot and the child. In other words, the child will initiate the robot, the robot will then have an effect upon the child, the child will respond to that effect and in turn the robot will react depending on the response from the child. Elements such as face recognition and adaptive behaviours enhance the degrees of interactivity. This will be illustrated later in this section.

Artefacts such as robotic dolls are members of the first category. These entities can be viewed as fully non-interactive according to my definition as all interactions are based purely upon the child's imagination, e.g. a vintage robotic tin toy. This robotic doll does not conform to any of Fleming's categories. Even though it is a doll in every sense, it does not reflect the theme of womanhood. An example of the second type of robotic artefact is one of the earliest battery-operated toys – a 1950's robot called 'Robert'. A remote-control device is attached to Robert via a cable, whereby its user can control whether Robert is moved forwards, backwards or sideways. Its arms swing back and forth and eyes also light up as it moves. A separate switch activates its voice box and it says, 'I am Robert, the robot, mechanical man. Drive me, steer me, wherever you can' (Stefoff, 2008:92). If the user does not stop the toy from moving forward into a wall, it simply crashes, i.e. there are no sensors that can detect obstacles. As a consequence, the interactions between Robert and its user are minimal. There is just two switches – one for movement and one to activate the voice box. In this sense, Robert is very similar to a wind-up toy that has to be manually 'powered up' for movement. As this toy is battery operated it conforms to Fleming's first category 'the theme of a machine', similar to other remote-control toy vehicles. However, not all toy vehicles are operated by remote-control. Additionally, Robert resembles a doll because it is based on the human figure; but again, it would not fit into Fleming's second category as it does not conform to 'the theme of young womanhood'.

An example of the third type of robotic artefact – finite state machines – is Bandai's *Tamagotchi* (Figure 2) released in 1996. The toy has a small display screen that is encased in a brightly coloured plastic container and has a number of small push buttons on it. The plastic case that embeds the digital screen can be worn as a bracelet, watch, keychain or even hung from the user's neck. The *Tamagotchi* is miniaturised so it can be easily held and transported (Bloch and Lemish, 1999).

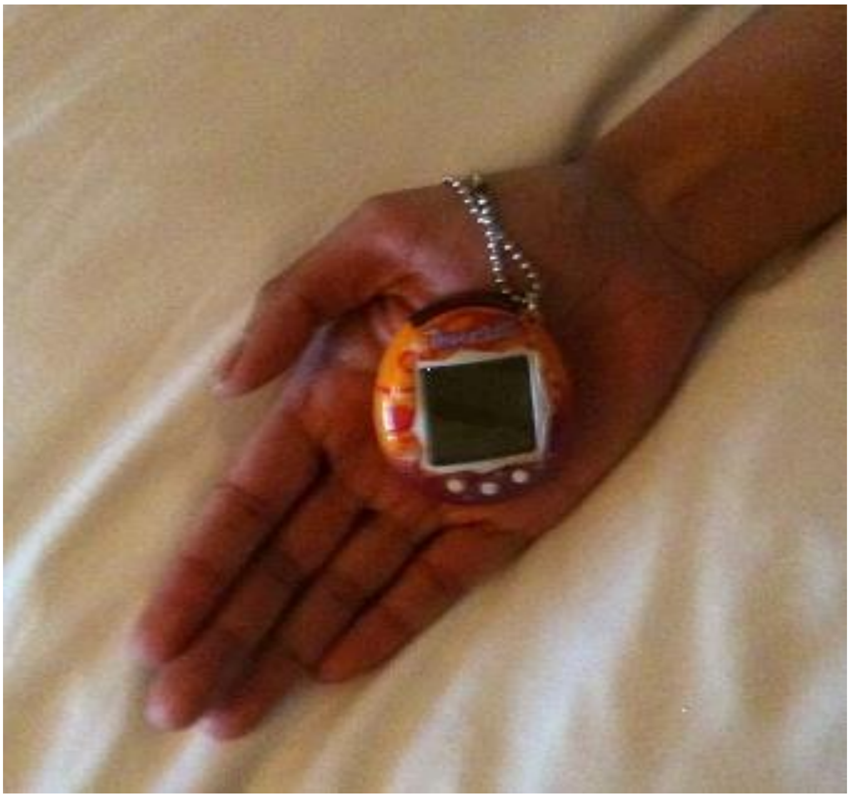

Figure 2 The Tamagotchi (Author's photograph)

Once the game is turned on, the virtual pet will hatch from a virtual egg and will start its growing process. The pets are depicted in the form of animals such as baby dinosaurs, puppies and chicks. In order for this virtual pet to grow older, the user is required to ascertain whether it needs food, cleaning or entertainment by assessing its state on the screen display or by the sound of an alarm. If the user successfully reads and responds to the digital creature's state of mind, the toy will thrive and grow older (Brezeal, 2002). The record lifespan of a *Tamagotchi* that any user has attained is 26 days (Bloch and Lemish, 1999). However, after the virtual pet's 'death', the game can be reset at the press of a button and a new egg will be hatched. The *Tamagotchi* has specific states such as being hungry, tired, bored, 'ok' or a variation of these states. The *Tamagotchi's* wellbeing is dependent upon the state it is in and what actions the owner takes. Therefore, if it is hungry and not being fed it will ask for food; if it is hungry and the owner wants to play, it would not play but will ask for food. If the *Tamagotchi* stays hungry for a long time it will 'starve'. However, the programmers have introduced an element of randomness based on probabilities. Therefore, when hungry, the *Tamagotchi* has a 90% chance of asking for food and a 10% chance of going to sleep. This arbitrary system of the *Tamagotchi* adds to the unpredictability of the toy, giving an illusion of autonomy.

Bloch and Lemish (1999), using Fleming's outline of the dominant themes in toys, argue that the *Tamagotchi* crosses boundaries as it neither seems to be a robot as such nor a conventional doll, but appears to be a mixture of elements. The *Tamagotchi* represents a machine because of its technological aspects, but also represents a type of animal such as a baby dinosaur, puppy, or chick to which is attached a cute, loveable aura. Finally, the *Tamagotchi* also represents a world where 'life is created and lived in a virtual space' (Bloch and Lemish, 1999:287).

Finally, an example of my fourth category is the most advanced form of robotic artefact: AIBO. AIBO is an acronym for Artificially Intelligent RoBOt and in Japanese means 'Companion'; it is a robotic pet dog released by Sony in 1999. AIBO was marketed by Sony as the perfect 'companion with real emotions and instincts'. It was designed to be an 'autonomous dog with moveable limbs, and sensors that can detect distance, acceleration, vibration, sound and pressure' (Melson, et al., 2009:95). AIBO's sensors allow it to sense the surroundings of its environment and react accordingly. However, reactions are limited to its six programmed emotions: 'happiness, sadness, anger, surprise, fear and dislike' (Jenkins, 2000:72). These emotions are expressed using a variety of sounds, melodies, body language and lights (shining from the eyes and the tail).

> 'As one of its activities, AIBO can locate a pink ball through its image sensor, walk toward the pink ball, kick and 'head butt' it. AIBO can also mimic many pet-like gestures, for example, it can shake itself, sit and lie down, stand up, walk or rest. Similarly, it is able to initiate interactions with humans, such as offering its paw and it may express pleasure through displaying green lights or displeasure via red lights, depending on the human's response to AIBO's initial action' (Melson, et al., 2009:95).

AIBO's behaviour is also dependent on how much interaction it has with its user, as well as the ability to 'learn' and 'forget' behaviours. When AIBO recognises that a certain action is met with a desirable response from its user, it stores this information and repeats this successful action when it encounters the same situation. To increase the probability of AIBO acting in a certain manner, its user has to tap its sensor after a disagreeable action. Since each person interacts with the AIBO differently, each AIBO has a different 'personality'.

The state of AIBO depends on what its sensors perceive from the outside world. The AIBO's main inputs come in the form of *infrared sensors* so it can acknowledge its surroundings, and audio from *microphones,* which assists AIBO in understanding the volume of noise in the environment and from what direction the sound is originating. The voice recognition system within AIBO has not yet reached a level where it will work with background noise. However, this could be advantageous as it adds to the illusion of autonomy. AIBOs act as if they do not hear you or as if they misunderstand you and therefore perform unexpected actions which can be interpreted as the robot showing personality. The third input is *image recognition.* AIBO comes with a colour camera and a pink ball with which it appears to play. Colour segmentation is one of the most commonly used methods of object detection and identification in robots. The image processing algorithm looks at the individual frames and classifies the pixels representing the object. The hardware and software in the AIBO have exploited the ability to separate pink- and grey-scale imaged objects to enable AIBO to perform basic mathematical calculations and to recognise things such as gestures of the human hand.

AIBO's creators have used a combination of programming and learning approaches. In many instances robots learn, like children, from examples they have been 'shown' before, which they register and have the ability to recall as and when necessary. The AIBOs are considered to be autonomous robots as they are able to learn and mature from the external stimuli that they receive from their user, environment and even other AIBOs (ShanieAIBO, 2004).

Manufacturers have implemented a number of interactive features in robots with the aim of promoting human–robot interaction. The main features 'involve touch, language with speech recognition, tracking maintaining eye contact and face recognition' (Sharkey and Sharkey, 2010:170). These attributes are important factors in developing relationships. For instance, face recognition is a valuable method in engaging and convincing the user that the robot has 'intent' (Kanda, et al., 2004).

AIBO conforms to Fleming's third category 'the theme of animality'. However, because of its interactive nature, it may also conform to elements of the first theme. These apparently contradictory characteristics signify that robotic toys such as the AIBO and the *Tamagotchi* do not fit into one particular domain of toys as defined by Fleming more than a decade ago. This suggests that children are growing up with entities that no longer conform to the type of toys which previous generations were exposed to, and that due to the hybrid nature of these toys, the manner in which children perceive artefacts will be distinctively different from that of their predecessors. Fleming's categorisation now seems somewhat outdated and I would argue that with the introduction of hybrid toys, categories based on levels of interactivity are more appropriate.

Because of their levels of interactivity, the last two forms of robotic artefacts – finite state machines and adaptive robots – provide the illusion of a rapport between the robotic artefact and its user (Goldstein, Buckingham and Brougère, 2004). It is possible that all interactions between the child and my first category (dolls) are dependent on the imagination. Conversely, there is interaction between 'Robert' and the child, albeit at a very minimal level as the relationship between input and output is more apparent. The *Tamagotchi* and the AIBO also require input from the user; however, the output is less predictable as the device chooses one action from a repertoire of behaviours. The AIBO, however, has ‘learning’ capabilities. The user’s behaviour alters the programming, allowing adaptive (AIBO) robots to ‘learn’ new behaviours and thus exhibit unpredictable behaviour. The unpredictability is enhanced by the limitations of the sensors of the AIBO. The ‘learning’ capabilities and unpredictability affects the perceived locus of control in robots. This is important, as these robots differ from those of previous generations. In the past, robot artefacts such as finite state machines gave the illusion of autonomy. For robots with learning capabilities, autonomy, is no longer simply an illusion as to some extent the robot controls its own actions. The next section explores the dual issues of control and the locus of control.

2.8.2. Control

In the previous section, the variations of interactivity levels amongst the four different categories of robotic artefacts were explored. I have suggested that the more interactive the robot, the more likely it will be able to portray unpredictable behaviour, resulting in illusions of autonomy. I have noted that robotic artefacts in the fourth category (AIBO) display an almost perfect illusion of autonomy, as the robot has the ability to ‘think’[8]. Nevertheless, it is possible that children may also construe this as similar to the autonomy of computational artefacts (the third

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[8] When considering machines**,** ‘thinking’ is referred to as the ability to ‘process information from sensors and other sources, such as an internal set of rules either programmed or learned, and to make some decisions autonomously’ (Lin et. al., 2011)

category). In this section I will explore different manifestations of the perceived locus of control being within the robot.

Throughout this section I use the term ‘control’ to indicate the extent to which an action is an intentional behaviour rather than a reaction to a stimulus. A robot user might relate to a robotic artefact as though it is an autonomous agent because it displays characteristics that appear to constitute ‘personality’ or ‘free will’. For example, when the AIBO offers its paw to a stranger, this provides a friendly aura and suggests that the AIBO has the ability to decide whether it likes you or not. However, the perception of locus of control within a robot can go much further than this. A robotic artefact can exert power over its user by demanding attention and expressing a constant need for ‘care’ even though users can redirect their attention at any moment. The constant attention that children are required to give a *Tamagotchi* in order for it to ‘survive’ suggests that the *Tamagotchi* is exerting an element of control over the child. If the child does not address the state of the *Tamagotchi*, it will ‘die’. The *Tamagotchi* was so popular throughout the world that some schools found the toy interrupted everyday school schedules. Consequently, many establishments implemented rules so that no custodian activities for the *Tamagotchi* were allowed during class hours. Other institutions adopted a more stringent policy, where the *Tamagotchi* was not allowed on school grounds (Bloch and Lemish, 1999). ‘This was an automatic ‘death sentence’ for the *Tamagotchi* as it cannot survive a full day without care’ (Bloch and Lemish, 1999:297). The *Tamagotchi* elicited a level of real control over the user, as the user is obliged to play with the toy in order for the game to continue.

As the *Tamagotchi* became popular, some of its users developed 'an almost cult like devotion' (Bloch and Lemish, 1999:286). In his book, 'Love and Sex with Robots[9]', Levy discusses Japanese *Tamagotchi* owners who:

> 'postpone or cancel meetings so as to be able to feed their *Tamagotchi* and attend to its other essential needs at appropriate times; a passenger who had boarded the flight but feels compelled to leave the aircraft prior to take off and vowed never to fly with that airline ever again because her flight attendant insisted she turned off her *Tamagotchi* which the passenger felt was akin to killing it' (Levy, 2007:92–93).

This anecdotal example is not presented as rigorous evidence of how all *Tamagotchi* owners treat their toys. Instead, it presents an extreme case scenario. In order to relate to this user's experience, I purchased a *Tamagotchi*. After playing with my toy for three days, I found myself in a similar situation. As the toy 'beeped' – an indication that it is in need of something– I felt obliged to attend to its needs. Despite knowing how the *Tamagotchi* works and being fully aware that my pet can be easily re-set, the 'sad' feeling expressed by my *Tamagotchi* elicited a response from my emotional side. Additionally, I felt slightly competitive, as I wanted to see how long I could keep my pet without 'killing it'. Furthermore, the 'beeping' sound that indicates the *Tamagotchi* requires care will not stop until its 'needs' are addressed. Eventually the sound became tedious and repetitive and so the toy got my attention because I wanted the 'beeping' to discontinue.

[9] Levy's book, 'Love and Sex with Robots' borderlines fiction in his prediction of the future of robotics.

In contrast, the perception of the locus of control being within the robot does not necessarily lead to a sense of being controlled by the robot. For example in one of Turkle's studies a child was confused about why an electronic game always seemed to win. The child ultimately decided that the game was cheating, but cheating requires intention (Turkle, 1984). This example suggests that the interactive nature of the electronic game provided the illusion of personality and free will, and thus also the ability to decide to cheat. Pressure groups believe that the *Tamagotchi* and similar programmed toys and robots fool children into thinking that the toys are alive and have human-like characteristics such as personality, prompting unhealthy emotional attachments (Plowman, 2004).

In the case of AIBO, the issue of control is ambiguous. To reiterate my definition of control, I stated that 'the user relates to the robotic artefact as though it is an autonomous agent because it displays characteristics that appear to constitute personality or free will'. Even though AIBO is programmed, it is capable of adaptive and learning behaviour. AIBO provides the illusion of control, but is also somewhat in control of its actions as it is capable of selecting a small number of actions without human intervention (direct input).

Throughout this section, I have suggested that the interactivity of robotic artefacts influences the patterns of children's thinking about the locus of control. Less technical robotic artefacts such as robotic dolls, clockwork and remote-controlled toys may be viewed by children as solely governed by their users. However, with software-programmable toys, 'intelligent robots', and interactive toys, ambiguity about control exist. I would argue that as children gain more experience interacting with intelligent technologies they may develop new ways of thinking about this form of technology. Today's robots actively respond to their respective environments, suggesting a level of intelligence and control. As a result, they are increasingly treated like living entities, which supports Turkle's findings that children treat computational objects as 'sort of alive'. As the actual locus of control in robotic artefacts such as the AIBO is at least in part contained within the robot because it is able to adapt its behaviour, the robot's control over itself is no longer fully an illusion.

A new technological genre may be emerging that encompasses autonomous and adaptive robots. Thus, we may require a new ontological category – one that breaks down the dichotomy between animate and inanimate (Khan, et al., 2006). The following section explores how people respond to these blurred entities.

2.9. Anthropomorphism and how we relate to the inanimate

In the human–robot interaction literature, various studies indicate that children form relationships with robots because they attribute anthropomorphic qualities such as personality, intelligence and emotion to these robots (Bumby and Dautenhahn, 1999; Khan, et al., 2007; Melson, et al., 2009; Turkle, Brezeal and Scassellati, 2006). A fairly standard definition of anthropomorphism is 'the tendency to attribute human characteristics to inanimate objects' (Duffy, 2003:180). The aim of this section is not to provide an account of why individuals are inclined to anthropomorphise - this is presented later in this chapter. Instead, this section reviews studies on whether or not children believe in the reality of their relationships with robots. As previously argued, advances in technological devices within robots such as face, language and speech recognition act as instruments to reinforce the illusion that robots are engaging with the user as though they were animate entities.

AIBO generated remarkable interest from those interested in human–robot interactions, possibly as it was one of the first robotic toys with such advanced technological capabilities marketed for children. Melson et al. conducted a series of studies investigating people's responses to and relationships with AIBO (Melson, et al., 2009). They reviewed forum postings by 182 AIBO users, observations and interviews with 80 preschool children, and observations and interviews with 72 children between the ages of 7 and 15 years who interacted with AIBO as well as with a living dog. In all three studies, they reported that individuals viewed AIBO as a social companion. However,

> 'the majority of preschool children and older children said that AIBO could be their friend, that they could be a friend to AIBO, and that if they were sad they would like to be in the company of AIBO' (Melson, et al., 2009:552).

In a related study, Turkle et al. (2006) demonstrates individual children's capacity to become attached to robotic artefacts. One of Turkle's participants, Melanie, aged ten, was given a robotic doll 'My Real Baby' and AIBO to take home for a number of weeks. Melanie's relationship with these robotic entities developed over time:

> ‘Researcher: Do you think the doll is different now than when you first started playing with it?
>
> Melanie: Yeah, I think we really got to know each other a lot better. Our relationship, it grows bigger. Maybe when I first started playing with her, she didn’t really know me so she wasn’t making as much [sic] of these noises, but now that she’s played with me a lot more she really knows me and is a lot more outgoing. Same with AIBO.’ (Turkle, et al., 2006:352).

In another paper, Turkle et al. (2006) reports 60 children’s first encounters with two humanoid robots – ‘Cog’ and ‘Kismet’. Even though the children classed these robots as ‘sort of alive’, they acted as though these robots were capable of friendship and possessed cognition. Interestingly, it was also reported that the children were so eager to construct a relationship with the robots, that they often provided justifications for why Cog or Kismet did not befriend them. For example, Kismet was silent on a few occasions so children provided numerous reasons to account for this, such as Kismet was ‘deaf’, ‘shy’ or ‘ill’. Furthermore, children’s views were not altered, even though the researchers spent considerable time explaining the mechanical aspects of the robots.

Adaptive, autonomous robots are being produced with technological advances in the robot industry that provide the illusion of complete control. As these studies indicated, the more time spent with robots, the stronger children’s relationships with these artefacts became. It is possible that perceived control and autonomy in robots enhance the blurred distinctions between animate and inanimate, thus amplifying the tendencies to anthropomorphise (Sharkey and Sharkey, 2010). The following section provides an overview of the theoretical discourse surrounding the relationship between humans and machines.

2.10. Theorising of the Human–Machine Conceptual Relationship

This section draws on the theoretical concepts of three key influential writers: Donna Haraway, Sherry Turkle and Don Ihde, who have all discussed at length people's relationships with technology. In the previous sections, studies suggesting that children form relationships with technology were described. In applying the key concepts of these three writers, the notion that the blurring of animate and inanimate compels us to engage positively with robots is explored. Their theories provide a useful way to think about our complex relationship with technology. As Haraway's work in particular stems from a feminist viewpoint, she focuses on women's relationship with technology. However, her concepts have been adapted and utilised in many disciplines. It is worth noting that there is a difference in terminology amongst these writers. Haraway discusses our relationship with the 'machine' whilst Turkle and Ihde refer to our relationships with technology, placing emphasis on robots. In this thesis, robots are considered to be both machine and technology.

This section will begin by addressing the basic premise of Haraway's cyborg theory, followed by an outline and comparison of Turkle's view about our relationship with robots. Even though Haraway and Turkle are from different disciplines, there is a convergence of their concepts. Haraway and Turkle are both noted for their social constructivist approach when looking at people's relationship with technology. Social constructivists argue that an individual's identity and actions are shaped by their interaction with the environment. In contrast, Ihde's theory somewhat opposes those of Haraway and Turkle. Even though Ihde proposes a different perspective, all three concepts still provide us with a unique way of looking at our relationship with robots.

Donna Haraway's cyborg has become an iconic symbol of the distinction between humans and machines and their interrelationships (Haraway, 1991). The cyborg represents what it means to be human in a technological culture; it is a border-blurring entity uniting both human and non-human elements. Haraway's was discontented with the Western dualist system of self/other, mind/body, culture/nature, male/female, civilised/primitive, reality/appearance and whole/part and sought to deconstruct and challenge these dualisms, as there is 'argument for pleasure in the confusion of boundaries and for responsibility in their construction' (Haraway, 1991:66). Haraway further suggests that the nature of the cyborg is 'ironic and contradictory' (Haraway, 1991:154) because it transcends most boundaries. The cyborg also produces a combination of fear and fantasy from this blurred human/machine distinction.

Haraway describes one of the first cyborgs as 'a standard white laboratory rat implanted with an osmotic pump designed to inject chemicals continuously' (Haraway, 1997:5). In more recent times, the cyborg is a 'transgressive mixture of biology, technology and code' (Turkle, 1995:21). When thinking about the cyborg, many images come to mind. These images range from day-to-day situations such as a person with a pacemaker or even 'anyone whose immune system has been programmed through vaccination to recognize the polio virus' (Gray, 1995:2–3) to the iconic Terminator-styled metallic warrior (Palmer, 2007). Therefore, we are all cyborgs (Haraway, 1991:150): The machine is us, our processes, and an aspect of our embodiment (Haraway, 1991:180). By suggesting that we are all cyborgs does not imply that we have all become some half-human, half-machine construct, but rather that our conditions, senses and experiences have changed as technology has become ever more prevalent in various ways in our daily lives. For example, whenever I forget my mobile phone at home, I feel like I am completely cut off from the outside world and 'something is missing'. One study argues that we have become 'cyborgs without surgery' (Clark, 2003:34).

As a result of these blurred identities, 'children are growing up in irony and they are adapting to holding incompatible things together' (Turkle, 1998:328). Haraway describes irony as being

> 'about contradictions that do not resolve into larger wholes…about the tension of holding incompatible things together because both or all are necessary and true' (Haraway, 1991:148).

Haraway's cyborg identity is very closely tied to many of Turkle's ideas. As Turkle's work spans decades, this section focuses on just one aspect of her theories. With reference to our relationships with technology, Turkle suggests robots are viewed as 'evocative objects' (Turkle, 2005). This refers to how relationships with robots, however simple, force us to think about other concepts such as 'aliveness' and 'human uniqueness' as children compare their similarities and differences with these entities. Similarly, consistent with social constructivist viewpoints, individuals construct their identities through their interactions with entities and artefacts within the environment. However, it can be argued that technology is more than a collection of artefacts – that rather, it is a 'culture'. It is a 'signifying system through which…social order is communicated, reproduced, experienced and explored'(Williams, 1981:13) Turkle (1984) argues that in the 1980s, the computer was classed as a 'metaphysical device' blurring the distinctions between animate and inanimate. Whereas today, according to Turkle, our body is 'evocative' as we are connected to artefacts such as the computer (Turkle, 2005). Children in particular live in an environment where they have embodied technology; and therefore it is no longer possible to separate the child from technology.

Don Ihde also characterised human–technology relations (Ihde, 1990). Ihde developed a post-phenomenological framework that included a technological dimension to discuss human–robot relations. Ihde argues that in our technological culture, many of our relationships are either mediated through or directed by technology. This can include looking through a pair of glasses or reading a thermometer (in Verbeek, 2008). Coeckelbergh (2010a; 2010b) in particular adapted Ihde's framework for looking specifically at human–robot interactions. Coeckelbergh and Ihde's concepts will therefore be discussed together.

Ihde (1990) classifies three levels of interaction between humans and technology:

- Embodiment – Technologies are ‘embodied’ by their users; technology becomes a part of us so that it is not noticed, for example, the wearing of glasses – they effectively become an extension of the human body. Many robots will not fit this category except for non-autonomous robots such as robotic arms (Coeckelbergh, 2010a).
- Hermeneutic relations – This refers to the role technology plays in us interpreting the world (Ihde, 1990). An example of this is the role played by scientific instruments such as telescopes or thermometers. Technology acts as a medium between us and the world. Again, Coeckelbergh argues that many robots may not adhere to this category except perhaps ‘remote controlled robots on other planets that enable us to see and manipulate the world through the eyes of the robot’ (Coeckelbergh, 2010a:2).
- Alterity relations – This refers to the anthropomorphising of a machine, thereby allowing dialogue between the human and this machine. This feature is probably most relevant in understanding our relations to robots (Coeckelbergh, 2010a). In using Ihde’s framework we can understand human–robot relations as alterity relations and can explain to what extent they appear to us as a ‘quasi-other’ (Ihde, 1990) or an artificial other.

In adopting Ihde’s framework, Coeckelbergh states that

> ‘The robot is neither a part of me (embodiment relation) nor something that mediates my relation to world. Instead, in our interaction with the robot ‘it’

appears to us more than a thing: another to which I relate' (Coeckelbergh, 2010a:2).

However, this statement can be seen as contentious. For instance, there are many robots that assist us in interpreting the world: e.g. there are robots linked to telescopes and microscopes where the computer system in the robots 'mines' data, which involves searching for patterns in data before presenting it to people. Ihde is using the term 'embodiment' in a literal sense, whereas Haraway and Turkle apply this expression more figuratively, suggesting perhaps that our lives and relationships are so intertwined with technology that we no longer see the division.

Coeckelbergh argues that in order to apply traditional phenomenology to the field of robotics, robot intentionality and consciousness are key requirements. However, he goes on to argue that these qualities may not be necessary prerequisites in the development of a human–robot relationship; what is important he argues is how the robot appears to us (Coeckelbergh, 2010a). Duffy (2003) makes a similar point, suggesting that it is irrelevant whether a robot actually possesses agency; what really matters is our perception of its agency. The robot's appearance and our perceived agency shape our responses; for example, 'it' becomes 'he or she'. Thus, the border blurring between animate and inanimate (Haraway, 1991) may initiate our gendered responses to robots. Additionally, by subconsciously referring to a robot as a quasi-other, we do not talk *about* the robot but we talk *to* the robot (Coeckelbergh, 2010b).

In sum, Haraway and Turkle make comparable assumptions about our relationship with technology. Haraway argues that technology has become part of humanity and it has not estranged us from ourselves. In line with this argument, Turkle suggests that as we can no longer separate ourselves from technology this forces us to think about concepts such as ‘human uniqueness’. Both Haraway and Turkle view technology as being somewhat beneficial, thus rejecting the many ‘techno-phobic’ claims. Conversely, Ihde rejects the claim that we embody robots in a literal sense, but rather considers that our engagement and responses to robots influence our relationship with them. Therefore, by anthropomorphising, we automatically form relationships with technology. In concurrence with Haraway and Turkle, I propose that we cannot separate children from technology, especially as children of this particular generation have grown up with technology as an intrinsic part of their culture and have embraced this by creating new relationships with technological artefacts.

Earlier in this chapter, I discussed how children tend to treat robots as if they possess mental states and control, while holding a contradictory view of robots as not quite alive. To provide some context for understanding why children may conceive of robots as animate, a social constructivist approach is taken to understand children’s perceptions of robots by building on significant links with the biological, cognitive, behavioural, social and cultural levels of analysis, which enhance the insights of human–robot interaction. The following section provides an overview of the literature on the animate–inanimate discussion from both sociological and psychological viewpoints.

2.11. Sociological and Psychological Perspectives on Children's Conceptions of Animacy

The disciplines of sociology and psychology have both made significant contributions to our understanding of childhood. Developmental psychology documents the stages and transitions of the child in Western society. Sociological researchers have been interested in viewing children as a social group and in studying how the concept of childhood has emerged in modern times (Kehily, 2004). Psychologists have often been concerned with following a child's stages and transitions- age, physical development and cognitive ability. The transition from childhood to adulthood is thus seen as a developmental process where the child will ultimately achieve rational subjectivity. While much of the theorising in developmental psychology stems from positivism, sociological approaches to the study of children have often focused on socialisation, the ways in which children become members of the society they live in and how childhood as a concept has been socially constructed. In addition, how childhood is socially constructed to create a binary with adulthood has been examined.

Even though it is instructive to think about the differences between developmental psychology and sociology, it is also equally important to consider the relationship between these two approaches. Sociocultural theorists have long argued that environmental stimuli can affect children's cognitive development (Cole, 1997; Rogoff, 2003). In the following section, the psychological and sociological understanding of children's conceptions of animacy and, in particular, robots will be outlined and the basis on which children formulate their ideas about living and non-living entities will also be explored.

2.11.1. Psychological Contributions to the Understanding of Children's Conceptions of Animacy

Research in developmental psychology suggests that anthropomorphism is rooted in an almost universal computational mechanism in human minds ('almost universal' because a minority of individuals such as those with autism do not possess it) (Baron-Cohen, 1995; Frith, 2003). More specifically, it is rooted in what psychologists call Theory of Mind. To possess a theory of mind is to possess the ability to recognise that the mental states of others differ from one's own (Wellman, 2002). However, the view that as children grow older, they gradually develop the ability to assign various beliefs and intentions in order to understand another person's behaviour has been disputed.

Numerous psychologists suggest that children's understanding of the mental states of others is framed in a theoretical manner whereby their beliefs gradually advance when presented with new information (Gopnik and Meltzoff, 1997; Wellman, 2002). However, simulation theory proposes an alternative viewpoint, suggesting that children's understanding and beliefs about others stem from their own experiences. During their development, children learn to transmit their own states and to take into account other people's perspectives (Harris, 1992).

Children's imaginary play requires the child to understand the beliefs and 'mind' of another individual (Singer and Singer, 1990). Therefore, children with imaginary friends are often likely to perform better on Theory of Mind tasks than children without imaginary companions and to possess improved mental representation abilities (Taylor, Cartwright and Carlson, 1993). Harris (1992) suggests that in imaginary play, the child takes into account the viewpoint of the character they are depicting.

The computational mechanism that enables Theory of Mind has been subject to much controversy. For instance, there is debate as to whether a child develops a theory to generate hypotheses about another person's behaviour or whether a child develops the ability to take into account the mental states of other people (Davies and Stone, 1995).

Many developmental psychologists propose that children's ideas about the nature of artefacts, both living and non-living, are influenced by naïve biology theories (Bernstein and Crowley, 2008). The naïve biology approach proposes that as children develop, their ability to categorise entities and infer further information from these categorisations increases (Gelman, 1988; Gelman, 1989). Piaget (1929) suggests that as children grow older and their physical theory of the world develops, they define life and 'aliveness' in terms of autonomous movement. The Piagetian tradition in particular illustrates the child applying an 'animistic' concept to explain the causation of movement to inanimate entities. In support of Piaget's theories, Laurendeau and Pinard report that four-year-olds appear to use intentional vocabulary to explain the clouds in the sky – ‘they want to go’ (Laurendeau and Pinard, 1962). Piaget asserts that by the age of eight, the child learns to distinguish whether or not an object is animate, based on whether its movement occurs spontaneously or is caused by an outside agent (Piaget, 1929).

More recent researchers have questioned the credibility of Piaget’s theories. Gelman and Gottfried (1996) reported that three and four-year-olds could determine the cause of movement in animate beings and artefacts. Children of that age report that movement in animals is biological, whereas movement in artefacts is due to power sources such as batteries or electricity (Gelman and Gottfried, 1996). Similarly, biological characteristics such as breathing and reproduction are attributed only to animate objects (Gelman, 2003; Greif, et al., 2006). Additionally, Laurendeau and Pinard (1962), despite supporting Piaget’s claims that childhood animism exists, argue that children’s criteria for understanding animism is not as systematic as Piaget suggests in his developmental stage theory.

Conversely, children’s attribution of animate qualities to robots may be a result of difficulties in categorisation (Gelman and Opfer, 2002), as robots do not fall into one distinct category. Even though robots are machines, some are designed to replicate animate entities such as humans or pets, both physically as well as psychologically. Research suggests that children attribute varying features to robots ‘cutting across prototypic categories of animate and non-animate’ (Severson and Carlson, 2010:1100). Jipson and Gelman (2007) report that children aged four seldom attribute biological properties to a robot, such as growth, yet they assert it possesses psychological characteristics such as emotion. Further incompatible assertions continue with age. Research indicates that children aged five reported that people have brains unlike robots. In contrast, children aged seven and older stated that robots also have brains, albeit different from the human brain, 'a sort of brain even though it is different from ours' (Scaife and van Duuren, 1995:370).

Research suggests that experience with robots also plays an important role in the development of nuances in children's characterisations (Bernstein and Crowley, 2008). Children with more experience of robots are less likely to judge the robot as alive but are more likely to judge it as intelligent (with a different form of intelligence to humans). Conversely, children with less prior experience of robots tended to believe the robot was not only alive, but also had psychological properties (Bernstein and Crowley, 2008; Khan, et al., 2006; Turkle, 1999). As a consequence, children gain experience as they move from conceptualising robots in terms of naïve biology theories to thinking about robots as intelligent technological entities.

Many of the psychological assumptions about children's notions of animacy are associated with their specific age or developmental stage. Thus, one might deduce that nuanced conceptions of inanimate artefacts are unique to children. However, this may not always be the case as several studies have demonstrated that animism is not limited to children.

Adults were shown a silent animation of two triangles and a circle moving within and around the triangles (Heider and Simmel, 1944; Springer, Meier and Berry, 1996; Taylor, 1988). Heider and Simmel conducted three experiments within their study. In the first experiment, 34 participants (undergraduate women) were asked to write down what they had seen in the animated film. In the second experiment, a different set of undergraduate women were asked to answer ten questions relating to the film. These questions interpreted the moving shapes as people, such as: 'What kind of person is big triangle?' and 'Why did the two triangles fight?' Finally, in the last experiment, another group of participants (also undergraduate women) were shown the film in reverse and were asked four out of the ten questions presented in the second experiment (Heider and Simmel, 1944:246). Results indicate that all participants except one tended to perceive the shapes in terms of animate beings. This may have been predictable for experiments two and three; however, this was unexpected in experiment one as participants were asked more general questions (What did you see in the film?). An example of a response from experiment one was: 'a man has planned to meet a girl and the girl comes along with another man. The first man tells the second to go; the second tells the first, and he shakes his head. Then the two men have a fight, and the girl starts to go into the room to get out of the way and hesitates and finally goes in. She apparently does not want to be with the first man…' (Heider and Simmel, 1944:246–247). Heider and Simmel concluded that their participants tended to attribute elaborate motivations, intentions, and goals to the shapes, based solely on their pattern of movements. Participants in this study may have made these attributions on the basis that objects that move in a straight line only when pushed are thought of as 'passive' and as eventually reducing in speed a moment after they have been pushed, whereas, objects that move independently in a nonlinear manner such as circular movements are attributed with intention (Ackermann, 2005).

Similarly, adults treat robots as though they were endowed with personality (Ackermann, 1991; Kruse, 2010; Nass and Moon, 2000; Turkle, et al., 2006). Research has shown that even though adults do not explicitly anthropomorphise robots, their behaviour suggests otherwise. Nass et al. (1997) calls this ‘ethopoeia’ where individuals respond to an inanimate artefact as though it were alive even though they themselves know that it is not. Similarly, Fussell et al. (2008) argue that even though various studies have shown that people attribute animistic qualities to robots, it is uncertain whether they believe robots possess these characteristics (e.g. the robot is sad the same way that a human is sad) or whether individuals are using human terms metaphorically (e.g. the robot is acting as if it were sad).

An example has been reported by Sherry Turkle:

> ‘Cog (a robot pet) noticed me as soon as I entered the room. Its head turned to follow me and I was embarrassed to note that this made me happy. I found myself competing with another visitor for its attention. At one point, I felt sure that Cog’s eyes had caught my own. My visit left me shaken – not by anything that Cog was able to accomplish but my own reaction to ‘him’…Despite myself, and despite my continuing scepticism about this research project, I had behaved as though in the presence of another human being’ (Turkle, 1995:266).

Bearing in mind the psychological theories of understanding children's characterisation of animate objects, it may be that adults behave *as if* robots were animate entities, rather than actually believing they are. With children there has been extensive research examining their abilities to differentiate between fantasy and reality. Studies have demonstrated that when children are faced with fictional characters in real life they can suspend their beliefs quite easily (Madhani, 2009). More specifically, it has been found that children can distinguish between fictional and non-fictional characters from four years of age (Corriveau, et al., 2009) with the exceptions of characters such as 'Father Christmas' or the 'tooth fairy' because of persuasion from adults (Sharon and Woolley, 2004).

Although social constructivists agree with psychological perspectives stating that children's views and perceptions may be a characteristic of their age, they also insist it is very much guided by social meaning and cultural expectations that stem from the media. Other cultural elements may include gender, class and ethnicity. Furthermore, there may be popular cultural beliefs that coincide with generational characteristics. Having explored the psychological basis for anthropomorphism, the following section takes into account a sociological approach to considering the impact that children's socialisation in the current generation has on their conception of animacy in robots.

2.11.2. Sociological Contributions to the Understanding of Children's Conception of Animacy

Children's relationship with technology is potentially very different from that of the previous generations due to the rapid change in technology. The current generation of children are more exposed to autonomous robots than previous generations and their views of robots in particular may have been transformed and influenced by a variety of other technologies that surrounded them. Studies have shown that children still relate to robots as though they were animate entities, even after researchers explained the essential machinery that resulted in the robot's functioning (Turkle, Brezeal and Scassellati, 2006). When Turkle conducted her research in the 1980s, she reported that children rationalised the behaviours of technological artefacts in animate terms because they were unsure about these artefacts' underlying computational mechanisms (Turkle, 1984). This is no longer the case because children of the current generation are more technologically literate (Turkle, 2005). This generation of children are so accustomed to interactive robotic artefacts, that they no longer question their animacy but instead relate to them in a manner they are comfortable with, endowing them with many animate characteristics. A potential source of influence for children's ideas may be the characteristics of their generation. This section explores the concept of a 'digital generation' and then discusses the problems of defining this term.

Today's generation of children are exposed to many robots that are more advanced and interactive than ever before and which form an integral part of society. The term 'digital generation' was coined and much used during the mid-nineties when there was substantial interest from social and behavioural scientists about the impact that the increase in and changing nature of technology may have on children. According to Buckingham and Willet (2006), children were often described as the digital generation, as they were the first generation to experience digital technology throughout their lives. Recently, Rosen in his book *'Rewired, understanding the iGeneration and how they learn'* describes children born between 1990 and 2009 as being part of the 'iGeneration', suggesting that technologies such as the iPhone, iPod, Wii and Twitter are affiliated with this generation (Rosen, 2010). The idea of a 'digital generation' and 'iGeneration' is typically applied to computers, games and 'smart' phones. Nevertheless, I extend this notion to the use of robotics, and suggest that the robotic industry may follow the same route as the computer industry. Bill Gates observed that 'the emergence of the robotics industry…is developing in much the same way that the computer business did 30 years ago' (Gates, 2007:60). It is possible that robots may become ubiquitous just as computers are today.

Admittedly, there is a degree of scepticism regarding the idea of a digital generation. Those in favour of the concept argue that there are generational differences between children and their parents and that these differences are produced by technology and its different levels of usage (Tapscott, 1998). On the other hand, critics argue that supporters of the digital generation ignore the social, historical or cultural forces that may influence a generation. Furthermore, Hargittai (2010) reports that parental education, gender and ethnicity influence the variation of skills in Internet use of children and adults. Also, the definition and characterisation of the term 'generation' is also complex. Many researchers have sought to explain the term such as Edmunds and Turner (2002:7) who suggest that a generation is 'an age cohort that comes to have social significance by virtue of constituting itself as a cultural identity'. The characteristics of a generation are produced by its members and these characteristics can include specific tastes or beliefs (Bourdieu, 1993). Additionally, generations may be characterised as a result of the life chances that are available to people when they are born and how people respond and attribute meaning to these life chances (Mannheim, 1979).

Nevertheless, the concept of generational characteristics contrasts with the approach taken by psychologists. From a psychological viewpoint, children's accounts of robots are explained by their developmental stage. Instead, sociological approaches consider generational characteristics such as children's level of exposure to robots in real life and the media, as important to children's conceptions of animacy in robots.

In line with social constructivism, the ability to conceptualise anthropomorphism is not solely associated with aspects of childhood development. Instead, external influences are viewed as a crucial component in the way that they interact with inner states. In a sense, knowledge acquisition and formation of perceptions are gradually developed under the influences of various sociocultural dimensions (Corsaro, 2005). In addition, these processes are closely related to past experience and exposure. It is possible that previous experiences children have obtained through the socialisation process (including what they have heard from adults, peers, the media and various other resources) feed into the construction of their belief system. Because children are exposed to new technologies on a daily basis, their belief systems are constantly changing.

2.12. Conclusion

A number of ambitious claims have been made about the impact of technology on children's lives. Technology evokes our greatest fears and beckons our wildest fantasies (Buckingham, 2004). It provides the promise of a better future whilst paradoxically provoking fears and anxieties about our disengagement with the past. Regardless of its positive or negative influences, technology appears to have power over 'children's consciousness, to determine their identities and to dictate the patterns of their everyday lives' (Buckingham, 2004:108). A child's autonomy in the midst of this rapidly evolving technological revolution has been questioned. Are children simply passive victims or are they technologically able and willing to welcome and embrace these changes on their own terms? In line with social constructivism, I argue that children are competent members of society who are constantly constructing and reconstructing their relationships with technology, welcoming the constant developments within the area and using technologies to meet their educational and social needs.

Robots are a form of technology that raises fundamental questions about the distinctions between animate and inanimate entities. I have argued that the perceived autonomy of robots is changing the way we respond to robots and many researchers have documented that children and adults alike are willing to attribute human characteristics to these inanimate entities. Developmental psychologists and sociologists have long debated the reasons why individuals attribute animate characteristics to inanimate entities. Psychological theories such as 'Theory of Mind', 'simulation theory' and 'naïve biology approaches' have been used to understand children’s conceptions of robotic artefacts. Sociologists have been concerned with the norms and values to which children have been exposed (socialisation) to understand how they relate to robots. Consistent with social constructivism, this thesis integrates the various disciplinary approaches to understand children’s conceptions. Together with children’s developmental characteristics and socialisation, I argue that generational characteristics such as media influences and children’s experiences with robots play an important role in understanding how children relate to robots and interpret the actions of robots.

In the next chapter I consider the methodological approach implemented in the empirical work of this thesis, an approach grounded in social constructivism, to investigate children’s conceptions of robots.

Chapter 3: Methodology, Method and Method of Analysis

3.1. Introduction

Many researchers and academics investigating children's views and experiences of social and educational issues argue that children should be given a 'voice' and that research methods should draw upon the abilities of children participating in research (Christensen and James, 2000; Lewis and Lindsay, 2000). Social constructivism acknowledges that research participants such as children have an active role to play in society and that children are

> 'co-creators of that society, not just absorbers of it...children play a key role in shaping the environment, which, in turn, shapes them' (Freeman and Mathison, 2009:4).

From this perspective social constructivism provides an analytical perspective for understanding how children construct meaning.

Clark's (2004) 'mosaic approach' recognises the value of conducting research with children in a participatory, multi-method framework and is in line with the social constructivist perspective. The mosaic approach is the overarching methodological framework for the empirical work in this thesis and the mosaic approach within this thesis includes visual methodologies, semiotics, observation, group interviews and aspects of phenomenology. The first part of this chapter outlines each of these methodologies, what could be termed as tiles within the mosaic, and associated ethical implications. The second part sets out the research design and the methods employed in the current study.

Part 1 - Methodology

3.2. The Mosaic Approach

Clark (2004) establishes her mosaic approach for conducting research with children by drawing on three theoretical perspectives. Firstly, she is informed by ideas within sociology of childhood studies that locate children as competent actors possessing the ability to provide insight about their lives and experiences (Mayall, 2002). Children are viewed as 'experts in their own lives' (Langsted, 1994:42). Secondly, Clark points to the use of participatory methods to explore how existing methods used to empower adults in community development research can be applied to children (Clark, 2010). The methods used in these studies were designed to provide research participants with a 'voice'. Thirdly, Clark draws on the work of educational theorists who suggest that learning is a collaborative process between adults and children where both parties search for meaning together (Rinaldi, 2001). In combining these three theoretical aspects in her mosaic approach, Clarke acknowledges the importance of children's perspectives and their contribution to research in understanding the complexities of the social world.

To provide children with a 'voice' in research requires an approach designed to acknowledge and utilise the abilities of children. Different research methods are able to capture different perspectives of children's social worlds. Through triangulating different methods we gain greater depth and detail about children's social worlds as experienced by them (Clarke 2004). Triangulation refers to 'the combination of methodologies in the study of the same phenomenon' (Denzin, 1978:291) in order to test the validity of the results (Creswell, 2003). It has been argued, however, that these methods simply result in more data to analyse (Darbyshire and Schiller, 2005), which may become unmanageable (Miles and Huberman, 1994).

With the mosaic approach, children are taken to be competent participants in research. This approach, however, does not specify methods or methodology and does not suggest how to combine data collected through different research methods. It does, however, provide a criterion for choosing research methods, specifying that the abilities of the children participating in the research be taken into account. In this chapter I will describe and explore the methodologies and methods that I chose to use for my empirical study.

3.3. Mosaic of Methodologies

Unlike mixed methodologies, which combine both qualitative and quantitative research approaches, the mosaic approach only uses research approaches from the paradigm of qualitative research, (Creswell, 2003). Quantitative methods would not have been appropriate for the research presented here primarily because this study explores children's perceptions and the meaning they attribute to robots. Creswell (2003) suggests that a qualitative approach best suits studies where meaning and experiences of a phenomenon are sought. This section explores the rationale for the inclusion of each of the following qualitative research methods within the mosaic: phenomenology[10], visual methods, semiotics, observations and group interviews. The limitations for each method are also provided.

3.3.1. Phenomenology

> 'Phenomenology aims to explore the different ways in which people experience and understand their world and their relationship with others and their environment' (Parahoo, 2006:68).

Phenomenology gained prominence in the early twentieth century and includes the transcendental, existential and hermeneutic traditions (Audi, 2001). Central to phenomenology is the work of Husserl (1969) who believed that natural scientific enquiry did not provide a basis by which human beings can be understood as individuals, instead reducing them to measurable objects.

Phenomenology is a suitable methodology for the purposes of this study for two reasons. Firstly, phenomenology is interested in the lived experiences of individuals. Those taking a phenomenological approach seek to capture individuals' narratives about a phenomenon, including their views, feelings and experiences. Children tend

[10] Even though phenomenology is commonly known as a philosophical underpinning, phenomenologists also provide an overview of specific approaches and methods to data collection.

to respond only to questions about a phenomenon that is within their experience and will become silent or lose interest if the phenomenon is not relevant to them. (Christensen, 2004). Secondly, a phenomenological approach aims to capture immediate experiences, what Husserl describes as the study of the 'lifeworld' or 'Lebenswelt'. He describes Lebenswelt as 'the world of immediate experience' (in van Manen, 1997:182) and as

> 'what we know best, what is always taken for granted in all human life, always familiar to us in typology through experience' (Husserl, 1970:123-124).

It is argued that phenomenology is a 'systematic attempt to relate to this world, to describe the structures of these lived experiences and gain an understanding of the meanings of these everyday experiences' (van Manen, 1990:10). Everyday experiences of technology (including robots) embedded in children's lifeworlds will be used in the current study to gain a better understanding of the meanings and structure of children's lived experience.

Husserl argues that in order to understand an individuals' perspective of a phenomenon, it is necessary to set aside the ontological status of the phenomena. According to Husserl, this is accomplished by a process he calls 'epoché' or 'suspension of judgement' (Velarde-Mayol, 2000:47). We need to suspend all of our assumptions and prejudgements that arise out of our cultural understandings of the world before we investigate the phenomenon (Husserl, 1969; Moustakas, 1994). Therefore, as a researcher, I should set aside my own views and perceptions of what a robot is and how it works and only take account of children's views. However, many will argue that completely setting aside prior views and perceptions may be unrealistic, if not impossible, and accept that some researcher bias is inevitable (Lindlof and Taylor, 2002). Practising reflexivity is, therefore, imperative when using this research approach. This involves acknowledging the likelihood of bias that I, as researcher, bring to the study and bearing in mind the influence of these biases on the data during the analysis process. I explore this concept of reflexivity further in the concluding chapter of this thesis.

Husserl argues that phenomenology attempts to explore the narratives of experience without determining their source or if they coincide with independent reality (Husserl, 1969;Kvale, 1996). Therefore, those who use phenomenological methods only seek to determine accounts that are offered by an individual's consciousness since 'pure essential truths do not make the slightest assertion concerning facts' (Husserl, 1969:57). Consequently, as a researcher using a phenomenological approach, I am not concerned with whether children's statements and accounts of robots and their behaviours are factually correct[11]; instead, what I am interested in from their accounts is their explanation of the phenomena.

Phenomenologists suggest that every experience consists of noema and noesis. 'Noema is that which is experienced… [while] noesis is the way in which it is experienced' (Moustakas, 1994:69). This study is concerned with the phenomenon of robot perception (noema) as children experienced it (noesis). The relationship between noesis and noema is referred to as intentionality (Audi, 2001) and this

[11] By using the term 'factually correct', I refer to the technical explanations of robots and robot functioning.

concept is central to phenomenological studies. It indicates that all individuals are connected to the world through experience: when one thinks, one always thinks of *something.*

3.3.1.1. The Phenomenological Perspective on Data Collection

The purpose of data gathering in a phenomenological study is to collate narratives and descriptions of the experience under investigation (Polkinghorne, 1989). The phenomenological approach is considered to be a ‘perspective that uses relatively unstructured data’ (Gray, 2006:28). Epistemologically, phenomenological approaches are based in a paradigm of personal knowledge and subjectivity, and emphasise the experiences and perceptions of individuals from their own perspectives. Phenomenological research has overlaps with other essentially qualitative approaches including ethnography. However, phenomenological research seeks essentially to describe rather than explain, and to start from a perspective free from hypotheses or preconceptions (Husserl 1970).

Within the phenomenological perspective, there are a variety of approaches and methods used to collect data and to capture experiences (van Manen, 1997), including individual and group interviews, journals, logs and case studies. Some phenomenologists have narrowed down these methods to three main methods of phenomenological study. These are interviews, documentary evidence and case study analysis (Stone, 1979). A further source of data that is commonly used involves simply asking participants to write down their experiences of a phenomenon (Parse, Coyne and Smith, 1985).

The phenomenological approach of analysing data involves basic elements such as bracketing (Giorgi, 1989). Bracketing refers to the temporary suspension of preconceptions and assumptions about the phenomenon (Ehrich, 1996). In simple terms, the researcher has to bracket their views of experience in order to view the phenomenon objectively (Giorgi, 1986).

The phenomenological approach accommodates the use of multiple data collection methods. This allows for the triangulation of data, as well as, involving children with varying abilities to participate in research. This is consistent with Clark's mosaic approach with its focus on participatory and non-text methods.

One such participatory method is the domain of 'visual sociology'. The first phase of the current research project 'write and draw' is consistent with this domain. I asked children to draw what they thought robots would look like as a way for children to depict their lived experiences. The following section describes visual sociology and how it was used to collect data in the current study.

3.3.2. Visual Sociology

Visual sociology is a relatively new domain within sociology that includes elements of anthropology, art, history, photography studies and qualitative research methods (Gauntlett, 2007). Gauntlett asserts that sociology should be more visual as 'Images allow us (as sociologists) to make statements which cannot be made by words, and the world we see is saturated with sociological meaning' (Harper, 1998:38). Similarly, Knowles and Sweetman (2004) state:

> 'The sociological imagination works particularly well through visual strategies, which capture the particular, the local, the personal and the familiar while suggesting a bigger landscape beyond and challenging us to draw the comparisons between the two…Visual techniques…are an analytically charged set of methodologies which incline researchers towards the tracing of connections between things of quite different social scope and scale' (Knowles and Sweetman, 2004:8).

Many studies have used visual sociological research methods (Prosser, 1998). For over 25 years, the International Visual Sociology Association has published articles of this genre (Gauntlett, 2007). I have selected studies to discuss that depict the different aspects of visual sociology relating to research with children and their experiences of diverse phenomena. To contrast research with children, a study that focuses on research with adults is also presented, to demonstrate that visual sociological methods, although typically applied to research with children, can also be used with adults.

O'Donoghue (2007) investigated 'masculinities at school' and was interested in how boys 'learn to speak, act, and perform in gender/sex in/appropriate ways' (O'Donoghue, 2007:62). His research method included a combination of art making and writing. He asked boys, aged between 10 and 11, to write and produce art in order to depict how certain masculinities are shaped, played out and performed in different parts of school. The participants were given a disposable camera and notebook to capture places in their school and in order to record the significance of each particular place. O'Donoghue argued that photographs taken by the boys demonstrate what the research participant, himself, wants the researcher to see and think. An analysis of what research participants attended to raised issues such as surveillance, power and segregation. O'Donoghue suggests that art in research can be advantageous as it captures and represents an understanding that cannot be recognized through verbal forms of communication. There may be instances where individuals who find it difficult to be linguistically expressive are provided with an opportunity to do so through pictures (O'Donoghue, 2007).

Schratz and Steiner-Loffer (1998) conducted a study where primary school children were asked to take photographs of aspects of their school they liked and disliked. The researchers concluded that this hands-on approach allowed quieter pupils to represent their feelings, and that their comments and images enhanced the teachers' appreciation of the children's feelings and views about school. Similarly, Radley, Hodgetts and Cullen (2005) gave 12 homeless individuals in London disposable cameras to gain an insight into their lives and to make a novel contribution to the understanding of homelessness. They aimed to explore 'how homeless people make their home in the city as a material expression of their way of life' (Radley, Hodgetts and Cullen, 2005:275). The homeless individuals were interviewed prior to taking their photographs. Afterwards, they discussed the photographs that they took and the researchers asked each individual to select one photograph which best described their experience of homelessness. Radley et al. (2005) found that the study was liberating for participants, instilling in them a sense of pride in their use of street knowledge and survival skills while providing an insight into the diverse experiences of homeless individuals.

Young and Barrett (2001) conducted a study of street children in Uganda. They employed four different ‘visual action methods’ to gather information about children’s ‘interactions with the socio-spatial environment’ (Young and Barrett, 2001:141). Firstly, 15 children were asked to produce a photo-diary of activities and places over a 24-hour period; secondly, 22 children were asked to draw a mental map of their village/town indicating where they slept and the areas of importance to them; thirdly, 23 children were requested to draw three pictures illustrating their everyday experiences; and, lastly, 22 children worked together to create icons that they placed on a timeline to represent their typical day. The researchers held discussions with the children before and after each exercise and they noted that the children thoroughly enjoyed the exercises, resulting in a high level of participation. Furthermore, they felt that the exercise revealed information that would not have been accessible any other way and ‘that would have been overlooked by an adult’ (Young and Barrett, 2001:151).

Gauntlett (2005) researched the relationship between young people and celebrities and whether ‘celebrity culture’ was affecting young people’s aspirations and their ideas about lifestyle and gender. The 14 to15 year old participants were asked to draw a celebrity or star in a particular setting or performing a specific activity. They were then given a questionnaire which asked if they would like to be their chosen celebrity and why. Gauntlett found that a number of male participants provided emotionally reflective responses. He suggested that either young masculinities were changing or that the drawing process gave participants more time to develop their thoughts on the subject matter, resulting in a rich set of data. Fralick et al. (2009) conducted research aimed at investigating students’ perceptions of engineers and scientists. Students were given a worksheet featuring a large framed area where they were instructed to draw either a scientist or an engineer. They were also asked to name their person and were given a space on the worksheet to explain what their person was doing in the picture. Fralick et al. (2009) found that scientists were typically portrayed as male with ‘crazy hair’ conducting dangerous experiments in the lab whilst engineers were portrayed as working outdoors as manual labourers.

Researchers have been broadly moving toward more participatory research methods of the type described above. For instance, it was only researchers who traditionally operated cameras but emphasis has shifted to ‘collaborative’ productions where participants are given a greater role in creating representations of their lived experiences (Gauntlett, 2007). Buckingham (2009) argues that these methods address aspects that other methods have failed to achieve. They are seen to address the participants’ views directly, have less contamination from the researcher and, as a result, empower participants (Buckingham, 2009). The researchers of the studies described above reported these advantages, and in addition they also noted that their participants enjoyed the process of taking photographs or drawing. To harness the benefits associated with these visual sociological methods, the 'Write and Draw Technique' was implemented in the current research. The following section provides an overview of this technique and a rationale for its use.

3.3.2.1. Write and Draw

Children's pictures are frequently used to depict stories that children may have heard, written about, or read and are also used to document places they have visited or activities that they have engaged in (Jarvis and Rennie, 1998). There has been a long history of research suggesting that children's drawings are linked to their developmental stages (Cox, 1993; Krampen, 1991; Lasky and Mukerji, 1980). For instance, Krampen (1991), drawing on the works of Piaget and others, identified four phases in children's drawings: scribbling (age 2-3 years); fortuitous and failed realism (age 3-5 years) where children find it difficult to amalgamate different elements of their drawing; intellectual realism (age 5-8 years), when children draw what they know about the object; and visual realism (age 8-12) when children draw what they actually see. Krampen's (1991) research indicated that children drew (from memory) six representations of buildings in which the specific details increased with age. Other research suggested that children aged 7 to11 can even illustrate difficult concepts such as evaporation (McGuigan, Qualter and Schilling, 1993).

Drawing can be an effective method for children to express their understandings of technology (Rennie and Jarvis, 1995). Rennie and Jarvis (1995) conducted a study to examine the extent to which children aged 7 to11 could demonstrate their understandings of technology through drawings. They found that children held a wide array of ideas about technology and that many drawings were easy to interpret. However, they also noted that even though 'the drawings reflected the range of children's ideas, sometimes they did not reveal the depth or breadth of the individual child's understanding' (Rennie and Jarvis, 1995:239). The researchers reported that a particular child drew a computer when asked to draw images of technology, but, when interviewed, the child stated that technology involves 'man-made tools and things made by machines' (Rennie and Jarvis, 1995:248). It has been suggested that in order to capture the full phenomenon, drawings should be used in association with other traditional methods such as interviews (Freeman and Mathison, 2009).

One of the first researchers to develop the 'Write and Draw Technique' was Noreen Whetton. She worked on the premise that while children aged 7 to 8 may not be able to communicate certain emotions through words (whether written or spoken); they may be able to communicate through other means, such as drawing. Since then, Whetton and her colleagues have used write and draw to explore various aspects of the world for this age group, including how children view drug dealers (Williams, Wetton and Moon, 1989a), how they picture inside their bodies (Williams, Wetton and Moon, 1989b) and children's interpretation of dental health campaigns (Wetton and McWhirter, 1998). Wetton and her co-researchers argue that these research projects have enabled health educators to provide information and educational resources that are ‘truthful, while respecting and being consistent with children’s own logical construction of meaning’ (Wetton and McWhirter, 1998:282).

I selected ‘write and draw’ as one of my mosaic of methods as it had three main advantages. Firstly, the use of drawings provides an alternative approach to more traditional methods of data collection for investigating children’s perceptions of robots:

> ‘different data sources provide different data as well as additional information on themes and concepts already shared by the participants’ (Freeman and Mathison, 2009:148).

Secondly, write and draw aids in communication between adult and child. Researchers first used write and draw as a data collection tool to assist in exploring sensitive issues such as abuse or to assess children’s levels of development (Goodman and Bottoms, 1993) . Whilst my research does not entail revealing sensitive information, this method offers an important means of communication between adult and child. The children did not know me which may have posed a barrier when using other data collection methods for children who find it difficult to voice their opinions to a stranger. Lastly, write and draw was selected as it gives children time to think and clarify their thoughts. It is argued that drawing allows participants to reflect upon the issues being explored (Gauntlett, 2007). Pridmore and Bendelow (1995) also found that ‘write and draw’ allowed children to express ideas for which they did not have words and to then seek help to write about these ideas. This is useful for all children but it also has the potential to enable children to participate regardless of their academic capabilities. Another advantage is that this approach is familiar to the classroom. Children write and draw on a daily basis in classroom activities which means they did not have to adapt to a new method. Therefore, as a result, Pridmore and Bendelow (1995) found that children enjoyed participating in write and draw and this allowed them to relax. For these reasons, it is possible that the rich data gathered was due to children being settled and not afraid to express their views.

Methodological Implications of Visual Methods

Gauntlett criticises talk-based approaches such as interviews and focus groups, arguing that 'such approaches do not provide participants with the opportunity to express themselves' (Gauntlett, 2005:2). Additionally, he claims that in focus groups, participants base their responses on what they feel the interviewer wants to hear. Therefore, this method fails to access 'the stuff that was originally in participants' heads' (Gauntlett, 2007:9). On the contrary, visual methods 'dig more deeply into the unconscious activities of the brain' (Gauntlett, 2007:185), which as a result produces data that is more 'complex and insightful' than the results generated from verbal methods.

Visual research methods are not, however, straight forward. For example, how do we analyse and interpret the data produced? And how do we know if this analysis is accurate? One response to these concerns is that participants should be invited to provide a verbal or written commentary to accompany their drawings (Freeman and Mathison, 2009). However, combining visual methods with written or verbal commentary is not necessarily easy to do. In a study by Gauntlett, adult participants were asked to make visual representations of their own identities, influences and relationships using Lego (Gauntlett, 2007). The study is criticised for failing to address the visual dimensions in the data analysis. The analysis relied mostly on what participants said or wrote rather than their drawings or Lego models Therefore, just like in focus groups, there is a risk of what people say being taken at face value, as a reflection of what they really think or believe (Buckingham, 2009).

Regarding children and visual methods, there are issues on a practical level, relating to the individual skill of each child. Children who are less capable of drawing may be at a disadvantage. Buckingham (2009) argues that drawings are only useful if they communicate something about children's ideas and, therefore, children's depictions have to be interpretable by others.

Critics of visual methods challenge the view that they can more accurately and authentically represent participants' beliefs, and that the data generated from these methods cannot be viewed as a direct depiction of the 'inner mental processes' (Buckingham, 2009:648). Thus, when analysing data collected using visual methods it is important to bear in mind the context in which it was collected as well as the relationship amongst research participants (Buckingham, 2009).

Buckingham suggests that a form of 'naïve empiricism', that participants are able to portray their thoughts and feelings without the influence of the researcher, is evident in debates about visual methods (Buckingham, 2009:635). It is argued that there is a failure to recognize the influence of the researcher in the production and presentation of the material and in the stages of analysis (Buckingham, 2009). Like all forms of data, the analysis of visual data, such as images, allows the researcher to project their own pre-determined views onto the data (Bragg, 2007).

Recent work on visual methodologies subscribes to the view that this method provides ways to tap into children's perspectives by allowing them to voice their opinions thereby weakening the power imbalance between participant and researcher (Kindon, 2003). These power imbalances are, however, inevitable as researchers will always play a 'steering role' (Pauwels, 2004). While power imbalances may be altered by visual methods, they can never be fully eradicated (Buckingham, 2009).

Critics argue that visual methods may not necessarily provide participants with a direct means to express themselves or provide opportunities for 'empowerment' and thereby eliminate questions of power relations between participant and researcher that are apparent in all realms of research. Despite the critical analysis given in his paper, Buckingham (2009) does not disregard the argument that visual methods can be more enjoyable and engaging, particularly for younger children in certain contexts. He challenges the claim, however, that these methods can be empowering by giving participants 'a voice', arguing that all research gives participants the ability to speak and represent themselves and that it is in the ways in which the research is carried out, distributed and utilized that determines whether participants feel 'empowered'.

Freeman and Mathison (2009) discuss the strengths of both the visual and non-visual methods. They state:

> ‘Generally, there has been mistrust in the reliability of images to depict social reality as there has been trust in the use of words to do so. Both modes of expression however have the same dilemma: mediating between lived experiences and representing the meaning of that experience. Both offer different strengths. A verbal sentence may have multiple meanings: the way the words are put together within a sequence of dialogue, the intonation and facial expression of the speaker, and the content of the statement all serve to assist with its interpretation. Images also express intonation and feeling. There is a living quality to images that is often absent in verbal statements’ (Freeman and Mathison, 2009:159).

It is evident that both visual and non-visual methods have advantages. The current study, therefore, uses visual methods in combination with other methods, including observation and group interviews, as recommended by Buckingham (2009). The limitations put forward by Buckingham of visual methods are, thus, reduced by adopting Clark’s mosaic approach.

3.3.3. Semiotics

To explore and interpret the visual data produced by children, the current study incorporated elements of semiotics and semiotic analysis into the mosaic approach.

> 'Semiology offers a very full box of analytic tools for taking an image apart and tracing how it works in relation to broader systems of meaning' (Rose, 2007:69) .

This approach provides an encompassing framework and method to address various aspects of an image, such as posture, dress, gesture, and speech. Representation is vital to semiotic theory; and as David Mick suggests there is 'no discipline [that] concerns itself with *representation* as strictly as semiotics does' (Mick, 1988:20). Semiotics, therefore, provides a useful method of analysis for the current study as it relies on representation and how meaning is acquired from images and speech.

Theorists Ferdinand de Saussure and Charles Sanders Peirce first applied semiotic theory as a method of linguistic analysis, in an attempt to develop a scientific structure for the analysis of language (Chandler, 2001). While I do not intend to review the work of Saussure or Peirce, it is useful to explore the basic concepts conceived by these theorists to see their influence on the work of the later semiotician and cultural analyst, Roland Barthes, who developed semiotics to include the visual representation. The shift of focus from language to visual representation did not detract attention from language, but expanded the scope of semiotics to include the visual field. This is important within the current study as I analyse children's visual depictions of robots as much as their linguistic responses.

Before further delving into Barthes's work, I will provide a brief overview of terms used in semiotics. 'Semiotics is concerned with everything that can be taken as a sign' (Eco, 1976:7). *Signs*, according to Saussure the founder of semiotics, are a basic unit of language and can take many forms, such as words, images, sounds and acts. In semiotics, a sign consists of two parts. The first part, the *signified*, is the mental concept to which the sign refers. For example, when the word 'dog' is heard, one may think of a 'bark', 'wiggly tail' or even 'sharp teeth'. The second part, the *signifier*, is the form that the sign takes, i.e. the material aspect of the sign (Cobley, Jansz and Appignanesi, 1997).

Saussure highlights that signs are only meaningful when they are interpreted in relation to codes (Chandler, 2001). Codes are 'structures' in people's minds that affect the way individuals interpret the signs and symbols they find in their everyday lives. We are often informally taught what certain things 'mean' and we carry these rules and understandings about life over to our exposure to media productions or to mass mediated culture (Berger, 2005). These codes can vary according to a person's social class, geographic location, ethnicity and gender. Berger further argues that codes 'inform almost every aspect of our existence' (Berger, 2005:29). For example, the colour white is usually associated with weddings and purity in Western cultures, whilst in some Asian cultures white is related to death and funerals. In semiotic study, meaning does not pre-exist and, as such, white is not inherently associated with purity or death, but these associations are created by individuals in the process of bringing codes or conventions to the interpretation of signs and symbols of everyday life.

The division of the signifier and signified is crucial to understanding how signs are divided between their mode of representation and their underlying messages. From the 1950s, Roland Barthes used semiotics to deconstruct a wide variety of media, from art to advertising and fashion, in order to reveal their underlying signification (Barthes, 1993). In his work, the process of signification can further be analysed as denotation and connotation, with primary importance accorded to connotation. Connotation and denotation are concepts that are used to describe the signified and to explore the relationship between the signified and the signifier. A denotative signified is the 'dictionary' or 'common-sense' meaning of a sign. Conversely, the connotative signified refers to the personal associations that individuals attach to signs (Chandler, 2001). For example, let us consider the sign for car. Both cars, a Ferrari and Ford, have the same denotation; they are functional modes of transport. However, at a connotative level, these cars signify a range of status attributes such as socio-economic status, wealth and lifestyle. Barthes stated that

> '... denotations are not the first meaning, but pretend to be so; under this illusion, it is ultimately no more than last of the connotations (the one which seems both to establish and to close the reading)...' (Barthes, 1993:9).

Saussure's semiotic theory, primarily concerned with the structure of language, focused on denotations. Barthes, however, extended semiotic theory to incorporate media and the image, and introduced the concept of connotations, the personal associations individuals attach to signs, which are more open to interpretation than denotations.

The concept of fashion is a sign that has two distinct meanings: a denotative and a connotative level of signification. At a denotative level clothes protect us against the natural elements, while on a connotative level clothes are a fashion that is interpreted through cultural and social conventions (Kuruc, 2008). Kuruc provides an example of this in her description of two differently dressed people. One person wears a formal business suit with short hair whereas the other wears torn jeans and high black leather boots and has a Mohawk hairstyle. Kuruc argues that at a denotative level both people wear clothes to cover their bodies to protect themselves from the natural elements. In contrast, at a connotative level, the two individuals are very different. The first individual is dressed very conservatively, suggesting a level of professionalism and perhaps even an upper-class identity. Kuruc states that the second individual can be viewed as belonging to a punk subculture. Therefore, these two individuals signify differing ideologies through their clothing; the first individual, the ideology of professionalism and capitalism, while the second connotes anti-establishment and youth culture (Kuruc, 2008). The fact that clothing is worn to protect against the elements is usually the last thought as 'denotations are not the first meaning...it is...no more than the last...' (Barthes, 1993:9).

However, despite the popularity of Semiotic theory, there are a number of criticisms leveled at semiotics. Critics have argued that the inconsistency of interpretations is a major problem of semiotic analysis. One analyst's interpretation may differ significantly from another. It has been suggested that 'it is heavily dependent upon the skill of the individual analyst' and some semioticians 'can do little more than state the obvious in a complex and often pretentious manner' (Leiss, Kline and Jhally, 1990:214). Chandler (2001) argues that in some instances, semioticians use semiotic analysis to display their expertise through the use of terminology which may exclude others from critically analysing their work. Another criticism of semiotics is the extensive jargon that is used to explain a concept (Berger, 2005). The use of jargon in semiotics and its preoccupation with classification risks cases of 'lost in translation' with potential for mistaken interpretation of meanings. Semiotics can be applied to all domains, extending across various academic disciplines (Chandler, 2001). While this might be viewed as a strength in some aspects of its application, in others semiotics can be viewed as 'imperialistic' and 'as a kind of intellectual terrorism, overfilling our lives with meanings' (Sturrock, 1986:89). Semiotics aids the researcher in considering and reflecting upon the process involved in the production of the image, and its symbolic and ideological implications, as well as multiple readings and interpretations.

However, as semiotic analysis is particularly used to analyse 'texts', it lacks a method for exploring an individual's account or narratives. Therefore, while semiotics is used in the current study to analyse images, other methods have been employed such as ethnographic or phenomenological approaches to the analysis of children's accounts and narratives.

The two approaches outlined above, Phenomenology and Semiotics, are two 'tiles' of my mosaic, my research approach adapted from Clark (2004). The following sections outlines two more tiles of the mosaic approach taken by the current study to further investigate children's accounts. These are observation and group interviews.

3.3.4. Observation

This section describes observation and its underlying methodology, ethnography, and how this approach fits in with other methodologies described in the mosaic approach of the current study.

Observation as a method of study is usually associated with ethnography (Parahoo, 2006). Ethnography was typically used by anthropologists to study 'pre-modern' and 'unknown' cultures through extensive engagement with the local people in their natural settings (Mason, 2002). Similarly, in the past, ethnography was a common methodology employed in research with children, as childhood was often viewed as an unknown culture by adult researchers (James, Jenks and Prout, 1998). However, since the growth of sociological research in the field of childhood, this view has changed. Now, as noted earlier, advocates of this field adopt the view that children are active social participants who interpret and co-create an understanding of the world together with adults. However, ethnographic methods, such as observation, remain valuable as they provide children with the opportunity to participate in research on their own terms. They can show the researcher aspects of their lives that are of importance to them (Christensen, 1993).

Researchers can explore and understand the context in which children convey their thoughts and views when observing children's interactions. This provides further insight into and understanding of the area being researched (Clark, 2004). For my study, ethnographic methods gave children the opportunity to express their thoughts and views about robots without little or no intervention from the researcher.

There are, however, potential problems with observations in research. Firstly, the observer effect, that is, individuals may not behave in their usual manner in the presence of a researcher because they are aware of being watched. It is argued that this may result in research bias (Spano, 2005). Observer effects are unavoidable and are an issue for all research methods (Wilson, 1977). It has been noted that 'staged performances' by participants may even provide valuable data about how 'individuals perceive themselves and would like to be perceived' (Monahan and Fisher, 2010). Secondly, power relations between children and the adult researcher may influence the way children act. Adults observing children in institutions or even in home settings may raise issues of authority and assessment (Robinson and Kellett, 2004). Furthermore, ethnographic methods may suggest that the child is incompetent at creating and representing their own meanings, as an adult is needed to observe and to then interpret these observations (Mandell, 1991).

Researchers have suggested a number of strategies in order to minimize the potential impact of these issues for ethnographic research. It has been noted that it is important for the researcher to be reflexive about their role, thereby, maintaining awareness of the hierarchical power relationship that may exist between researcher and child (Etherington, 2007). Allowing children to voice their views may assist the reconstruction of a child's relationships and may, thus, provide opportunities for empowerment. It is further suggested that researchers should provide children with the opportunity to share their perceptions rather than seeking to demonstrate the absolute truth about a phenomenon (Manias and Street, 2001). Therefore, in order to limit potential problems associated with observations in research, a degree of reflexivity was practiced and I was only interested in children's views and perceptions of robots, not what is deemed to be factually correct.   Using these strategies, the researcher can.

In conclusion, despite the historical context of ethnography as a colonial study of remote cultures, the adoption by ethnography of a contemporary stance towards children offers children and adults the potential to work together to create shared meanings in a way that limits the impact of the researcher's intervention.

3.3.5. Group Interviews

This section describes the last 'tile' of the mosaic approach: group interviews. It provides a rationale for the use of group interviews as against using focus groups and describes how this method contributes to the multi-faceted methodology of the current study.

Group interviews are distinguished from focus groups in one significant way; where group interviews involve

> 'asking questions of each person in turn, focus group researchers encourage participants to talk to one another: asking questions, exchanging anecdotes,

> and commenting on each other's experiences and points of view' (Kitzinger and Barbour, 1999:4).

Although piloted, the focus group approach was not adopted for two practical reasons. Firstly, when it was tested in the pilot study, children all spoke at once making it very difficult to interpret the discussions. Secondly, the more vocal children dominated conversations while quieter children remained silent. Thus, asking children to respond to questions in turn ensured that everyone had the opportunity to speak.

A key advantage of group interviews is that they can produce shared social meanings. Buckingham suggests that social groups 'provide concrete instances of the ways in which participants define and negotiate meanings through social interaction and thereby also perform and construct social identities' (Buckingham, 2009:645).

Group interviews serve to create an opportunity for a group dynamic as participants relate to the perspectives of others. It is suggested that this group dynamic may significantly affect the findings of the study (David and Sutton, 2004).

> 'It is not always clear to what extent an individual's behaviour is influenced by others, but it is at least theoretically possible that each group member's actions are determined in part by other group members...evidence from research indicates that people do, in fact, behave differently in groups than when alone' (Shaw, 1981:46).

The effective use of group dynamics in research has generated a great deal of interest over the years and researchers have long been interested in the behaviour of groups and the interaction amongst people in groups (Shaw, 1981). Shaw's statement above suggests that individuals behave differently in groups to when they are alone. Some individuals may have the potential or ability to influence others in a group setting (Lewis, 1992; Stewart and Shamdasani, 1990) and there is often a danger that those with dominant personalities within a group may take the lead of a discussion either by setting the tone or the amount of time spent in conversation. One way of overcoming this according to Krueger (1998) is for the researcher to reassure other participants that their contributions are welcomed. For example, he suggests stating something like: 'that's one point of view. Does anyone have another point of view?'(Krueger, 1998:59). The use of group interviews in place of focus groups helped to address this issue in the current study, ensuring all participants were given the opportunity to respond while creating the group dynamic.

There are, however, difficulties when trying to create a group dynamic with groups of children. There is evidence to suggest that children will often provide the same or similar answers previously given by their fellow classmates in a group. Piaget (1954) argues that children's attitudes, behaviours and beliefs are highly influenced by other people, particularly their peers. Similarly, there is evidence to suggest that if a group shares a certain point of view, other group members will agree, thinking uncritically, and will also provide the same or similar responses (Hennessy and Heary, 2005). A possible explanation for this is that participants may want to fit in with other group members. Participants holding alternative opinions may also withhold their views due to fears of being wrong or ridiculed by their peers.

There are also gender conformity implications. Researchers argue that gender roles are prominent among 5 to 10 year olds. McGuffey and Rich (2001) suggest that children who deviate from these gender roles are likely to experience disapproval from their peers, as well as, adults. However, researchers have found that despite this disapproval, deviancy from these set rules does occur. Browne (2004) gave an example of an interview about children's play preferences that was conducted with 'Lizzie', a 6 year old girl. Lizzie states:

> 'I should think girls like to play with Barbies and Polly Pockets and boys like Pokemon cards. I like Pokemon too. I think only boys might like to play with Knex (a construction toy). If they like Barbie they must be gay' (Browne, 2004:73).

This interview excerpt shows that even though Lizzie ignores her 'deviation' in liking Pokemon, she disapproves of any boys who like Barbie. Lizzie uses the term 'gay' in a derogatory manner. 'Researchers have consistently found that terms such as ''gay'' and ''poof'' are often used to refer to anything deemed unmasculine, non-normative or ''uncool''' (Thurlow, 2001:26). This may indicate that children can be quite wary of deviating from specific gender roles to avoid condemnation from peers. It was, therefore, important to take into account the implications of gender and group conformity when analysing the results from this study.

3.4. Putting the Mosaic Together

The mosaic approach used in this study combines four different qualitative methods: phenomenology, semiotics, observation and group interviews. Phenomenology is viewed as a research philosophy that accommodates the use of group interviews and visual methodologies. Semiotics was incorporated as a way of exploring and interpreting the visual data produced by children, as well as, exploring fictional robots in children's popular culture. There is, however, conflict with ethnographic methods (observation) and phenomenology. Ethnography is based on the premise of an outsider 'looking in' whereas phenomenology actively seeks to explore the lived experiences of participants. By combining both methodologies within the mosaic approach of the current study it was hoped that data collected of children's experiences of their social world would be rich and multi-faceted.

Despite the tension between methodologies, their collaboration under the mosaic approach offers flexibility in the overall methodological design, allowing for the accommodation of traditional methods, such as participant observation and group interviews, with more innovative methods, such as drawing. This does not provide a purely phenomenological approach but allows children's experiences, views and perceptions to be explored through methods that are consistent with the social constructivist view of children as competent and active members of society

3.5. Triangulation

The mosaic approach used in this study can be viewed as a form of triangulation. Triangulation is generally referred to as a combination of several methodologies in the study of one phenomenon. However, Denzin (1989) distinguishes four main types: (1) Data triangulation – gathering data on the same phenomena from a different sample at a different place and time. (2) Investigator triangulation- different observers or interviewers are employed in order to minimise researcher bias. (3) Theory triangulation- the use of more than one theoretical stance in the research. (4) Methodological triangulation- this refers to using different research approaches with different data gathering and analysis methods.

The fourth approach can also be distinguished into different types: within-method and between-method triangulation. Within-method involves the use of similar methods to investigate an issue. For example, using different subscales for measuring items in a questionnaire. Conversely, between-method triangulation is the combination of different methods such as a questionnaire with an interview (Flick, 2009). The mosaic approach is almost identical to the 'within-method, methodological triangulation'. The mosaic approach was the preferred approach for the current study as it focuses particularly on research with children, and stresses the use of child-appropriate methodology that acknowledges and utilises the abilities of children. For example, in all four phases, children were given opportunities to convey their thoughts and perceptions with methods that they are familiar with such as writing, drawing and speaking in turn amongst their peers.

Triangulation is often used as a method of validating results. The mosaic approach is based on the premise that each method has both its strengths and weaknesses. Children may experience difficulties in choosing appropriate words to convey their thoughts and opinions in group settings and the presence of an unfamiliar face may also enhance this fear, restricting the collection of data. The methods used in this study tried to minimise this by employing visual methodologies and group interviews where children spoke amongst their peers and were in familiar surroundings or attending an event with their family. In addition , the use of various types of data also assists in balancing strengths and weaknesses (Esterberg, 2002). For example, drawing was accompanied by writing to assist in the interpretation of the drawing.

3.6. Open Science

One aim of the wider project of which this PhD is a part, is to explore whether any patterns of behaviour can be identified in a group of robots interacting. Children were recruited to assist in this interpretation as 'novice scientists' (See Chapter 1 for more details). Therefore, children were viewed as having the ability to contribute to the data collection and results of the research. The following section provides details of the open science aspect of this project.

Open Science is a form of public engagement and according to Poliakoff and Webb, public engagement is defined as 'communication that engages an audience outside academia' (Poliakoff and Webb, 2007:244). One example of this is the Manchester Science Festival's *Walking with Robots* project. This project collaborated with various members of the public to 'increase awareness of where robotics research is heading and how they (the public) can contribute either as engineers or as informed citizens' (Walking with Robots, 2010:no pagination).

The Open Science approach relies on making details of a scientific investigation public, particularly using the medium of the Internet. Research data is made available for members of the public to engage with and make contributions to the scientific research. It is argued that those who adopt this approach should aim to 'promote the sharing of information, know-how and wisdom' (Open WetWare, 2010:no pagination).

There are a number of research approaches within the open science paradigm. One such approach, 'citizen science', uses non-professionals to assist in research. Cohn (2008) states that 'volunteers do not analyse data or write scientific papers but they are essential to gathering the information on which studies are based' (Cohn, 2008:193). Bonney and colleagues (2009) identified three types of open science projects. The first is contributory, where the project is pre-designed by scientists and volunteers are requested to provide data. The second is collaborative in which volunteers assist scientists refine the project design, as well as assist in data analysis and distribution. And the third category, co-created, is where volunteers and scientists work together in all aspects of the research and the public is actively involved from start to finish.

An example of a citizen science project is Galaxy Zoo. This is an astronomy project where members of the public are invited to classify images of around 250,000 galaxies. Initially, astronomers tried analysing data by computers, but this proved difficult so they sought assistance from volunteers good at spotting patterns and pattern variation. Starting with around 200,000 volunteers, they provided extensive and valuable data that resulted in 9 publications by 2008. Additionally, in July 2009, a group of volunteers wrote a paper that was accepted by the Monthly Notices of the Royal Astronomical Society (Galaxy Zoo, 2009).

As demonstrated by the Galaxy Zoo project, public engagement has the potential to generate valuable data. Others argue that it is ‘important to engage the non-specialist public’ (Royal Society, Wellcome Trust and RCUK, 2006:no pagination), as ‘taxpayers money may ultimately fund their research’ (Poliakoff and Webb, 2007:247). However, some researchers are reluctant to make their work available to the public due to worries that it could be misunderstood or misused (Poliakoff and Webb, 2007).

The following section explores the ethical implications of conducting research with children and highlights some of the issues that arose from the current study.

3.7. Ethics

A fundamental principle of social research practice is that participants in research should voluntarily provide informed consent, and that no intentional harm and anxiety should be caused during their participation. By informed consent, the participant must understand the purpose of the study and must agree to partake without coercion. Additionally, the option to withdraw at any time should also be provided (Morris, 1998).

The notion of informed consent raises fundamental issues, especially relating to research with children (Gallagher, et al., 2010). Williams (2005) states: ‘we can view informed consent as a powerful case study of how any principle- however valid it may be- is always more complicated and ambivalent in its practice than we might like to think’ (Williams, 2005:52). The following section highlights some of the challenges relating to informed consent and addresses key ethical issues such as harm to informants, accessing participants, anonymity and ownership of drawings, as they apply to this research project.

Even though ethical ideologies relating to informed consent and harm to participants are not new (Small, 2001), there has been a much greater emphasis on their use in the post-Second World War years as a result of the harm and distress caused by research in the medical field (Gallagher, et al., 2010). However, the social sciences adopted a more relaxed approach to informed consent and ethics as social research was viewed as less threatening. In more recent times, however, there has been a drift toward more bureaucratic guidelines for social research. Critics argue that bureaucracy relating to informed consent only serves to protect individual researchers and institutions from legal implications rather than protecting participants from harm and exploitation (Homan, 1991). It is, therefore, important to consider the ethical implications from the perspective of participants to ensure they are neither harmed nor exploited.

3.7.1. Informed Consent

There is an on-going debate as to whether children are capable of consenting for themselves (e.g. Lindsay, 2000; Masson, 2000). It is argued that gatekeepers may underestimate a child's decision-making ability and therefore consider it their responsibility to protect the child (Heath, et al., 2007). However, this underestimation may not relate to all children, for example intellectually disabled children may not have the capacity to make individual decisions. In this study, even though children were viewed as competent to consent, 'legal requirements and organisational hierarchies in schools mean that parents and professionals still act as gatekeepers' (Gallagher, et al., 2010:478). Therefore, children's participation in this study was determined in the main by adult 'gatekeepers', for example, the head teacher of the school. In providing consent, the head teacher acted on behalf of children's parents, i.e. in loco parentis. Parental consent was not sought as the activity in which the children were engaged for the research was consistent with the national curriculum. Even though the government's curriculum provides a broad outline of the nature of topics to be taught in schools and of children's learning outcomes, it is teachers who ultimately decide how it will be taught (Sadker et al., 2006).

Nevertheless, children were briefed about the study and were reassured that they could stop their participation at any time. However, even though children were given this option, some researchers argue that children may feel compelled to participate in research with ‘visitors’ to the school (David, Edwards and Alldred, 2001). Therefore, even though overt coercion may be preventable, aspects of school culture such as peer pressure, institutional hierarchies, and the desire to conform, may prevent children from not rejecting a teacher’s or researcher’s request to participate. As Heath and colleagues state: ‘it is invariably a very brave act to say ‘no’ in an institutional context’ (Heath, et al., 2007:413).

3.7.2. Harm to Informants

No apparent anxiety or harm was caused to participants in this research. In all research there is potential for distress: ‘while ethnographic research is unlikely to cause harm as, for example, drug trials may, it can for example lead to emotional distress or anxiety’ (Hammersley and Atkinson, 1995:268). Nevertheless, there were no apparent signs of distress during this research since children appeared to have enjoyed drawing, writing and discussing the topic of robots.

Similarly, in the observation phase, the e-pucks used were by nature low risk. If a child's finger was to touch a wheel, the e-puck would stop moving; ensuring no impairment or harm would be caused. In addition, the small size of e-pucks ensured that no harm would be caused if children accidentally dropped the e-pucks on themselves. Furthermore, the procedure itself involved children watching robots interacting and then answering questions, and it is unlikely that these activities would jeopardise their health or wellbeing.

3.7.3. Honesty in Research

In research, it is vital to maintain rapport and a relationship of trust between researchers and individuals (Prosser, 2000). On the other hand, it is debatable as to whether children can fully understand what they are consenting to (Miller and Bell, 2002). Researchers may use language that children of a very young age may not fully understand. Gallagher states: '…a researcher may explain what a research project is about, and the participants might seem to understand and perhaps genuinely believe that they do – but none of this guarantees that they share the same conception of the project' (Gallagher, et al., 2010:474). Bearing this in mind, the decision was made to use very simple language that children would understand such as 'I am doing a project about robots and I would love to hear what you think about them' instead of giving in-depth information about the nature of the project.

3.7.4. Anonymity and Confidentiality

According to Prosser (2000), anonymity and confidentiality are two areas that are considered central to any ethical research. As stated previously, anonymity was preserved by asking children not to write their names on their drawings and stories. Similar to other researchers (Marquez-Zenkov, 2007; Mizen, 2005), pseudonyms were used to disguise the participants' names when discussing pictures and stories in presenting the analysis. However, there can also be problems associated with pseudonyms. The use of a particular name may lead to inferences about certain identifying factors such as ethnicity and social class.

Anonymity was preserved by asking children not to state their names whilst speaking into the audio-recorder. In the event of a child stating their name, this was omitted during the transcribing process. In addition, pseudonyms were used to disguise participants' names in the results and analysis sections of this chapter.

3.7.5. Ownership of Drawings

Another ethical issue in the write and draw technique is the ownership and use of the drawings and writings (Pridmore and Bendelow, 1995). According to Prosser et al. (2008), the copyright holder is usually the person who creates the image. Prosser argues that this may change in two circumstances: (1) if the individual created the image as part of work in which the employer acquires the copyright or (2) if the individual willingly sells or gives the copyright to someone else. The latter applies to the current research as all the children participating in this study agreed to their images being used in a 'project'. In School B, a child who was fond of his drawing asked if he could keep his work. It was agreed that he could, as I did not legally own his drawing. However, he changed his mind when he saw other children handing over their drawings and offered the picture as a present. In this case, there is still a level of uncertainty as to who owns the drawings. Even though the child provided the picture, it is questionable whether he fully understood the complexity of the situation.

The ethical issues arising out of this research are minimal as this research involved children drawing, writing, and observing robots, which are activities not dissimilar from those conducted in the classroom. Nevertheless, the complexities of and ambiguities associated with conducting ethical research with children, as explored above, were taken into account throughout the research project.

Part 2- Research Design and Methods

This section of the chapter sets out the research design and methods employed in this study. After describing how participants were accessed and selected for this research, this section explores the method used to collect and analyse data in each of the four phases of this study.

3.8. Research Design

As discussed earlier, this study draws on Clark's (2004) mosaic approach. It is an overarching research strategy influenced by social constructivism that recognises the value of conducting research with children and proposes a participatory, multi-method framework. Within this framework, social constructivism and phenomenology have influenced the use of visual methodologies, semiotics and ethnographic methods. These methods are combined in the current study in the following ways:

Phase 1-Write and Draw: Visual methods, Semiotics.

Phase 2 - Children's Observation of Robots: Observation and Group Interviews.

Phase 3 -Manchester Science Festival: Visual Methodology, Semiotics, Observation and Group Interviews.

Phase 4 – Pilot study engaging children in spotting patterns of behaviour: Observation and Group Interviews.

Social constructivism and phenomenology regard children as active and rational members of society who are capable of making important contributions to research. And the methods employed in this study seek to draw upon children's abilities to act as co-creators of the society they live in. Prior to negotiating field access, these methods were reviewed by the University of Warwick ethics committee.

3.9. Negotiating Access and Selection of Participants

3.9.1. Phase 1: Write and Draw and Phase 2: Children's Observation of Robots

Letters were sent to six primary schools in the West Midlands area, summarising the objectives of the research and requesting their participation (See Appendix 1). These schools were selected as they were located within a five mile radius of my residence. Of the six schools, two agreed to participate. They were School A[12] and School B in a post-industrial town in the West Midlands. School A was towards the bottom end of the regional league table[13]. Over 90 per cent of pupils from School A came from ethnic minority backgrounds and spoke English as an additional language. The proportion of these children entitled to free school meals was above average whereas the proportion of those with special educational needs and/or disabilities was below average.

School B was one of the top five schools in the table[14]. Approximately half of the pupils from this school were of White British heritage and the other half came from ethnic minority backgrounds. The proportion of pupils known to be eligible for free school meals was well below the national average, while the number of disabled pupils and those who have special educational needs, mainly moderate learning, social, emotional and behavioural difficulties, was broadly in line with the national average.

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[12]The names of the schools have been removed to preserve anonymity.
[13] A government published UK academic ranking chart based on educational attainment data such as SAT results. SAT's are national curriculum tests taken at age 10 or 11.
[14]Based on the 2009 SAT results.

Pupils at the Year 3 level were selected as participants for this study as the developmental psychology literature suggests children of this age group (7 to 8 years) are likely to be more intuitive than those of a younger or older age group (Brewer and Samarapungavan, 1991), allowing them to act as 'novice scientists'.

Two meetings were held with the head of School A and the deputy head of School B prior to the 'write and draw' sessions. In the first meeting, an explanation of the purpose of the study together with the required number and age group of children for Phases 1 and 2 was provided. The dates and times of sessions were negotiated in the second meeting. The write and draw sessions were judged to be an educational activity within the school's curriculum, as children of this year level are taught about science and technology, and are asked to describe or respond appropriately to objects and events they observe and communicate their observations in simple ways, either verbally by talking about their work, or pictorially through drawings or simple charts. Thus, no parental consent was sought as the methods used in this research were consistent with children's day-to-day educational activities.

A copy of my Criminal Records Bureau (CRB) disclosure was collected and stored in the records of each school. All members of the required year level aged 7 to 8 who were in attendance on the day of the research participated in the study.

3.9.2. Phase 3: Manchester Science Festival

The Manchester Science Festival is an annual nine-day public event that usually takes place over October half-term. ‘The event is aimed at inspiring and engaging people in the areas of science, technology and engineering. The programme hosts a wide range of activities including workshops, exhibitions and tours’ (Festival, 2009). The festival takes place primarily at the Museum of Science and Industry (MOSI). However, other venues in and around Manchester city centre, such as the Greater Manchester Universities, also host activities. The festival is organised by leaders in the areas of business, culture, local government and healthcare and its aim is to increase the public’s understanding of science and its applicability to everyday settings, as well as increase children’s enthusiasm for science in the hope that more schoolchildren go on to study science, technology and engineering at a higher level (Festival, 2009). The first event was launched in 2007 and in 2009 it was reported that over 100,000 people attended the festival ‘making it the most popular event of its type in the UK’ (BBC, 2010:no pagination).

I attended the majority of activities and exhibitions organised by the festival as many of them were less than an hour long and were held on consecutive days over a five-day period. To further assist in answering the overall research question: How do children perceive robots? I choose three sessions for the collection of data. The three activities were: Big Draw - X-Ray Art: Under your skin; Swarm Robots; and Build a Bugbot. (See Table 2, below, for my rationale for selecting each activity).

Activity	Activity Details	Rationale for choosing activity
Big Draw - X-Ray Art: Under your skin	Children chose either a paper outline of a human body or a robot from two piles that were displayed on a table. They were issued with crayons and paint by the workshop coordinators and were instructed to draw the relevant parts/organs with the wax crayon. Children then applied paint over their drawing in order to create an image that looked like an x-ray.	Big Draw - X-Ray Art: 'Under your skin' assisted in answering my research question for primarily two reasons. Firstly, the method of activity coincided somewhat with the write and draw and observation research previously conducted. In the write and draw sessions that I conducted, children were asked to draw what they thought a robot looked like. However, in this activity they were already given an outline and were asked to draw the insides. Furthermore, in the observation session of my research, children were asked what was going on inside the robot. Therefore, this activity gave me an opportunity to assess, using visual methods, children's perceptions about the insides of robots. This would then allow me to use the results attained to compare and contrast the findings from my previous write and draw and observation sessions. Secondly, this activity was more likely to attract all age groups, as many of the other activities and workshops were aimed at teenagers. As I am focusing on 6 to7 year olds in this research, I anticipated that drawing and colouring would appeal more to this age group.

Swarm Robots	The students demonstrated four e-pucks that were programmed to do three different things; one of which was very similar to the program that was installed in the e-pucks I demonstrated. These programs were: *Robots follow each other in lines*. They did this by following the illuminating lights on the back of another robot. These lights were programmed to blink at a specific frequency which another robot could detect using a filtering algorithm. This allowed the robots to see the tail lights of another robot but removed the strobing of ambient lights in the surrounding environment (i.e. ceiling lights). Their behaviour was self-organised: it looked as though the robot at the front was leading but really it was looking for a robot to follow - unaware that it was being followed by a line of robots. A robot cannot see its own tail lights, and this is the key to them forming long lines. The only difference between this program and the one that I demonstrated in schools is the allowance of other environmental lights so the robots did not go astray. *Flocking*- Flocking has three basic rules: - Get close together (aggregate) - Keep a safe distance away from each other (disperse) - Align to face the same direction. This was achieved by programming the e-pucks to communicate by blinking their infrared sensors so they could send numeric information as packets of data. They have eight sensor/senders around their body. The information they sent was on which sensor was sending the message. A receiving robot would know which sensor (its own) the message came in on. By looking at the difference between the sending sensor and the receiving sensor angles, robots could line up to face the same way. This worked because the sensors on each robot were the same. With lots of robots, a single robot could collect lots of messages and work out the most popular direction to face. They each did this alone, but the effect led to group behaviour. *Aggregation*: In this demo, a robot would search for another robot and then head towards it. Once too close, the robot would turn about and drive away. When too far, the robot would turn back in. In effect, the robots would clump up and oscillate toward and away from each other. This involved using the transmission of infrared again, and measuring the highest intensity. They avoided crashing by looking for reflected infrared.	I decided to observe this exhibition particularly because the e-pucks that were used looked almost identical to the ones used in my research. The only difference was that there were no coloured bands differentiating them. I found that the exhibition was opened to all ages, therefore, not only would I be able to explore what 7 to 8 year-old children were saying about the e-pucks that were programmed differently but also explore the range of responses from older or younger children. This provided additional data on children's perceptions of robots from different age groups.
Build a Bugbot	This activity was divided into two parts: a question and answer session and an activity where a simple robot would be constructed. The question and answer session involved the coordinator showing pictures to children and asking them if the picture was a robot or 'no bot'. The children would then also be prompted to provide an explanation as to why they thought the picture was a robot or not.	I anticipated that the first session would explore children's perceptions about what qualities and characteristics they thought were needed in order for a robot to be classed as one. In addition, even though the activity was aimed at children between the ages of 8 to 12, I saw this as an opportunity to gauge the responses from children of differing ages.

Table 2 Rationale for selecting activities at the Manchester Science Festival.

Negotiating access and participant selection differed in all three exercises at the festival. Each of these is discussed individually in more detail below.

3.9.2.1. Big Draw- X- Ray Art

Prior to the commencement of the workshop, I introduced myself to the workshop coordinator as a PhD student interested in children's perception of robots. I also stated my affiliation with one of the organisers, Professor Alan Winfield, the principal investigator of this project. Permission was requested to speak to children and take photographs of their drawings and verbal consent was given. Verbal consent was sought from the parent(s)/guardian(s) of each child after providing a brief introduction and description of the nature of the research; and all the children who participated were in the presence of their parents/guardians.

Data was collected from children who approached the activity area requesting a robot outline. Children between the estimated age of 5 to11 were asked to participate in the discussions. Whilst occupied with one participant, no further children were recruited. Having completed a discussion with a child, the next child aged between 5 to11 choosing a robot outline was asked to participate.

3.9.2.2. Swarm Robots

I had met the PhD students organising the *Swarm Robots* exhibit on previous occasions at the robotics laboratory in Bristol. I explained my previous fieldwork with school children observing e-pucks and requested permission to observe children viewing their exhibit and to also ask children questions about the exhibit. The students provided verbal consent, but as they were from engineering and computer science disciplines they may not have been familiar with the ethics of qualitative research. An ethical judgement was therefore made, similar to the 'X-ray art' workshop, to ask for verbal consent from the parent(s)/guardian(s) of children prior to engaging in discussions with children. Data was also collected from all children who made audible comments during the demonstration.

3.9.2.3. Build a Bugbot

Access was negotiated in advance with the coordinator of the *Build a Bugbot* exhibit. Children's responses about whether the images they were shown were a robot or 'no-bot' (i.e. not a robot) were noted together with their explanations. Data was collected from all children who attended the activity. Parental consent was not required and as the researcher I did not speak directly with children.

3.9.3. Phase 4: Pilot Study Engaging Children in Spotting Patterns of Behaviour

Phase 4 was conducted in School C as Schools A and B (from Phases 1 and 2), initially contacted in regard to conducting additional fieldwork, were unavailable to participate. School C responded positively to a request sent to local schools in the East Midlands area asking if they would participate in Phase 4 of the research. Due to time limitations, details of the research including space required, time and participant selection were negotiated over the telephone. The stated requirement of 10 children from a Year 3 level was requested as this was only a pilot study. Similar to schools A and B, no parental consent was sought as School C's deputy head deemed the research exercise to be within the school curriculum for Year 3 students. As before, my CRB check was photocopied and placed in the school's records. The classroom teacher selected the 10 children who participated in the exercise because they were 'the brightest and most well-behaved'. This, therefore, needs to be taken into account during data analysis. Before commencing the video demonstration, the children were asked if they wanted to participate and were offered the opportunity to withdraw at any time.

3.10. Methods and Analysis

One element of the mosaic approach used throughout this study is the phenomenological viewpoint of capturing the reality of an individual's views, feelings and experiences about a phenomenon. Inspired by phenomenology, Collaizi (1978) developed a seven-step process of analysis. In analysing the data generated from the mosaic of methods, Collaizi's seven steps were taken into account. These steps are:

1. 'Read all the subjects' descriptions in order to acquire a feeling for them, and to make sense of them.
2. Return to each description and extract from them phrases or sentences which directly pertain to the investigated phenomenon; this is known as extracting significant statements.
3. Try to spell out the meaning of each significant statement; these are known as formulated meanings.
4. Repeat the above for each description and organise the aggregate formulated meanings into clusters as themes.
    - Refer these clusters of themes back to the original protocol in order to validate them.
    - At this point discrepancies may be noted among and/or between the various clusters; some themes may flatly contradict each other or may appear to be totally unrelated.
5. The results of everything so far are integrated into an exhaustive description of the investigated topic.
6. An effort is made to formulate the exhaustive description of the investigated phenomenon in as unequivocal a statement of identification of its fundamental structure as possible. This has often been termed as an essential structure of the phenomenon.

7. A final validating step can be achieved by returning to each subject, and, in either a single interview session or a series of interviews, asking the subject about the findings thus far ' (Collaizi, 1978:59-61) .

Collaizi (1978) particularly encourages those adopting his steps to be flexible and to bear in mind their own research aims and requirements. In this study, the data gathered from each element of the mosaic was initially analysed independently using different approaches, but the findings from each approach was integrated into the overall analysis in order to provide a unified comparison of the data.

To analyse data collected in the observation and group interview sessions, it was transcribed and coded. Coding encompasses three procedures '(1) noticing relevant phenomena, (2) collecting examples of those phenomena, and (3) analysing those phenomena in order to find commonalities, differences, patterns and structures' (Coffey and Atkinson, 1996:29). This is often referred to as 'open coding' (Esterberg, 2002). This coding process develops potential meanings, as recurring themes begin to emerge during the open coding process. After noting key themes, the data was interrogated line-by-line, focusing on key themes identified during the open coding process. The use of key themes to analyse the data line-by-line is termed 'focused coding'.

Triangulation of the data was conducted at a data-set level. At a data-set level, patterns and themes were identified at each phase of the research. For example, anthropomorphism was a significant theme in phase 1. Data relating to anthropomorphism in phase 1 was then compared and contrasted with data from subsequent phases, searching for similarities and differences. This was possible as each phase of research was distinctively different

The following section details the methods used in each phase of the research. A description of the pilot study for Phases 1 and 2 is followed by a description of the changes implemented as a result of conducting the pilot study. The method used for Phase 1 and 2 of the study is then discussed. For Phase 3 (The Manchester Science Festival), the method used for each activity is addressed individually. The details of the pilot study engaging children in identifying patterns of behaviour (Phase 4) are then provided. Additionally, each phase of data collection was analysed separately and details of the method of analysis follow the description of the method used for each phase.

3.11. Phase 1: Write and Draw

The write and draw study was conducted in five sessions with a total of 144 children. The first session was a pilot study consisting of 24 children. After analysing the results, the methods were revised and four subsequent sessions (definitive study) were conducted with 120 children.

Pilot Study

The pilot study for Phase 1 was conducted in School A. There were a total of 24 children in the class, consisting of 14 girls and 10 boys. The exercise took place in the children's classroom during class time and all members of the year group in attendance on the day of the research took part. The exercise was divided into two sessions. In the first part of the exercise, children were invited to draw one or more pictures of what they thought robots looked like. Any enquires as to the type of robot children were required to draw, received the simple response that children should draw *their* thoughts on the robots' appearance. Children were asked to write their age and gender at the top of the page and were specifically instructed not to write their names in order to preserve anonymity. The researcher asked the children unplanned questions relating to their drawings to clarify what was drawn and their responses were documented in field notes. For example, one child drew lines emerging out of the robot's eyes and the child was asked to explain what the lines signified. An account was written as soon as possible after the session and a copy was attached to the child's drawing. The first session of the pilot exercise took 20 minutes.

In the second part of the session, children were requested to write a story about the robot they had drawn. The length of the story was not specified, only that they should write as much as possible. The children were asked to stop writing after 15 minutes. Stories and drawings were collected together and were classified as 'School A' and each child's work was designated with a number.

Definitive Study

The data was analysed using Collaizi's (1978) seven-step process of analysis (see section 3.10). After analysing the results of the pilot study, the drawing exercise remained the same but the procedure for the writing exercise was slightly changed. Even though children were requested to write a story about the robot they had drawn, an additional two questions were asked in order to provide guidance and prompt more detailed responses. In the definitive study, they were written on the board as a guide for children to follow: (1) 'Why have you drawn your chosen robot?' and (2) 'Where did the idea come from?' Children were asked to bear these questions in mind when constructing their stories.

The procedure was changed because in the pilot, the children had written very little (3 to 4 lines) when requested to write a story about the robot they had drawn. The following is an example of a story from the pilot:

> *'One Monday morning I saw a little robot moveing around in the frunt by the door. My robot was chaned in Blue then somebody took my Robot and my Robot is noty all the time. I put my robot in the frunt by the door.*

In addition, whilst walking around the classroom taking field notes, a child was overheard telling her friend that she was drawing that particular robot because she had seen it in a film. Since my interest is the origin of children's perception of robots, these comments were relevant data for my research. Furthermore, the questions provided a structure to the writing pieces which made coding and classifying easier. Thus, due to these advantages, the use of prompting questions was implemented in the subsequent three sessions.

3.11.1. Write and Draw Method of Analysis

Drawings

Collaizi's (1978) seven step process was implemented in analysing children's drawings and stories. The data was coded and key themes that emerged from the coding process were identified. Various aspects of each drawing such as shape, colour, method of movement and general characteristics of each robot were then compared. Consistencies and inconsistencies across the drawings of robot characteristics were noted, as well as robot characteristics that were gendered. Drawing on semiotic analysis, the representation of images were scrutinised for connotative meanings; in other words, the ways in which the word 'robot' produces not only an image but also a set of ideological assumptions. The analysis here seeks to explore specific stereotypes of robot imagery. However, Collaizi's seventh step, where he suggests returning to the subject to interview them about the findings thus far, was not implemented in this research. Collaizi's stages were taken into account during the analysis phase of the research, after the data collection phase had been completed.

Writings

The children's stories of robots were transcribed together with the field notes. A range of questions was formulated in order to interrogate the data. The questions were: 'How does the robot function?' 'Who or what controls the robot(s)?' 'Where is the robot?' 'What is the robot doing?' 'What is the identity of the robot?' 'What is the relationship between the robot and the child?' and 'What are the origins of children's ideas?' The analysis of the data using these questions identified five key themes: 'anthropomorphism', 'gender attribution', 'robot identity', 'child/robot relationship' and 'story setting'.

In the results chapter that follows, the findings of the pilot study are included with the overall analysis. Despite the introduction of two prompting questions, stories from the pilot study were relatively similar to those in the definitive study, and demonstrated identified themes (albeit in a shorter and less detailed way). In addition, the method used for executing the drawing exercise remained the same in both the pilot and definitive study.

3.12. Phase 2: Children's Observation of Robots and Group Interviews

The following section outlines the details of the pilot study followed by changes implemented as a result of performing the pilot study. Details of the method of analysis are then provided.

Session 1 (Pilot Study)

The pilot study was conducted on a sample of 34 children (18 boys and 16 girls) from School A, who also participated in the write and draw exercise. The study took place in the school's squash court. This open area ensured that there was enough space for children to form a large circle around the robots. Furthermore, as it was an enclosed space, there were no disturbances from passers-by. The activity was held during class time.

The robots were almost identical; the only differentiating feature was a coloured 'skirt' worn by each robot (blue, yellow, white or red), allowing children to distinguish between robots. The coloured skirts were a modified version of the e-pucks from the manufacturer and covered the robot's on/off switch. In order for robots to start/stop, the batteries had to be inserted or taken out. The batteries were inserted in front of children and the robots placed inside a plastic barrier, and children watched the e-pucks for approximately 30 minutes. There were several variations in the robots' activities, such as movements where robots bumped into each other or the plastic barrier. Whilst children observed the robots, they were encouraged to speak about what they were viewing and were prompted with the question 'What do you think they (the robots) are doing?' Depending on their reply, further questions were asked about the reasons for their reply. In addition to audio-recording the entire exercise, comments were also noted. Furthermore, a teacher or teaching assistant was always present to assist with interpreting what was said. For example, one child made reference to an electronic learning tool used by the school and the teacher clarified the child's reply by providing details of this tool. After completing the session, the children returned to their classroom and the robots were passed around the class so children could feel and more closely examine the robots. They were then thanked for their participation.

Findings from the Pilot Study

After transcribing and analysing the data collected from the pilot study, several problems emerged. The transcription of recordings was very challenging as they were mostly inaudible due to children speaking at once. And facilitating the class proved to be quite difficult as the pilot group of 34 children was too large, resulting in much noise. Furthermore, as my approach sought to minimise power differences by adopting a ‘least adult’ role (Mandell, 1991), facilitating the class conflicted with this approach.

Also, the transcriptions indicated that children’s responses were very limited. When asked to say what children thought robots were doing, they usually gave one-word answers such as ‘racing’ and did not elaborate. This, therefore, did not provide detailed, in-depth data about children’s overall perception of robots interacting.

Finally, in the pilot study, the gender of each child was not noted in reference to their responses as it was presumed it would be possible to differentiate the voices when transcribing. However, this proved to be difficult as the boys and girls sounded very similar.

As a result of these difficulties four main changes were implemented. Firstly, in order to facilitate the class adequately, smaller groups of no more than 15 children were formed. It was anticipated that not only would this size be more manageable but it would also assist in achieving greater attentiveness. Additionally, the teacher or teaching assistant was requested to settle the children if they became too noisy so that a ‘least adult’ role could be adopted.

Secondly, a further two questions were developed for children to answer. Children were initially asked ‘What are the robots doing?’ Following this question, the children were asked: ‘Why are they doing these things?’ and ‘What is going on inside the robot?’ in an attempt to generate more in-depth responses, as well as to explore children’s perception of robot behaviours and their explanations of how and why these behaviours may come about. Leading questions were avoided, for example, ‘What is going on inside the robot?’ was used instead of ‘How does the robot function?’.

Thirdly, in order to overcome the problem of children speaking at once, the structure of the activity was altered. Children were given 10 minutes to view the robots interacting and a further 20 minutes to answer questions on an individual basis. The children took turns in responding to questions instead of speaking at once.

Fourthly, an approach was employed that was designed to capture everything said by children. It was anticipated that this method would ensure that quieter children were given an opportunity to speak. When children were asked a question, they were requested to hold the audio-recorder and speak into the microphone. After speaking, they passed the audio-recorder to the person seated next to them and this was repeated until each child had responded. The last child then passed the audio-recorder back to me and then the second question was asked and the process was repeated. It was considered that this technique would reduce spontaneous comments, as children would have to wait until it was their turn to speak. Nevertheless, this method was implemented for all three questions as its advantages for the process of data collection were seen to outweigh its disadvantages.

Finally, in order to differentiate boys and girls, each child's gender and the first word of their sentence were recorded in a notebook. It was then possible to distinguish the responders' gender when transcribing the recordings of sessions.

Session 2 (Definitive Study)

The second observation consisted of a sample of 11 (6 girls and 5 boys) Year 3 level children who also participated in the Write and Draw exercise from School A. Since the class contained 32 pupils, the class was divided into three sessions.

Similar to the pilot study, the batteries were inserted into the e-pucks in the presence of the children and set up in the circular arena made from a bendable plastic strip in the school's squash court. After re-introducing myself to the children, they were advised that they would watch the robots for 10 minutes and then answer questions. The audio-recorder was turned on after the introduction and the children were reassured that it was being used to capture all the important information that they provided. The children were then given questions so that they could be mindful of them whilst watching the robots. These questions were:

What do you think the robots are doing?

Why are they doing these things?

What is going on inside the robot?

After watching the robots for 10 minutes, children were asked the first question while the robots kept running. The audio-recorder was passed around from child to child recording each child's individual responses. This was repeated for all three questions. The child's gender was also noted. Finally, after children had answered these questions, robots were passed around to provide children with an in-depth look at the robots.

Session 3- Definitive Study

The third observation session was conducted with 11 children (5 girls, 6 boys) from the same Year 3 class at school A. The same methods that were implemented in the first definitive observation session were intended to be used; however, two unexpected changes arose. Firstly, the robots were set up early, as I was early for the exercise and the children were still on their lunch break. The children, therefore, walked into the squash court with the robots already in operation.

Secondly, this particular group of children were quite inquisitive and wanted to put their hands into the 'arena' in the 10 minute viewing of robots. They were therefore allowed five minutes for viewing the robots and in the other five minutes they were each allowed a turn to put their hands/fingers into the arena in order ‘to see if the robots would avoid them’.

From analysing the results of the second session, it emerged that there were fewer instances where children thought batteries caused robots to function and there were a variety of other responses regarding the robots’ functionality. Thus, the method of inserting batteries before children arrived was implemented in subsequent sessions. Furthermore, allowing children five minutes to interact with the robots sparked their enthusiasm, as children enjoyed the hands-on approach, and this was also implemented in subsequent sessions.

Session	**Male**	**Female**	**Total no. of children**	**School**
1	18	16	34	A
2	5	6	11	A
3	6	5	11	A
4	4	6	10	A
5	5	7	12	B
6	5	7	12	B
1-6	43	47	90	

Table 3 Gender, school and number of children for each session of observation and group interviews conducted.

3.12.1. Method of Analysis

All recordings and field notes were transcribed and the field notes and the text generated from the audio-recorder transcriptions were analysed together. An inductive approach was taken in the analysis of the results. By reading the text several times, significant statements, as well as tentative meanings became apparent. These statements were categorized into codes. Each code was given a description and an inclusion and exclusion criteria was developed. If the statement was consistent with the description of a code, it was included; but if the statement did not fit a code, a new code was created. From this process five main themes were identified:

'Purpose of the robots', 'Actions of the robots', 'Robot functionality', 'Description of robots' and 'Gender differences'.

3.13. Phase 3: Manchester Science Festival

The subsequent sections provide details of the method of study for each exercise at the Manchester Science Festival.

3.13.1. Big Draw- X-ray Art under your Skin

This activity was conducted at the Manchester Science Festival in an open area where children could participate at any time and no prior sign up was required. Children chose either a paper outline of a human body or a robot from two piles that were displayed on a table. They were issued with crayons and paint by the workshop coordinators and were instructed to draw the relevant parts/organs with a wax crayon. There were also pictures of organs and robot parts displayed on the walls in order to assist children with their drawing. Children then applied paint over their drawing to create an image that looked like an x-ray. This exercise attracted a range of children from 1 year-olds to 16 year-old teenagers.

Prior to the activity, three questions were developed to present to children. These were:

- 'What have you drawn?' ('What is this?' - pointing to the robot picture). By asking this question, it was anticipated that children would define each part of the robot's insides that they had drawn.
- 'How do you think robots work?' Or 'What goes on inside the robot?' It was expected that children would then explain how the parts that they had drawn worked together in order for the robot to function.
- 'Do you think robots are like humans?' (If yes, then) 'In what ways?' This question surfaced as a result of the findings from my previous studies (write and draw and the observation sessions). In the previous research, children for example tended to use gendered pronouns and attach emotions and feelings to robots. Thus, it was interesting to explore whether children perceived robots as having human-like qualities or whether these terms were being used as part of common speech.

As stated earlier, I introduced myself to the parent(s)/guardian(s) of child and sought permission to ask their child some questions about their drawing and their thoughts on robots. All parents/guardians seemed quite happy for me to do so and there were no objections. I introduced myself to children as a student from the University of Warwick conducting a project on robots. They were informed that participation was not compulsory and they could withdraw at any time; however, no children objected to speaking to me. The children were asked their ages, followed by the three previously developed questions. Only one child was inaccurately estimated to be between 5 to 11 years of age. However, the same procedure was conducted for this child but the data generated was excluded from the results data set. All notes and discussions were hand-written. All discussions were labelled in numerical order stating the session's number, the gender and age of the child. Using my digital camera a photograph of the child's drawing was taken after the discussion and the picture number from the camera was noted next to each discussion.

The first session differed slightly from the other two sessions. In the first session, children used crayons and coloured pencils to draw the insides of robots. However, in the subsequent two sessions, children used a white crayon to draw the insides of robots and then painted over them in order to highlight what was drawn. The difference in materials was a result of the session's coordinator misplacing the paintbrushes.

Discussions were held with 64 children from three, two-hour sessions. Table 4 demonstrates the age and gender distribution of the children and Table 5 depicts the children's age and session distribution.

Ages	Girl	Boy
4-5	1	1
6-7	12	19
8-9	6	23
10-11	1	1
Total	20	44

Table 4 ‘X-ray Art’ exercise age and gender distribution

Ages	Session 1	Session 2	Session 3
4-5	0	1	1
6-7	11	12	8
8-9	8	8	13
10-11	1	0	1
Total	20	21	23

Table 5 ‘X-ray Art’ age and session distribution

3.13.1.1. Method of Analysis

The data generated from the *Big Draw- X-ray art under your Skin* was divided into 'drawings' and 'discussion' sections. The following section explores the method of analysis for each type of data collected.

Drawings

Aspects of each drawing, such as the different parts drawn and the use of colour were examined. The number of times a characteristic was repeated, as well as inconsistencies and gender differences in drawings were documented. Only 22 of the 64 pictures were clear as the paint covered the crayon markings making it difficult to decipher.

Discussion

All field notes taken and discussions that occurred were transcribed. The data from all three sessions was analysed collectively. The same questions presented to children were used to analyse the data: 'What components did the children draw? 'How do the robots function?' and 'Do the children think that the robots are like humans?' The data was also investigated for gender differences in children's statements, as gender was quite influential in the previous 'write and draw' and 'observation' sessions. Furthermore, the answers of children from different age groups were compared in order to determine whether age was influential in children's perception of what components could be found in robots.

3.13.2. Swarm Robots

The *Swarm Robots* exhibit was observed for a total of five hours over a three-day period. Responses were gathered from 21 children. Demonstrations were exhibited throughout the day, but *Swarm Robots* were only observed when the researcher was not conducting other sessions. There were people watching the demonstration almost all of the time. However, most audible comments were made by adults.

The *Swarm Robots* exhibitors (two PhD students) were demonstrating three sets of programmed robot behaviours (See Table 2), while explaining how the e-pucks functioned along with the details of their project. It was held in an open arena and no prior sign-up was required. The demonstration was aimed at all ages. The audience gathered around a 1.5 x 1 metre table to view the demonstration. The explanations of the e-pucks programming differed depending on the target audience. For example, a young child would be told that 'the robot has sensors that pick up light so the robot is following the light of the other robot'. However, if the students were talking to older observers, they would discuss the aim of their research and provide in-depth explanations of the robots' capabilities.

As the exhibitors were already informing the audience about how the robots work, asking questions about robots' functionality would have been of little use to discovering children's own perceptions and thoughts of robots. I decided, therefore, to observe and note if the children responded to the information that they were being told and to note comments made whilst observing the e-pucks. Depending on the comment, further questions were asked in order to prompt the child to clarify and elaborate on their statements. For example, one child mentioned that the robots were 'like termites'. I then asked 'Why do you think the e-pucks are like termites?' The gender and estimated age of each child was noted. Field notes were also taken. Additionally, the type of programme was noted to indicate if robots were flocking, aggregating or following each other in lines when children commented.

3.13.2.1. Method of Analysis

Children's comments as well as field notes were transcribed and analysed collectively. The data was analysed in relation to the particular robot programming being demonstrated at the time comments were made.

3.13.3. Build a Bugbot

I attended three *Build a Bugbot* sessions in total. Each session consisted of 15 children, with a total 45 children participating across the three sessions. There were three girls in the first session, two in the second and four in the third. Many of the children were over the age of seven with some over the age of 13. The coordinator provided details of children's ages as the child's age was required to register for the workshop.

The event took place in a classroom-like setting (a room consisting of tables and chairs). Each session was divided into two parts. The first session involved the coordinator presenting children with a picture of a car, humanoid-shaped robot, clock, humanoid-shaped wind-up toy and a dinosaur model on a projector, while asking children to raise their hands if they thought the object in the picture was a robot or if they thought it was a 'no-bot' (not a robot). The children were then asked why they thought the object was a 'robot' or 'no-bot'. Children's responses, together with their gender and approximate age, were noted, but not all children raised their hands in answer to this question.

The second part of the session involved building a bugbot quite similar to that of a Braitenberg vehicle[15]. Children were given loose parts and an instruction manual and were requested to assemble the pieces within a 20-minute period. Children were not asked questions in this part of the session as it was anticipated that they would be too engrossed in reading the instruction manual and constructing the model in the limited time that was allocated. Therefore, data was only collected in the first part of the session.

[15] An autonomous agent that moves around using very simple sensors and wheels.

3.13.3.1. Method of Analysis

All field notes taken were transcribed. The data from all three sessions was analysed collectively using the question: What characteristics do children think are needed in order for an object to be called a robot?

3.14. Phase 4: Pilot Study Engaging Children in Identifying Patterns of Behaviour

Phase 4 of the current study involved children identifying patterns of behaviour. This phase of the project was undertaken as a pilot for the 'open science' approach to research to be used by the wider project within which this PhD was nested.

3.14.1. Method

The exercise was divided into four parts. In part one, children were shown a video of e-pucks following each other. This was conducted in a classroom where 6 tables were joined together (each table was approximately 1.5 x 1 metre) and children sat on chairs around the table. The e-puck demonstration was running before the children entered the room. Children, therefore, did not see how the batteries were inserted or how robots were switched on. The same method as Phase 2 of the research was implemented. The children were also asked the same three questions: 'What are the robots doing? Why are they doing these things?' and 'What is going on inside the robots?'

The responses were collated in the same manner as in Phase 2 – answers were recorded through an audio-recorder and field notes were taken. The time also remained the same (10 minutes watching the robots and 20 minutes answering questions). Part 1 followed the same method as Phase 2 of the research, allowing children a closer examination in order to acquaint the children with the e-pucks. The responses generated from this part provided a background for children's perceptions of the e-pucks and how they function.

In part 2, children were shown a video recording on You Tube of two e-pucks programmed to imitate each other (http://www.youtube.com/watch?v=hygWbKcAaTs). The robots are programmed to look for a signal from the other robot, watch the robots' dance (pattern of movement), then after signalling imitate what the robot observed. The message that is transmitted from one robot to the other is the dance. Therefore, an interaction takes place, that of observation and imitation of one robot by the other. The e-pucks were programmed to move in the shape of a triangle. How well the robot imitates will depend on various factors such as lighting and how well the robot's camera captures the movements of the robot it is imitating. Children watched the video on a 15.5 inch laptop. As this sample consisted of 10 children, the screen used was of an adequate size. Children's responses whilst they were watching the e-pucks were noted. The video lasted approximately two minutes. They were then asked two very general questions: 'What do you think the robots are doing?' and 'What do you think is happening in the video?' The children then took turns in answering the questions.

In part 3, children were shown a player stage video, an animation of the robot imitation video in part 2 and this video was approximately two minutes long. Children were then asked the same two questions: 'What do you think the robots are doing?' and 'What do you think is happening in the video?' Responses were noted whilst children watched the video. After the video ended, children took turns in answering the two general questions.

In part 4, children were shown an animation of film with tracks (player stage with tracks) as if drawn in the sand[16]. As before, children took turns in answering the two general questions. All three videos in parts 2, 3 and 4 were sped up by an order of 3 to retain children's attention.

3.14.2. Method of Analysis

Audio recordings were transcribed. The aim of the analysis was to discern whether the children spotted any new patterns of behaviour emerging from robot interaction. The data was investigated by searching for instances where children had made reference to any form of 'pattern' or 'interaction'.

In conclusion, this chapter provided an overview of the methodology used in the current study to investigate children's perceptions of robots. The strengths and

[16] The player stage video can be found here: https://docs.google.com/leaf?id=0B9awXWRFVNvTM2Y3NjA4YjgtOWZkNy00ZTAxLWEwZWMtMGQ0NzFiYWY2ZmJkandsort=nameandlayout=listandnum=50.

limitations of each method were considered, as well as ethical issues pertaining to this research. The following chapter describes the findings generated using this methodology.

Chapter 4: Results and Analysis

4.1. Introduction

This chapter presents the findings and data analysis from each phase of research. Quotations[17] from children's discussions are provided and, as data from each phase was analysed separately, the findings are presented in the same manner. How research objectives were achieved in each phase of research is described and then all four phases of research are integrated and discussed collectively.

4.2. Overall Research Objective

The overall research objective of the current study is to gain an overall understanding of how children perceive robots as a way of better understanding how children co-create meanings and are influenced by their environments. This overall objective consists of three sub-objectives.

4.2.1. Sub-Objectives

4. To investigate children's perceptions and understandings of robots prior to any researcher-led prompts involving robots.

[17] All children's quotations are verbatim.

- To explore children's responses regarding the characteristics required for an artefact to be classified as a robot.

5. To understand children's perceptions of e-pucks.
    - To explore children's perceptions of how e-pucks (robots) function.
    - To obtain responses about robots and how robots interact with other robots from children of different ages, with varied interests in and levels of exposure to robots, and within a variety of settings.

6. To explore how children interpret robots interacting with each other.
    - To explore whether children can spot any emergent patterns of behaviour in robots' movements.

4.3. Phase 1: Write and Draw

Phase 1 of the research involved 144 children (78 girls, 66 boys), between the ages of 7 to 8, drawing a robot and then writing a story about the robot they had drawn. The following section is divided into two parts: analysis of drawings and analysis of stories.

4.3.1. Analysis of Drawings

This section reports the findings of the drawing exercise in Phase 1. Children's pictures were examined for common themes and inconsistencies and the findings were also interpreted through previous research in this field. Throughout this section it became evident that children's drawings mostly depicted humanoid figures, yet many non-humanoid characteristics were also incorporated within drawings. Figure 3 is a robot drawn by Jim.

Figure 3 Jim's robot (an example of a humanoid robot)

At first glance Jim's drawing of a robot appears to be very humanoid, as its overall appearance is based on the human body. However, upon closer inspection this robot has a very square torso and head, and is also missing body parts such as ears, fingers and a nose. Many of the drawings from this sample of 144 children were of a similar design: the robot's shape consisted of a head, torso and limbs.

Children's gender also appeared to play a role in determining the shape and characteristics of the robot they drew. There were five pictures where robots had oval-shaped heads with limbs and no torso (An example is given in Figure 4 below) and all these rounded robots were drawn by girls (Appendix 2 and 3 contains further examples of pictures drawn by girls).

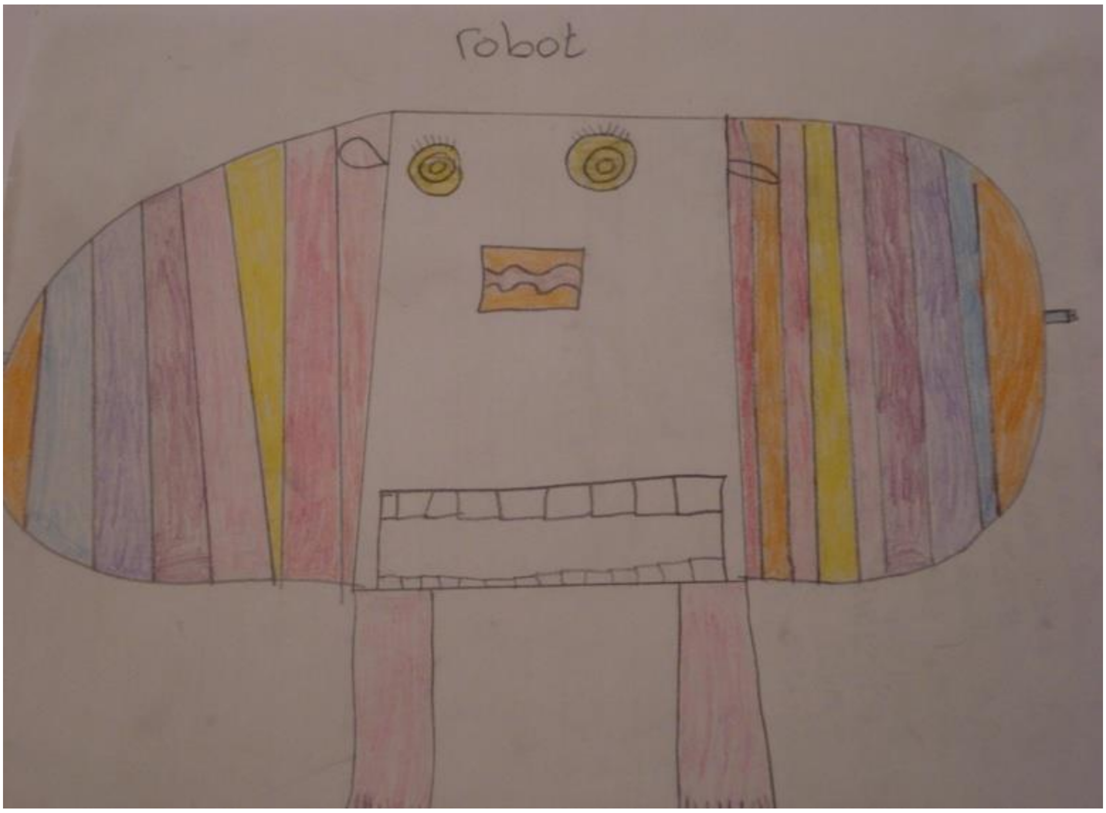

Figure 4 Oval-shaped robot drawn by a girl

When drawing human figures, the results of this study indicated that girls added more gender differentiating items than boys. These items included gender-appropriate clothing and other embellishments (Cox, 1993). Characteristics somewhat resembling eyelashes and earrings in other drawings by girls were also noted. This suggests that children may have extended the prototype for drawing human figures to the drawing of robots.

Children who did not draw an outline resembling a human body tried replicating film characters such as ‘Wall-E’. Twenty-two children from the sample drew images of robot characters found in the media; Wall-E was specifically depicted 14 times. An example of a child’s drawing that resembles Wall-E is given in Figure 5 (Appendix 4 and 5 contains further examples of pictures from films). When children drew robot protagonists, they always labelled the picture stating either the character’s name or the film/programme in which the character appeared, which assisted the interpretation of pictures. Nineteen of the twenty-two children who drew robot characters were boys.

Figure 5 Depiction of the robot film character Wall-E

The other 122 children drew similar sketches, but each robot possessed distinctively different features such as diverse colours and accessories. The colours of robots varied; some robots were brightly coloured whereas others had little colour or were simply outlines of robots. Many children (108) applied colour whereas 36 children used no colour. It was noted that the majority of children who used no colour were boys (69 per cent).

Apart from the use of colour, the types of accessories drawn were also noted. This included buttons or wheels on robots' chests (Figures 6 and 7). Appendix 6, 7 and 8 contains further examples of children's' pictures; these pictures do not add any further themes for analysis') Fifty-seven out of one hundred and forty-four children drew buttons, wheels or an object resembling a keypad, on their robots. Explicit comments made by children assisted in the interpretation of these drawings and the identification of the objects drawn as buttons and wheels. For example, Amy when questioned about her drawing (Figure 6) stated *' it is a wheel and buttons so when you want the robot to do something, all you have to do is press it and it will do what you tell it to do'*. Enquiries were then made about the purpose of the wheel. Amy stated *'you can control the robot by turning the wheel and it will move'*. Similarly, when Susan (Figure 7) was asked what she had drawn, pointing to the robot's torso, she stated:*' when you press the buttons, the robot will work. It is like a walking computer'*.

Figure 6 Amy's robot with wheels and buttons

Figure 7 Susan's robot with buttons

Other accessories that children gave their robots resembled antennas, light bulbs or perhaps ears. Forty-nine children in the sample drew an object projecting from their robot’s head. In Susan’s picture (Figure 7), the protruding lines emerging from the robot’s head are similar to a television antenna. Robert stated that he drew ‘*a light bulb that switches on when the robot is moving*’ (Figure 8).

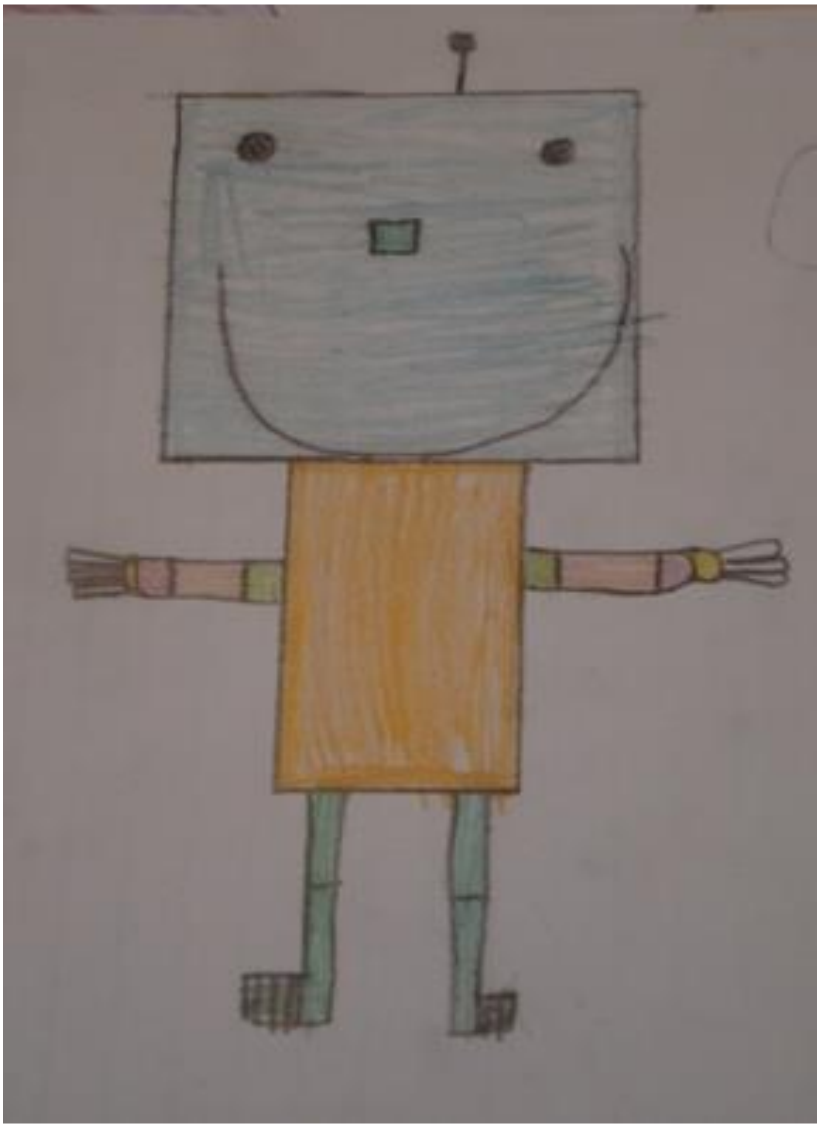

Figure 8 Robert’s robot with a ‘lightbulb’

Similarly, Amy (Figure 6) drew an object emerging from the robot’s head. However, it is unclear whether they represent a device such as an antenna or robot ears. Although humans have ears on the side of the head, there are animals such as rabbits with ears on top of the head, and, therefore, perhaps this is a representation of a robot's hearing device. Alex (Figure 7) drew spiky features on his robot's head that appear to be the robot's hair or possibly a hat. From this sample, 32 children drew features that resembled hair.

Representations of how robots move also varied from picture to picture. Eighty-six children drew robots with feet resembling those of humans (but without toes), forty-two children drew robots with wheel-like objects and sixteen children drew legs with no feet. When Alex was asked what he had drawn on his robot's feet (Figure 9), he replied *'wheels so the robot can move really fast when he is fighting the baddies'*. Therefore even though the robot is portrayed as partly human with legs, the inclusion of wheels suggests it is also partly mechanical.

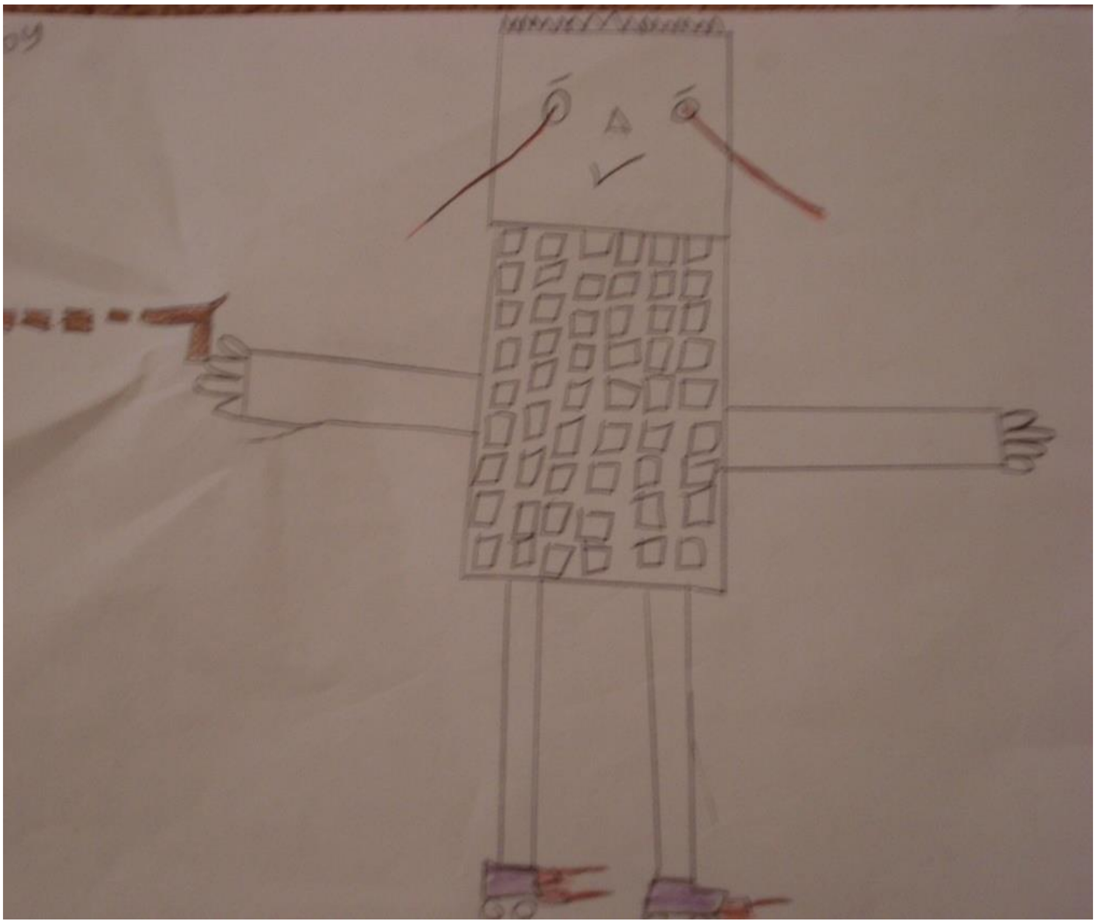

Figure 9 Alex's robot with wheels and weaponry

Sixty-eight robots from the sample are depicted with fingers. In Alex's picture (Figure 9), his robot has four fingers. Similarly, 29 children also drew only four fingers on their robots. Many cartoon characters are depicted as having four fingers[18] as this is easier to draw than a hand with four fingers and a thumb. It is unclear whether children were deliberately likening robots to animated characters seen in cartoons or were unintentionally doing so due to the ease of drawing robots in this way. Twenty-seven children drew arms with no hands on their robots, while others drew objects resembling clamps in place of hands.

When pictures were examined for the depiction of weapons it was found that only eight children had drawn objects resembling weaponry. Alex's picture (Figure 9) was one of those and he stated *'it is a gun and bullets are coming through it'.* Initially, I presumed that Susan's robot (Figure 7) had a gun in each hand; however, Susan's story suggested that she was illustrating a set of keys.

Finally, other characteristics that children drew included laser beams and x-ray vision. When asked to describe what the lines on the robots eyes were, Alex stated that *'he has laser beams to cut through metal doors and see inside of things'*. It is therefore possible that the five other children who drew similar lines radiating from their robots' eyes were depicting similar characteristics.

[18] E.g. The characters from the popular 'Simpson' animation.

The analysis of robots' shapes and characteristics drawn by children indicated that many children depict humanoid robots when asked to draw a robot. It is possible that as children sat together they may have copied each other's pictures. However, this group setting encouraged children to discuss their drawings and stories with each other, allowing field notes to be taken of the discussions about their robots that they may not have necessarily written about. Additionally, children sat in their usual places in their day–to-day classroom setting, which may have been the reason for the rich data that was generated. This data is explored further in the following section.

4.3.2. Analysis of Stories

> *'Me and my sararaite robot*
>
> *I have chose best robot because he would teach me the best karati moves and I would teach him the best karati moves I know. Even he would turn a car and dive me to school. Even I could show my friends how to do the karati moves my robot taught me. Even I could play Xbox games. He could cut the fruits instead of mum doing it. He is powered by a switch and that switch is powered by batteries. He is a good robot robot. He can fire misiles at my friends bad robot. He can make little robot's. I saw him in my garden shed.he3 is a medium robot.he can turn into a TV. He can have CCTV so I know what is going in my shop and Resturant.'*

This story is written by Jim. Throughout this section, the use of Jim's story will be used to explore the five main themes identified through the interrogation of the data. The five main themes are: 'Anthropomorphism' 'Gender attribution', 'Story setting' 'Robot identity' and 'Child/robot relationship' and each is discussed further in the following section.

4.3.2.1. Anthropomorphism

The term 'anthropomorphism', defined as the attribution of human characteristics to inanimate objects, is not as straightforward as it may first seem. Even though humans require food and drink to survive, a machine like a car also requires energy to function, yet it is not classified as anthropomorphic. In this sense, the term anthropomorphism can be potentially confusing. Thus, this section introduces the nuances involved in categorising anthropomorphic qualities and then proceeds to provide examples of anthropomorphism in children's stories according to a set criterion. Four very broad themes were developed from the data that are classed as anthropomorphic: day-to-day human activities (eat, sleep), reproduction, free-will and gender. These themes will be explored in this order. However, due to the number of gendered references, the theme of gender is explored in detail in the 'gender attribution' section.

An example of the potential confusion in the use of the term anthropomorphism is seen in Jim's story about his robot that can '*cut the fruits instead of mum doing it'*. On one hand, it is possible to suggest anthropomorphism exists here as Jim appears to have modelled his robot on his mother. On the other hand, Jim may only be portraying his robot as a service robot. As the number of robots manufactured for performing domestic tasks increase, robotic products such as 'iRobot Roomba' (a robotic vacuum) are becoming more pervasive (Klingspor et al., 1997). Furthermore, service robots are often portrayed in children's films and cartoons such as 'Wall-E' and 'The Jetsons'. If Jim were portraying his robot in this light, this then would not be classified as anthropomorphism as the robot was simply manufactured and programmed to perform such tasks.

Similarly, in the second line of Jim's story he states '*he* (the robot) *would turn a car and d*[r]*ive me to school'.* This can also be interpreted in two ways. Let's assume that Jim's robot turns the car around and drives him to school. Again, similar to cutting fruits, Jim's robot may be modelled on a parent who may drive him to school. Alternatively, Jim may be trying to suggest that his robot can change into a car as robots do in the film 'Transformers', where robots with limbs can transform into everyday vehicles such as cars and trucks and, thus, making his robot mechanical rather than anthropomorphic. Therefore, children's writing can be interpreted in more than one way. Due to spelling mistakes and grammatical errors and children's limited writing skills, children's stories can be easily misinterpreted. Nevertheless, Syrdal and colleagues (2009) provide evidence to suggest that children tend to assign duties to robots that are similar to familiar human activities.

Seventy-eight stories from the sample contained some reference to food. A story written by Jack stated that his robot's '*fovrit food was chips and pasta'* and '*One suny wensday my robot who went to get some bread for himself to eat a diner time he* *went over a big bridge that took him half hour to cross the bridge'.* Similarly, Sophie's robot could also '*could cook the tea, wash up'* and she '*filled him up with water for engey'* and '*feed him peas mashpatoa'.* This may suggest that Jack and Sophie's robots have similar needs to humans such as the need to eat. This may suggest that children anthropomorphise their robots by portraying them as consuming human food. However, at present there are cars that run on chip fat since the law changed in July 2009 making it legal to produce your own biodiesel (Pirie, 2007). While chip fat is a by-product rather than a food 'consumed' by humans, it does suggest machines can consume food stuffs like humans do. However, putting energy into a machine is quite different to that machine 'enjoying' chips or pasta.

Not all children stated that robots received energy from food and drink. Thirty-six children also stated that their robots were battery operated. As Jim wrote '*He is powered by a switch and that switch is powered by batteries'.* However, some children while stating that their robots were battery operated also stated that they enjoyed things such as eating cakes. This suggests that children do not fully anthropomorphise robots but blur the distinction between animate and inanimate.

Other than the consumption of food, children portrayed their robots engaging in other day-to-day human activities. In Sophie's story her robot '*dressed in yellow and purple socks and a big smiley mouth'* and every night she would '*tuck the robot up in a cot with a blanket and put on a little light'.* The use of a blanket may indicate that the robot may feel cold or it could be that the blanket is simply a representation of the act of going to sleep that may be apparent in the child's own life or seen in bedtime story books. In addition, Sophie's robot is being tucked into a cot. As cots are used for babies and children, this may indicate that Sophie's robot is modelled on a baby or small child. Also, the act of 'tucking in' further reinforces this.

Another example of anthropomorphism is '*he can make little robot's'.* This may indicate that Jim thinks that robots can reproduce. This idea is also apparent in other stories such as the one written by Lisa: '*He had lots of robot children and he let them go on it...the mummy robot would never talk because she was shy…'* However, these descriptions may suggest that Jim and Lisa believe that robots are capable of manufacturing little robots such as in a factory setting.

Eighty-six children suggested their robots possessed agency. Agency is defined here as having the ability to make decisions and exercise free will:

> '*He likes swimming in the pool but doesn't realy like singing very much'*
>
> '*Nanuel likes party's and he plays which ever game he likes with his best friend waterpipe',*
>
> *'My robot is going to take over the world and kill everyone in it'*
>
> *'My robot will talk to the presdent and tell the presdent who to kill and who is good'.*

Robots are also depicted as having supernatural capabilities, very similar to action heroes whose job is to save those in despair:

> *'One fine morning there was a robot that is called robot boy. Robot boy was always running and jumping about. When robot boy was walking his watch was flashing 'oh no, I've got a job to do' so he rushed to his office. Robot boy went to this computer 'what do I have to do theres a boy in truble in America' so he rushed off to America. Robot boy could not swim so he used his super powers to fly 'up up and away' Robot boy could not control himself'*

And

> *'Once upon time there was an army robot. Everyday he went to work at the afternoon to kill enemies of him. Oneday he said to his boss "oh no theres enemies destroying the world we have to do something". The boss said how do you know. He said my sence on my head can tell. The boss said chop, chop, chop everybody lets get to work. They all went in an army helicopter. The robot had wheels under his feet he got rocket boosters as well and in time he was nearly there.'*

Even though robots are depicted as having anthropomorphic tendencies (e.g. being employed and making decisions about a task), they are also given super-human qualities such as the ability to fly.

Although many children attributed their robots with agency, some stated that their robots could also be '*controlled*'. Twenty-five children believed their robots were controlled by a remote control while only ten children stated that a button controlled the robot despite fifty seven children actually drawing buttons/wheels on their robots' torsos. Controlling the robot by a switch and a red light occurred both only once. This indicates that there is tension in the stories between robots having agency and being controlled. At times, children implied that robots could both have agency and also be controlled via varying components.

As only animate objects can be gendered, anthropomorphism of robots may also have been a result of children assigning gender roles to their robots. One child stated that he had '…*named him. He is called Joe'.* In the other stories, children mainly referred to their robots using the male pronoun. The possible reasons for the allocation of the male gender to robots are explored in the following section.

4.3.2.2. Gender Attribution

Jim stated in the first line of his story: *'**he*** [the robot] *would teach me...* ' Throughout the story Jim used the male pronoun to refer to his robot. Children tended to attribute gender (rather than simply referring to it as 'it') to the robot they had drawn. Ninety-six children referred to their robot as male whilst only three children referred to their robot as female. Therefore, not only did children tend to allocate gender to their robots, but when they did attribute gender the gender choice tended to be male. The three children who referred to their robots as female were girls:'*I have a girl Robot ho is fun She is good and dos all the clening for me*.' This finding is consistent with Bumby and Dautenhahn's (1999) research, which also used the write and draw method. The researchers reported that children attributed gender to the robots in their stories. Similarly, Beran and colleagues (2011) also reported that almost 75 per cent of children allocated the male gender to the robot that they were presented with.

One possible reason for this allocation of male gender in the current study may be that technology is mainly viewed as a masculine domain. One study reported that boys largely prefer to entertain themselves with interactive video and computer game products, whereas girls prefer to read and listen to music (Lemish and Liebes, 2001). An explanation for technology being considered a male domain was given by Wajcman (1991) who argues that there are unequal power relations between genders. She further states that technology is only viewed in terms of cars and industrial machinery ignoring other technologies that affect the everyday lives of women. Therefore, in relation to this study, it can be argued that robots were perhaps viewed by children as male because robots were categorised as technology.

Perhaps the choice of pronoun can also be related to traditions in grammar structures in the English language. According to Carpenter (2009) when the sex of the subject is not known, it is customary to use *'he'.* Thus, it is possible that children used the masculine pronoun because they were unsure of the robot's gender rather than viewing the robot they drew as male.

The three stories written by girls whose robots were female contained descriptions of their robots engaging in traditionally feminine tasks: '*She is good and dos all the clening for me, Cindy* (the robot) *likes making iceing'* and *'she sings in a beautifull voice'.* However, gender specific characteristics are subject to much debate. It is argued that gender appropriate behaviour is culturally variable as it is culturally produced. For instance, in England until the late twentieth century, it was customary for men to go out to work while women attended to domestic chores (Grint and Gill, 1995). However, even though both genders now make up the workforce, researchers argue that domestic chores continue to be associated with the female role. Research suggests that despite women's increased commitment to the labour force market, as well as their political, social and academic achievements, they still perform the vast majority of household tasks (e.g. Arrighi and Maune, 2000; Manino and Deutsch, 2007; Pinto and Coltrane, 2009; Erickson, 2005). Therefore it is possible that children's stories reflect societal norms and customs. In contrast to gender norms, there were examples where traditional feminine characteristics were displayed by robots that children referred to as 'he'. The robot in Jim's story '*could cut the fruits instead of mum doing it'* and in another story, the child wrote *'he loves making cakes'*.

It is also important to consider the impact of media on children's perceptions of the gender of robots. If robots in fiction tend to be portrayed as male, this may also influence gender allocation. Twenty-seven children sourced their ideas for their robots from the media (e.g. television, video game, and poster). Jack's story reflected the influence of media in his perception of robots:

'I choose to draw General Greavious because I like him and star wars. He's easy to draw. I have a figure of him at home.he is Great.he has four lightsabers and a weapon called a bulldog RLR. I have a Xbox and I play star wars battlefront 2. I've unlocked every charater inclouding general Greavious. I also choose to draw otimus prime. he is out of transformers the movie. I have a toy of him at home. he has guns and cannons from his wrist. Hes an autobot witch means Goodie. General grevious is a rebels Jedi and is in bettween good and bad but does get defeated by another Jedi. I like star wars and transformers because the charaters are cool and I like most action films. I've got two star wars films star wars The sith lords 1 and 2'.

Other stories include *'I made my ninja Robot because I saw it in a television film called I Robot and I added a few extra things'* and *'I whatch buzz on toy story and I chous this robot because a like the game wall. E'.*

The media appears to influence children's imagination and views about the world. They may have therefore used this influence to actively create their own meanings (Götz, 2005) within drawings. Additionally, researchers have argued that pictures in children's environment impact considerably on what children draw (Thomas and Silk, 1990). Therefore, when children were drawing pictures or writing stories, they may have had a particular robot character in mind, and more than likely this character was male.

4.3.2.3. Story settings

Many children indicated a setting for their robot story. Forty-seven children interacted with their robot outdoors in a '*park*', '*forest*' or '*garden*'. Examples include *'my robot loves playing in the forist'* and '*me and my robot play foot ball in the garden'*. Similarly, 26 children discussed their robots in a home setting *'in my house I had a robot'* and '*my robot sits by me in my beddrom*' while 11 children described their robots in space,*'I found my robot in space'*. Children wrote about their robots as though they were accessible and easily befriended.

Researchers have reported that young people have positive feelings toward robots, whereas the more elderly are frightened by the prospect of robots becoming ubiquitous (Dautenhahn, 2005). As robots become popular in schools and the number of robotic toys increase, young people have increasing contact with robots (Scopelliti, et al., 2004). Therefore, it may be possible that children are more comfortable with evolving and advancing technologies than previous generations.

Despite many researchers and academics embracing the advancement of robots, controversies regarding the anxieties created from manufacturing robots have always been a key feature in the debate about the future of robotics. It is possible that older people still hold fears and are less willing to embrace changes that robotics may produce. Children, however, may perceive robots differently as a result of growing up surrounded by these technologies, although this is not to say that children are unaware of potential issues. This is indicated by some stories that included robots running amok, which is explored further in the next section.

4.3.2.4. Identity

The third theme, 'identity', refers to the attribution of personal characteristics to robots. .In Jim's story his robot *'...is a good robot. He can fire misiles at my friends bad robot'.* The personal characteristics attributed by children to their robots include 25 children who referred to their robots as evil. Examples include:

> *'It was a evil robot. When I bought it went flying into space. Then is started to destroy the world but when he was about to shoot he went crash into the sun.'*
>
> *'One day there was a fat robot that wanted to eat everyone. He saw this girl and said "I want to eat you up" the girl got scared and ran home.'*

Another child stated:

> *'to take over the world and hypnotis all the people of the world to make them do what he wants. I flicked the swich on to make him work and then he started to walk around and crashed all the little dolls. Later on he said "I will extrminate all of you little people and then hipnatis you so you can all be over my control".'*

In this story, the child has ultimate control over the robot. This is in contrast to some earlier stories where '*wheels*' and '*switches*' controlled the robot. However, this story is a typical scenario of 'robots taking over the world' that is often seen in Western cultures (Bartneck, et al., 2005).

Thirty-six children, including Jim, referred to their robots as 'good': *'My robot is a good robot because it saves the world and takes me on adventures'* and *'my robot is good and good to the world'*. Again, this indicates that these children viewed robots in a positive light.

Nine children referred to their robots as magical*: 'my robot takes me on majical jorneys around the world and in space'* and *'my robbot is magical and do lots of things anything you want it to do'*. This may signify that robots are seen as magical or like aliens, which suggests why some children view robots as far superior to humans and capable of being almost perfect. This mirrors a statement by Arthur C. Clarke, a famous writer and scientist who states, that 'any sufficiently advanced technology is indistinguishable from magic' (Clarke, 1962).

Twenty-six children claimed their robots were clever or a synonym of clever such as smart. Stacey said '*my robot is very clever and does everything right'*. This may be a result of viewing robots as powerful or perhaps in a similar light to computers. Perhaps Stacey was indicating that her robot is similar to another child Susan's *'walking computer can do everthing and she knows everthing'*.

Children also discussed their robots' changing personalities:

> *'Once upon a time I saw a robot in a shop (smyths) and it was real. It was a evil robot. When I bought it it went flying into space then it started to destroy the world but when he was about to shoot he went crash into the sun. He came straight down to earth. He went straight back to the shop. Then two years later I bought him again. But today he was a good robot. Then he went out of control and went back to being bad.'*

And

> *'When you press the green it turns it on and there is a button for you to turn it good and bad but it wont turn good when I touch it it says swar words it trys to eat you and exspelly animals sometimes it is very good and very funny but most of the time it is bad.'*
>
> *(girl 8)*

This suggests that robots are unreliable and cannot be trusted, a view of robots portrayed in many science fiction films (Bukatman, 1993). Another child wrote: '*The robot was my friend but one day it got silly and silly and he don't rember me. I said his batres would be low'.* It may be possible that robots are 'silly' when there are technical problems such as when batteries run low.

Even though 25 children referred to their robots as evil, on the whole robots were mainly viewed as friendly characters who can be easily interacted with. Children's interactions with robots in their stories suggest that robots took up a companion role and this is explored further in the following section.

4.3.2.5. Relationship between child and robot

In interrogating the data, the theme 'relationship between the child and robot' emerged. It was found that half the sample (45 out of 90) viewed their robots as service robots. Even though portrayed as possessing super-human powers, robots were also depicted as being subservient. Features such as 'servant', 'cleaner', and 'protector' were categorised as 'service robots'. Raj wrote *'my robot will do everything for me'*, '*I like my robot. When I say something it listens to me'* and Daniel stated *'my robbots are made to serve you and comevert you I fort that I would needed a friend that they can belive in you are the first ones that have been served. they do not hurt you'.* Daniel specifically stated that his robots did not harm, possibly implying that he was aware of the popular discourse of robots' malfunctioning resulting in destruction. Despite Jim and Daniel's robots being of service to them, their stories also indicated a sense of friendship and companionship between the boys and their robots. In these cases, robots were classified as 'friend' along with 'service robot'. In other stories, the majority of children (56 out of 90) considered their robots to be their friend: *'he is my best friend and I take him everywhere I go'* and *'I like him, he was my best friend but I could not take him to school'*. Ten children regarded their robots as toys: *'I play with him everyday and he is a good toy to me'*. These findings support a study by Lin and colleagues (2009) that also aimed to explore children's perceptions of robots. Their methodology was based on questionnaires issued to 167, 8 to 9 year olds and they found that the top two expectations of children were (1) for robots to be their servant, e.g. to do their homework and (2) the robot to keep the child company, e.g. *'I hope it can be my good friend and accompany me forever'*.

It is possible that children drew humanoid robots because they viewed robots in a similar manner to humans or friends. For example, Susan stated:

> *'One day there was a robot.he was male he was lonely and small but he was small and very clever he went to bed because tomorrow he was going to a advencher to the moon with the robot keeper and all of the other robots. The next day it was time to go everything was packed and ready to go the keeper said evry wan in the rocket but walle was still at home in his bed his alam ringed he wacked up and fond they had gon all of them had gone leeving him behind and he was just bord and he did not know wat to do.'*

Susan depicted her robot in a similar manner to that of a child going on a field trip.

It may also be that robots are regarded to be of a childlike nature as children are more likely to befriend fellow children than adults. Children's relationship to robots may be comparable to their relationship with pets. In studying the relationship between children and pets, it was reported that 'children may cast their pets as functional younger siblings, as peer playmates, as their own "children," or even as a security-providing attachment figure' (Melson, 2003:37).

Finally, children may have categorised their robots as toys as there are many robot toys being produced such as AIBO (explored in Chapter 2). In addition, it is not unusual for toy manufacturers to produce figurines and models of characters in films.

4.3.3. Summary of Write and Draw

This phase of the research generated 144 pictures and stories. Even though this seems like a relatively large data set, many of the pictures were very similar and the stories were usually limited to no more than one paragraph. Each picture and story shared common themes and all themes were explored in this section.

The write and draw sessions provided an insight into how children depict robots physically, as well as their views and perceptions of robot features and capabilities. Anthropomorphism was the strongest theme reflected in the drawings by the depiction of robots with a humanoid body (arms, legs) and in stories by children with robots attributed with agency and gender. Children depicted their robots as undertaking many human functions such as household tasks and engaging in friendship roles. However, children also simultaneously depicted non-humanoid characteristics such as laser beams emanating from the eyes of robots. From the field notes taken, many children discussed robots from films and cartoons and when questioned, further children discussed robot protagonists of films as though they were human. This is not unexpected as inanimate characters in film are often depicted as having personalities and agency.

In conclusion, the write and draw exercises provided useful data concerning children's perceptions of robots. The incorporation of drawings in the methods of this study provided an insight into children's perception of the physical attributes of robots. The stories, on the other hand, explored their perceptions of the capabilities of robots and their relationship between their robot character and themselves. According to Irwin and de Cosson (2004) 'image and text do not duplicate one another but rather teach something different yet similar, allowing us to inquire more deeply' (Irwin and de Cosson, 2004:31). Thus, these methods contributed to the overall mosaic of research investigating children's perceptions of robots.

4.4. Phase 2: Children's Observation of Robots and Group Interviews

This phase of the research explored school children's responses when introduced to the e- pucks (see chapter 1 for more detail on e-pucks). The exercise was divided into two sections. In the first ten minutes, field notes were taken as children observed the e-pucks that were programmed to follow each other. In the second part of the exercise, children were asked three questions: (1) What do you think the robots are doing? (2) Why are they doing these things? (3) What is going on inside the robot?

Each section is divided into two parts: analysis of observations (the first 10 minutes of the session) and analysis of the question and answer sessions. Four themes were identified: 'Action of the robot' 'Purpose of the robot', 'Robot functionality' and

'Description of robot characteristics and appearance'. The first three themes are directly linked to the questions asked. The next theme of 'Description of the Robot characteristics and appearance' emerged from children's comments about robots with no particular connection to any questions asked. As gender differences were identified throughout this phase, they will be discussed in the final section.

4.4.1. Actions of the robots (What the children think the robots are doing)

4.4.1.1. Observation

During the observation sessions children looked at the robots in awe and said very little. Children made comments like *'they are so cool'* and *'wow, where can I buy one?'*[19] More elaborate statements emerged from the question and answer sessions.

Even though children had not yet been asked to state what the robots were doing, few made comments relating to this. From the children involved in the observation sessions, 10 stated that robots were racing. However, particular comments were popular amongst certain groups. Seven of these children were from the same group or session whilst three were from another group. Nine children from the sample of ninety children stated that robots were '*bumping*', '*bashing*' or '*crashing*' into each other during the observation session. These responses emerged from three out of the six group sessions. Two children belonging to the same group stated that robots

[19] Taken from field notes

were following each other. In the first session, one child gave the response that the robots were *'playing bumper cars'*; a comment made while the robots were colliding.

4.4.1.2. Question and answer session

From the question and answer session, 22 children said they were bumping/bashing/crashing into each other. These responses emerged out of five groups. Eighteen children from two sessions stated that robots were following each other or playing *'follow the leader'* whilst nineteen children said they were '*playing bumper cars'*. Seventeen children responded that the robots were '*having a race'*. Eight children stated that the robots were *'trying to get out of the circle'*. The majority of the children (7 of the 8) who thought that the robots were *'trying to get out of the circle'* belonged to the same group. In addition, four children from the same session said the robots were '*walking'*. *'Dancing'* and *'spinning around'* were singular responses.

This is consistent with Bumby and Dautenhahn's (1999) study, as they also found children tended to use 'violent terminology' in onomatopoeic terms; words like 'bang' and 'crash' when discussing what robots were doing in their study. It is also possible that terminology used by children may have been prompted by the resemblance of the shape and size of the e-pucks to that of toy cars. One child remarked: *'It looks like a car or an olden day invention of a car'*. Eight other children thought the e-pucks looked like cars. Therefore in line with 'car-racing' terminology, comments were made such as *'bumping*', *'crashing'*, *'having a race'*, *'following each other'* and *'spinning around'*. However, four children likened the robots to a spaceship referring to the speakers as a satellite dish. These comments related to the flashing lights in the front of e-pucks. On the contrary, one child stated that the robot was 'dancing' as it rotated. In rationalising why the e-puck was rotating, it is plausible that the child explained the behaviour using vocabulary that was consistent with her age. The following section further explores how children rationalised the behaviours of e-pucks when asked about the purpose of robots.

4.4.2. Purpose of the Robots (Why the children think the robots are doing this)

This section describes children's explanations for their earlier statements about robots' actions.

4.4.2.1. Observation

Of the seventeen children that stated that the robots were having a race in the observation exercise, four children said this was because the robots *'wanted to be in the lead'* and another two children stated that they were doing so because robots *'wanted to see who was the fastest'*. Some children (11) did not give any reason at all. Three children from two groups in the observation part of the session stated that robots were bashing into each other *'because they did not like each other'*. Another two children from the same session stressed that they were *'enemies'*. Four children did not give reasons for the robots bashing into each other. The children that commented on the robots following each other responded that they were doing so because they were *'playing a game'*. Finally, the child who suggested that the robots were playing bumper cars also stated that the robots were playing a game. The next question and answer session yielded similar results.

4.4.2.2. Question and Answer Session

Twelve children from three groups who said robots were bumping, bashing and crashing into each other thought they were doing so because they were enemies. Seven children from two groups stated that the robots did not like each other and three children (all from the same session) stated that the robots did not know what they were doing so they crashed into each other.

Six children from two sessions (from the seventeen children who said the robots were having a race) said they were doing so as the robots all *'want to be in the lead'*. Three children from the same group stated that the robots were trying to *'see who was the fastest'*. This may be indicative of children comparing robots to cars having a race. Alternatively, children may have been imagining that the robots were having a race similar to humans as two children thought the robots were *'winning the robot Olympics'*. In addition, children thought the robots were having a race *'so they don't get bored'*, again implying a similarity with humans.

Robots were following each other because *'they are friends'* was also another way of rationalising robots' behaviour. In addition, two children from the same group stated that robots *'want to show off'* whilst others thought *'they want to play'* or that robots were *'playing a game'*.

Sixteen children from two groups described the robots as playing bumper cars as they were *'playing a game'*. Three children thought that robots *'didn't like each other'* or *'hated each other'*. There appeared to be an attribution of agency within children's reasoning for robots following each other and playing bumper cars.

Eight children who stated that the robots were trying to get out of the circle all gave different explanations as to why robots might do this. Their responses were: *' they are bored'*, *'they want more room to run about'*, *'they want to get out the circle to have a fight'*, '*it feels trapped'*, *'they don't like each other'*, *'they want more space'*, *'they are trying to see which one is the fastest'* and *'they are trying to make friends'*.

Children also stated that robots were walking because *'it wants to'* and *'it feels like it'*. Another child did not know why she thought the robots were walking. Annalisa felt that the robots were dancing because they were *'happy'* whilst Lisa thought the robots were spinning around because they were *'divorced'*.

Many of these statements indicated that children attributed the e-pucks with a level of control. It may be possible that children were assigning various beliefs and intentions in order to rationalise the e-pucks' behaviours (Theory of Mind).

However, as ‘Theory of Mind’ is typically applied to human-human interactions, it is questionable if children would apply the same theory to non-living objects.

Children discussed the e-pucks’ actions using humanistic terminology. Studies demonstrate that children as young as four can distinguish between animate and inanimate objects, yet when faced with inanimate characters, they easily ‘suspend’ their beliefs (Madhani, 2009). For instance, this is evident when children and adults alike become emotionally involved whilst watching a film. Even though we are fully aware that characters on screen are only ‘acting’, we are capable of ‘suspending our beliefs’ in order to engage with the cinematic experience. In applying this concept to children’s interactions with e-pucks, the comments provided by children may indicate that they had sub-consciously suspended their beliefs so that they might engage fully with the robots.

Another explanation is that the patterns of movement may have influenced the comments made by children. In the popular Heider and Simmel (1944) study, (see Chapter 2 for more detail) the adult participants attributed animate characteristics to shapes based on patterns of movement. In relating Heider and Simmel’s research to this study, it may be that the actions of the e-pucks prompted certain responses. For example, the e-pucks’ sensors prevented them from approaching in close proximity to other e-pucks. Therefore this movement could be construed as ‘*the robots did not like each other’*. Similarly, objects that move independently provide the illusion of autonomy (Gelman and Gottfried, 1996). It is therefore possible that the independent movement of e-pucks may have given the impression that they were in control of their actions.

In questioning children's tendency to endow inanimate entities with animate characteristics, Holland and Rohrman state that 'animistic thinking is not a genuine phenomenon but a linguistic confusion' (Holland and Rohrman, 1979:367). Perhaps as suggested earlier, children may be rationalising the robots' behaviours in language that they are familiar with. However, the following section, which explores children's explanations of how robots function, illustrates that children did not solely refer to robots in animate terms when discussing how they worked.

4.4.3. Robot Functionality (What is going on inside the robot?)

This section explores the different responses that children gave in relation to how they thought robots functioned. These are categorised into two sub-themes: mechanical and non-mechanical explanations. Mechanical explanations refer to components supporting the functioning of robots such as batteries and sensors, while non-mechanical explanations refer either to independent agents controlling the robots' functioning or to the robots themselves possessing agency with thought processes that lead to decision-making.

4.4.3.1. Observation

There were very limited responses as to how the robots functioned in this part of the exercise. From the sample of 90 children, only two children stated that '*there are sensors in the robots that make them work'*. Similarly, two other children referred to the robots having batteries which resulted in robots moving.

4.4.3.2. Question and answer session

As one of the three questions presented to children was 'What is going on inside the robot? There were numerous comments about robots' functioning in this part of the exercise.

4.4.3.2.1. Mechanical Explanations

> *' I think that there's batteries in there and there's little wires in there what starts from one bit then it goes to the other and the battery makes and there's the wires in there, you touch one and it goes to another and they go to all three of the robots and the battery makes them actually move'.*
>
> *(Emmanuel)*

Many children (44 per cent) gave technical responses when explaining how robots functioned. Among those, 20 children from all six sessions thought their sensors were responsible for the functioning of the robots whilst 11 children, also from across all six sessions, said there were batteries inside the robots. Eight out of the 11 children who stated that robots functioned due to batteries belonged to the first two sessions where I inserted the robots' batteries in the children's presence. Other responses given to explain how robots functioned were: brain chips, monitors, electrical machine, electricity, remote control, airwaves, circuits and magnets. There were many different combinations of responses; some children thought that wires and circuits made robots function while others thought that it was electricity and magnets.

4.4.3.2.2. Non-Mechanical Explanations

Thirty-nine (43 per cent) children provided non-mechanical answers when they were asked about the robots' functioning. Nine children provided both mechanical and non-mechanical explanations simultaneously. Three children did not answer the question. The non-mechanical explanations were divided into two sub-sections: 'Control' and 'Thought Processes'.

Control

Eight children from two question and answer sessions thought that the robots were being controlled. There were no responses relating to control in the observation session of the exercise. Who or what controlled the robots varied. Aaron stated '*there's a bloke inside telling the robot what to do'*. Similarly, two other children also from the same session thought that the robots were being controlled by a man or an invisible man: *'there's an invisible man inside the robot and it is telling the robot* *exactly where to go'*. Additionally, children also thought that aliens were controlling the robots and that '*little people or statue is controlling the robots'*. Another child stated:

> *'I think like em you know those buttons there, I think they like there's little people inside and you know they just pressing buttons and turning around and everything. It got its own universe.'*

Some children stated that '*people*' were controlling robots while attributing agency and autonomy when asked to explain robots' actions. For example, one child referred to robots as being enemies, despite being controlled by a '*man*'. The following section explores the comments that can be regarded as more consistent with the view that robots are independent agents.

Thought Processes

Sixteen children including Susan thought that some kind of thinking process was involved in robots' functioning in the question and answer session. There were no references to thinking processes of robots in the observation session. Susan stated *'I think they have a brain and they are thinking about which way to go and they can sense stuff'*. Eight children from the sample (one from the observation and seven from the question and answer session) made statements that implied they thought that robots might be capable of independent thought. Examples of this include *'the robots think about what it wants to do, then just goes and do it'* and *'the robots have a mind of its own'*. One child, also from the question and answer session stated that

‘*There is a nose inside the robot that senses fingers*’. The last comment was made when the child put his hand in the ring enclosing the e-pucks.

Nine children gave mixed responses incorporating two or more themes about the functioning of robots. An example of this was *‘the robots decide about where it wants to go, then it tells the batteries and the batteries will start moving and then it will do what the robot wants it to do’.* This indicates that the child believed both the battery and the robot itself were responsible for the robot’s functioning.

Upon first glance, these comments might suggest that children were attributing animistic qualities to robots such as the ability to think (an inherently animate characteristic). However, researchers in the field of robotics define a robot as ‘a machine that thinks and acts’ (Lin, Abney and Bekey, 2011:943). This is consistent with children’s explanations of robot functioning, although expressed in language consistent with their age.

4.4.4. Description of Robot Characteristics and Appearance

The questions presented to children in the question and answer sessions did not ask children to describe robots. Therefore, children’s description of robots’ characteristics and appearance emerged mainly out of the observation part of the exercise.

Comparable to the write and draw sessions, 17 children referred to robots using a male pronoun such as *'Hello, Mr. Robot'* and *'I am going to call him Twirly'*. Similarly, 18 children attributed agency to robots. Examples of this included '*they are trying to be funny'* and *'the robots like me'*. These comments emerged when children put their hands in the arena and the robots bumped into them. Children interpreted the robots' bumping into them as an attempt to be '*funny*' or a sign of the robots' affection towards them. Other characteristics include '*the yellow one likes to cheat'*. This comment emerged when children thought that the robots were racing and the yellow e-puck bumped into the other e-pucks. Another statement made by a child that demonstrated agency within robots was *'they like having fun'*. This statement was a result of the robots not stopping during the entire exercise.

Ten children stated that there was something dysfunctional with the robots. There were comments such as *'the robot's gone mad'* or *'the yellow one is crazy'*. These comments emerged when the robots bumped into each other or bumped into the plastic strip. It is possible that children had preconceived ideas about the actions of robots and if these ideas were not adhered to they were classed as dysfunctional. One child commented that '*miss, before you told me they were robots, I thought they were cars'*. This suggests that children have an ideal robot type, possibly one that is humanoid.

However, 27 children referred to robots as small animals or pets. Allison stated *'He's really cute, look at that one, I can take him home and keep him under my bed'*. Michaela also remarked *'they're cute pets, look at him, he keeps coming to me'*.

Bumby and Dautenhahn's (1999) study investigating children's attitudes towards robots also yielded similar findings, with children in their study speaking to robots as if they were animals or small pets.

4.4.5. Gender Differences

A large proportion of children (86 per cent) who stated that robots were crashing/banging/bumping into each other were boys, whereas the majority of children (93 per cent) who referred to robots as small pets were girls. Furthermore, children who gave technical responses to the robots' functionality were mostly boys (35 out of 42). Conversely, of the 27 children who suggested that robots functioned due to their being controlled or because they thought independently or because other thinking processes were involved, 19 were female. This contrasts with a study by Schermerhorn and colleagues (2008) which found that males tended to view robots as more human-like, whereas females viewed robots as more machine-like.

It was noted that boys more actively engaged in dialogue with me, their peers and even the robots compared to the girls. This was particularly apparent in cases where children assigned a football team or cartoon character to robots thereby imagining a competitive game between robots. Sixteen children associated the robots with either a football team (Liverpool, Manchester United), the characters from the cartoon series ‘Mario Brothers’ or the colours of their houses at school[20]. In these instances, the girls became passive onlookers.

The girls in this study were generally quieter than boys. This may be due to males being more dominant in groups, or to robotics appealing more to boys. Browne (2004) conducted a study exploring children’s friendship patterns and found that ‘boys’ games’ and ‘girls’ games’ were very clear in children’s minds; they established fixed views about certain toys and activities being ‘girls’ stuff’ or ‘boys’ stuff’. Similarly, girls often spoke about ‘mummies and daddies’ whilst boys discussed games such as Batman, Spiderman and Power Rangers. In her discussions with boys about superhero play, it was apparent that this was a way for boys to exercise male power together with exploring their hegemonic masculinity (Browne, 2004). Browne argued that from a young age, guns are associated with boys whereas girls claimed that they had no interest in playing with guns as guns were ‘for boys’. It may be the case that girls from this sample of children may have construed the e-pucks to be ‘boys’ stuff’; thus, inhibiting their interest and participation.

Kohlberg (1966) suggests that by the age of three, children are able to identify whether they are a girl or boy. However, the concept of gender constancy is established around the ages of five and six. He further states that around the age of 10, children begin to understand that gender roles are socially constructed rather than biologically or naturally constructed. In order to maintain a stable gender identity, children usually adhere to what they believe is ‘gender appropriate’ behaviour and

[20]A ‘house’ at school is representative of the teams that each child will be placed in relating to sporting activities and other school competitions.

demonstrate disapproval at ‘gender inappropriate’ behaviour (Marcus and Overton, 1978). As the children from the current sample where aged 7 to 8, it is possible that girls would view robotics as gender inappropriate.

4.4.6. Summary

Children’s anthropomorphising of e-pucks raises some interesting questions. Did children really believe that robots were living entities? This would seem to contrast with reports indicating that children have the ability to differentiate biological from non-biological entities (Fox and Mc Daniel, 1982). Similarly, Inagaki and Hatano (2002) found that children as young as five can distinguish between living entities (both animals and plants) and non-living entities. Is it that children were trying to understand and conceptualize robots as ‘people’ with beliefs and desires? Or were they guessing, having not enough information? (Beck, Robinson and Freeth, 2008). Research has shown children find it difficult to resist making interpretations even when they are uncertain or have insufficient information, and even when an adult reminds them of this (Beck, Robinson and Freeth, 2008; Robinson and Robinson, 1982; Taylor, 1988).

Not all children in this study referred to e-pucks in animistic terms. Throughout this section, comparable to the write and draw results reported, children gave ambiguous statements referring to robots as being animate as well as inanimate. It was noted, however, that when asked about what robots were doing, children mainly attributed agency and elaborate intentions to robots' actions. In contrast, when children were asked about how robots worked, children referred to technical aspects of robots such as sensors and batteries. These findings differ from those reported by Weiss and colleagues (2008) who reported that children provided a range of creative and imaginative accounts of robots' actions. However, when asked to provide explanations about these actions, children lacked the knowledge to do so.

Nevertheless, it is useful to note that the majority of children who referred to the mechanical aspects of robots belonged to the group where batteries were inserted in their presence. It is therefore likely that as children observed the insertion of batteries, they were prompted to discuss mechanical components when asked questions about robots' functioning. Furthermore, peer influence may have resulted in similar results amongst children as there were certain animate descriptions that emerged from the same group. For instance, the two children who stated that the robots '*want to show off'* were part of the same session.

Despite observing 90 children, responses were very similar as children often copied their peers. On several occasions, children seemed to struggle to find something to say, indicated by long pauses and statements such as '*I don't know'*. After reassuring children the question was repeated. However, after a short period, children often repeated something that was said earlier. As a result, there appeared to be little variation in children's statements. Regardless, all data collected were thoroughly investigated, searching for any variation. Even though children seemed interested in the robots, they were easily distracted. Therefore, obtaining in-depth data proved to be difficult at times.

The following section explores the findings from the Manchester Science Festival that builds on the results generated from this phase as well as Phase 1 (write and draw) of the research. The views of children from different age groups are explored within a different context. As children were unlikely to know each other, peer pressure and conformity were minimised, providing a different perspective of children's perceptions of robots.

4.5. Phase 3 -Manchester Science Festival

As discussed in the previous chapter, the Manchester Science Festival is an annual public event that hosts a variety of displays and exhibitions related to science and technology. Data was collected from three activities at the festival: Big Draw - X-Ray Art: Under your skin, Swarm Robots and Build a Bugbot. This section explores the findings from each activity.

4.5.1. X-Ray Art Analysis

The X-Ray Art activity conducted at the Manchester Science Festival provided children with the opportunity to draw the 'insides' of a robot from an outline. Upon completion of their drawing, children were asked three questions: 'What have you drawn? (What is this? - pointing to the robot picture)', 'How do you think robots work? Or 'What goes on inside the robot?' and 'Do you think robots are like humans? If yes, then in what ways?' (see Chapter 3 for more details).

Many drawings were difficult to decipher as children were provided with white crayons to draw the insides of the robot and then provided with paint to highlight what was drawn by painting over the crayon markings. The paint covered the crayon markings making them barely visible. Figure 10 illustrates this difficulty.

Figure 10 Example of an indecipherable drawing

The focus of this section is therefore primarily on the discussions generated from the questions that were asked of children. It is worth noting that drawings were an important tool in prompting discussions. However, as pictures could not be analysed independently, the collection of data from pictures was addressed through engaging children in discussions. Nevertheless, approximately one third of the pictures were visible (34 per cent). From these pictures, children used a variety of colours; 'squiggly' or straight lines were drawn to demonstrate wires, and square boxes were drawn to indicate batteries or 'chips'. Many children drew facial features such as eyes, noses and mouths comparable with the results generated in the Write and Draw exercise conducted in schools. An example is given in

Figure 11.

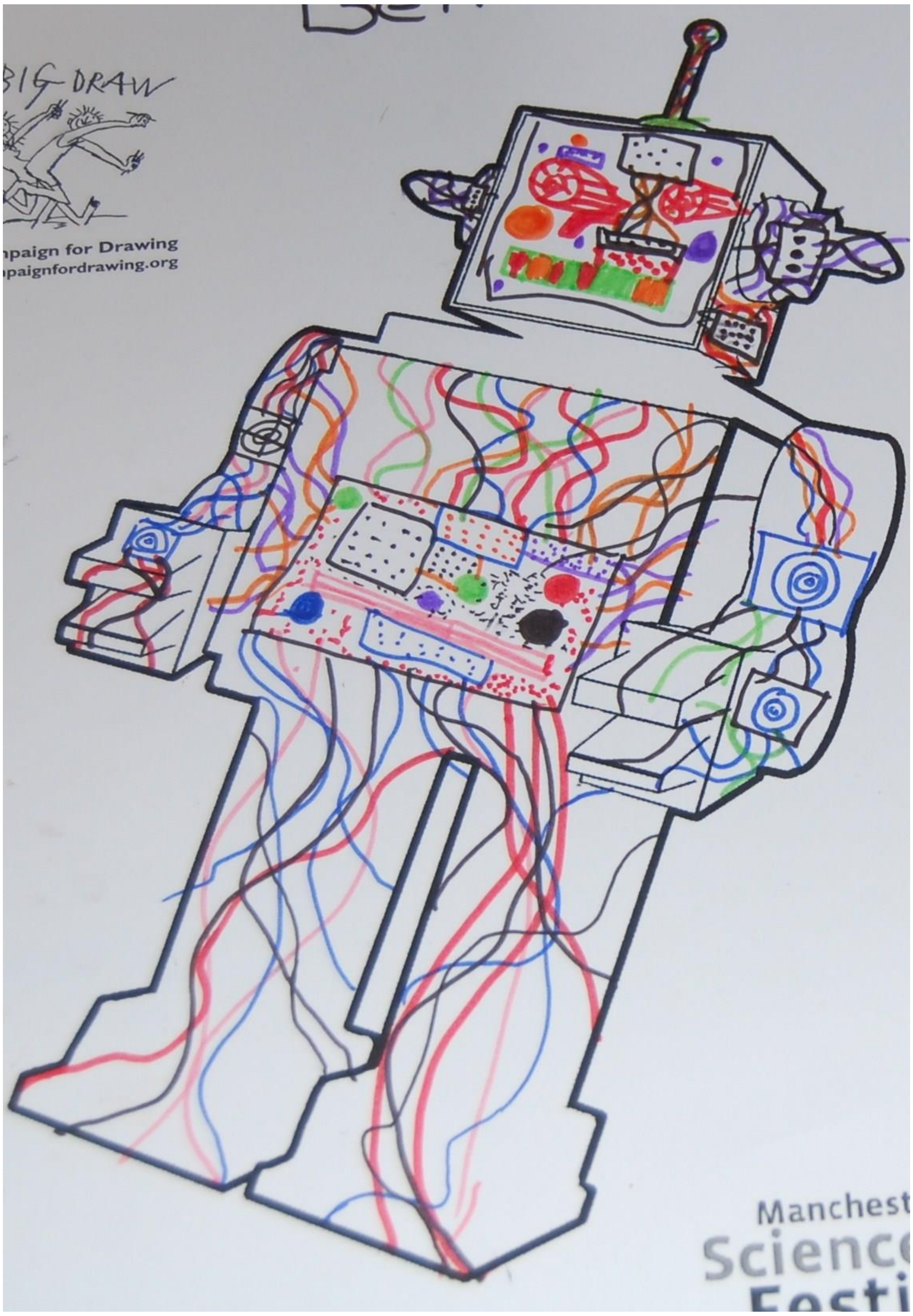

Figure 11 Example of robot drawing with visible insides

4.5.1.1. Analysis of Discussion

The results from discussions held with children are presented in accordance with the three questions asked. The theme of control, apparent in children's responses from the last two questions, is discussed in a separate section. The data generated from each question will be presented with the use of illustrative statements from children. No correlation between age and gender was found in this phase of the research. Therefore all age and gender related identifying data has been omitted. However, in order to demonstrate the lack of correlation between age and gender, this data is included in Table 6.

Components	No. of children	Age Group	Male	Female
Wires	38	4-11	21	17
Keypads	14	6-11	8	6
Batteries	12	6-11	9	3
Computer chip	10	6-9	6	4
Sensors	8	6-9	4	4
Nails	7	6-9	3	4
Antenna	7	6-9	4	3
Voice box	7	6-9	2	5
Bolts	5	6-7	3	2
Screws	5	6-7	2	3
Circuit Boards	5	6-9	3	2
Magnets	4	6-9	2	2
Arms	4	5-8	1	3
Eyes	4	6-9	2	2
Gears	4	4-7	3	1
Legs	3	4-7	1	2
Lights	3	4-7	2	1
Lasers	3	4-7	2	1
Nuts	3	6-9	2	1
Infrared Lights	2	6-9	1	1
Radio-transmitter	2	6-9	2	
Mouth	2	4-7	1	1
Heart	2	4-5	1	1
Mini-Computer	2	6-9	1	1
Metal Fingers	1	6-7		1
Moveable Fingers	1	6-7	1	
Metal Body	1	8-9		1
Tubes	1	6-7	1	
Metal Pieces	1	6-7		1

Table 6 Components in descending order drawn by boys and girls of different ages

4.5.1.1.1. ‘What have you drawn? (What is this? - pointing to the robot picture)’

Each child drew at least two components in their robot outlines. The most popular features that children drew were lines indicating wires (59 per cent). These wires were running within the outline of the robot figures. Similarly, components such as nails, bolts, screws and nuts were present throughout the body. Children’s explanations of the purpose of these components will be explored in the following section.

The second most popular component drawn was ‘*a keypad*’ (14 of 64); these were all positioned across the ‘chest’ area. Twelve children illustrated batteries also positioned across the top half of the robot outline. Two children drew both components positioning them side by side. Computer chips, radio transmitters, circuit boards and mini-computers were also positioned in the centre (chest area) of the robot outline. The central location of these parts suggests the importance of this area for robots’ functioning. This area correlates with the heart and lungs in the human body, which children may have knowledge of from their school education.

Interestingly, the sensors and magnets that children illustrated were not placed internally within the robot or in the feet area, but specifically in the fingertips. This suggests that children know and understand the purpose and use of magnets and sensors; however, only in terms of touch.

Two of the four children who drew gears placed them at the feet of the robot whilst the other two children positioned the gears in the hand area. The placing of gears in both positions would seem anatomically correct, as opposed to placing them in the centre of the body or in the upper arm or leg area. Children would be familiar with gears from playing with toys such as Lego sets where gears are traditionally used for moving parts, for instance, to drive a car. Therefore placing gears in the feet or hand area is practical in this situation.

Seven children who depicted a voice-box in their drawing situated it in the neck area. This is synonymous with its position in the human body, suggesting that children understood the location of the voice box within the human body and thus attributed the same positioning to their robots. Laser lights and lights were mainly depicted as emanating from the eyes of robots. This coincided with six drawings from the earlier write and draw session where children drew 'laser beams' also radiating from the eyes of robots. All children who drew antennas typically positioned them at the top of the robot's head. The outline of the robot that children were given already included an antenna. Nevertheless, children emphasised this feature by drawing over it in order to enlarge the component.

To summarise, this section builds on the findings reported in Phase 1 (Write and Draw) in schools. In Phase 1, children were given the general instruction to draw a robot and many children drew humanoid-shaped robots. In this exercise, children were already given a humanoid outline and were asked to 'draw the insides'. The components that children depicted can be viewed as the mechanical equivalent to biological organs in humans. For example, wires can be compared to veins in the human body, the battery in the chest region to human heart and lungs and the voice box was displayed a similar anatomical region to the throat. Thus children drew humanoid-like insides for their robots. It is possible that if children had been given a non-humanoid robot outline, the positioning of the components may have differed. Nevertheless, children appeared to demonstrate understandings of systems and the notion that interdependent parts or components constitute a system. Children's explanations for the use of these components are explored in the following section.

4.5.1.1.2. How do you think robots work? / What goes on inside the robot?

In response to the question, 'What goes on inside the robot?', children used the components they had drawn to provide explanations of how robots function. In explaining how robots function, their answers were categorized into 'Components as connection and holding mechanisms' 'Components as energy sources resulting in an action or output' and 'Components as an information or instruction source.'

Components as Connection and Holding Mechanisms

Components such as wires were described as instruments to connect and hold the differing parts of the robot together. More than a quarter of the sample (22 of 64) stated that wires connected or held parts together. Other children who illustrated wires in their outline did not provide an explanation of their use. Examples of the use of wires included: *'The robot moves when all the wires are connected to a system that makes it move'* and *'wires hold all the robot parts together so the robot can move'*. However, an alternative explanation given by two children suggests that electricity is responsible for robots' functioning and wires are a medium to transmit this electricity. '*Electricity can pass though it which will give the robots energy to move' is an example of an explanation given by one of the two children*.

'*Nails, screws, bolts and nuts'* were also drawn by children to hold or connect parts together. Children stated '*the wires and nails connect together and that connects to the circuit board that makes the robot move'* and *'the nuts and bolts keep the robot from falling down so the robot can walk on its own'*.

More than half the sample drew wires on their robot outlines. This indicates that children considered wires to be an essential component found in robots. Children also indicated that the wires were flexible, to allow robots to move. Nails, screws and bolts appeared to function in a similar way to wires, by acting as securing components to ensure all parts were attached. The components illustrated in this section referred to the practical elements of the robots' functioning, i.e. nails are widely used to secure objects. The following two sections explore the more essential components that were perceived as powering robots or guiding their behaviour.

Components as Energy Sources Resulting in an Action or Output

Components such as batteries were discussed by children as providing robots with an energy source that facilitated a reaction: *'The battery makes the robot move, if you take the batteries out, the robots will not move'* and *'batteries make the robot work, if the batteries was not charged, the robot would not work'*.

Other components such as gears were responsible for '*moving all the parts'*. Children also drew outer physical features on the robot's outline such as arms, legs, eyes, mouths and moveable fingers. Interestingly, even though the robot outline consisted of arms and legs, children highlighted these features by drawing over the outline. The children stated *'they have moveable fingers so they could pick things up'* and *'arms and legs so that the robot could move'.* However, many children did not specify why they drew arms and legs and although it is likely that children did not elaborate on the purpose of these features as they were more obvious than components such as sensors and batteries that may have had a variety of functions.

Two children who depicted the heart organ in their robots referred to it in their account of how robots function:

> '*There's a heart in the robot's body. If the heart is not working, the robot will get a heart attack and collapse, the robot will be in pain and will think that the heart attack is hurting him.'*

> *'The robot needs a heart to pump blood to his head for it to work and do things.'*

Children who depicted a heart in their robot outline were from the 4 to 5 age group. The depiction of the heart organ is the only common correlation with this age group.

Components as an Information or Instruction Source

Children stated that they drew antennas in order to pick up information such as *'The robot's antenna picks up messages from other robots telling it what to do'* and *'There is an antenna on the robot that picks up the news on TV telling the robot what to do'*. Similarly, sensors were drawn as they were used *'to pick up information'. 'The sensors pick up messages to do things'* and '*The sensors pick up the infrared lights from the other robots and that is why one robot may follow something'*. This is similar to the programming of the e-pucks in the Swarm Robots demonstration that will be discussed later on. It is possible that this child attended that exhibition before participating in the X-Ray Art exercise. It is interesting to note that sensors were drawn on the robot's fingertips, suggesting that there was a connection with the sense of touch, yet they were described as *'picking up messages'*.

Keypads and chips were discussed in terms of an information or instructive device: *'the robot can press the keypad which will tell the wires to move'*. Some children suggested that information such as messages was stored in chips which could then be relayed to the robots. Therefore, the robot received instructions from this chip in order to function: '*There is a chip inside the robot that tells the robot what to do* and *'There is a computer chip in the robot that makes it work. The computer chip is programmed with information and rules that the robot follows...like how to walk and talk'.*

Similarly, some children stated that components such as mini-computers, circuit boards and radio transmitters assisted in the robot's functioning *by 'telling it what to do'*:

> '*The radio transmitter tells the robot what to do.'*
>
> '*The mini-computer in the robot's head controls the robot and all the information that the robot needs is from this mini-computer.'*
>
> *'[The] circuit board tells it what to do, like to move.'*
>
> *'The robot pick things up with his magnetic hands and the circuit board tells the robot what to do.'*

Children provided various explanations of how robots function and were aware of the different components that robots consist of. Some responses were vague, such as components *'made the robot work'*. When asked to elaborate, children were unsure. These children did not attribute agency to their robots, instead locating the locus of control within the robots' components.

4.5.1.1.3. Do you think robots are like humans? If yes, then in what ways?

For the question, 'Do you think robots are like humans? If yes, then in what ways?' The majority of children (41 of 64) explicitly stated that they did not think robots were like humans, whilst some acknowledged that robots and humans shared similar characteristics. Another three children explicitly stated '*No, robots are not like humans'* and did not give further explanations whereas other children gave varying explanations for their decision. Conversely, 13 children stated that robots were like humans. When asked how, one child replied '*I dunno, they just are'* and did not elaborate further. However, other children gave various responses to support their answer. Children's responses will be explored in more detail in the following section, which is divided into two categories: (1) Analogy to machines and computers and (2) Human Qualities.

Analogy to Machines and Computers

Sixteen children stated that robots could not be like humans because they were comparable to machines and computers as they are comprised of parts. Responses included '*they are like machines'* and '*they are mechanical things'.* Another child, drawing reference to a popular science fiction character, responded '*They are like a machine, like Robocop'.*

Other children discussed the parts that they thought a machine may consist of in relation to human parts:

'*The wires and nails make them into a machine but they cannot be human.'*

'The keypad and lights in them mean that they are like a machine because humans don't have these things.'

'The magnets and computer chip don't make them human, it makes them like a machine, like a computer or something.'

The use of the word machine suggested that robots were artificial beings comprising different parts that were human-made. As one child stated *'they are not like humans, they completely machine like and people have made them'*. Children further referred to robots as computers with responses such as '*the computer chip in them makes them similar to computers so they are not human'* and *'they are like a mini-computer'*.

Additional differences between robots and humans were given by children when they discussed the different parts of robots. Four children noted the parts that robots possessed that humans do not:

'They are not like humans, humans do not have a keypad and antennas.'

'They have batteries and other parts that humans do not have.'

'No they are not humans because they need batteries to work and when the batteries run out, they stop working.'

Three other children described the presence of parts in robots but specifically stated that they had been placed there by people: *'They are made up of parts and other things that people put in there so they are not like humans', 'they are not like humans because people build robots from parts'* and *'they are not like humans because all the parts were put inside them by engineers and other people who design robots'.* One child explained the difference between humans and robots by stating: *'they are not like humans because we eat food to survive but these robots have different kinds of parts in them and uses electricity and other things.'*

It is possible that some children in this study were presenting the typical adult ready-made response that robots are simply machines, a finding also in Turkle's (1984) study. Turkle states 'there is a difference between individual familiarity which allows for and even encourages the elaboration of ideas and cultural familiarity, which provides ready-made answers' (Turkle, 1984:33).

Human-like Qualities

Five children stated that robots were like humans because '*nobody tells it what to do, it does everything on its own', 'they can do everything by themselves'* and '*it is like a human cuz it can do what it wants it to do.'*

Similarly, seven children suggested that robots were like humans due to commonalities between them:

> '*Yes ,they have arms and legs like humans.'*

' They can talk so they are like humans.'

' *Robots talk like humans so they are human-like.'*

'*Yeah, they look like humans.'*

The other three children were less specific in why they thought robots were like humans:

'*Because they can do the same.'*

'*They are like humans because they do things like we do.'*

'*They do everything like we do so yeah they are like humans.'*

Nevertheless, other children acknowledged that robots and humans shared similar characteristics *'they do the same things we do but they are not human'* and *'they have a voicebox so they can speak like us but they can't do other things like eat so they're not like humans'*.

A key animate trait is the ability to think. Some children associated being able to think with the main prerequisite for humanness. Children suggested that as robots did not fulfil this requirement, they were not like humans:

'Other people control the robots and tell them what to do so they can't think on their own like us.'

'They are not like humans because they cannot think and they are controlled by people.'

The concepts of 'agency' and 'control' appeared to be key aspects when differentiating humans from robots. Throughout this session, some children acknowledged the commonalities between humans and robots whereas other children focussed on differences. A small minority of children attributed agency to robots in their explanations as to why robots are like humans, while other children opposed this stating robots are not like humans because they did not have agency and were controlled.

5.5.1.4. Locus of control

Throughout this section the locus of control refers to children's perceived location of control of the robot; in other words, who or what controls the robot to act in a particular manner. In the earlier section (Phase 2), the issue of whom or what had the locus of control arose when children discussed '*someone*' controlling robots' actions. Throughout the current X-Ray Art section the theme of control also featured in many children's statements when explaining robots' functioning and in their reasons for stating that robots were not like humans. Children variously placed the locus of control within the robot itself, within its user and also within its components. The following section explores each of these categories.

The Locus of Control Exists within the Robot

Five children suggested that the robot was in control of its actions. One child stated:

> '*There is a keypad on the robot chest. When the robot wants to do something, it press it chest and it gets done. So if it wants to sing, it will have to press the sing button on the chest, then it will sing.'*
>
> and
>
> *'The robots use the keypad to control what they want to do, the robot uses the gears to move and all the parts hold together by the bolts and nails.'*

These two excerpts suggest that children believed that the locus of control existed within the robot even when they believed that components such as the keypad were used to perform actions. Other extracts from the data suggesting that the locus of control was within the robots include:

> *'Nobody tells it what to do, it does everything on its own.'*
>
> *'The robots can think when they want to do something.'*

These children appeared to be attributing agency to robots. In the sample of children from the X-Ray Art exercise, only a small number of children placed the locus of control within the robot itself, while the majority of children located the locus of control within the user.

The Locus of Control is with the User

Seven children stated that individuals or the children themselves were responsible for the actions of robots. The use of a keypad is mentioned but instead of robots '*pressing the keypad*', individuals used the keypad:

> *'The keypad is so that people could press the buttons so the robot will do something.'*
>
> *'People press the keypad for the robots to do something.'*

Three children mentioned the use of a computer chip and keypad working together where the keypad was used by individuals to initiate the robot's actions:

> *'The computer inside is programmed for the robots to do things and when we want the robot to do something, all we have to do is press the keypad and it works.'*
>
> *The computer chip has all the information stored in it and that's how it works and we can touch the keypad if we want it to do something.'*

These excerpts may be interpreted as children's attempts to portray the notion that even though the pressing of the keypad results in robots acting, there is also another component (the computer chip) that is required for robots to function. Inevitably, the human action of pressing the keypad resulted in the final action (output). Therefore such components were used as an intermediate step between the user and the robots' actions.

The third response was somewhat different: '*the computer chip controls the robot and tells it what to do and we could use the keypad to control everything.'* This child appears to be indicating that the locus of control resides in both the computer chip and the individual pressing the keypad. It is possible that the child's statement was similar to the previous excerpts in that without the '*we*' that controls everything; the computer chip would not initiate its pre-programmed actions.

Another child also mentioned people controlling the robot via the keypad. However, instead of the computer chip storing information, the antenna collected information: '*the antenna collects information that goes into the keypad that people can control the robot with.'* However, it is unclear who sent the signal to the antenna. Nevertheless, akin to the above statements, the keypad was a medium for people to control robots and other components, such as the antenna, were important to the functioning of robots.

One child stated that '*people or the scientists or whoever controls them'*. This statement indicated that the boy was almost certain that *someone* controlled the robots. However, he seemed uncertain who that might be.

Similarly, other children suggested that the locus of control was located within individuals, albeit indirectly. Indirect locus of control refers to information or components that were placed in robots beforehand that influence and affect their actions. Thus, these children appear to distinguish the initial programming of the robot to execute a particular action from the originator of an input (via the programming) that resulted in this action. Three responses from children suggested that people were indirectly in control of the robot's actions:

> *'The robot people program the chip so they can put different rules in there depending what they want the robot to do.'*

> *'There is a chip inside the robot that tells the robot what to do… a chip that the engineers put there.'*

> *'The robot moves when all the wires are connected to a system that makes it move, like a system that the robot people make so the robot is programmed to do things.'*

These statements depict engineers or '*robot people*' in control of robots' actions as they were ultimately responsible for the components and instructions that allowed the robots to act in a particular manner.

The majority of children in this section suggested that the user had the locus of control when interacting with robots. In many cases components such as the keypad served as an intermediary between the robot and the agent.

The Locus of Control is Located both with the Robot and the User

One child in particular stated that the robot was responsible for its actions but that people also exercised control over the robot via the keypad:

> *'…the robot can press the keypad which will tell the wires to move and you can control the robot though the keypad too.'*

However, when this child was asked whether robots were like humans, he stated: *'No, other people control the robots and tell them what to do so they can't think on their own like us*.' This suggests that the notion that only people have control is somewhat contradictory to the initial response about the keypad. On one hand, the child recognised that the robot had some level of control over its actions, whilst on the other hand that individuals had full control over the robot.

The Locus of Control is Located within the Components of Robots

Eight children suggested that components such as the radio transmitter and the computer chip in the robot controlled the robot's actions: '*the radio transmitter tells the robot what to do'* and '*the computer chip in the robot makes it move and there is information stored in this chip that tells the computer how to move and do things.'*

Other components such as the mini-computer, keypad and antenna also provided information to the robot hence determining its actions:

> '*The mini-computer in the robot's head controls the robot and all the information that the robot needs is from this mini-computer.'*

'There's a keypad inside the robot that controls what the robot does.'

'There is an antenna on the robot that picks up the news on TV telling the robots what to do.'

The above excerpts suggest that certain components were in control of the robot's action. However, there is no mention of who or what had installed these components. These children were later asked if robots are like humans. All the children who mentioned parts as being responsible for the actions of robots replied that robots were not like humans.

The data from this section suggests that only a minority of children thought that the locus of control existed within the robot while many children implied that the user had the locus of control, albeit at times, through components.

4.5.1.5. Summary

Sixty four children participated in this phase of the research. Due to issues concerning the instruments used in this activity, there were very few legible drawings. The discussion segment generated the majority of the data. Similar to the earlier phases, children often provided very limited answers and when probed, would often respond by saying ‘I don’t know’. Nevertheless, substantial rich data was generated and this was thoroughly investigated, searching for all possible variations.

The results in this section differ significantly from the results reported in Phases 1 and 2. In the earlier phases of the research, many children held ambiguous assumptions about robots endowing them with both animate as well as inanimate qualities. In this exercise, even though a few children attributed intention and agency to robots, the majority of children discussed robots in mainly inanimate terms.

Even though all phases of the research involved children as participants, the settings varied. Phases 1, 2 and 4 were at two schools whereas Phase 3 was an open science event. This may have influenced the results of the data as children attending the Science Festival may have had more experience regarding robots and may have been more enthusiastic about technology. Also, children may have attended and participated in other exercises and demonstrations at the Manchester Science Festival before attending the exercise or the demonstration where the data was collected. Therefore, the levels of exposure to and knowledge of robots may have differed between phases. In Phase 3, discussions with children were held on a one-to-one basis with no peer influence. In addition, parents and guardians of the children were usually present in Phase 3 of the research and this may have had some influence on children’s statements.

4.5.2. Swarm Robots

The Swarm Robots activity in the Manchester Science Fair was observed for five hours, and responses were gathered from twenty-one children (four girls and seventeen boys). Seven children commented when robots were 'aggregating', eight children commented when robots were 'following each other' whilst six children commented when robots were 'flocking'. There were people watching the demonstrations almost all of the time. However, most audible comments were made by adults and, therefore, not noted. The findings in this section will be discussed in relation to the robots' programmed behaviour.

4.5.2.1. Aggregating Behaviour

To quickly recap, aggregating behaviour involves robots searching for another robot, and then heading towards them. Once too close, robots turn around and steer away.

One child stated *'the robots have ghosts'*. After questioning her further about her response, she stated *'the ghosts in the robot tell the robot to move away and not crash into each other'*. In contrast two boys stated *'some people are controlling what the robots are doing'*. When interrogated about their statement, the boys responded *'the robots can't move on its own; someone is controlling it not to come too close and move away'*. These statements coincide with earlier findings of the observation (Phase 2) in schools. Some children in Phase 2 commented that *'a* *bloke'* or *'invisible man'* was controlling the robot whilst others discussed external forces controlling the robot.

One girl between the age of 6 to 10 stated that *'the robots are like mummy and daddy'*. When I asked her reason for saying that, she responded by stating *'when daddy comes close to mummy, she moves away just like the robots'*. This child appears to be drawing on her own experiences to account for the robots' actions through the use of analogy and narrative.

4.5.2.2. Robots Following Each Other

The demonstrators introduced this behaviour as *'The sensors of the robots detect and follow the light which looks as though the robots are following each other.'* Seven children stated that robots were *'following each other'*. When children were asked to explain their response, they stated that:

> *'those guys programmed them to do that.'*
>
> *'he* (referring to the PhD student) *want them to follow each other and not bump into each other.'*
>
> *'the sensors make them detect each other.'*
>
> *'the sensors make them follow each other.'*
>
> *'the sensors make them want to get close to each other.'*

The children were again simply reiterating what the demonstrators had explained.

Another child stated *'they are like termites.'* When asked his reasons for his statement, he said *'because termites follow each other in a line like that.'* This child is using a functional explanation to account for the actions of robots. It is also possible that he is ascribing social meaning to the interactions of robots by drawing from his own experiences.

4.5.2.3. Flocking

The flocking behaviour is caused by robots getting close together (aggregating), keeping a safe distance from each other (dispersing) and then aligning to face the same direction.

One child stated that the robots *'clump together'*. Her reasoning for saying this was *'they all want to bunch together to keep warm.'* Similarly two children stated that the *'robots want to get really close to each other'* because '*they all want to be friends.'* These statements coincide with school children's responses in Phase 2, as these children also applied intentional explanations to account for the behaviour of robots. It may be possible that children were rationalising the behaviour of robots within a discourse that they are familiar with. In contrast, providing a more technical response, three children stated that '*magnets*' were involved in explaining the robots' behaviour: *'magnets draw the robots in together'*.

4.5.2.4. Summary

Children in this section mainly attributed intention to robots' behaviour when observing the programmed behaviours. This activity generated very little data as observations were conducted in large crowds which made hearing what children said very difficult. A few children repeated what they were told by demonstrators whilst others used analogies to describe the robots' behaviour. It was noted that children sometimes reiterated what was said by other children within the same group, emphasising that peer influence may have played a role in children's responses.

4.5.3. Build a Bugbot

In this exercise, 45 children were presented with images of a car, humanoid-shaped robot, clock, humanoid-shaped wind-up toy and a dinosaur model on a projector. They were then asked to raise their hands if they thought the object in the picture was a robot or if they thought it was a 'no-bot' (not a robot). They were then asked to state their reasons for saying why they thought the object was a 'robot' or 'no-bot'. The coordinator provided children with Alan Winfield's definition of a robot: '...a self-contained artificial machine that is able to sense its environment and purposefully act within or upon that environment' (Winfield, 2006:no pagination) before they were shown the various images.

When children were presented with an image of a remote controlled toy car, four children from the three sessions raised their hands when they were asked if it was a robot. The explanations given by two out of four children who stated that the car was a robot were '*because it is mechanical'* and '*you can control it'*. They further elaborated by saying '*robots are machines just like cars and you have to make the robot do something just like a car cannot drive by itself'*. Two children did not give explanations. The remaining 41 children thought the car was a 'no-bot'.

The workshop coordinator then explained that the car was not a robot as it was remote controlled and lacked 'intelligence'. She did not elaborate further. The next picture was that of a humanoid-shaped robot. Every child from all three sessions raised their hands when they were asked if the object was a robot. Children stated that the robot had '*sensors*', *'can move on its own'*, '*it is intelligent'* and '*it can control itself'*. The children were then informed that the object was in fact a robot.

The third picture was a digital clock. No children in any session raised their hands when they were asked if the object was a robot. However, everyone raised their hands when asked if it was a 'no-bot'. The coordinator questioned the children as to why they thought the object was a 'no-bot'. There were a few responses such as '*because it is just a clock'* and *'there are no sensors'*. Many children did not respond to the question. The children were then informed that the clock was a 'no-bot'.

The next picture was a wind-up toy/model that resembled a humanoid-shaped robot. When asked if the picture of the object was a robot, everyone from all three sessions raised their hands. The children then stated that the toy was a robot because *'it does* *not have wheels'*, *'it has got a screen and power'*, *'there are different sensors'* and '*all robots look like that'.* The children seemed surprised when they were told that the picture of the object was not a robot but a 'no-bot'. The coordinator additionally stated that it was a plastic toy shaped in the form of a robot with no sensors or mechanical properties.

Finally, the last picture that was shown was a toy that resembled a dinosaur. There were mixed responses from children. From 45 children, 21 stated that the object in the picture was a robot. Their explanations were '*it has sensors', 'it can move on its own',' it moves'* and *'it's very mechanical'*. Twenty-four children thought the dinosaur toy was a 'no-bot' because '*it is just a toy'*, *'it can only move if you move it'* and *'it does not look like a robot'*.

The coordinator then informed the children that the dinosaur-shaped object was a robot. She explained that even though the dinosaur did not look like a robot, it possessed many robot features such as sensors and was capable of moving around and acting in its environment.

4.5.3.1. Summary

Build a Bugbot formed an introductory session to a task where children were asked to construct a simple mechanical device. The co-ordinator therefore spent approximately five – ten minutes on this exercise. After children raised their hands in response to whether the image was a robot or not, they were then asked to provide an explanation for their choice. Even though many children raised their hands to be given an opportunity to speak, the coordinator only chose a few children due to time restraints. Consequently, this limited the data collected.

However, this exercise provided an insight into the qualities that children associate with robots. Appearance played an important role as children suggested that the screen image '*looks*' or '*does not look like a robot*'. Children also associated components such as sensors as essential to a robot's composition. This may have been due to the definition provided at the start of the session. Again, the theme of control arose, as one child suggested that the image displayed was a robot because *'it can control itself'*. However, this exercise may not have been accurate as the pictures displayed on the screen were at times difficult to assess. For example, the image of a dinosaur was in fact a popular robotic toy called 'Pleo'. If unfamiliar with this object, one could assume that it was simply a dinosaur figurine. The pictures presented were therefore potentially deceptive.

4.6. Phase 4 – Pilot study Engaging Children in Identifying Patterns of Behaviour

In Phase 4 of the research, ten children watched a video of robot imitation. Four children acknowledged that that the e- pucks were '*making a triangle*' or '*all sorts of shapes*' and a '*star*'. Similarly, when children were watching the player stage video without tracks many children also recognised that the e-pucks were making shapes. However, only one child stated what the robots were programmed to: *'copy each other'*. In addition, four out of ten children suggested that they were *'playing a game'*. These four children recognised that an interactive process was occurring between the two e-pucks in the video. In a sense, children had located an emergent behaviour and described it using the limited vocabulary and terms available to them at their age.

The player stage software video with tracks demonstrates robots as an animation with their tracks as if 'drawn in the sand' (Figure 12). This almost confirmed that e-pucks were making shapes. However, as the copying was not identical, many children regarded this as a problem, suggesting that the e-pucks might be broken or not working properly. One child stated that perhaps I, the facilitator, *'need to take the robots back for the robot scientists to fix them'*. This was also reported in the observation phase of the study when children made comments about the robots being dysfunctional. This suggests that children had set criteria for the actions of robots. Drawing upon the findings of Phase 1 (Write and Draw), children depicted their robots as *'clever'* and *'very smart'*. It is possible that children viewed robots as somewhat perfect as they thought machines were not subject to error as people are. The variations displayed by the e-pucks may therefore have been inconsistent with their perceptions of robot intelligence.

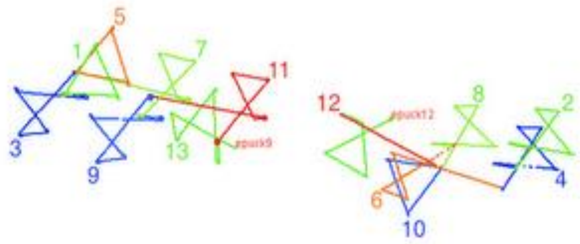

Figure 12 Player stage animation

In the introduction to this thesis the concern of project team members about children being able to recognise emergent social behaviour was discussed. As previously suggested, researchers have questioned whether children are the best participants for pattern spotting. In a study conducted by Wood (1998) assessing children's perceptual development, he reported that children under the age of seven are able to identify the individual components of Figure 13 such as a light bulb or pen but are not able to distinguish the overall picture: the shape of a face. Wood suggests that a small number of children in this age group are capable of spotting the larger configuration but are not able to identify the smaller objects in the picture. Children, he states, 'cannot perceive both at the same time. It's a case of one thing or the other' (Wood, 1998:89). Children were recruited in the current study in order to evaluate whether they could recognise and interpret emergent social behaviour.

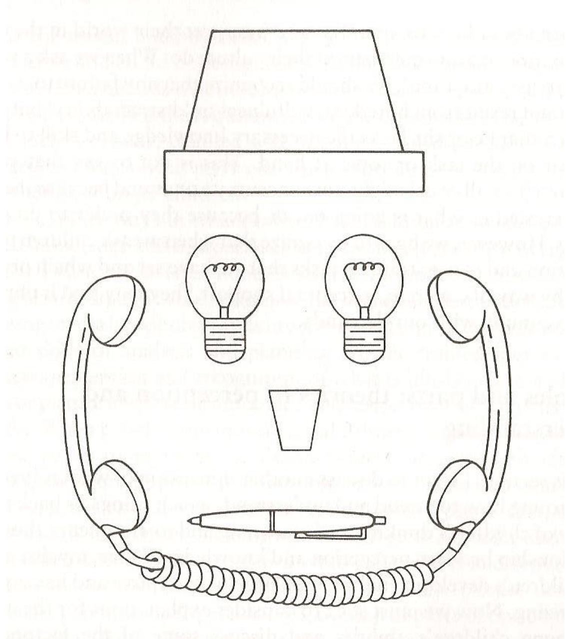

Figure 13 Individual objects forming the figure of a face used to test children's perceptual development (Wood, 1998:90)

After the age of seven, psychologists argue the accuracy in children's perceptual judgements increase. As Piaget suggests, they are able to 'decentre' themselves to take into account various points of views (Piaget, 1929). Children in this phase of the study were between the ages of 7 to 8. Therefore, according to Piaget's theory, children may be developing the conceptual mechanisms that will enable them to spot patterns.

Wood (1998) suggests that experience and expertise play an important role in recognising patterns or unusual behaviour. He provides an example of an American football game to argue that a fan of the game (expert) will be able to judge what is happening in the game in a wider context and be more likely to spot mistakes, remember more and provide a more accurate synopsis of the game, compared to a novice who's more likely to be engaged in understanding and making sense of the events occurring (Wood, 1998). Accordingly children may be less qualified in spotting any emerging patterns of behaviour due to a lack of expertise.

However, analysis of the data from this pilot study challenges the concept that children are less qualified to spot emerging patterns of behaviour. From the small sample gathered, children appeared to have recognised an interaction between robots. This notion of e-pucks 'playing a game' can be described as an emergent behaviour as it demonstrates an understanding of patterns of activity. Even though the mechanisms within robots and their interactions did not express the idea of a game and were in no way analogous to humans playing a game, the interaction between robots may have produced behaviour that could be viewed as robots interacting in a social manner, if viewing their behaviour to spot patterns.

Children's responses that robots are 'playing a game' have generated a great deal of interest and enthusiasm from the project's team members. A number of simple interactions between e-pucks have led to children ascribing social meaning through the use of metaphor and this supports the view that children from the ages of 7 to 8 are capable of some forms of pattern spotting.

4.7. Triangulation of data

This section explores the results obtained from triangulating the data. The following table outlines the themes found in each phase of the research. Meta-themes were then created from the themes outlined (Table 7). In this section, each meta-theme is discussed addressing the similarities and differences between the varying data sources.

Phases		Themes
Phase 1- Write and Draw	Drawings	- Humanoid Characteristics – body, limbs, eyes, ears, mouth - Machine Characteristics – laser eyes, antennas, light bulbs - Shape - Colour - Accessories - Weapons
	Stories	- Anthropomorphism – gendered roles, gender attribution, food, sleep, reproduction, intention/control/free will. - Setting of Stories – Park, home, school, out of space, garden. - Identity/Personal characteristics – supernatural, evil, destructive, good, kind, hardworking, caring. - Relationships – friends, companion, domestic servant, slave. - Gender Differences
Phase 2 E-puck observation in Schools		- What is the e-puck doing? – following each other, having a race, playing a game, trying to cheat, 'going crazy' - Why is it doing this? - trying to get out of the circle, playing a game, it is bored. - How does the robot work? – Has a man inside controlling it, has a mind of its own, has batteries. - Description of robot – machine like characteristics, animal characteristics, human characteristics - Gender Differences
Phase 3 Manchester Science Festival	X-Ray Art	- What have you drawn? – various mechanical components – batteries, wires, voice box, keyboard - How do you think the robots work- Components hold things, connect things together, components provide energy to the robots e.g. batteries, components provide the robots with instructions. - Are robots like humans? – Machine/computer like, similar characteristics to humans, but are not human. - Control – Locus of control – with robot, user, robot and user and components.
	Swarm Robots	- Anthropomorphism – Robot has a mind of its own, robots are in control of their actions. - Analogy to social situations - Appearance –'does not look like a robot'
	Build a Bugbot	- Control – robots are in control, components control the robots, user (coordinators) controlled the robots - Analogy to humans - Analogy to machines/computers
Phase 4 Identifying patterns of emergent behaviour		- Anthropomorphism - Playing a game - Analogy to computers – clever, smart - Broken – malfunctioning - Copying each other – imitation

Table 7 Themes identified for each phase of research

Meta-theme	**Attributes**
Machine- like characteristics	Laser eyes, antennas, light bulbs, weapons, batteries, wires, keypads, voice box, computer-like.
Humanoid characteristics	Shape of robot outline, limbs, eyes, ears, mouth, fingers, eyelashes; gendered roles; gender attribution; food consumption; sleep; reproduction; free-will; intention.
Identity/character/personal attributes	Supernatural, evil, destructive, good, kind, hard-working, caring, clever, smart like computers, crazy, dysfunctional.
Robot functionality (how does the robot work?)	Components (e.g. batteries), the user, 'mind of its own', 'someone is controlling it'.
Appearance	Does not look like a robot, looks like a car, looks like a toy.
Are robots like humans?	Similar to humans, similar to computers, has human characteristics but are not human.
Control (who controls the robot)	User, components, external power source, robot controls itself, user and components.
Relationship between child and robot	Friend, companion, domestic slave, servant.
Setting of the stories	Park, home, school, out of space, garden.
Gender	Gender specific answers/comments.

Table 8 Meta themes created from the themes outlined in table 7

The data from all four phases were interrogated searching for instances when children provided machine like characteristics to robots. In phase 1, children depicted mechanical aspects to their robot drawings. These features included laser beans emanating from the robots eyes, antennas and light bulbs. Similarly, in phase 2 of the research, children referred to the robots' batteries and other mechanical components. Children in phase 3 emphasised the existence of components present in robots more than the children from the other phases of the research. In the X-Ray Art activity, children highlighted that wires, keypads and batteries were important components found in robots. Similarly, in the swarm robot exercise, children discussed 'sensors' being responsible for the robots' movements. Children in the 'Build a Bugbot exercise' discussed the mechanical elements that constitute robots. There were no comments made regarding machine like components in phase 4. This is likely to be because the questions asked led children to talk about what was happening in the video demonstrated to them. These results suggest that when talking about robots, children seem consider the mechanical components of robots thus regarding robots as machines. This was a consistent finding throughout the different phases.

The attribution of humanoid characteristics was apparent from the first phase of the research. In the Write and Draw exercises (Phase 1), children mainly depicted humanoid robots and their stories primarily endowed robots with agency. In the drawing activity, children drew traditional humanoid features such as limbs and facial features. In the stories, robots were depicted as having personalities and were capable of independent thought. Robots were portrayed as possessing many anthropomorphic qualities such as the consumption of human foods such as 'pasta and chips' and engaging in daily activities such as sleeping, yet at the same time children displayed knowledge of robots' mechanical components. Similarly, in Phase 2 (observation in schools) children conversed with robots as though they were animate entities, often attributing gender and endowing them with the ability to think independently.

The attribution of humanoid characteristics was less common in the X-Ray Art exercise at the Manchester Science Festival as children mainly discussed the mechanical aspects of a robot even though they suggested that robots share similar characteristics to humans. Similarly, many children at the Swarm robots demonstration at the Science Festival also discussed robots in mechanical terms. There were no statements relating to anthropomorphism in the Build-a-Bugbot activity, as children were asked to assess whether images on a screen were robots or not. The results in phase 3 differed significantly from the results reported in Phases 1 and 2. In the earlier phases of research, many children held ambiguous assumptions about robots, endowing them with both animate and inanimate qualities. In this exercise, only a few children attributed intention and agency to robots, while the majority of children discussed robots in inanimate terms. However, consistent with the first two phases, children in phase 4 attributed human characteristics to the e-pucks demonstrated in the video clip.

Findings from the analysis of this meta-theme suggest that children consistently attribute humanoid attributes to robots. However, whether emphasis is given to humanoid attributes or to mechanical attributes depended on the context in which the data was collected. In the context where children were given no cues about robots, such as in the write and draw activity, children seem to freely move between humanoid and mechanical attributes. Where there are cues, such as at the science festival, the humanoid attributes are still discussed but more emphasis is given to the mechanical aspects. Additionally, children present at the science festival may have been generally more enthusiastic about technology and therefore more knowledgeable about the mechanical constituents of robots.

Another theme explored was the question: Are robots like humans? This question was specifically asked in the X-Ray Art activity at the science festival (phase 3). Children acknowledged that robots are similar to humans as they have shared human characteristics but are not human. Others suggested that robots are similar to computers with some suggesting that they are like both humans and computers. In phases 1, 2 and 4, as discussed, children attributed many human characteristics to robots.

The difference in the data collection in the X-Ray Art exercise is that children were specifically asked the question ‘are robots like humans?’ However, the data findings from phases 1 2 and 4 are ‘spontaneous’ as explored in the interrogation of the ‘humanoid characteristics’ meta-theme. This suggests that children consider robots to be machine like and humanoid at the same time, and when asked directly, children also provided a similar answer. They subtly expressed the human-like characteristics of robots while also bearing in mind its mechanical composition. Children expressed these views in a ‘science’ context where the cues they may have received while attending the festival may have pointed them towards a more machine like view.

Children in phase one of the study provided both positive and negative attributes to robots. They were sometimes viewed as evil and destructive. However, they were mainly depicted as kind, hardworking, caring and smart. Others viewed their robots as supernatural and magical giving them the ability to fly. In the second phase, whenever a robot performed an unexpected action, comments such as *‘the robot’s gone mad’* were made. In phase 3, children suggested that robots were ‘*smart like computers’*. In the X-Ray Art activity, children also stated robots were *‘like computers’.* The findings from this phase were consistent from the findings in the earlier phases. In phase 4, one child stated that perhaps I, the facilitator, *‘need to take the robots back for the robot scientists to fix them’*. The variations displayed by the e-pucks may have been inconsistent with their perceptions of robot intelligence.

As the children were asked to write a story in phase 1, they exerted their creativity by depicting robots in different contexts. Children also appeared to have been influenced by what they had seen in films as there were several references to media depictions of robots. It may be possible that media was an important contributing factors to the ways in which children described robot characteristics and their expectations of robot actions and intelligence.

Closely related to children's preconceived ideas of robots and the notion that children may have an ideal robot type is the meta-theme of 'appearance'. Children in phase 1 all depicted a particular type of robot; one that is humanoid. In the second phase of the research, one child after being introduced to e-pucks stated *'miss, before you told me they were robots, I think they are cars'* suggesting that the e-pucks were not in line with the child's notion of robots. For the phase three, X-Ray Art activity, the task provided was for the students to 'draw the insides' of a humanoid robot outline, therefore it was difficult to assess whether children would have also depicted a humanoid form if given a blank sheet of paper. There were no references to the theme of 'appearance' in the swarm robots demonstration. In the Build a Bug-Bot exercise, in line with the earlier phases, children appeared to have notions of a robot's ideal type. Appearance played an important role in this distinction as children stated a non-robotic humanoid figurine was a robot, when in fact it was not.

Even though all three exercises were designed differently, the results for each confirmed that children had an 'ideal robot image' and appearance played an important role in their perception of whether an entity is classified as a robot or not.

Another meta- theme was the notion of control. Even though the theme of control was present in three of the four phases of the research, this was most apparent in X-Ray Art activity. In phase one, some children wrote that the robots were controlled; usually by the child him/herself. Others suggested that robots were not controlled and often possessed free –will as they were capable of making independent decisions. In Phase two, the locus of control was usually with the robots. Likewise, robots endowed with human characteristics controlled their own actions. The children's responses generated from the X-Ray Art activity in phase 3 suggests that the locus of control at times exist with robot, the user, the robot and user and the components. The theme of control also emerged from children's responses at the swarm robots demonstration. Children stated that 'some people are controlling what the robot is doing' and 'something is controlling it'. Similarly, the notion of control was also apparent in the Build a Bugbot exercise. Children outlined a key requirement for an entity to be classed as robot is for the robot to be controlled. For example, when children were shown an image of a car, one child raised her hand when the coordinator asked if it was a robot. She then elaborated by saying 'it is a robot because it is mechanical and you can control it'. In phase four, the theme of 'control' was not apparent. It may be possible that this not arise as the children were only asked the general question of 'what do you think is happening in the video?' which resulted in the children discussing the robots' actions.

Children in schools predominantly attributed the locus of control to the robots themselves. This was in contrast to children at the Manchester Science Festival (Phase 3) who perceived the locus of control to be mainly with the user and/or the robots' components. Results suggest that children who attributed the locus of control to robots were more likely to attribute animate characteristics to robots' actions, supporting the argument that the location of the locus of control plays an important role in the attribution of animate characteristics to robots.

The theme of robot functionality is closed linked with the theme of control. In phase one, there were no comments relating to how the robots functions as children wrote stories about their robots. In phase 2, children were specifically asked 'What is going on inside the robot?'. This led to children mainly stating that the robot itself or 'someone' was responsible for its functioning. In the X-Ray Art activity (phase 3), children discussed components (e.g. batteries), the user, 'someone' or a combination of these when they were asked how the robots function. In this phase, only a small minority of children suggested that the robot is responsible for its own functioning. In phase 4, children made no reference to robot functionality as they were asked questions relating to the actions of the robots. Consistent with the earlier findings, children at a science festival may have a particular interest in science and technology and may have been exposed to events of this nature in the past, therefore are more conscious of the technological components involved in the functioning of robots.

The theme 'relationship between child and robot' was interrogated across all four phases. However, data referring to the relationship between child and robot only emerged from phase 1(write and draw). Children suggested that they had a friendly relationship with the robot in their stories and the robot was sometimes a 'companion'. Others stated that their robot was a servant who would complete all household chores as well as their homework. Children also suggested that robots were their 'enemies' as they were evil. Similarly, data emerging from the theme 'setting of the stories' was only limited to phase 1 as children were asked to write a story about a robot. Children often placed their robots in social settings such as parks, home, school, and the garden. Few children suggested their robots were 'out of space'.

As children were asked to write a story about the robot they had drawn, they created fictional, narrative plots about robots. Children created varying story genres ranging from action to fantasy. As a result, robots were given different humanoid characteristics consistent with their chosen genre.

Gender differences were reported in Phases 1 and 2 but not in Phases 3 and 4. In Phase 1, girls tended to depict rounded-shaped robots in their drawings and to engage robots in traditionally feminine tasks in their stories. In contrast, boys typically portrayed robots as aggressive or displaying masculine traits when '*fighting the baddies*'. In Phase 2, the majority of children who used violent terminology such as '*crashing*' and '*banging into each other*' were boys. In addition, a large proportion of children who gave technological explanations of robots' functioning were male (35 of 42). Girls in this phase were also generally quieter than boys. It may be possible that robots, as they are technological, were associated with 'boys games' (Browne, 2004), and thus gender role restrictions may have inhibited girls' participation.

Peer influence may have been a contributing factor to gender differences. Children may have been aware of their specific gender roles and deviation from these roles may have provoked condemnation from their peers in schools. Particularly in Phase 2, children appeared to have been influenced by peers, as responses amongst children of the same group were similar. At the science festival, no gender differences were reported. It is possible that as children did not know each other, peer pressure and gender conformity were lessened.

Triangulation of the data using themes and meta- themes provided a more comprehensive exploration of how children perceive robots. Each meta- theme was used to interrogate the data searching for similarities and differences. Triangulating the data in this way strengthened and reinforced the main finding that children can move freely between humanoid and mechanical attributes and that control is an important issue when discussing these attributes. The following section explores this further.

4.8. Conclusion

Four phases of research were conducted investigating children's perceptions of robots and their understanding of robot behaviour. Across all four phases, children attributed animacy to robots while often concurrently expressing views of robots as animate as well as inanimate.

The locus of control of robots' actions emerged as an important element in children's narratives. Some children stressed that robots were 'controllable' whereas others suggested that the locus of control was located within the robot itself, contributing to robots' autonomous movements. Children also expressed both ideas simultaneously, stating that at times both the robot and the user had control over robots' actions. The empirical findings in this study provide new understandings of animacy, that is, for children the notion of control is interconnected with attributions of animate characteristics.

Even though many children attributed animate characteristics to robots' actions and placed the locus of control within the robots themselves, children generally appeared to be knowledgeable about how robots function and aware of their different parts, as well as the differences between humans and robots. Children also appeared to show signs of 'systems thinking' as they acknowledged that robots were comprised of a set of components that are interconnected in order to enable robots' functioning.

In all four phases, social meanings and the media were also important contributing factors to the ways in which children described robots. It is possible that as the children were asked the general question of 'What do you think robots are doing?' they created a fictional, narrative plot about robots' actions. Children ascribed social meaning to robots' interactions through the use of metaphor consistent with their age. However, when asked about robots' functioning, they incorporated mechanical justifications in answer to this question.

The next and concluding chapter of this thesis further integrates the findings from the four phases of research as well as contextualising the findings in relation to other research conducted in this area.

Chapter 5 – Conclusion

5.1. Introduction

The current study investigated children's perceptions of robots to assist with determining whether children as 'novice scientists' would identify patterns of emergent robot behaviour. In this chapter, I will draw together the findings of this investigation and discuss them in the light of the literature. In particular I will develop the key findings that add to new understandings of children's perceptions of robots: that notions of control play a central role in children's conception of animacy in robotic artefacts, and that children endowed robots with animate qualities while simultaneously discussing the mechanical components of robots.

However, the context of the research appeared to influence the extent to which children can freely move between attributing humanoid and mechanical attributes to robots. In schools, where no cues are given, children were less likely to discuss the mechanical components. On the other hand, where there were cues, such as at the science festival, the humanoid attributes are still discussed but more emphasis is given to the mechanical aspects.

Children seemed to have a robot 'ideal type'. The ideal robot appearance was the humanoid robot that dominates much of the media. Children also compared robots to computers and suggested that robots are 'perfect'. If an e-puck performed any unexpected actions, it was seen as a malfunctioning robot.

Although popular culture often depicts malfunctioning robots taking over or controlling the human environment, the results of this study indicated that children's understandings of robots are not dominated by this discourse, instead the results indicated that children viewed robots as mainly controllable.

Gender and group dynamics appeared to influence children's statements, particularly in schools. The boys in the school were more interested in the e-pucks and would often dominate conversations. There were also gender specific drawings in schools. Children appeared to be influenced by their peers as they often repeated each other's answers in the classroom. This was less apparent at the Manchester Science Festival.

The second section of this chapter explores intergenerational issues relating to conducting research with children and discusses the reflexivity of the researcher, particularly in relation to the researcher's personal conceptions of childhood as well as designing methodology for children and taking into account children's backgrounds.

The strengths and limitations of the study and the implementation of the mosaic approach is also discussed. The limitations of the current study are explored by looking at the difficulties in data interpretation and issues relating to always introducing e-pucks as robots.

Returning to the artificial culture project, the next section provides an overview of the issues relating to the use of robots as a simplified replica of society and discusses the role of children within this aspect of the project by exploring the question 'are children really novice scientists?' in relation to the research findings. Finally, the last section of this chapter provides an outline of the research implications and the directions for future research.

5.2. Attribution of animacy and inanimacy and its relationship with locus of control

Throughout this thesis I cited several studies that investigated people's attribution of animate qualities to inanimate objects. While my particular study undertook a broader approach (exploring children's general perceptions of robots), the results of my research confirm Turkle's (reference) findings that children attribute animate as well as inanimate qualities to robots. However, this study furthers the understanding of the attribution of animacy to robots by highlighting the important role that the perception of control plays for children when attributing animacy to inanimate objects.

The data from all four phases of the research showed that children's perceptions of the location of the locus of control influenced whether they viewed robots as autonomous agents or completely controllable entities. For example, in Phase 2 many children suggested that robots were in control of their actions: 'the robots have a mind of its own' and 'I think they have a brain and they are thinking about which way to go'. In these cases, robots were considered to be autonomous as the locus of control was viewed as within the robot. Other children, particularly in Phase 3, viewed robots as controllable as they viewed the locus of control to be with the user: 'people press the keypad for the robots to do something.' As a result, robots were discussed mainly in technical terms.

My findings suggest that children who stated that robots were in control of their actions were more likely to attribute animate characteristics to robot behaviour. This was particularly apparent in Phase 2. However, this was not always the case. Some children who were aware of the different components that contribute to robots' functioning still attributed animate characteristics to robots. For example, one child stated 'I think that there's batteries in there and there's little wires in there what starts from one bit then it goes to the other and the battery makes and there's the wires in there, you touch one and it goes to another and they go to all three of the robots and the battery makes them actually move'. The child when asked what the robots were doing attributed animate qualities to the robot, responding that one robot was 'cheating'.

Many children did not appear to have firm notions that either the locus of control exists within the robot or within the user. Instead, there were variations in children's statements suggesting that at times children perceived the locus of control to be located both within the user and the robot, and at other times within components. Sometimes the components themselves were used as an intermediary between the robot and the user to control the robot. One child stated 'the robots decide where it wants to go then it tells the batteries and the batteries will start moving and then it will do what the robot wants it to do', indicating that the locus of control is located both within the robot and the robot's components.

These variations in children's perceptions of the locus of control may reflect the multiple understandings of robots that children hold simultaneously. Children can concurrently express contradictory ideas: talk about robots as if they have minds of their own and in the same story or discussion talk about robots as machines that need people to design and operate them. For example, in the writing and drawing exercise (Phase 1), one child stated 'he is a good robot'. The use of a male pronoun suggests the robot has a gender 'I would teach him the best karati moves I know'. On the other hand, 'he is powered by a switch and that switch is powered by batteries' indicating that the child also considers the robot to be a mechanical entity. In Phase 2, many of the children's descriptions implied that the e-pucks were capable of intentional behaviour. For example, children claimed the robots were bumping or bashing into each other, having a race, following each other, playing bumper cars or trying to get out of the arena that enclosed them. Children stated that robots were doing these things (such as bumping or bashing into each other) because they were 'enemies' or they were 'playing a game', and having a race because 'they are in the robot Olympics' or because 'it is fun'. On the other hand, when children were asked 'what is going on inside the robot?' children talked about the robots as machines needing something external for them to work such as 'I think a sensor is something that kinda like controls what is inside it'. However, within the same group some children suggested control of the robot's actions was within the robot. For example, 'the robot does what it wants to do'.

In Phase 3, children mainly attributed inanimate qualities to the robots stressing the importance of mechanical components in the robots' functioning. Nevertheless even though children stated that components were present, some children perceived robots as having agency: an animate quality. One child said 'there is a keypad on the robot chest. When the robot wants to do something, it press it chest and it gets done...' Children's statements were influenced by the context in which the data was collected. In the context where children were given no cues about robots (Write and Draw), children seemed to move freely between humanoid and mechanical attributes. When there were cues, such as at the science festival, the humanoid attributes were still discussed but more emphasis was given to mechanical aspects.

The perceived locus of control is possibly a key factor in the attribution of animacy. The e-pucks actually possess a limited level of autonomy rather than simply providing the illusion of autonomy. Even though they are programmed, they are also capable of adaptive and learning behaviour. E-pucks are autonomous as they are capable of selecting a small number of actions without human intervention (direct input) allowing nominal control over their behaviour. Therefore these e-pucks display an almost perfect illusion of autonomy due to their adaptive behaviours.

In the 1980s, Turkle reported that children attributed agency to simple computational devices that possessed no adaptive behaviour and a limited repertoire of interaction. Even though the robots presented to the children in my study were more advanced than the simple computational devices, children still referred to them in a similar manner. It is possible that children from both studies construed robot autonomy in a very similar manner due to children using the same approach: the perceived locus of control. Alternatively, the children in Turkle's studies may not have been familiar with these simple computational devices, and were thus unsure about the mechanisms and the location of the locus of control. In contrast, many of the children in my study were aware of the mechanical constituents present in robots, albeit at different levels of understanding, but the interactivity levels and perceived autonomy of these advanced robots, made determining 'who' or 'what' was in control of the robot difficult.

Children in the current study appeared to use a human frame of reference to view robots possessing adaptive behaviour. This confirms the previously noted capacity of robots to 'amplify anthropomorphic and zoomorphic tendencies because unlike other objects, a robot can combine visual, movement and auditory features to present a powerful illusion of animacy without a controller being present' (Sharkey and Sharkey, 2010:167). Additionally, it has been reported that as robots are becoming more physically anthropomorphic, e.g. the appearance of a mouth and eyes, they are attributed with a fundamental human quality: the impression that they are in control of their actions (Tremoulet and Feldman, 2000). Importantly, the results of this study suggest that appearance and auditory features are not altogether necessary for the attribution of animacy. Robots used in this study bore no resemblance to animate entities nor did they make any sounds, yet children responded to e-pucks as though they were autonomous and in control of their actions. This suggests that a tendency to anthropomorphise does not rely solely on human-like appearance. Several studies have reported that the independent movement of an object prompts the observer to attribute elaborate motivations, intentions, and goals to the object's actions (Heider and Simmel, 1944;Springer, Meier and Berry, 1996). Therefore when related to robots, the appearance of independent movement is sufficient for the attribution of goals and intentions to a robot.

Similar to Heider and Simmel's (1944) study, children used a human frame of reference in narratives and plots to account for robots' behaviours. However, the results of my study also indicated that children appeared to demonstrate understandings of systems and the notion that interdependent parts or components constitute a system when questioned about the robots' functioning. Whilst at first glance it may appear that children's statements are contradictory, it is possible that what children are doing is distinguishing what robots 'are' (denotation) from what they are 'like' (connotation), thus allowing apparently contradictory beliefs about robots to sit comfortably side by side. Many children ascribed social meaning to the robots' interactions based on their understandings and lived experiences. Children drew on their experiences of their own lives and on ideas present in the media to provide metaphorical explanations of robot behaviour: 'the robot is playing bumper cars' and, in reference to the media, 'my robot will fight all the baddies'.

Unlike many of the children's stories, robots being uncontrollable dominate much of the media. The following section explores this further, drawing together popular media depictions and children's statements from this study.

5.2.1. Are Robots Going to Take Over the World?

Throughout the study, children made several references to media depictions of robots suggesting that they had been influenced by what they saw in popular culture such as films, television programmes, and comics. The influence of media in shaping people's perceptions of robots was also demonstrated in Khan's study as her participants expressed their concerns about robots in reality based on the 'robot-running-crazy-syndrome' concept that has been propagated by science fiction films (Khan, 1998). In this study, children mainly depicted robots as an indication of technological advancement. In the children's stories, robots were primarily represented as 'clever' and 'does everything right'. Similarly, in Phase 4, one child suggested that robots needed to be fixed because they were not functioning properly. It is possible that children have a set criteria for the capabilities of robots, one that is not subject to error.

In children's stories, robots were depicted as being engaged in many household tasks. Robots would assist children in 'homework' and robots were friendly taking the children on 'magical journeys'. In sum, the children mainly viewed robots as positive, as a sign of hope. However, there were a few instances where children indicated that robots would 'destroy the world'. In contrast, throughout this study even though children attributed autonomy to the robots, they mainly viewed robots as 'controllable' as they were aware that certain components and disconnection of energy sources resulted in the cessation of robots' functioning.

Despite the negative depiction of robots in the media, children generally portrayed positive beliefs about robots. Robots were seen as technologically advanced entities that could substantially improve the quality of life. Similarly, robots were viewed as harmless as the majority of children in the sample were aware that robots could be controlled via the various components present. It is the case that 'science fiction primes us to expect robots to run amok' (Winfield, 2011:32). However, the results of the study suggest that children are more discerning and pragmatic towards these technologies than science fiction films appear to be in their narratives. It may be that the experience of growing up with these artefacts, allows children to constantly accommodate to and welcome the change due to the ongoing development of the robotics industry (Turkle, 2005).

Another important aspect of the findings was the differences that existed in how children viewed robots depending on their gender. The following section explores this further.

5.2.2 The Influence of Gender and Socio-economic Background on Children's Perceptions of Robots

Gender differences were apparent in Phases 1 and 2 but not 3 and 4. In Phase1, the write and draw exercise, girls drew rounded robots whereas boys drew more box-like robots. Girls used more colour and their robots tended to be accessorised with embellishments such as jewellery. In the children's stories, girls engaged robots in tasks conforming to the traditional gender roles of women such as undertaking housework. Boys generally portrayed their robots with typically masculine characteristics. However, there were many common features between the genders as well, with some children straying from stereotypic gender roles.

In Phase 2 (observation in schools) girls did not participate as actively as boys. The boys appeared to be more enthusiastic and thus more assertive in conversation. They played games amongst themselves such as assigning the robot to their favourite football teams. Boys were more dominant possibly because technology was considered to be a male oriented domain and by definition robots are technological.

The children in my study were probably aware of gender appropriate norms. Browne (2004) reported in her study that children possessed very clear notions about toys and activities that are gender appropriate. Therefore, if something is deemed to be suitable to one gender, a child from the opposite gender would not be interested. It may therefore be the case that girls showed less interest in robots as robots were seen as ‘boys stuff’,

Peer influence may also have impacted on these gender differences. Since it is stipulated that children are aware of gender appropriate behaviour and interests, straying from these norms may invite negative peer responses from gentle teasing to ridicule or even exclusion.

Leaving gender aside, there is always the issue of peer pressure and issues of conformity within group settings. There is always concern that certain participants will dominate the conversation and influence others. More reserved participants may adopt the prevailing views rather than assert their own opinions for fear of being ostracised. In Phase 2, there were similarities between children's responses suggesting some children may have felt uncertain and agreed with the popular opinion in the group.

In Phase 3, children were spoken to individually and in-group settings in which children were not familiar with one another. Therefore, gender and conformity issues were minimal. However, the parents and guardians of the children were present and this may have influenced children's responses with regards to conformity.

Regardless of socioeconomic background and academic achievement, my research shows that children have similar perceptions of robots. Schools A and B were academically different. School B was a higher achieving school compared to School A. Children at School A were from a lower socioeconomic background with greater cultural diversity. Children that attended School B were predominantly from middle class backgrounds. There are a number of possible explanations for this similarity in perception. It may be because all the children had access to similar sources of reference such as films or books. Another plausible reason may be that they were all shown the same e-puck robots and asked the same questions. The children from both schools were also in the same year group, and therefore at similar developmental stages.

5.3. Reflexivity in Research

> ‘Reflexivity requires an awareness of the researcher's contribution to the construction of meanings throughout the research process, and an acknowledgment of the impossibility of remaining 'outside of' one's subject matter while conducting research. Reflexivity then, urges us ‘to explore the ways in which a researcher's involvement with a particular study influences, acts upon and informs such research’ (Nightingale and Cromby, 1999:228).

The main issue that emerged from the notion of reflexivity in research related to my role as a researcher conducting a study with children. In relation specifically to this research there was a need to consider how adult researchers are required to be reflexive about their position relative to children’s perceptions and how methodologies employed can be inclusive of children’s perspectives. My personal and professional history of working with children influenced the approach taken in this study. While a range of developmentally appropriate methods was employed to document children’s perceptions of robots, I was responsible for determining their suitableness, and while methodologies were adapted to suit children, they were not generated by children. Therefore, children had a limited choice in how they contributed to the research.

Intergenerational issues may also have influenced this research. Children and adults are by definition from different generations. Therefore adult researchers need to be conscious of their personal conceptions of childhood (Mayall, 2002). For example, if the researcher holds preconceived notions about children’s level of intelligence at different stages of development and does not see children as competent and able to form their own views, it could limit or influence the research methods chosen or questions asked during the course of a study.

Perhaps even more importantly, adult researchers need to be aware of how they present themselves when conducting fieldwork with children. My approach to the study of children's social worlds viewed children as competent research partners. As a result, my research methodology recognised children as active social actors, who should be empowered through participatory methods to co-create knowledge with adults.

Consequently, when conducting research with children, it has been suggested that the 'least adult role' should be employed (Mandell, 1991); this means that researchers should not present themselves as authoritative figures. In the pilot stage of the research, I often found myself settling children when they were introduced to the robots as, due to their excitement, children spoke all at once and often wanted to touch the e-pucks. Upon reflection, considering children to be competent research partners depended on the children feeling comfortable to express their views, and asking children to be quiet contradicted this. Therefore it was necessary so not to compromise my position in the eyes of the children to inform the teacher/teaching assistant of my position in the 'least adult role' for the purposes of the research so that the teacher/teaching assistant could discipline the children if necessary.

Even though consideration was taken when designing the methodology to accommodate children with different levels of speaking and academic capabilities, my preconceived assumptions about children's age-related abilities had to be 'bracketed'. The notion of 'bracketing', established by Husserl (1969), assisted in formalising the reflexivity of the research as bracketing involves suspending one's judgement about the phenomenon being researched.

Additionally, children's cultural, social and economic backgrounds were taken into consideration when conducting fieldwork. Therefore when introducing robots, care was taken to speak slowly and to use simple terminology. Due to the natural variations in the levels of ability of children in any given school year, I had to ensure that I was able to communicate with children regardless of their cultural backgrounds and academic abilities. The children at the science fair appeared to be more interested in technology and were very aware of terminology used in robotics. Therefore, in this phase of the research I tailored the language to suit their level of comprehension.

A degree of reflexivity was also required when analysing the data. Any findings generated by children are always going to be understood and presented through an adult filter rather than as a pure reflection of the child's experience. For example, I was aware that children's statements may have been influenced by my presence resulting in the data collected being biased towards my views. While accepting that this may be inevitable, reflexive research practice involves acknowledging the possibility of bias being present in research and retaining an awareness of how that bias may have influenced findings.

5.3.1 Strengths and Limitations of the Study

The most important strength of this study is the implementation of Clark's (2004) mosaic concept. Underpinned by a sociological approach, this approach complied with the rationale of the study as it promotes the use of participatory methods whereby children and adults co-create meaning together. This study also drew on phenomenology, ethnography, semiotics and visual methodologies with each of these methodologies contributing to the overall mosaic. Phenomenology was employed as it provided an open approach allowing for a comprehensive investigation of a particular phenomenon. The flexibility of phenomenology accommodates the use of multiple methods that allow for triangulation of the data and also provides an opportunity for children with varying abilities to participate in research. This is consistent with the mosaic approach that emphasises the importance of participatory methods.

The ethnographic method was also adopted. This provided the opportunity to gather in-depth data relating to children's perceptions of robots and interpretation of robot activity. Similarly, visual methodologies allowed for participation in a fun and engaging non-textual manner whereby children illustrated the physical robot attributes and provided narratives about robots before being introduced to e-pucks. In addition, elements of semiotic analysis were also incorporated into the mosaic approach as a method by which the visual data produced by children was explored and interpreted.

Although phenomenology, ethnography, semiotics and visual methods all have potential problems when used in research with children, these were minimised by combining these methodologies within the one framework. For example, with the visual methodological approach, there can be difficulties interpreting writings and drawings with different researchers holding different views. For instance, in one drawing I initially presumed that Susan had depicted her robot as possessing a gun in each hand. However, from Susan's story I learnt that she was actually trying to illustrate a set of keys. Similarly, due to the illegibility of some of the children's writing and due to several spelling mistakes, the data was reviewed with supervisors in order to corroborate my understanding of the texts. Regardless, consideration was also given to the issue of interpretation from an 'adult world view'.   Even though visual methodologies may be enjoyable to young children, other methodologies within my mosaic such as ethnographic methods countered this issue of interpretation. Therefore each of the methodologies within this mosaic approach complimented the limitations of others.

A key limitation of this study is that e-pucks were always introduced as robots. The results generated may have been completely different if introduced differently: for example, if e-pucks had been introduced as toys, or even not given any introduction at all, leaving the children to state their own ideas about what they thought e-pucks were.

These e-pucks could also have been introduced by their names: e-pucks. The decision to call the e-pucks robots was made at the start of the research. Since I was interested in children's perceptions of robots, this seemed a logical choice. However, later in the research, when I discovered that there are many connotations associated with the term 'robot', I realised this may have been an inappropriate choice. Children's responses may have reflected animate robots often depicted in the media. For example, children discussed Transformers and Wall-E (popular robot films) during the Write and Draw exercise and demonstrations in schools (Phases 1 and 2).

Another issue that was not addressed in this study was whether children's responses about the location of the locus of control in the robot would have changed if they had been given more detailed explanations about the mechanisms involved in the robots' functioning. For example, if children had been informed that e-pucks were pre-programmed before they saw them in action, would the children have interpreted their behaviour any differently? Would they have relied less on a human frame of reference to explain their behaviour or would they have viewed the robots in the same way? Throughout the fieldwork, explaining the e-pucks adaptive behaviour to children was at times a challenging task. Likewise, the wider artificial culture project team also encountered similar difficulties when explaining programming and adaptive behaviour to various public audiences.

Another limitation of the current study was that children's drawings were difficult to interpret. If I had had more time, one option might have been to spend time talking to the children individually about their drawings as I did in Phase 3 (The X-Ray Art activity at the Manchester Science Festival). Even though Collaizi's (1978) framework for analysing data was implemented (See Chapter 3, section 3.10.), due to issues relating to school access and school time, validating results by returning to participants and reaffirming their findings was not viable, limiting my approach that children and adults should co-create meaning together.

One of the rationales for exploring the perceptions of children in order to interpret patterns of behaviour was that they would have fewer preconceived notions and fewer biases. However, throughout the study I reported that children's perceptions of robots had been influenced by popular culture. Therefore another limitation of this study is the mistaken notion that children would not have predetermined ideas about robots.

5.4. Identifying patterns of Emergent Behaviour

One of the key concepts of the artificial culture project – the wider project, to which this research is a part – is that a simple model of society can be replicated by using a swarm of robots. Swarm robots were used due to the benefit of being able to capture and analyse data from the internal processes of robots. Even though the mechanisms within robots are in no way similar to those of a human, the interactions generated from these mechanisms can be likened to those of human behaviour. As stated in the introductory chapter to this thesis, the robots were programmed to imitate each other, a fundamentally inherent human behaviour. In addition, the senior team members decided to use e-pucks in order to minimise anthropomorphism on the part of observers. However, I would argue that the term 'robot' itself raises many connotations, such as those of robots being humanoid entities capable of walking, talking and engaging in many human tasks. Therefore even though the e-pucks' appearance did not bear any resemblance to animate entities, the term 'robot' itself may have encouraged children's tendency to anthropomorphise e-pucks.

What does this mean for children identifying patterns of behaviour? Findings from the small pilot study (Phase 4) indicated that children could discern emerging patterns. This sample of children suggested that robots were 'playing a game', 'making a triangle', 'making all sorts of shapes' and a 'star'. Four out of ten children suggested that they were 'playing a game'. These four children recognised that an interactive process was occurring between the two e-pucks in the video. In a sense, children ascribed social meaning to the robots' behaviour, albeit using metaphorical language and activities that they are familiar with. Thus, children used a human frame of reference to explain robots' behaviours when discerning emerging patterns.

It is possible that if these robotic entities had been addressed differently (e.g. as cars) different results may have been generated. By using the term 'robot', we may have prompted children to ascribe social meaning. Using robots enhances the potential for children to interpret the ‘model of society’ i.e. the swarm robots, as if they were a human society to some extent. Therefore, it may be possible that using robots as a model is more effective than, for example, using a simulation on a computer screen.

It is also possible that children may have also been distracted from the task at hand because they were occupied with pre-held connotations of robots. This may have led to misleading interpretations about the actions of the e-pucks.

5.4.1. Are Children Really Novice Scientists?

The decision to include children in identifying patterns of behaviour stemmed from the child-as-novice-scientist concept; that is, the notion that children may employ a systematic approach to understanding and conceptualizing patterns of robot behaviour in a similar manner to that of scientists. Importantly, it was assumed that children may be able to identify patterns of behaviour that adults miss as children possess fewer preconceived ideas.

It appears from my study that children do seem to employ a logical approach; with explanations involving metaphors and language that is consistent with their developmental age. The main pattern identified by children was that of game playing, which was age-appropriate. Children acknowledged that there were rules to be followed in a game, and had a common understanding of the rules and goals of the game. This led to one child to interpret a robot's actions as 'cheating' when an e-puck went against the child's perceived rules of the game. This therefore supports the argument that children are novice scientists as rules, goals and games are rationally understood attributes.

In terms of the second assumption that children possess fewer preconceived ideas, my research suggested otherwise. Research findings suggest that children are well informed about the popular cultural discourse surrounding robots. However, the evidence from this study suggests that when asked about the robots' functioning, children were aware of the technological mechanisms involved, referring to batteries and sensors, choosing to leave aside the notions of robots depicted by the media.

Even though children blur the distinction between animate and inanimate in their explanation of robots' actions, they appear to employ a logical approach when asked how robots work. It cannot be disregarded that children hold many preconceptions of robots and these notions emerge when they are addressing robots. Nevertheless, children take a rational approach when asked about the e-pucks' behaviour, displaying the ability to leave aside their preconceived notions. While children are thus similar to novice scientists, I would argue alongside Brewer and Samarapungavan (1991) that children are not consciously reflective or aware of their own biases when formulating theories of a phenomenon in the way that professional scientists/researchers or adult novice scientists can be.

5.5. Implications for Study and Directions for Future Research

The limitations of my research have pointed to a number of avenues for further research. Given sufficient time, more children would have been recruited to identify patterns of behaviour amongst e-pucks. Further research could explore children's perceptions of e-pucks if introduced as non-robotic artefacts. Even though previous research suggested that individuals attribute animate qualities to objects such as shapes (Heider and Simmel, 1944), it would be interesting to note whether introducing e-pucks as non-robotic artefacts instead of robots would generate different responses. Therefore, future research could investigate children's perceptions of and responses to e-pucks introduced as other objects such as toys, cars, or domestic items, for example, or (as suggested earlier) e-pucks could be given no introduction at all and children invited to say what they thought the object was.

Similarly, further research could compare differences in children's responses to e-pucks when they are provided with explanations about how e-pucks function compared with when children are given no details. The risk with this approach is that the group with the explanations may simply repeat what they have been told. However, having a number of control groups with varying degrees of information allows researchers to observe how different levels and types of information influence children's perceptions of robots. This helps to establish to what extent children retain their independent interpretations of robot behaviour despite the information given to them.

This research has specifically focused on children's perceptions of robots. Future research could explore further the sources that contribute to children's perceptions of robots. This could take a number of different directions: an in-depth robot film analysis could be undertaken, or the research could be broadened to encompass other forms of media and entertainment, such as depictions of robots in television programmes or books. Alternatively, children could be interviewed to establish whether their expectations of robots stem from the media (stereotypes) or their own needs. The rationale for doing this would be to refine our understanding of just how free and creative children are in forming their ideas of robots, and therefore how much their involvement as novice scientists can benefit developments in this field. After all, if children are simply absorbing concepts about robots from the media and adult world rather than creating their own conceptions, research into children's conceptions of robots will not obtain independent interpretations by involving children in research.

This study also has implications and importance for future interdisciplinary work. As my research relied on psychological, as well as sociological, viewpoints to explain children's conceptions of robots, I suggest that future research in this area should also incorporate these perspectives as the findings of this research suggests that both the developmental stages of children as well as their generational characteristics influence children's perceptions of robots.

This research may also have implications for future technological literacy programmes seeking to narrow the gender gap in relation to technology and to educate children about the capabilities and limitations of robots.

The findings of this study have a number of important implications for research in the field of robotics. Firstly, there are implications for robot design. In the past, it was the norm for developers of new technologies to consult parents and teachers as to the requirements of children or students, instead of asking children directly (Druin and Solomon, 1996). However, this is now changing; extensive research has been conducted whereby children have more direct involvement with technology developers. Children are being viewed as competent individuals who are constantly making sense of the world (Götz, 2005) and as creative and honest collaborators assisting adults to think unconventionally in contributing to the research and development process (Druin, 2002).

Few studies have explored robotic artefacts placed in social settings (Forlizzi, 2007; Turkle, 2005). Even though I researched robots in social spaces (schools, museums) they were still artificial situations and the purpose of the robots being there bore no relation to children's normal day-to-day activities. Therefore additional research should be conducted investigating robots with specific purposes in social settings, such as the home, hospital etc. I would argue that there is a need for more research in this area, especially as many robotic artefacts are being manufactured to assist people in everyday situations. In particular, the children of today may be the first generation to experience a shared workspace with these autonomous robotic agents and due to their nature as agents, children's relationships with these entities will be different from previous machines (Brooks, 2003).

My study shows that children hold positive views of robots, grant them autonomy, and love engaging with them, whilst at the same time retaining an awareness of their controllability and the fact that they are not alive. There has been much debate about whether the development in robotics will lead individuals, particularly the young and old, to believe that they are forming meaningful relationships with robots (Sharkey and Sharkey, 2010). Given that current robotic technology is accessible to all children, the findings of the current study suggest that future robot designs can be less wary about the risk of deceiving children into forming meaningful relationships and believing that a robot is anything other than a technological entity.

The technological changes that take place in society will have a considerable effect on children's lives and play culture. The rapid pace of technological development means we know relatively little about children's views and perceptions of these technologies. Even though many studies have been conducted looking at the impact of these technologies on children's social behaviour and wellbeing (Wartella, Lee and Caplovitz, 2002), a negligible amount of research is based on viewing these technologies from the perspective of the child. The ways in which children perceive robots and robot behaviour, in particular the ways in which children give meaning to robots and robot behaviour together with their understanding of the world and how it functions will potentially come to characterise a particular generation. Therefore, I argue that all research situated in the interdisciplinary field of human–robot interaction should not only research the impact of these technologies on children but should focus on capturing children's perceptions and viewpoints of these technologies to better understand the impact of the changing technological world on the lives of children.

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Appendices

Appendix 1: Initial letter sent to schools

THE UNIVERSITY OF WARWICK

Sajida Bhamjee
PhD Student
School of Health and Social Sciences
University of Warwick
Coventry
CV4 7AL
s.bhamjee@warwick.ac.uk
30th October 2008

[redacted]

Dear (Headteacher),

I am a PhD student at the University of Warwick conducting research exploring children's perceptions and interpretations of robots. With permission from you and parents at your school, I would like to carry out research involving around 30 children. They will be asked to draw and write about their perceptions of robots. In another study at a later date, I will then ask them to monitor small robots for an estimated 30 minutes. Each robot is 70mm in diameter, 55mm in height and has an approximate weight 150g. They have been designed by the University of the West of England (Bristol) Robotics Laboratory and are safe to use with children. I live locally and would appreciate the opportunity to carry out this unique study in the local area. I have a current CRB clearance and would provide all documentation including any consent forms required.

I would appreciate if we could meet to further discuss my proposal and to possibly show you one of the robots. Please contact me at your earliest convenience on 07877 420 697 or at the above address.

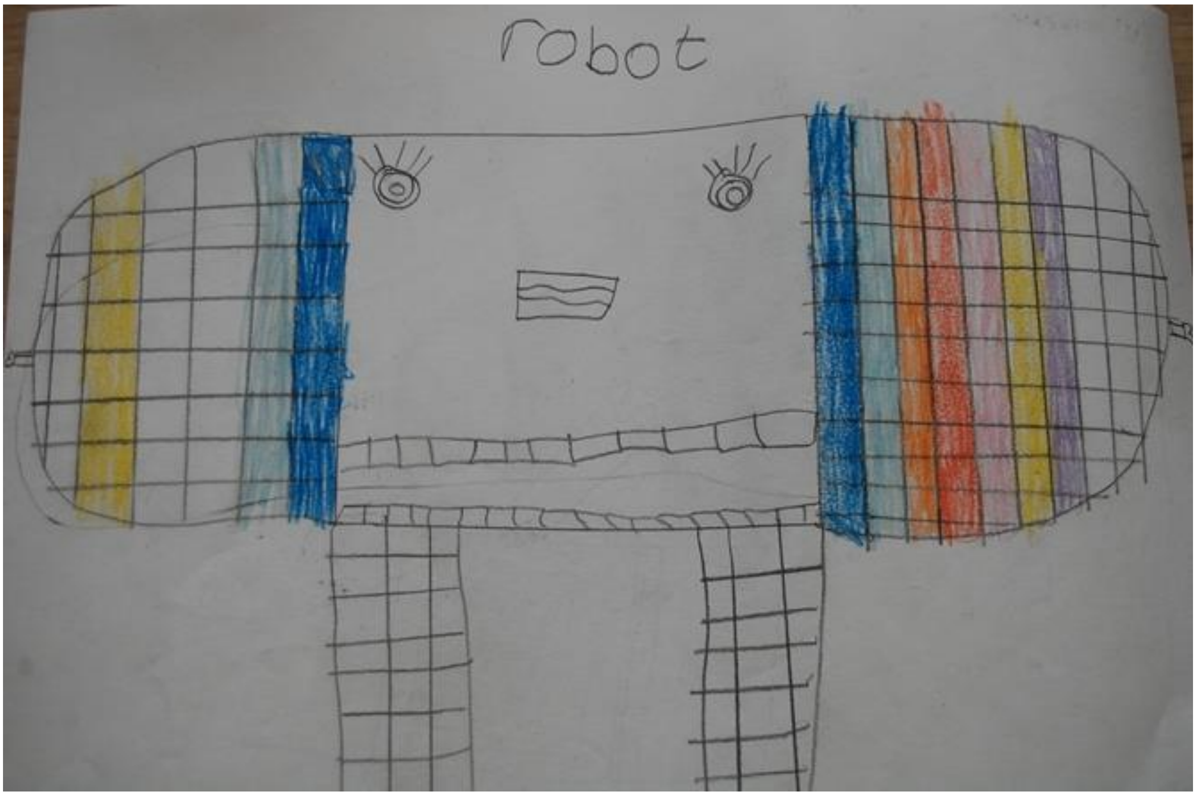
Full details of the study can be found at:

http://www2.warwick.ac.uk/fac/med/research/hsri/primary_care/research_/centrepatexp/complexityhealth/emergence/robotsociety

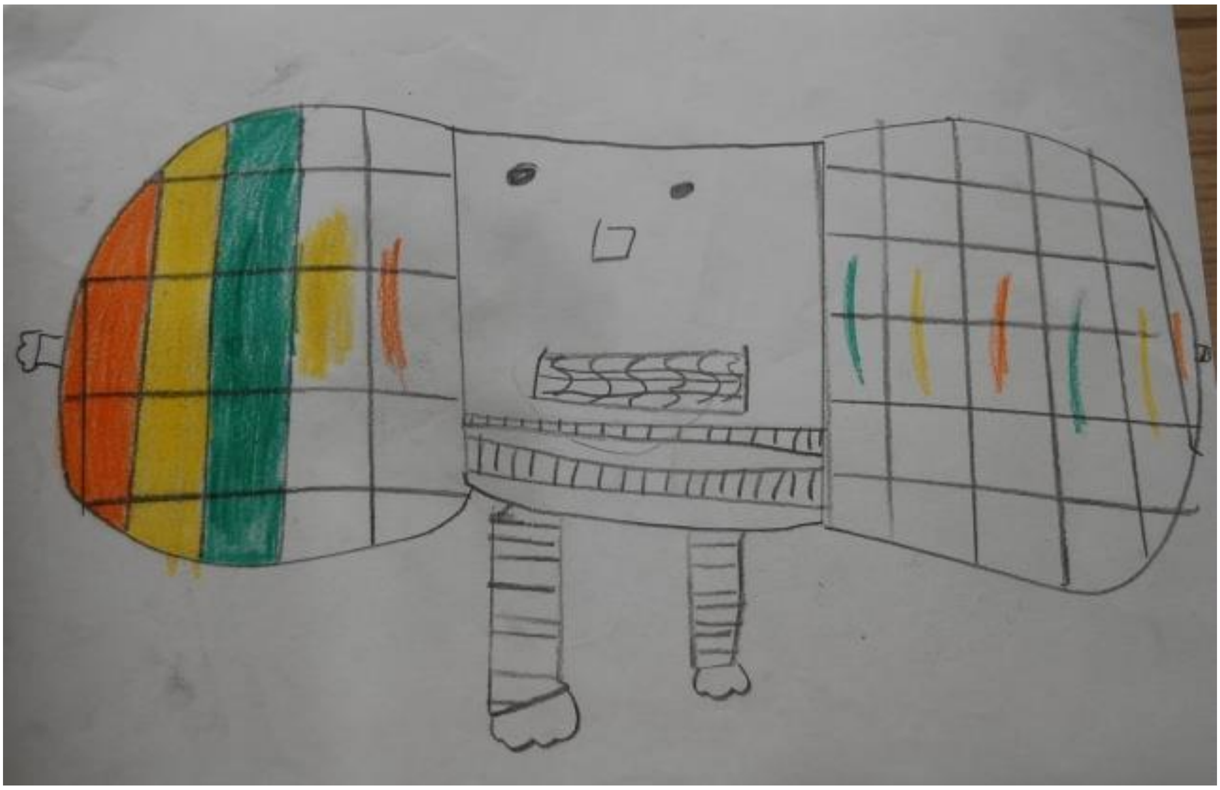
Yours Sincerely

Sajida Bhamjee

Appendix 2: A 'rounded' robot drawn by a girl



Appendix 3: A ‘rounded’ robot drawn by a girl

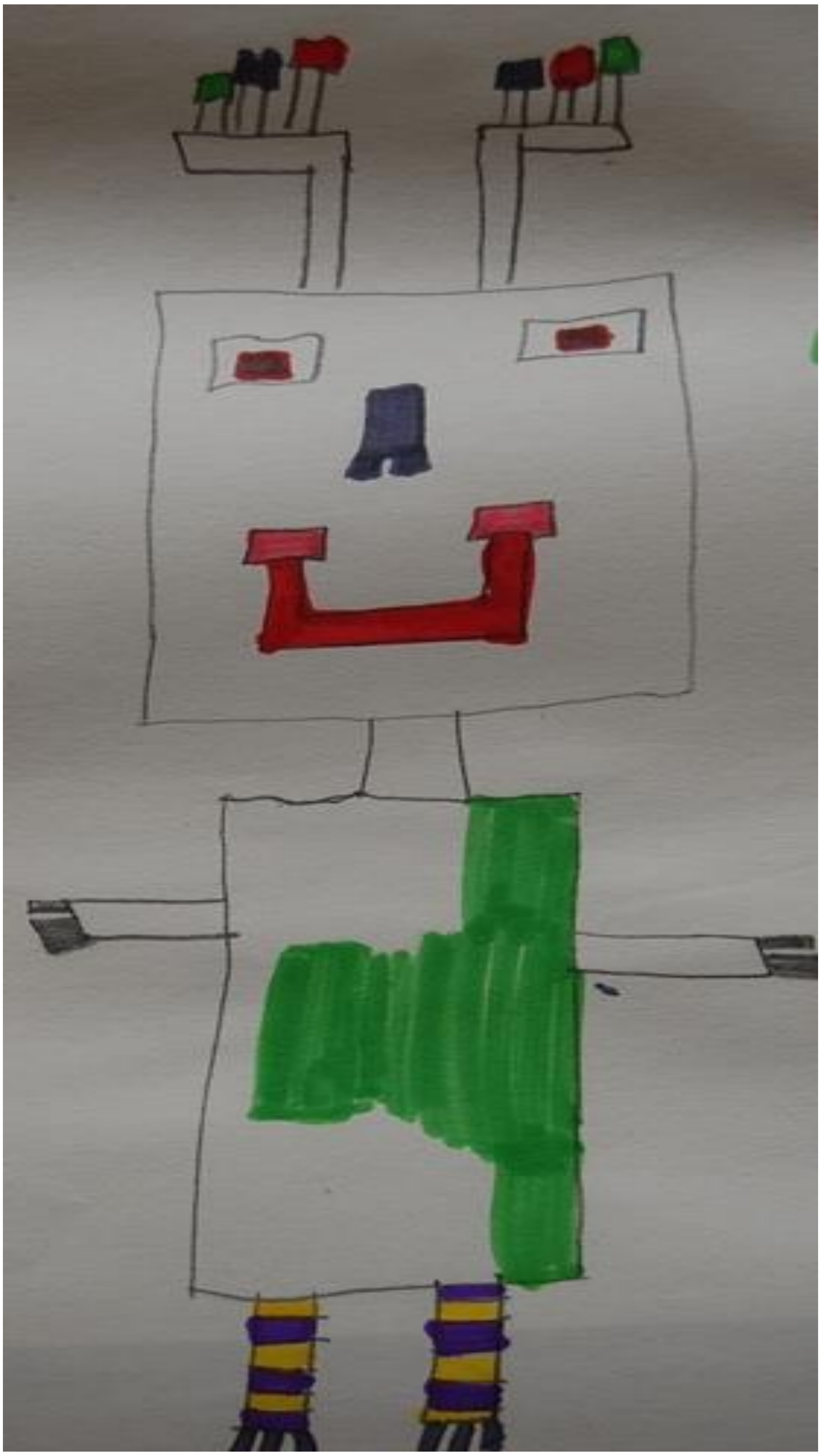


Appendix 4: ‘Buzz Light Year’- Character from popular media

Appendix 5: 'Joe': Character from popular media

Appendix 6: Example of a child's drawing

Appendix 7: Example of a child's drawing



Appendix 8: Example of a child's drawing