FP6-IST-002020

COGNIRON

The Cognitive Robot Companion

Integrated Project

Information Society Technologies Priority

D6.3.1
Evaluation of User Studies on Attribution of Intentionality

Due date of deliverable: December 31st 2004

Actual submission date: January 31st 2005

Start date of project: January 1st 2004
Duration: 48 months

Lead contractor for this deliverable: University of Hertfordshire

Revision: final

Dissemination level: PU

Executive Summary

This report presents results from an exploratory user study with adult subjects that was conducted in 2004 as part of the University of Hertfordshire's contributions to RA3 and RA6. In this particular deliverable we focus on results relevant to WP6.3 in RA6. Results from our work in RA6 will contribute to CF-IA: "Intentionality Attribution" and will help in the design of more focused user studies during the second project phase. Results from our work in RA6 are expected to yield design guidelines for robot's behaviour and appearance in scenarios relevant to the KE's. The particular approach we chose in order to investigate intentionality and attribution in adult subjects was a psychological approach. More specifically, we analyzed subjects' personality traits and characteristics with respect to their ratings of personality traits and characteristics attributed by the same subjects to two different predefined robot behaviour styles. The two different modes of robot behaviour rated were: Socially Ignorant and Socially Interactive. Our results so far show some interesting correlations between the subjects' and the robot's attributed personality traits and characteristics. Also, significant group differences have been identified. We extensively used questionnaire data, in addition to behavioural data that is part of our research in RA3 (cf. deliverable D3.1.1). A rigorous statistical analysis of the data and a discussion of implications for future work is documented in this report. The evaluation of the data presented in this deliverable will be completed at the end of the first Cogniron project phase (month 18).

Role of Evaluation of User Studies on Attribution of Intentionality in COGNIRON

Intentionality and attribution are key elements in designing robots where a central, if not primary purpose addresses the interaction with people. Cogniron investigates the scenario of a "robot in a home", with the vision that such a robot might ultimately be used as a service robot performing useful tasks in people's homes. It is therefore crucial to find out people's perception of and attitudes towards robots in order to usefully inform the design and implementation of such a robot companion. This particular deliverable which informs CF-IA takes a psychological approach which is becoming increasingly used in the field of Human-Robot Interaction. This work was carried out by an interdisciplinary team of psychologists, engineers and computer scientists at University of Hertfordshire.

Relation to the Key Experiments

The role of CF-IA, which is central to the work described in this deliverable, in the key experiments is to find out how the appearance and behaviour of robots can usefully be designed in order to support and encourage human-robot interaction which is a central element for the key experiments. CF-IA is particularly relevant to KE1 (Home Tour), but also has implications for the social interaction elements in KE2 and KE3 (Specification of Cogniron Key-Experiments document, 2004). The work reported here is the first step towards the development of CF-IA, based on an exploratory study that will inform later in-depth investigations.

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1. INTRODUCTION

1.1. Introducing WP 6.3

The present report details work carried out to date as UH's contribution to Research Activity RA6, and in particular the progress made towards the work outlined in Work Package 6.3 (WP6.3). Briefly, the main area of interest is the issue of believable robots, specifically the role of anthropomorphism and the attribution of intentionality in how humans perceive robots. Our exploratory user study measured how humans react to social robots (using quantitative and qualitative data techniques), assuming that the robots are able to interact with people in a basic way, e.g. can approach and follow humans. Thus, we aimed to identify fundamental parameters of behaviour that influence the attribution of intentionality in human-robot interactions.

A Robot Interacting with a Single Adult: A Living Room Scenario

The present study was run during July and August 2004. This study involved twenty-eight subjects (sessions) and was run with a view to conduct a series of experiments with individual adults interacting with a single robot in a number of carefully controlled ways. Each session was run as a simulated living room scenario where a single robot was interacting with a single adult subject. The sessions were run at the University of Hertfordshire where a large conference room was converted and furnished to provide a homely environment. The robots used in the study were commercially available human scaled PeopleBot™ robots. Also included adjacent was an enclosed section where the Wizard-of-Oz (WOZ) operators, recording and robot control equipment could be housed, monitored and operated.

This study was primarily devised as an exploratory investigation. The main aim of the experiments was to concentrate on the *human-centred perspective*; which is concerned with how a robot's behaviour appears to humans, regardless of the cognitive processes that might happen inside the robot (robot-centred perspective). Results from this study will provide interesting directions for future more detailed studies in 2005 and later. To achieve these aims it is necessary to study a wide range of issues relevant to how people perceive robots. It is also necessary to explore issues of personality, intentionality, controllability, autonomy, and predictability that are very relevant for the COGNIRON scenario of a "robot in the home". The scenario used in the current study was carefully designed to feature aspects of as many of these issues as possible within an experimentally restrained scenario, where a robot performed according to two different styles referred to in this study as *Socially Interactive* and *Socially Ignorant*.

1.2. The Present Study

In this particular study we examined people's perceptions and attitudes towards different types of robots in terms of personality characteristics. A psychological approach was adopted for this study using a questionnaire approach and a quantitative statistical framework to analyze the results. We hope that the results from this exploratory study will assist in the future progress of this research project which aims to develop the technologies and capabilities that will be needed for a domestic companion robot.

Our research questions for the current study were:

1. Is there a relationship between subjects' personality characteristics and their attribution of personality characteristics to the robot? Do they attribute intentionality to the robot? Our expectations were that we would find statistically significant correlations between subjects' personality traits or characteristics, and those attributed to the robot (Research Hypothesis RH 1).
2. Do different groups of subjects depending on their gender, age, occupation, educational background attribute different personality characteristics to the robot? We expected to find statistically significant differences in how subjects interpreted the robot's behaviour based on their group membership (RH 2).
3. Are subjects able to recognize differences in robots' behaviour styles depending on robots' different behaviour? We hypothesized that the two robot behaviour styles would be clearly identifiable and be reflected in differences in how subjects interpret the robots (RH3).

1.3. Brief Introduction to Human-Robot Interaction

Robots have been used within increasingly diverse areas and researchers are particularly interested in exploring robots that can directly interact with humans (Bartneck, 2004). Robot-human interaction encapsulates a range of factors that need consideration, such as perception, cognitive and social capabilities of the robot and the matching of the robot interaction with the target group (Breazeal, 2004).

The amount of human-robot interaction with traditional service robots, that are used to deliver hospital meals or operate factory machinery is still minimal, requiring little social behaviour or perception of humans other than obstacle avoidance (Wilkes et al., 1997). Robots known to be able to engage in social interaction with humans among others include AIBO (Sony, 2004), Kismet (Breazeal, 2002), or Feelix (Canamero, 2002). It is claimed that social robots should be able to demonstrate some "human social" characteristics including personality characteristics (Fong et al., 2003) both in terms of physical appearance and behavioural competencies.

1.3.1. Robot Appearance

The overall appearance of robots is important as it helps to shape the social expectations that humans have. For example, a robot which has an overall animal appearance will be interpreted differently to a robot which has a human like appearance. Robotic appearance will no doubt impact on people's overall perceptions in terms of likeability, whether they would approach the robot and feel comfortable with it, believability and overall engagement with the robot (Fong et al., 2003). There is limited research that has directly considered the impact of the design of robot appearance on human-robot interaction. However, the categorisations proposed by Fong et al. (2003) provide a useful starting point for understanding the different dimensions of robot appearance including anthropomorphism, zoomorphism, and caricatured robots.

Anthropomorphism is the tendency to attribute human characteristics to objects with a view of helping to understand and interpret their actions. It has been argued that for humans to have believable and meaningful interactions with robots then the robot should be structurally and functionally similar to a human, cf. (Breazeal, 2002). The tendency to attribute human-like characteristics is viewed as a useful tool to enable engaging human-robot interaction (Friedman et al, 2003), and has led researchers to pursue research into robots that resemble humans as closely as possible. Zoomorphic robots are designed to imitate living creatures to allow owner-pet relationships, (e.g. Sony, 2004). Caricatured robots primarily focus on developing exaggerated features such as the eyes or mouth, (e.g. Cañamero, 2002).

Goetz, Kiesler & Powers (2002, 2003) revealed that people expect a robot to look and act appropriately for different tasks. For example, a robot that performs in a playful manner is preferred for a fun carefree game but a serious robot is preferred for a serious health related exercise regime. Kanda & Ishiguro (2004) attempted to offer a novel approach to developing a social robot for children where the robot (Robovie) can read human relationships from their physical behaviour. This example highlights the importance of Robovie being designed appropriately for young children. It seems that if a robot cannot comply with the user's expectations, they will be disappointed and unengaged with the robot. For example, if a robot closely resembles a human in appearance but then does not behave like one, there is the danger of the human-robot interaction breaking down. It could even lead to feelings of revulsion against the robot as in the 'Uncanny Valley' proposed by Mashiro Mori (Dautenhahn, 2002).

1.3.2. Robot Personality

People use personality in a similar way to other social stereotypes to try to make sense of social behaviour in terms of goals, beliefs and emotions. There is no universal definition, although it can be generally viewed as a collection of individual differences, dispositions and temperaments that have consistency across situations and time (Dryer, 1999). The tendency for humans to assign personality qualities to robots may facilitate the user's understanding of its behaviour, and help to shape the user interaction and assist with design restrictions, cf. (Norman, 1994). Experiments have shown that robot personality should match its design purpose (Druin, 1999). For example Goetz and Kiesler (2002) carried out trials with a robot assistant and found that people may like happy robots more, but follow robot instructions to a greater extent if the robot behaves seriously. Dryer (1999) & Fong et al. (2003) have provided classification systems which may assist in the design of agent and robot personality. However, few studies have yet considered peoples' perceptions of robot personality and whether it relates to their own.

1.3.3. The Target Population

An important consideration for the designers of robots involves the target population; whether it is children, adolescents, adults, or the elderly, as the attitudes and opinions of these groups towards robot interactions are likely to be quite different.

The studies by Khan (1998) and Scopelliti et al. (2004) are among the first to have used a psychological design framework using questionnaires to explore adults attitudes towards the design of a domestic robot. Khan et al. (2004) examined adult's attitudes towards an intelligent service robot, using a survey which included a variety of different concepts including what people thought robots should look like, how robots could be used for service purposes in the household, how the robots should behave and how humans have conceived their ideas and images of robots. The survey results revealed that most participants were positive towards the idea of an intelligent service robot.

Similarly, Scopelliti et al (2004) used a psychological approach to investigate people's representation of domestic robots across three different generations, taking into account gender and educational level, in an attempt to bridge the gap between technological capabilities and user expectations. Their results demonstrated that young people tend to have positive feelings towards domestic robots, whereas elderly people are frightened of the prospect of a robot in the home.

The research by Friedman, Kahn and Hagman (2003) and Kahn et al. (2004), using unstructured play sessions for children and online discussion forums for adults, demonstrated that AIBO was psychologically engaging for both adults and children in terms of life-like essences, mental states and social rapports. However, participants rarely attributed moral standing to AIBO. Another recent research programme considering the possibility of communication with robots using 'Robovie' explored people's negative attitudes toward interaction with robots by developing the 'Negative Attitude for Robots Scale (NARS)' which was strongly grounded in psychological personality theory (Nomura et al., 2004).

It is our position that the input of psychologists could assist the design of Socially Aware robots by examining what social skills are desirable for robots, what an appropriate appearance and behaviour is for robots in different roles and for different target groups, and assisting in the design of robots with personality, empathy and cognition (Friedman et al., 2003; Kahn et al., 2004; Khan, 1998;DiSalvo et al., 2002; Nomura et al., 2004; Woods et al., 2004).

1.4. Eysenck's 3-Factor Model of Personality

In order to address the issue of intentionality and attribution in human-robot interaction, in our first exploratory study we utilized the broader framework of personality traits and characteristics. This allowed us to explore a wider range of issues into how people perceive robots. Specifically, we chose Eysenck's PEN model.

Among the criteria suggested for a good model of personality is evidence of "temporal stability and cross-observer validity" (Costa & McCrae, 1992a, p. 653), universality, testability, replicability, and practicality (Eysenck, 1991; Gray, 1981). In particular, Eysenck (1991) proposes the PEN/3-Factor model and suggests that it constitutes a paradigm in personality research. To support the theory, proponents of the PEN model (e.g., Eysenck & Eysenck, 1985) emphasize the use of not only correlational research methods such as factor analysis, but also experimental research methods.

Eysenck (1991) implies that traits themselves intercorrelate and make up superfactors, which he calls "types." These are: extraversion (E), neuroticism (N), and psychoticism (P). These three superfactors or dimensions of personality are orthogonal to each other, which means that they do not correlate with each other (Eysenck & Eysenck, 1985).

There are vigorous debates regarding the number of dimensions that define personality (Costa & McCrae, 1992a, 1992b; Eysenck, 1991, 1992b, 1992c). In this respect, Eysenck strongly advocates that there are only three major dimensions in the description of personality: extraversion-introversion; emotional stability versus instability, or neuroticism; and psychoticism versus impulse control (Eysenck & Eysenck, 1985). In the PEN model, these dimensions or superfactors are based on "constitutional, genetic, or inborn factors, which are to be discovered in the physiological, neurological, and biochemical structure of the individual" (Eysenck & Eysenck, 1985, pp. 42-43).

Researchers of the PEN model emphasize the dimensional aspect of personality, as opposed to categorization (Eysenck, 1992a; Eysenck & Eysenck, 1985). That is, each person does not necessarily have either 100 percent or zero percent of extraversion, neuroticism, or psychoticism. An individual may show some degree of these superfactors on the continuum.

On this continuum, a person with high extraversion is sociable, popular, optimistic, and rather unreliable, whereas a person with low extraversion is quiet, introspective, reserved, and reliable. A person with high neuroticism is anxious, worried, moody, and unstable, whereas a person with low neuroticism is calm, even-tempered, carefree, and emotionally stable. A person with high psychoticism is troublesome, uncooperative, hostile, and socially withdrawn, whereas a person with low psychoticism is altruistic, socialized, empathic, and conventional (Eysenck & Eysenck, 1985).

Furthermore, the superfactors of extraversion, neuroticism, and psychoticism appear to be universal. Such universality has been demonstrated in cross-cultural studies using the Eysenck Personality Questionnaire (EPQ). Evidently, the studies show that the same dimensions of personality emerge in many different nations and cultures other than Western countries (Eysenck, 1991; Eysenck & Eysenck, 1985).

On the whole, the PEN model has contributed to the study of personality in three distinctive ways. First, it combines both descriptive and causal aspects of personality in one theory (Eysenck, 1997; Stelmack, 1997). This characteristic clearly distinguishes the PEN model from most other trait theories such as the five-factor model (Costa & McCrae, 1992a, 1992b; Eysenck, 1991, 1992b, 1992c). By providing causal explanations in addition to the description of personality, the PEN model is supported by more credible evidence than purely descriptive models. The combination in one theory of two important aspects of personality makes it possible to understand personality as a whole.

Second, the PEN model is comprehensive in description by proposing a hierarchy and by making a clear distinction among those levels (traits => superfactors). This characteristic can play another critical role for the comparison with other trait theories. Even though Costa & McCrae's (1992a) five-factor model is also hierarchical, their model seems to mix up lower-level factors with higher-level superfactors (Eysenck & Eysenck, 1985; Eysenck, 1991, 1992b). That is, the big five dimensions of agreeableness and conscientiousness are traits at the third level that combine as part of a superfactor of psychoticism at the top level of the PEN model. For understanding the very nature of personality, fewer independent factors are better than many factors overlapping one another. Moreover, the five-factor model includes "intellect" or "openness" at the top level (Costa & McCrae, 1992a). But the PEN model draws a clear line between temperament and cognitive ability and treats intelligence differently. That does not mean the PEN model totally excludes intelligence from personality. Rather, advocates of the PEN model "adopt the more common view that intellectual processes can be discriminated from emotional ones" (Eysenck & Eysenck, 1985, p. 159).

Finally, the PEN model becomes most compelling because of its experimental approach to the study of personality, which makes the model more testable. Consequently, the PEN model is likely "to generate more specific predictions because knowledge about the functioning of the specified physiological structures is available" (Eysenck & Eysenck, 1985, p. 192). The experimental approach of the PEN model serves as a good role model for other personality theories (Eysenck, 1991, 1992b, 1992c, 1997; Stelmack, 1997).

2. METHOD

2.1. Data Sample

A sample of 28 adult volunteers [male: N: 14 (50%) and female: N: 14 (50%)] were recruited from the University of Hertfordshire. A small amount (7.1%) were under 25 years of age (no one less than 18 took part), 42.9% were 26-35 years old, 28.6% were 36-45 years old, 10.7% were 46-55 years old and 10.7% were over 56 years of age. 39.3% of the participants were students, whereas 42.9% were academic or faculty staff (e.g. lecturers, professors) and 17.9% were researchers in an academic institution. As far as their educational or employment background was concerned, 50% came from a technology-related department (e.g. computer science, electronics and engineering), and 50% came from a non-technology related department, such as psychology, law and business. All subjects completed consent forms. The subjects were not paid for participation; however, at the end of the trial they were surprised with a book present.

2.2. Design

This exploratory study used a counterbalanced repeated samples design using questionnaires and quantitative statistical techniques. The participants completed six different questionnaires (Appendix 1) after carrying out various tasks during the experiment.

2.3. Instruments

Cogniron Introductory Questionnaire

An introductory questionnaire was designed to enquire about participants' personal details, such as gender, age, occupation, as well as their level of familiarity with robots, rated according to a 5-point Likert scale. Subjects' were asked about prior experience with robots (at work, as toys, in movies/books, in TV shows, in museums or in schools). At the end of the questionnaire, participants had to indicate their level of technical knowledge with robots along a 5-point Likert scale.

Cogniron Subject Personality Questionnaire

The subject personality questionnaire was designed based on Hans J. Eysenck's personality types using the three basic personality factors (Eysenck & Eysenck, 1985): Neuroticism vs. Emotional Stability, Extraversion vs. Introversion, and Psychoticism. 12 of the characteristics he identified were selected as most relevant to this study. These were:

- Anxiety, Tension, Shyness, emotional (Vulnerability) representing Neuroticism vs. Emotional Stability,
- Sociability, General Activity Level, Assertiveness, Excitement-Seeking, Dominance representing Extraversion vs. Introversion,
- Aggressiveness, Impulsiveness, Creativity representing Psychoticism.

Autonomy was added as another personality characteristic of interest to the present study. The questionnaire required the participants to rate themselves in terms of the 13 different personality characteristics using a 5-point Likert scale. Autonomy was assessed using a 5-point Likert Scale ranging from 'prefer being told what to do' to 'prefer to decide myself what to do'.

Subjects were all informed that this information would be treated confidentially and would not be linked to their real name during any stage of the evaluation.

Cogniron Robot A (Socially Ignorant) Personality Questionnaire

The Robot A personality questionnaire was designed similarly to the subject personality questionnaire based on Hans J. Eysenck's personality types. The characteristics used were:

- Anxiety, Tension, Shyness, emotional (Vulnerability)
- Sociability, General Activity Level, Assertiveness, Excitement-Seeking, Dominance
- Aggressiveness, Impulsiveness, Creativity
- Autonomy, Intentionality, Predictability of behaviour, Controllability and Considerateness were added as personality characteristics of interest in the present study.

This questionnaire required the participants, based on their experience with the robot during the experiment to describe the socially ignorant robot's A personality in terms of the above 17 different characteristics using a 5-point Likert scale.

The robot's autonomy was assessed along a 5-point Likert Scale ranging from 'seemed to do what it was told/ programmed to do' to 'seemed to make its own decisions'.

The final section included four questions about how comfortable or uncomfortable the participants felt with the robot in different situations (approaching robot, being physically close to robot, moving in the same room, when sitting at a table) and one question on how much they enjoyed their interaction with the robot. The subjects had to indicate levels of comfort and enjoyment along the 5-point Likert scale.

Cogniron Robot B (Socially Interactive) Personality Questionnaire

The Robot B personality questionnaire was exactly the same as the Robot A personality questionnaire.

This questionnaire required the participants, based on their experience with the robot during the experiment to describe the Socially Interactive robot's B personality in terms of the above 17 different characteristics along a 5-point Likert scale.

Cogniron Final Questionnaire

The final questionnaire was designed to enquire about participants' perceptions of what a future robot should be like. Section one referred to questions about what is a robot companion (e.g. do you like the idea of having a robot companion at home? What role do you think a future robot companion in the home should have? What tasks would you like this future robot to be able to carry out?). Also, questions were included referring to how predictable, controllable and considerate the future robot should be, and how human-like it should appear, behave and communicate. Moreover, at the end of this section, five questions were included to clarify the subjects' thoughts on what is a Socially Interactive robot (e.g. with what speed it should approach? how close it should come? should it pay attention to what subjects are doing? should it be polite and give way if they encounter it? Should it try to find out if they need help before it helps?). The subjects had to indicate their perceptions along the 5-point Likert scale.

Section two concerned questions about the subjects' feelings after the session. The participants had to write down what they found most interesting and most annoying during the experiment. Then, there was a question about whether anything should be changed regarding the robot (appearance, speech, behaviour) and the participants were asked to write down in detail how they thought the robot should be changed as well as any other comments they had regarding the whole experiment.

NARS (Negative Attitude towards Robots Scale) Questionnaire

The NARS (Negative Attitude towards Robots Scale) Questionnaire was developed by Nomura et al (2004) for measuring humans' attitudes towards communication robots in daily-life. The English statements were corrected from the original instrument, and sentence 13 was added. As a consequence it was composed of 16 sentences and the participants were asked to judge these sentences ranging along the 5-point Likert scale: (1) I completely disagree, (2) I disagree, (3) undecided, (4) I agree, (5) I completely agree. The sentences are presented in the following table (1).

Table 1: NARS Sentences

1.	I have seen live robots before
2.	I would feel uneasy if robots really had emotions.
3.	Something bad might happen if robots developed into living beings.
4.	I would feel relaxed talking with robots.
5.	I would feel uneasy if I was given a job where I had to use robots.
6.	If robots had emotions, I would be able to make friends with them.
7.	I would feel comforted being with robots that have emotions.
8.	The word "robot" means nothing to me.
9.	I would feel nervous operating a robot in front of other people.
10.	I would hate the idea that robots or artificial intelligences were making judgments about things.
11.	I would feel very nervous just standing in front of a robot.
12.	I feel that if I depended on robots too much, something bad might happen.
13.	I feel that if I trust robots too much, something bad might happen.
14.	I would feel paranoid talking with a robot.
15.	I am concerned that robots would be a bad influence on children.
16.	I feel that in the future society will be dominated by robots.

2.4. Experimental Set-up Simulated Living Room

The simulated living room was set up in one of the larger conference rooms adjacent to the Adaptive Systems Groups Office. This room was made available for an extended period over the months of July and August so that there was no need to disturb the experimental set-up once installed. The original room measured 8.5 x 4.75m and had one outside window on one end wall, a pair of large double doors on the opposite wall, and a single door (Position 1) on one of the longer side walls, closer to the window end wall (Figure 1). The room was partitioned off at one end (AA), by means of office partitions and high wardrobe and shelf units, to form an area with the double doors to serve as a control area for the WOZ operators and space for the control, network and recording equipment. The close proximity of the WOZ meant that they could hear directly what was being said in the experimental room area, though this did mean that absolute silence had to be observed by the Wizards while the experiment was running.

The room was provided with a whiteboard (9) and two tables. One table reinforced the partition (adjacent to 4) and also was furnished with a number of domestic items – coffee cups, tray, water bottle, kettle etc. The other table (2) was placed by the window to act as a desk for the subject to work at while performing task two (see below). There was also a relaxing area, with a sofa (3), small easy chair and a low rectangular coffee table (6). Directly opposite, next to the white board was another low round coffee table with a television resting on it. There was also a second small easy chair in the corner.

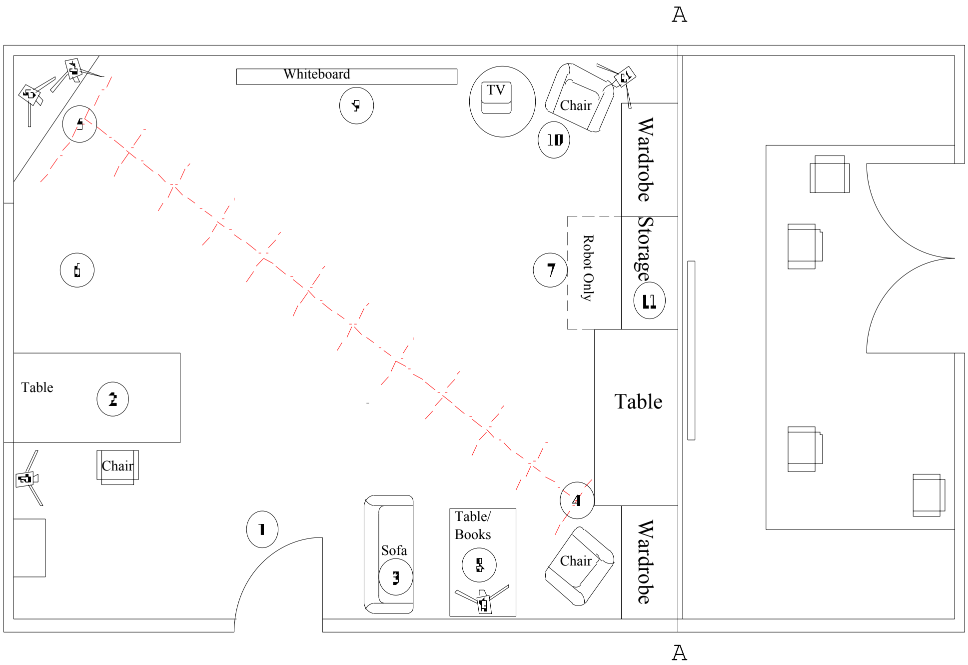

Figure 1: Overview Diagram of Experimental Living Room Layout

Five network video cameras were mounted on the walls in the positions indicated, so that multiple views of the experiment could be recorded.

Marks were made on the floor using masking tape at positions 4 and 5, and scale marks made at 0.5m intervals between them. This acted as a means by which human-robot comfort and approach distances could be estimated from the video records, rather than having the experiment supervisor making intrusive measurements or notes during the experimental sessions.

2.4.1. Experimental Principles

One of the main problems was to eliminate human unpredictability from the experimental scenarios, while at the same time allowing the human subject free expression of their reactions and behaviour towards the robot, rather than the constraints of the experiment.

The approach taken in the design of the experimental layout, scenarios and room layout was that possible actions by the human were limited, but not explicitly. For example, an area in front of the storage shelf (pens etc) was labelled “Robot Only”. It was not brought directly to the attention of the subject by the experimenter, but this did provide a mental justification for the subjects to allow the (slow) robot to fetch a pen when required, rather than to simply get it for themselves. The scenarios, which involved a human working in the same area as the robot, were all designed to keep the human subject busy, so that there was little time for the subject to actually indulge in unpredictable (and arbitrary) behaviour. These constraints were necessary to coerce the human subjects into undergoing a similar set of physical and social interaction experiences with the robot.

2.5. Experimental Procedure

On the way to the experimental room, the experimenter asked the subject which Department he/she came from. When the subject entered the room, the experimenter gave him/her a general welcome and introduced the subject to the room (Location 1, Figure 2).

"Welcome to our simulated living room. This is the robot that we will use in the experiments"
(The robot moves forward close to the subject and speaks: "*Hello there*").
" During the experiments you will be asked to perform certain simple tasks and fill in some questionnaires. Our goal is to evaluate the robot's performance. Behind the screen experimenters are based who operate the video cameras and make sure they are functioning properly."

Figure 2: General Welcome and Introduction of the Subject to the Room

Following a WOZ approach (Maulsby et al, 1993; Gould et al., 1983; Dahlback et al., 1993), we intended to give the illusion that the robot operated fully autonomously. However, we assumed that subjects would notice that two people were sitting behind the screen and we therefore had to explain their presence (Figure 3).

Figure 3: Experimenters based Behind the Screen

Then the experimenter asked the subject to have a seat at the desk near the window (Figure 4) and offered him/her a glass of water (Location 2). Then, the experimenter handed out the information sheet and asked the subject to read it carefully. After that, the subject had to sign the consent form attached to the information sheet if he/she agreed to participate in the study (Appendix 1). All subjects agreed to take part in the exploratory study.

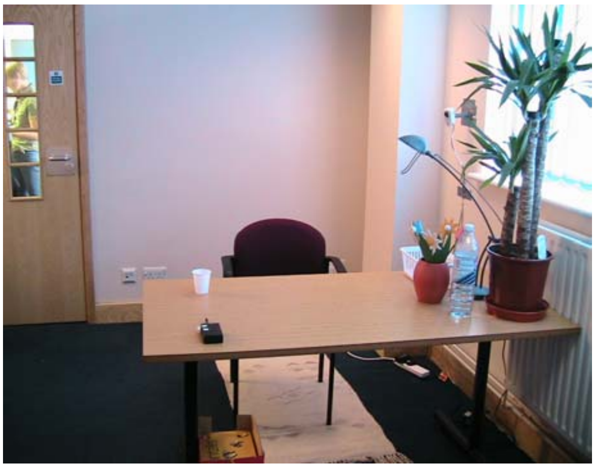

Figure 4: The Desk near the Window

When the subject had signed the consent form, he/she was asked to complete the Introductory Questionnaire and the Subject Personality Questionnaire, and was reminded not to think too hard about the answers to the questions, as the experimenter was interested in spontaneous answers. Also, if the subject did not understand any question, he/she was encouraged to ask for clarification. At that time, the experimenter sat on the sofa (Location 3) and read a newspaper until the subject had finished. During this period the robot wandered randomly around the room to acclimatize the subject before the experiment started.

We decided to have the experimenter withdrawn from the actual experiment, but she was present in the room to provide help when needed and to explain the different tasks of the experiment. During the experiment, the experimenter did not encourage conversation or interaction with the subject.

In the next phase, the experimenter made it clear that during the following tasks, it is of interest to measure how comfortable the subject felt. Thus, the experimenter gave the subject a device that indicated his/her comfort level and asked him/her to try it a few times, explaining first how it works. One end of the scale meant very comfortable, the other end meant very uncomfortable.

"Do you write with your left or right hand? Then please hold the device in your XXX hand. Please try it out now a few times" (-> robot moves to corner.). *"How you would indicate the most comfortable and the most uncomfortable scale……? That works very well, thanks. Please keep it with you during the remainder of the experiment."*

2.5.1. Approach Task (First interactions with robot)

The experimenter introduced the subject to the first task. The experimenter explained that we were interested in the subject's spatial comfort zone, which is the distance the robot should maintain towards him/her (Figure 5). More specifically, the experimenter wanted to know how closely a robot should approach the subject, and how closely the subject desired approaching a robot, so that they felt comfortable. During the task, certain instructions were given.

Figure 5: Area used for Approach Task

"First, please stand on this mark (Location 4) and approach the robot standing over there (Location 5). Please stop in front of the robot at a distance that you feel (still) comfortable with, but you don't want to reduce further. Great.....now please approach the robot as closely as possible until you almost touch it. Now, please go backwards to a distance that you again feel comfortable with, and then stop."

Then, the subject is asked to go back to the starting point (Location 4) and repeat the procedure.

"Now, please stand again on the mark, and wait for the robot to approach you. While the robot is approaching, please use the comfort level device to indicate how comfortable you feel. If you don't want the robot to come any closer, say "stop"."

Then, the robot goes back to its starting point (Location 5), and the procedure is repeated. The experimenter thanks the subject for finishing the first experiment and the robot moves over to the window (Location 5).

2.5.2. Main trial

The main trial consisted of two different tasks, namely the whiteboard task and the desk task.

2.5.2.1. Whiteboard Task

The experimenter introduced the second task and reminded the subject that we were not judging him/her performance on the task. While the robot was moving in the room (Locations 6-7), the subject had to go through 8 books that were piled on the table (Location 8), read one title of each book at a time, walk over to the whiteboard and write down each title at a time (Location 9, Figure 6). The subject also left the books on the table and if he/she forgot the title while going to the whiteboards, he/she could return to the table (Figure 7). The experimenter reminded the subject to use the device to indicate his/her comfort level during the task and also made it clear that she would be sitting on the chair, reading her newspaper so as not to interrupt the completion of the task (Location 10). She also asked the subject to let her know when he/she had finished the task.

Figure 6: Area used for Whiteboard Task

The robot's behaviour depended on the experimental condition; the Socially Ignorant robot moved fast, whereas the Socially Interactive robot was more hesitant and moved slowly when it was close to the subject, also moving its camera to indicate it was taking notice of the subject (See full description of robots' behaviour in section 2.6).

Figure 7: Subject intersects robot, returning to the table during Whiteboard Task

2.5.2.2. Desk Task

Then, the experimenter asked the subject to sit again at the desk near the window (Location 2). While the subject was sitting, he/she had to write down the titles from the whiteboard on a list provided on a sheet of paper and underline all "o" letters with a red pen.

Depending on the experimental condition, the socially Socially Ignorant robot A (Location 6) did not wait for a sign or a command of need for the right pen and just took the initiative to go and fetch the pen (Location 11). Whereas, the Socially Interactive robot B waited for the subject to ask or look for the pen and then offered help (Figure 8).

Figure 8: Robot helps the Subject by fetching the right pen

After the completion of the main trial, the experimenter asked the subject to fill in the Robot Personality Questionnaire.

While the subject was completing the questionnaire, the experimenter arranged a new pile of books and cleaned the whiteboard.

2.5.2.3. Repetition of Main trial (robot shows different behaviour style)

The same task was repeated with a new set of books, to see how the robot (Socially Ignorant or Socially Interactive robot, depending on the experimental condition) behaved this time as the experimenter explained to the subject the same procedure and reminded him/her to use the comfort level device.

While the robot was moving in the room, the subject had to go through the new set of books that were piled on a table, only read one title of each book at a time, and write down each title on the whiteboard. Then, the experimenter asked the subject to sit again at the desk near the window, write down the titles from the whiteboard on the provided list, then take a highlighter and highlight the letter "M" in each word.

After the repetition of the main trial, the experimenter asked the subject to fill in the Robot Personality Questionnaire followed by the Cogniron final questionnaire and the NARS questionnaire (Location 2).

When all questionnaires were completed, the subject was thanked for their participation and as a token of appreciation the experimenter gave the subject a copy of Isaac Asimov's books 'The Complete Robot'.

Each session lasted for approximately 50-60 minutes. The experimenter, robot and subject shared the room during the whole experiment (Table 2).

Table 2: Overview of the Experimental Procedure

INTRODUCTION

- General Welcome
- Introduction to the robot and the room
- Information sheet read by subject
- Consent form signed by subject
- Introductory Questionnaire
- Subject Personality Questionnaire
- Robot moves around the room to acclimatise subject

↓

COMFORT PHASE/APPROACH-AVOIDANCE TASK

- Comfort Level Device given
- First interactions with robot
- Subject Approaching Robot
- Robot Approaching Subject
- Repeat Procedure

↓

MAIN TRIAL
(WHITEBOARD AND DESK TASKS)

- Robot moving in the room either as Socially Ignorant or Socially Interactive
- Subject goes through books piled on the table, only reads one title at a time, and writes down each title on the whiteboard.
- Use of comfort level device
- Subject sits at a desk, writes down again the titles from the whiteboard on the provided list and underlines specific letters with a red pen/highlighter
- Robot brings the pen
- Robot Personality Questionnaire

REPETITION OF MAIN TRIAL

- Robot Personality Questionnaire (either for Socially Ignorant/Interactive)

↓

FINAL PHASE

- Final Questionnaire
- NARS Questionnaire
- Thanks for participation
- Handout a book as a present

2.6. Robot Behaviour Styles and Differences

A key interest was in how comfortable people felt with "a robot in the home", and how they reacted in the presence of a robot in different situations. The subjects were exposed to two different styles of robot behaviour and tested as to how they reacted under different situations. The same task scenarios were used to test both robot behaviour conditions, which allowed within-subject comparison & thus reduces number of subjects required. The behaviour styles were always referred to as behaviours A and B during the study so that the experimenter did not give any clues or prior expectation when describing the procedure to the subject.

The robot behaviours to be tested during the main scenario phases of the exploratory study were classified into two types:

A: Socially Ignorant.

B: Socially Interactive.

Since each subject would perform the same tasks twice, to avoid any effects caused by repetition and habituation, the order in which robotic behaviours A and B were tested was alternated from one subject to the next, so that any effects would cancel out over the subject set.

The selection and classification of behaviours into these two categories was done, for the purposes of this initial experiment, purely on the basis of what changes the robot would make to its behaviour if there was no human present. If the robot made little or no change to its behaviour in the presence of a human the behaviour was classified as Socially Ignorant. If the robot took account of the human's presence, by modifying its optimum behaviour in some way, this was classified as Socially Interactive behaviour. As little was known about how the robot should actually behave in order to be seen to be Socially Aware, this assumption was chosen as it was in accord with what the COGNIRON team, and probably many robot researchers would agree, would be seen as social behaviour by the robot (Table 3).

Therefore, during the study, the following behaviours were classified as ***Socially Ignorant***:

- When moving in the same area as the human, the robot always took the direct path. If a human was in the way, the robot simply stopped and said "Excuse me" until the obstacle was removed.
- The robot did not take an interest in what the human was doing. If the human was working at a task, the robot interrupted at any point and fetched what was required, but did not give any indication that it was actively involved, or was taking any initiative to complete the task.
- The robot did not move its camera, and hence its gaze, while moving or stationary unless it was necessary to accomplish the immediate task.

These behaviours were classified as ***Socially Interactive***:

- When moving in the same area as a human, the robot always modified its path to avoid getting very close to the human. Especially if the human's back was turned the robot moved slowly when closer than two meters to the human and took a circuitous route.
- The robot took an interest in what the human was doing. It gave the appearance of looking actively at the human and the task being performed. It kept a close eye on the human and anticipated, by interpreting the human's movements, if it could help by fetching items. If it talked, it waited for an opportune moment to interrupt.
- When either moving or stationary, the robot moved its camera in a meaningful way to indicate by its gaze that it was looking around in order to participate or anticipate what was happening in the living room area.

The behaviours were implemented by means of a mixture of autonomous programs where possible (E.g. Wandering was entirely autonomous), or were controlled directly or initiated by the WOZ operator. Details of the robot program and operation are given in Deliverable D3.1.1.

Table 3: Robot Behaviour Styles and Differences

Robot's Behaviour	**A: Socially Ignorant**	**B: Socially interactive**
Whiteboard Task	• Moving in straight line • Moving fast • Encounter: "Excuse me", continue as soon as possible • Camera not moving	• Moving in straight line • Moving slowly when close to s subject, more hesitant, slowing down when close to people • Encounter: "After you", continue after the subject • Camera moving
Desk Task	• Camera not moving • "I notice you need a pen, I'll go and fetch one" • Bringing basket to side of table, close to subject, putting it down "Here you are, please take the pen"	• Camera moving, facing subject whenever possible • Waits for person to look for or ask for a pen, "I notice you need a pen, I'll go and fetch one" • Waiting in front of table facing subject, waiting for subject to notice, then putting basket down "Here you are, please take the pen"

2.7. Statistical Analysis

The following statistical framework was followed to analyse the data and meet the study requirements:

- Frequencies were calculated separately for each questionnaire in order to provide a descriptive analysis of the sample.
- Paired Samples T-tests were used to explore significant differences between subjects' perceptions of Socially Ignorant robot's personality characteristics/types and subjects' perceptions of the considerate robot's personality characteristics/types.
- Pearson's Product Moment correlations were calculated to examine whether subjects attribute their own personality characteristics/types to either the Socially Ignorant or the Socially Interactive robot.
- Independent Samples T-tests were carried out to explore significant differences on the responses between males and females, young (>35) and old (<35) subjects, staff and students, those with a robotics/technology related and those with a robotics/technology non-related educational or employment background, and to explore differences between the responses of those exposed to experimental condition A=>B (Socially Ignorant Robot=>Socially Interactive Robot) and those exposed to experimental condition B=>A (Socially Interactive Robot =>Socially Ignorant Robot).
- Independent Samples T-tests were carried out to look at significant differences on subjects' responses between 1^{st} and 2^{nd} robot exposure (Habituation Effect).

3. RESULTS - DESCRIPTIVE ANALYSIS

3.1. Overall Frequencies for Introductory Questionnaire

Overall, only 14.3% of the subjects were familiar with robots (Figure 9). 75% denied having any professional or private experience with robots; however, the most experienced subjects with robots derived their experience from movies or books, or toys or TV shows (57.2%). The vast majority (82.2%) had limited or quite limited technical knowledge of robots.

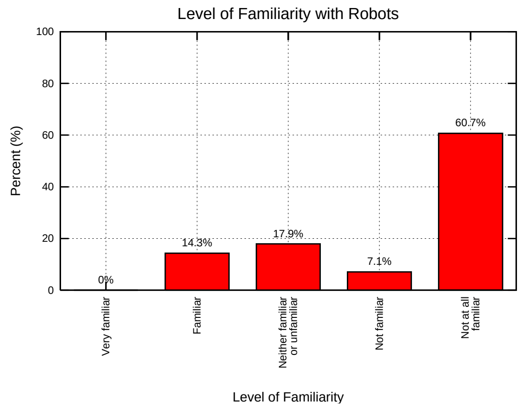

Figure 9: Level of Familiarity with Robots

3.2. Overall Frequencies for Subject Personality Questionnaire

In summary, the majority of the participants perceived themselves as (see Figure 10):

- Sociable (46.4%)
- Neutral in terms of shyness (42.9%)
- Neutral in terms of vulnerability (67.9%)
- Quite active (57.1%)
- Assertive (50%)
- Not anxious (35.7%)
- Not tense (39.3%)
- Creative (64.3%)
- Neutral in terms of seeking excitement (35.7%)
- Neutral in terms of dominance (39.3%)
- Neutral in terms of aggressiveness (42.9%)
- Neutral in terms of impulsiveness (35.7%)
- Quite preferred to decide themselves what to do (50%)

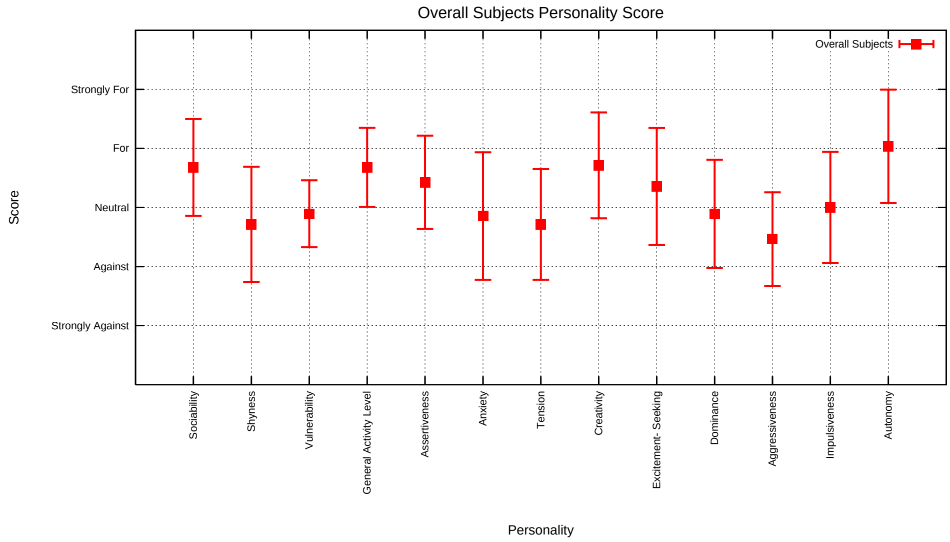

Figure 10: Items for Subject Personality scored on a 5-point Likert Scale, means and standard deviations are shown for each item

3.3. Overall Frequencies for Socially Ignorant Robot Personality Questionnaire

Based on their experience with the Socially Ignorant robot during the experiment, the subjects had to describe the robot's personality based on the following characteristics (see Appendix 2 for detailed description of Robot A Personality Frequencies and Percentages).

In summary, the majority of the subjects described the Socially Ignorant Robot A as (Figure 13):

- Not sociable (39.3%)
- Not at all shy (46.4%)
- Neutral in terms of vulnerability (35.7%)
- Quite active (39.3%)
- Assertive (28.6%) and Neutral in terms of assertiveness (28.6%)
- Not at all anxious (53.6%)
- Not at all tense (64.3%)
- Not creative (35.7%)
- Low excitement seeking (39.3%)
- Not at all dominant (32.1%) and Neutral in terms of dominance (32.1%)
- Not at all aggressive (64.3%)
- Not at all impulsive (35.7%)
- Seemed to do what it was told/ programmed to do (28.6%)
- Behaved intentionally (39.3%)
- Predictable (32.1%)
- Felt neutrally about controlling the robot (25%)

- Behaved very considerately towards the participants (53.6%)

Based on their general experience, most of the subjects felt either very comfortable or comfortable with the robot when they approached the robot or the robot approached them (71.4%). It is also noteworthy that 75% of the participants felt either very comfortable or comfortable being physically close to the robot, and interestingly again, 75% felt either very comfortable or comfortable when they and the robot were moving in the same room. The subjects' level of comfort with the robot when they were sitting at a table illustrated that the majority (89.3%) either felt very comfortable or comfortable (Figure 11). Eventually, when they were asked if they enjoyed their interaction with the robot overall, most of them (78.6%) responded that they either enjoyed or enjoyed very much their interaction with the robot (Figure 12).

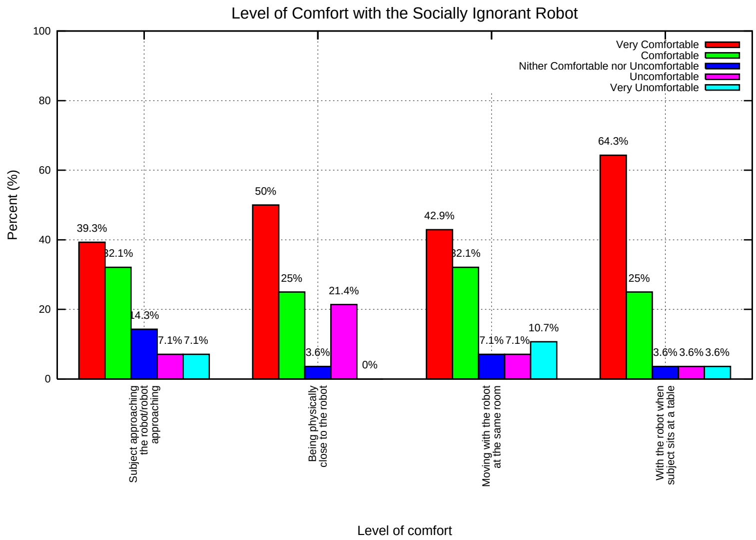

Figure 11: Level of Comfort with the Socially Ignorant Robot

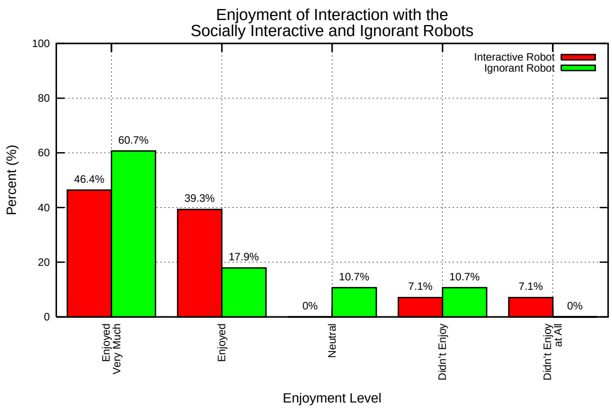

Figure 12: Enjoyment of Interaction with the Socially Interactive and Ignorant Robot

3.4. Overall Frequencies for Socially Interactive Robot Personality Questionnaire

In summary, the majority of the subjects described the Socially Interactive Robot B as (Figure 13):

- Not sociable (39.3%) and Sociable (35.7%)
- Not at all shy (53.6%)
- Not at all vulnerable (32.1%)
- Quite active (60.7%)
- Assertive (39.3%)
- Not at all anxious (57.1%)
- Not at all tense (50%)
- Not at all creative (32.1%)
- Low excitement seeking (39.3%)
- Not at all dominant (35.7%)
- Not at all aggressive (57.1%)
- Not at all impulsive (35.7%)
- Seemed to do what it was told /programmed to do (39.3%)
- Quite behaved intentionally (42.9%)
- Predictable (42.9%)
- Did not feel in control of the robot's behaviour (35.7%)
- Behaved very considerately towards the participants (46.4%)

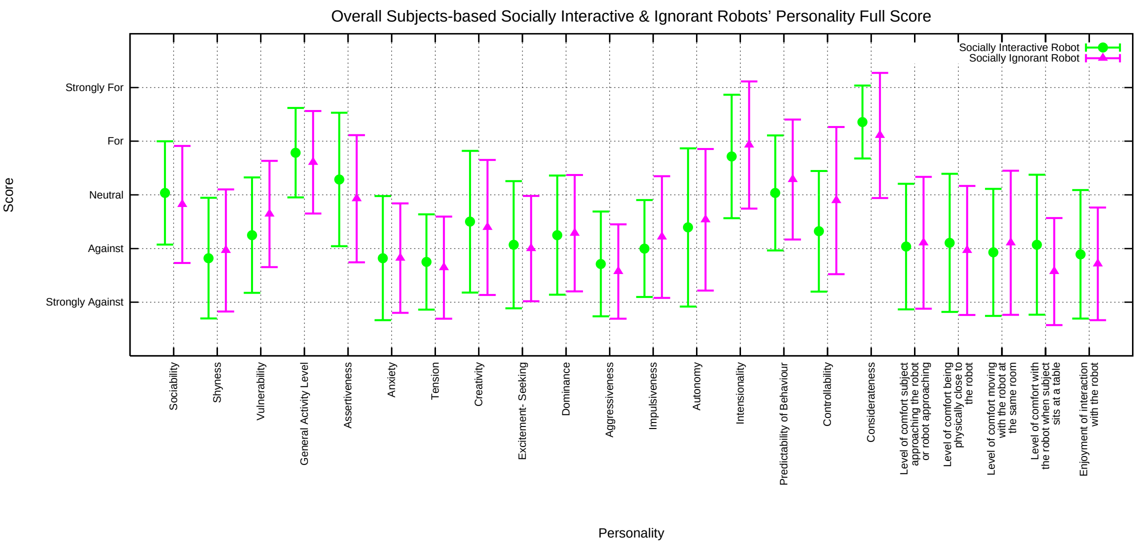

Figure 13: Items for Robot A and Robot B Personality scored on a 5-point Likert Scale (means and standard deviations are shown for each item)

Based on their general experience, most of the subjects felt either very comfortable or comfortable (75%) when they approached the robot or the robot approached them. It is also noteworthy that 78.6% of the participants felt either very comfortable or comfortable being physically close to the robot, and 75% felt either very comfortable or comfortable when they and the robot were moving in the same room. The subjects' level of comfort with the robot when they were sitting at a table illustrated that the majority (75%) either felt very comfortable or comfortable (Figure 14). Eventually, when they were asked if they enjoyed their interaction with the robot overall, most of them (85.7%) responded that they either enjoyed or enjoyed very much their interaction with the robot (Figure 12).

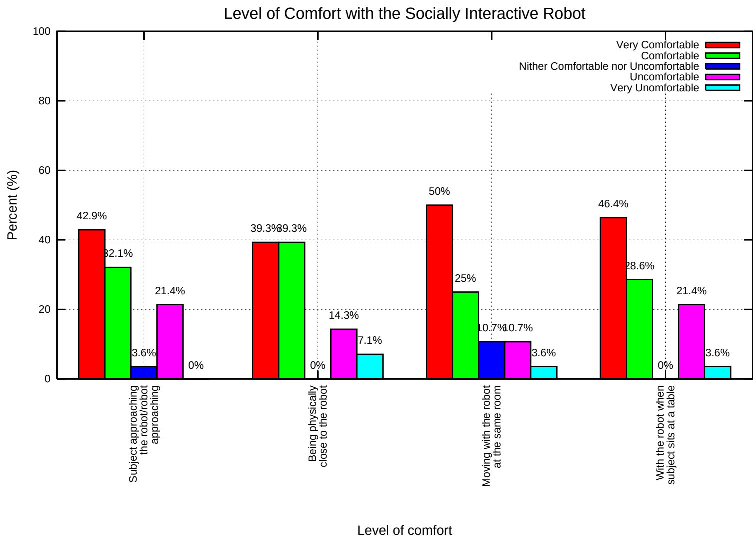

Figure 14: Level of Comfort with the Socially Interactive Robot

3.5. Differences in Personality characteristics between Robot A & Robot B

In order to examine differences between subjects' perceptions of personality characteristics for Robot A and Robot B, Paired-Samples T-tests (two-tailed) were computed. Few significant differences emerged, although Robot A (Socially Ignorant) was perceived by subjects as being more vulnerable than Robot B (Socially Interactive) [t (27) = 2.09; p=.05] (Figure 15).

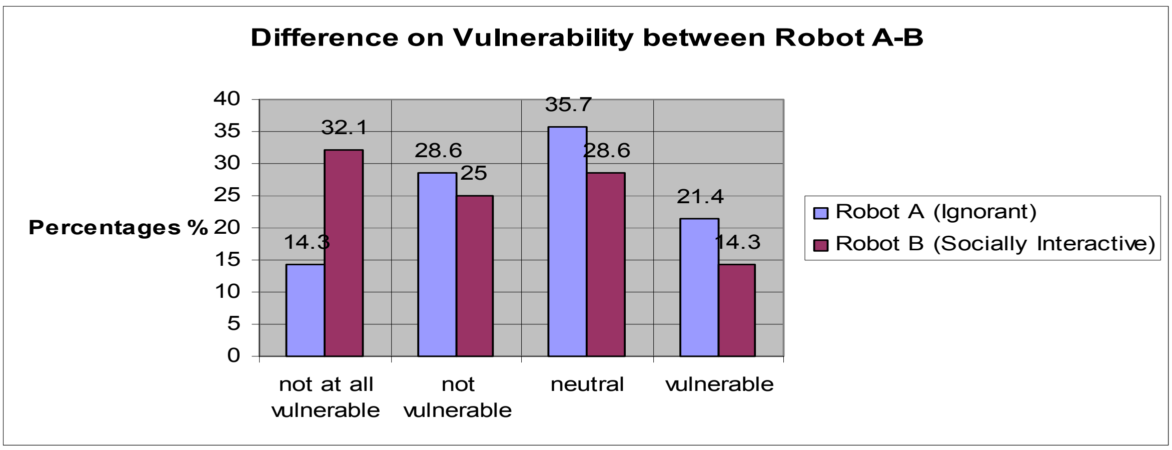

Figure 15: Difference on Vulnerability between
Socially Ignorant and Interactive Robot

The only other significant difference found was for assertiveness [t (27) =-2.42; p=002]. (Socially Interactive) Robot B (14.3% very assertive, 39.3% assertive) was perceived by subjects as being more assertive than (Socially Ignorant) Robot A (7.1% very assertive, 28.6% assertive) see Figure 13.

3.6. Differences in Personality characteristics between Subjects & Robot A/B

In order to test whether there were any significant differences in terms of personality between Subjects and Robot A (Socially Ignorant) and, between Subjects and Robot B (interactive), Paired-Samples T-tests (two-tailed) were computed.

The following significant differences were revealed when subject personality characteristics were compared to the personality of Robot A (Socially Ignorant) robot, subjects perceived themselves as:

- more sociable [t (27) = 3.75; p=.001] compared to Robot A
- shyer [t (27) =2.32; p=.02] than Robot A
- more assertive [t (27) =2.26; p=003] than Robot A
- more anxious [t (27) =4.56; p=.001] than Robot A
- more tense [t (27) =4.35; p=.001] compared to Robot A
- more creative [t (27) =5.03; p=.001] than Robot A
- higher in excitement-seeking [t (27) =5.15; p=.001] compared to Robot A
- more dominant [t (27) =3.01; p=.01] than Robot A
- more aggressive [t (27) =4.17; p=.001] compared to Robot A
- more autonomous [t (27) =5.78; p=.001] than Robot A.

Similar results were found from Paired-Samples T-test between subjects and Socially Interactive Robot B, subjects perceived themselves as:

- more sociable [t (27) =3.01; p=.006] compared to Robot B
- shyer [t (27) =2.77; p=.01] than Robot B
- more vulnerable [t (27) =3.01; p=.006] compared to Robot B
- more anxious [t (27) =3.91; p=.001] than Robot B
- more tense [t (27) =3.58; p=.001] compared to Robot B
- more creative [t (27) =3.97; p=0.001] than Robot B
- higher in excitement seeking [t (27) =5.35; p=.001] compared to Robot B
- more dominant [t (27) =2.78; p=.01] than Robot B
- more aggressive [t (27)=3.69; p=.001]compared to Robot B
- more impulsive [t (27) =4.15; p=.001] than Robot B
- more autonomous [t (27) =4.92; p=.001] compared to interactive Robot B.

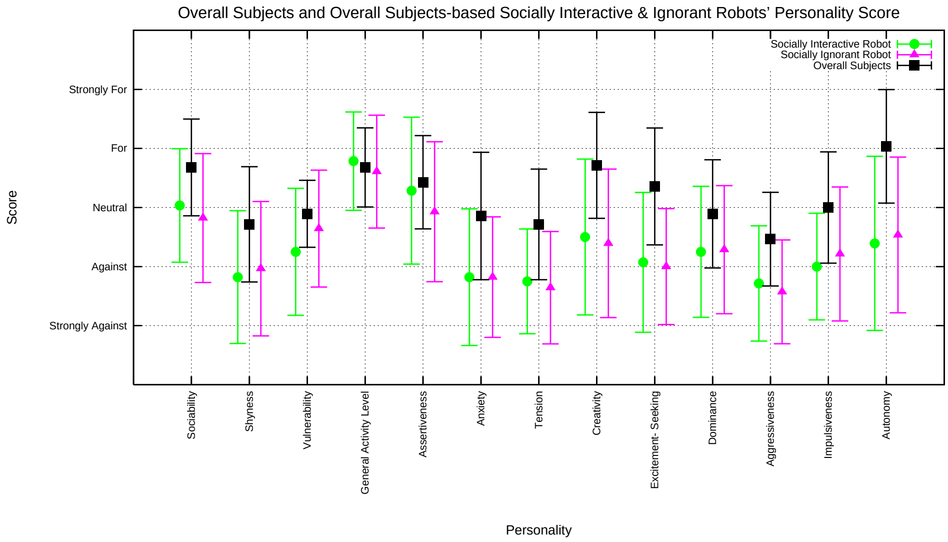

Figure 16: Compares personality characteristics for subjects and both robot A and B; means and standard deviations are shown

3.7. Overall Frequencies for Final Questionnaire

3.7.1. What is a robot companion?

Overall, 82.2% of the subjects liked or liked very much having computers/computer technology as part of their home environment. However, subjects' responses were divided on the idea of having a robot as a companion in the home (Figure 17). For example only 25% of all the participants liked very much the idea of having a robot as a companion at home.

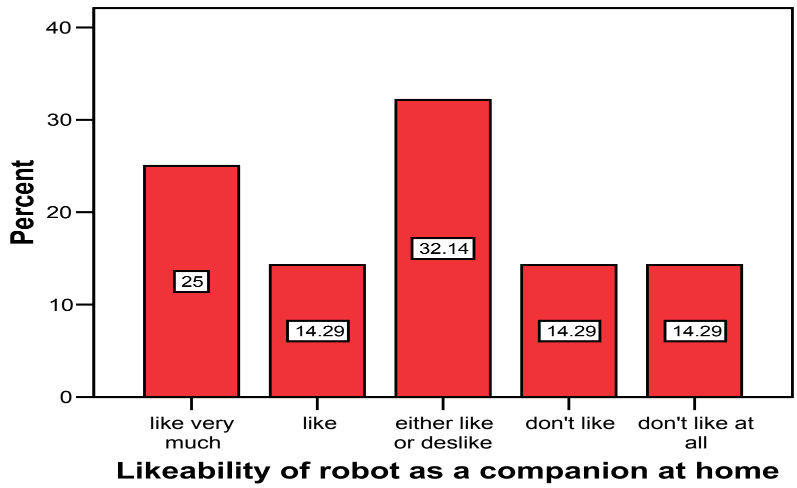

Figure 17: Likeability of Robot as a companion at home

When asked what role they thought a future 'robot companion in the home should have', the majority of subjects wanted the robot as an assistant (78.6%) and as a machine/appliance (71.4%) (Figure 18). When they were asked what tasks they would like this future robot to be able to carry out, the majority of the subjects wanted the robot to be able to do household (vacuuming) (96.4%). Only 10.7% of subjects wanted the robot to be able to look after their children (Figure 19). Guarding the house, entertainment and gardening were also popular choices for robot roles around the home (Figure 19).

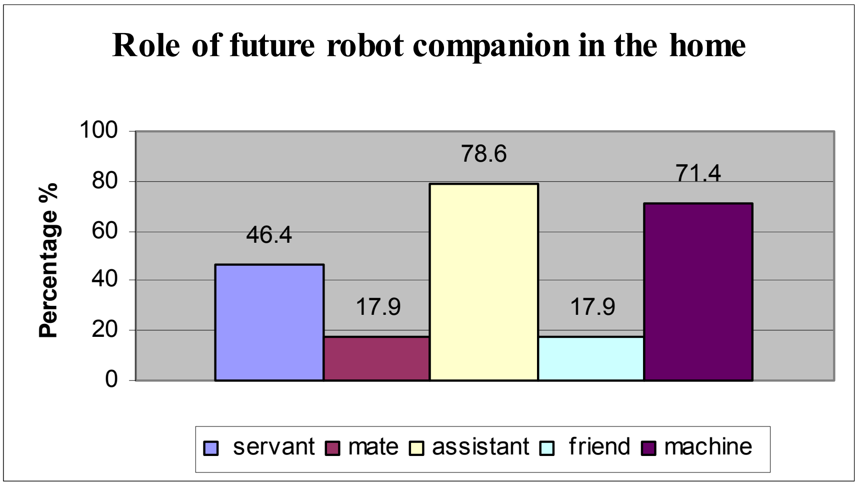

Figure 18: Role of Future Robot Companion in the Home; items presented, have been scored in a dichotomous format as either yes or no answers

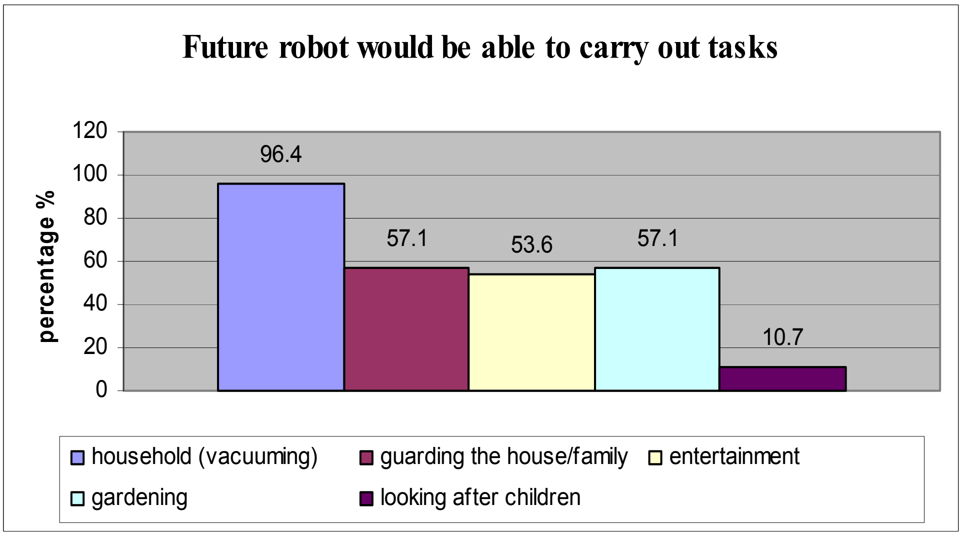

Figure 19: Future Robot would carry out different tasks; items presented, have been scored in a dichotomous format as either yes or no answers

The majority of subjects noted that the behaviour of a future robot should be

- Highly predictable (53.6%) or predictable (35.7%), and only 10.7% were neutral.
- 71.4% wanted the future robot to be highly controllable or controllable (25%) by the subject or other family members, and only one person (3.6%) thought it should not be controllable.
- Most of the participants wanted the future robot to behave either highly considerately (85.7%) or considerately (14.3%) towards them or other members in the family.

Regarding a human-like appearance for a future robot, the results show that:

- 28.6% of the subjects thought it should **appear** either human-like or very human-like

- 35.7% thought it should **behave** either human-like or very human-like
- 71.4% preferred the future robot to **communicate** either very human-like or human-like (Figure 20).

This indicates that most subjects attach more importance to human-like communication rather than human-like appearance.

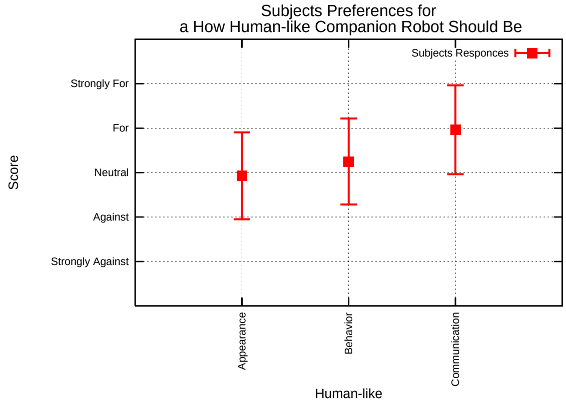

Figure 20: Future Robot's Human-like Appearance, Behaviour, Communication; Means and Standard deviations are shown

Subjects were asked with what speed should a considerate robot approach them and the majority (55.6%) responded neither slowly nor fast (Figure 21). When they were asked how close a considerate robot should come to the subject, most of the subjects reported close (63%) (Figure 21). Furthermore, the majority regarded that a considerate robot should pay attention (37%) or quite a bit of attention (48.1%) to what the subject is doing (Figure 21). Most of the subjects considered that if they encountered a considerate robot, it should be polite and give way to the subject (70.4%) (Figure 21). It is also noteworthy that when they were asked if a considerate robot should try to find out if the subject needs help before it helps, most subjects preferred (37%) the robot to try to find out if they need help or quietly wait to find out if they need help (40.7%) (Figure 21).

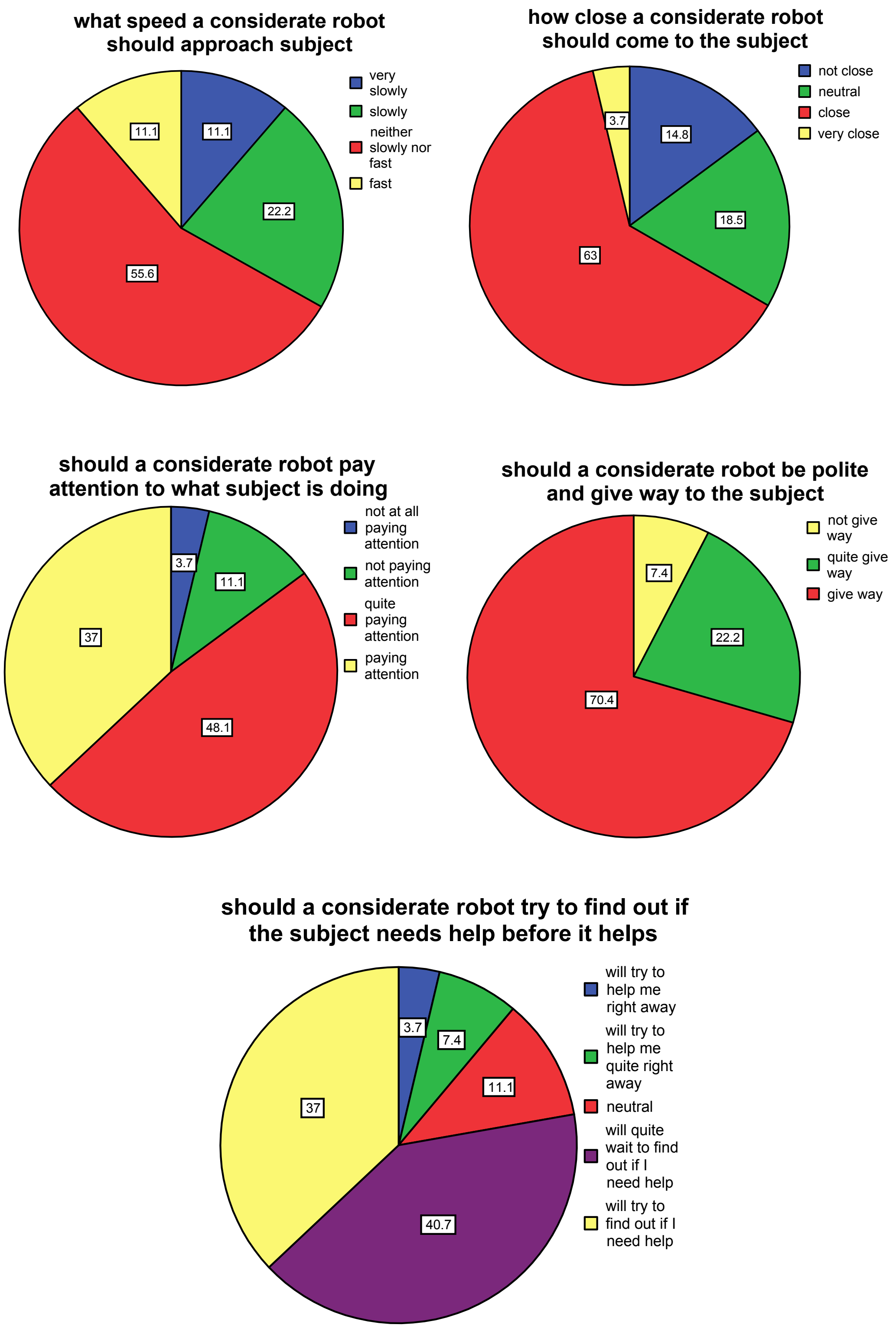

Figure 21: Pie Charts for what is a Considerate Robot

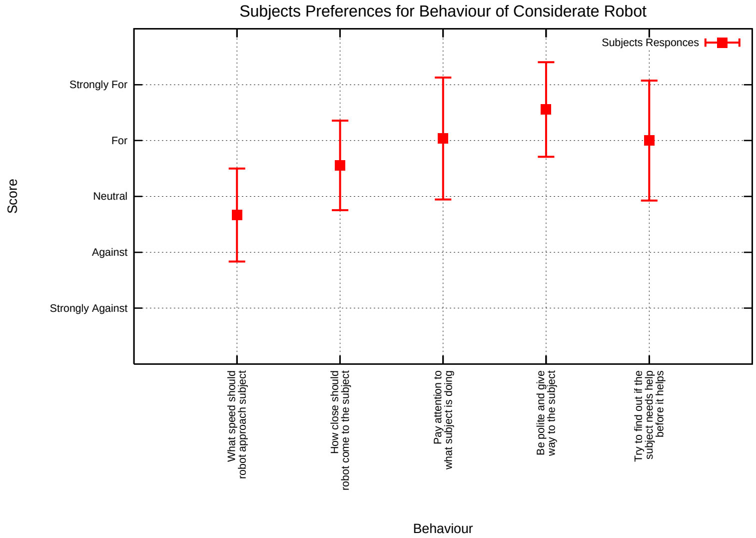

Figure 22: Means and standard deviations are shown for each item of what is a considerate robot?

3.7.2. The subjects' feelings after the session

In this section, the 28 subjects are asked to write down what they found most interesting about the robot during the experiment (their responses in number order):

1. The robot's camera pointing towards me, robotic arm, robot talking with me, the room atmosphere with lots of cameras. Overall, it's a very good robot both technically and socially.
2. The robot seems to communicate well or respond well to what I was doing.
3. My level of comfort grew with the robot the longer I was in the room; I wanted to know if it was thinking for itself or being controlled. I felt that it was interesting when it spotted I did not have a pen and helped out. I also enjoyed the fact that it spoke.
4. Getting the pen for me, general attitude.
5. Ability to get me the right colour of pen required, polite 'you go first' attitude and behaviour, mostly it amused me.
6. It understood what I meant: first time it took time but the second time, it was fast so I felt very relaxed to do my work.
7. Its helpfulness in completing the tasks, assisting while allowing me to finish the tasks.
8. Verbal communication, varied vocabulary, just use of functional language made me feel more comfortable.
9. Its spatial awareness.
10. Robot was helpful and I almost thought of it as human-like at the point which amazed me.
11. The way it spoke and moved without being intrusive.
12. It was considerate and polite to me.
13. Ability to recognise I needed a pen.

14. Trying to be helpful.
15. Its slow speed.
16. The appearance of the robot was interesting, the mobility, the communication was quite amusing.
17. This experiment gives the feeling of having a look at a future situation.
18. When I needed pens it brought them to me; it gave way to me during my task.
19. That it decided I needed extra pens.
20. Fetching pens showed potential usefulness; polite when getting in the way.
21. Able to navigate freely without contact collisions; impressed with accuracy of retrieving objects.
22. Ability to recognise I needed a pen.
23. It has a degree of autonomy; it is a great bonus to have minor tasks done for you.
24. I was surprised that I felt very at ease with the robot.
25. Watching the behaviour of the robot; not knowing how the robot would behave next.
26. It appeared to observe my actions and act accordingly; it did not seem entirely programmed.
27. It is polite.
28. Human-like interchange- ‘Hello’, ‘After You’.

Then, the 28 subjects are asked to describe what they found most annoying about the robot during the experiment (their responses in number order):

1. The robot’s sound, and not walking with two legs like a human.
2. Looking at you when you’re doing something, especially when you need to concentrate.
3. I felt uncomfortable by its continued moving around and activity, particularly when it was behind me, and got too close, it felt it was too busy.
4. When it spoke critically, background noise as it moved around because it did not seem to be doing anything.
5. It was slightly in the way when I was copying from the board; cameras felt as if they were watching a lot, although it did not make me feel uncomfortable.
6. Only the noise that it made.
7. Slowness and its attentiveness towards me. I would neither have a cat nor a dog.
8. At the desk, the robot felt too ‘human’ and I had the sense of being too closely observed, I felt uncomfortable.
9. It responded to me rather than entering into any sort of physical or communicative challenge.
10. In the second experiment, the robot was getting in my way as it wandered across the room.

11. Slowness at getting pens, quicker to do it myself and noise when moving
12. Nothing at all.
13. When it was lurking behind me as I wrote on the whiteboard and when it appeared to be monitoring me intensely at the desk.
14. Hanging around the desk and wandering around when it did not seem to be doing anything.
15. Small vocabulary.
16. The electric 'sizzling' sound was a bit unpleasant; I wondered whether you would get an electric shock if it came too close.
17. Robot should not behave as a person.
18. Noise; it moved a bit too much when I was writing down the names of the books on the whiteboard.
19. Occasionally it got in the way.
20. I wasn't sure when it was going to come towards me; I couldn't really have a conversation with it.
21. When writing, it came over uninvited and watched me.
22. When writing, it came close to the desk and watched me; move around the room.
23. Noise, especially distracting when behind you.
24. Occasionally it got in the way.
25. The robot having a camera.
26. When writing, it came close to the desk and watched me; move around the room while I had my back turned.
27. It did not ask whether I needed the pens, but just went for it; I had the feeling it stared at me when I was writing the book titles.
28. Occasionally it got in the way.

[Preliminary analysis of subjects comments are discussed in WP. 3.1 Report, D3.1.1]

At the end of the questionnaire, when the subjects were asked if they thought anything should be changed regarding the robot, 92.9% replied positively. 42.9% would change the robot's appearance, 39.3% wanted to change the robot's speech, and 42.9% suggested changing the robot's behaviour.

All subjects made a suggestion about changing the robot that is reflected in Table 4, and each of them has made one statement.

Table 4: Other changes of Robot

Other changes of robot	Frequency
Better no sound	1
Clearer speech	2
Better female voice	1
More gentle speech	1
Give personality to the robot	1
Give hand/fingers and two eyes	1
Pen should be brought only after request/ act only after command for a task	5
Less noise/ remain more quiet/more still	4
Less speed move/Observe at more distance	2
More behaviours	1
More colour, More chatty	1
More gentle/friendly	1
More human-like speech/More words	2
More human-like appearance/eyes	2
More motion	1
More smooth behaviour/ movement	2
Total	28

3.7.3. Overall comments at the end of the final questionnaire

The 28 subjects' responses in number order:

1. I like the robot very much, as I am very much interested in Robotics and making a walking robot. It's a very good idea to develop a human robot. Thanks very much for inviting me for this project as I had seen robots only on television, and today I got the chance to see an actual robot and to interact with it.
2. It should look friendlier, gentle, not like a killing robot (e.g. its arm). It makes me thinking of terminator.
3. It was moving about too much in a relatively small space. Speech could have been softer in terms of accent. I would have liked to have chatted with the robot.
4. Clearer speech
5. Cameras could be less obvious so you don't feel as watched
6. More human kind of appearance and speech, excited about helping with the project.
7. Remain quiet in a specific place until needed.
8. I would be interesting to interact directly with the robot.
9. I believe that the robot exhibits behaviours that appear to be human controlled because I am not totally sure the robot is autonomous, my reaction to it is perfectly directed towards the human controller.
10. I loved the robot; I can't wait to see it performing more tasks.
11. Does everything need to be in correct/ same place for it to operate?
12. It should be more functional in terms of motion.
13. It was very interesting to learn something about the development of robots.

14. It should respond only to commands and be faster.
15. Enjoyable experience for me.
16. It would be interesting if robot had female voice.
17. This was a very interesting experience.
18. I enjoyed the experiments very much.
19. Speech should be more human-like.
20. I could see one robot being useful at work, fetching tea, photocopying, taking messages etc. The home version would have to be smaller for lots of homes.
21. Very interesting experiment, I am glad I took part.
22. I saw 'I robot' a couple of weeks ago which made me more scared than perhaps I might have been!
23. More human-like, have a personality would probably make interaction feel more natural.
24. More human-like, than machine.
25. This was a fun experiment.
26. As the experiment progressed I felt very comfortable with the robot; I was able to trust it was not going to malfunction and walk into me.
27. A more human-like voice; ask question before acting.
28. No need to constantly move around when not performing a task; Very interesting.

[Preliminary analysis of subjects comments are discussed in WP. 3.1 Report, D3.1.1]

3.8. Overall Frequencies for NARS Questionnaire

The NARS (Negative Attitude towards Robots Scale) instrument is composed of 16 sentences describing attitudes towards robots. The subjects were asked to judge these sentences. (Appendix 2 for detailed description of subject's responses; Frequencies and Percentages are shown).

To summarise, the subjects' predominant responses were:

- They completely disagreed about having seen live robots before (46.4%)
- They completely agreed about feeling uneasy if robots really had emotions (50%)
- They completely agreed that something bad might happen if robots developed into living beings (53.6%)
- Half of them completely agreed feeling relaxed talking with robots (32.1%) and the other half were undecided (32.1%)
- They completely disagreed feeling uneasy if they were given a job where they had to use robots (78.6%)
- If robots had emotions, half of the subjects completely disagreed that they would be able to make friends with them (25%) and the other half were undecided (25%)

- They completely disagreed feeling comforted being with robots that have emotions (32.1%)
- They completely disagreed that the word ‘robot’ means nothing to them (64.3%)
- They either disagreed (39.3%) or completely disagreed about feeling nervous operating a robot in front of other people (39.3%)
- They completely disagreed that they would hate the idea that robots or artificial intelligences were making judgments about things (39.3%)
- They completely disagreed feeling nervous just standing in front of a robot (82.1%)
- They disagreed with the statement that if they depended on robots too much, something bad might happen (32.1%)
- They were undecided about the statement that if they trust robots too much, something bad might happen (35.7%)
- They disagreed about feeling paranoid talking with a robot (42.9%)
- They were undecided about whether robots would be a bad influence on children; however half of the subjects either disagreed or completely disagreed with that statement (32.1%)
- They were undecided about whether in the future, society will be dominated by robots, although a good proportion of subjects either disagreed or completely disagreed with that statement (39.3%)

Further analysis has not been performed.

3.9. Analysis of Personality Types

In Hans J. Eysenck’s (1991) view, personality types are not categories that a few people fit; rather, types are dimensions on which all persons differ. Types, like traits, tend to be normally distributed, meaning that they are continuous dimensions and most people fall around the average mark.

Eysenck’s model of personality is structural. Types are composed of traits; traits are composed of habitual responses.

He applied factor analysis to ratings and classifications of 10.000 soldiers. From all his research, he concluded that personality can be understood in terms of three basic personality factors (Eysenck & Eysenck, 1985):

Neuroticism vs. Emotional Stability

- An individual’s adjustment to environment and stability of behaviour over time
- Traits associated: Anxious, depressed, guilt feelings, low self-esteem, tense, irrational, shy, moody, emotional
- Traits used for our study: Anxiety, Tension, Shyness, emotional (Vulnerability)

Extraversion vs. Introversion

- Degree to which a person is outgoing and participative in relating to others

- Traits associated: Sociable, lively, active, assertive, sensation seeking, carefree, dominant, surgent, venturesome
- Traits used for our study: Sociability, General Activity Level, Assertiveness, Excitement-Seeking, Dominance

Psychoticism

- The loss of distortion of reality and the inability to distinguish between reality and fantasy
- Not a dimension like the other two (it does not consist of polar opposites) — but present in all individuals to some degree
- Traits associated: Aggressive, cold, egocentric, impersonal, impulsive, antisocial, un-empathetic, creative, tough-minded
- Traits used for our study: Aggressiveness, Impulsiveness, Creativity

3.9.1. Overall Frequencies for Personality Types

Subject Personality Types

Overall, the majority (71.4%) of the subjects were neutral towards the neuroticism versus emotional stability dimension. Also, only one person (3.6%) was introvert, whilst all other subjects (96.4%) were either neutral towards the extraversion versus introversion dimension or extroverts/very extroverts. Furthermore, most (60.7%) of them were neutral towards psychoticism.

Robot A (Socially Ignorant) Personality Types

Most of the subjects perceived Robot A either as emotionally stable (39.3%) or very emotionally stable (25%) (Figure 23). 35.7% described the Socially Ignorant robot as introvert, whereas only 14.3% thought it was extrovert (Figure 24). Most participants perceived robot A as not being psychotic and only 7.1% perceived it as psychotic (Figure 25).

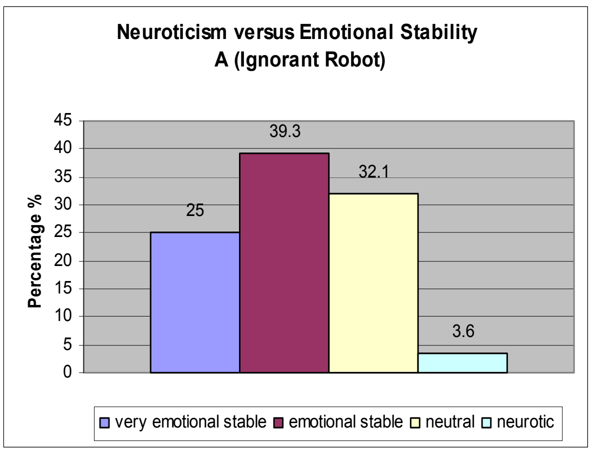

Figure 23: Socially Ignorant Robot's Perceived Neuroticism vs. Emotional Stability

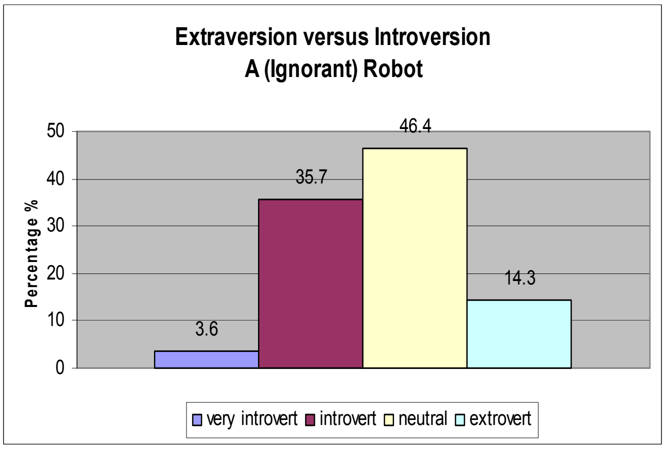

Figure 24: Socially Ignorant Robot's Perceived Extraversion vs. Introversion

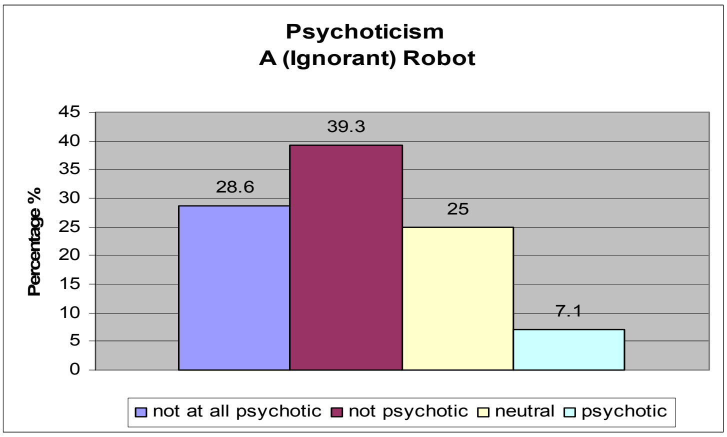

Figure 25: Socially Ignorant Robot's Perceived Psychoticism

Robot B (Socially Interactive) Personality Types

Most of the subjects thought Robot B was emotionally stable and only 7.1% perceived the interactive robot as neurotic (Figure 26). Most participants thought Robot B was introvert (28.6%) or neutral (50%) (Figure 27). Furthermore, most of the participants perceived robot B as not being psychotic (Figure 28).

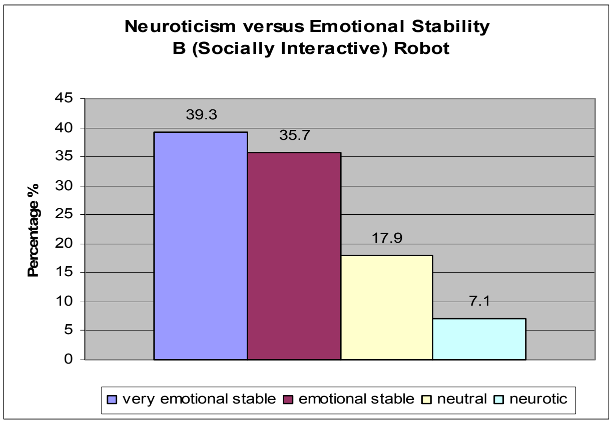

Figure 26: Socially Interactive Robot's Perceived Neuroticism vs. Emotional Stability

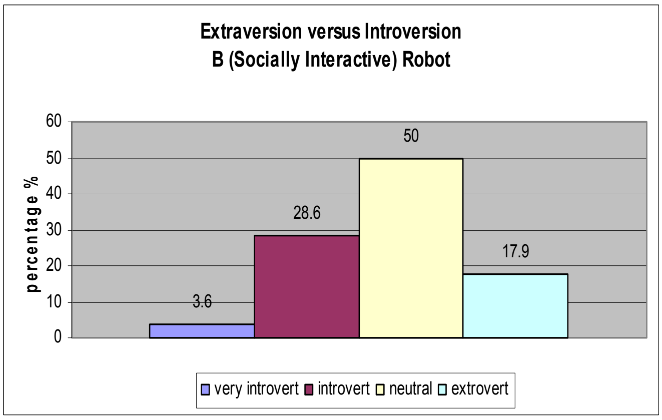

Figure 27: Socially Interactive Robot's Perceived Extraversion vs. Introversion

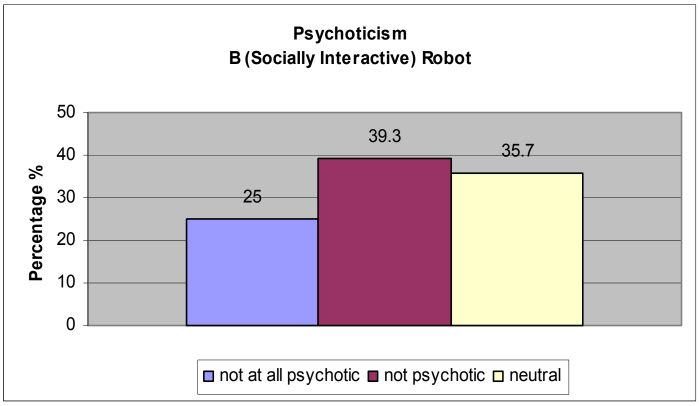

Figure 28: Socially Interactive Robot's Perceived Psychoticism

3.9.2. Differences between Personality Types

In order to examine differences between the two robots' personality types, Paired-Samples T-tests (two-tailed) were computed; nevertheless no significant difference was found between the two robots.

In order to test if subjects attributed their own personality types to the robot, Paired-Samples T-tests (two-tailed) were computed to examine if there are any significant differences in terms of personality types firstly between Subjects and Robot A (Socially Ignorant) and then between Subjects and Robot B (Socially Interactive).

The result suggests that there was no similarity between the subjects' and the robots' personality types. They perceived:

- Both Robot A [t (27) =4.08; p=.001] and Robot B [t (27) =4.79; p=.001] as more emotionally stable than themselves.
- Both Robot A [t (27) =4.75; p=.001] and Robot B [t (27) =3.65; p=.001] were described as more introverted than themselves.
- They thought of themselves as being more psychotic than both Robot A [t (27) =5.39; p=.001;] and Robot B [t (27) =5.39; p=.001].

3.10. Gender Differences

In order to examine gender differences in the subjects' responses for all questionnaires, Independent-Samples T-tests (Two-tailed) show that male participants had more extensive technical knowledge of robots than females [t (26) =2.30; p=.03]. For example, 79% of females had limited technical knowledge of robots whereas only 50% of males had limited technical knowledge, and 14% of males had extensive technical knowledge of robots compared to no females.

Females were found to be more sociable than males [t (26) =-2.86; p=.008], and females were noted to be more dominant than males [t (26) =-2.47; p=0.02]. For example 85.7% of females rated themselves as being sociable or very sociable compared to only 35.7% of males. For dominance, 42.8% of females rated themselves as dominant or very dominant compared to only 7.1% of males.

Males also felt more in control of the Socially Ignorant (A) robot's behaviour compared to the females [t (26) =2.98; p=.006]. For example, 28.6% of males stated feeling in control of the robot's behaviour compared to no females. 35.7% of females stated that they did not feel at all in control of the robot's behaviour compared to only 7.1% of males.

The remaining significant difference was between males and females desirability for a future robot being able to do the gardening [t (26) =-2.45; p=.02.] 78.6% of the female subjects wanted the future robot to be able to do gardening in comparison with only 35.7% of the males.

3.11. Differences in responses between Staff & Students

In order to examine differences in responses between staff members and students of the university, Independent-Samples T-tests (Two-tailed) were computed.

The majority of the students (81.9%) responded that they would feel relaxed talking with robots compared to only a few staff members who were mostly undecided (58.3%) [t (21) =2.18; p=.04]. Some of the staff members (32%) suggested that they would be nervous operating a robot in front of others in comparison with none of the students (0%) who stated that they would be confidant operating a robot in front of others (63.5%) [t (21) =-2.53; p=.02]

3.12. Differences in responses between technology related & non-related subjects

According to the subjects' educational or employment background, differences on their responses were examined between those who came from a technology-related department (e.g. computer science, electronics and engineering) and those who came from a non-technology related department, such as psychology, law and business; Independent-Samples T-tests (Two-tailed) were computed.

Few significant differences emerged. However, the results suggest that subjects who came from a technology-related background enjoyed their interaction must more with the Socially Ignorant A robot than those that came from a non-technology related background [t (26) =2.83; p=.009] (see Figure 29). Secondly, subjects who came from a technology-related background described the Socially Interactive robot B as impulsive compared to none of those that came from a non-technology related background [t (26) =-3.48; p=.002] (Figure 30).

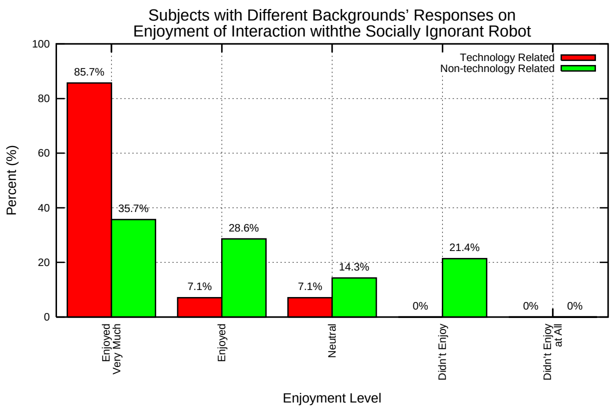

Figure 29: Difference between subjects with technology related & non-related background on enjoyment of interaction with the Socially Ignorant Robot

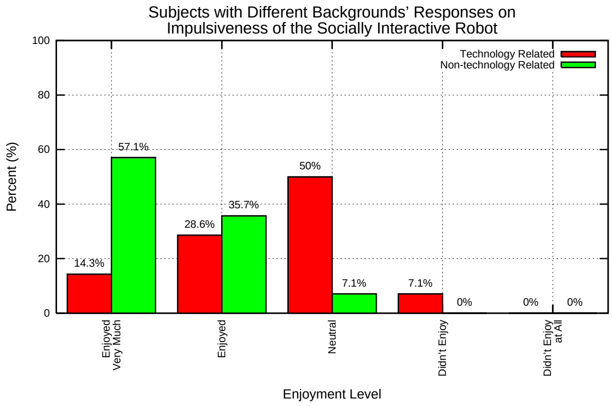

Figure 30: Difference between subjects with related &non-related robotics/technology background on impulsiveness of Socially Interactive Robot

3.13. Differences on subjects' responses between experimental conditions

The experiment with the robots was counterbalanced; meaning that half of the participants were exposed firstly to the Socially Ignorant robot A and then to Socially Interactive robot B (Experimental Condition A=>B) and the other half were exposed firstly to the interactive robot B and then to ignorant robot A (Experimental Condition B=>A). The responses of those exposed to experimental condition A=>B were compared to the responses of those exposed to experimental condition B=>A, and Independent-Samples T-tests (Two-tailed) were computed to see if there were any significant differences.

Results indicate that those exposed to experimental condition B=>A described themselves as more tense than those exposed to experimental condition A=>B [t (26) =-2.15; p=.04] (Figure 31).

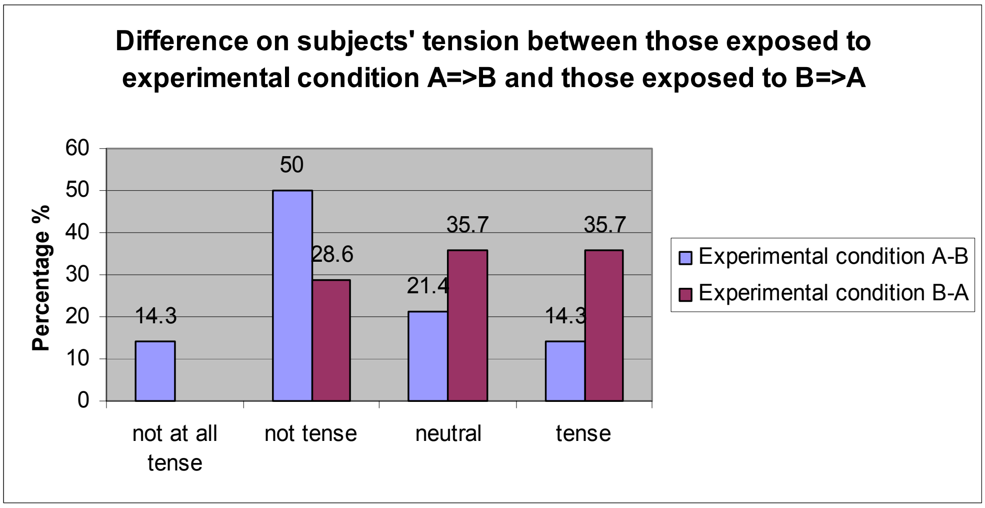

Figure 31: Difference on subjects' tension between those exposed to A=>B &those exposed to B=>A

Only the participants were exposed to experimental condition A=>B perceived the Socially Interactive robot B as aggressive or were undecided. All of those exposed to experimental condition B=>A thought that robot B was not aggressive [t (26) =2.55; p=.02] (Figure 32).

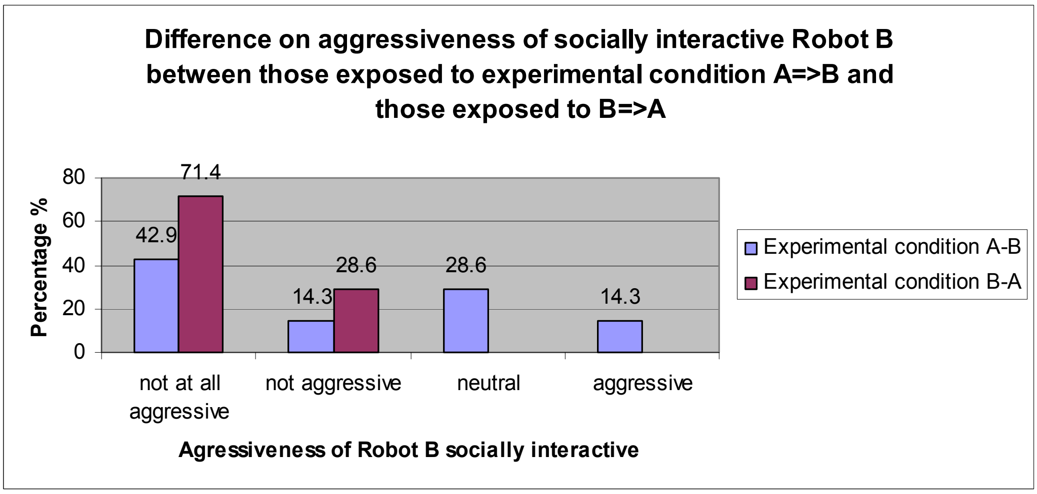

Figure 32: Difference on aggressiveness of Socially Interactive Robot between those exposed to A=>B &those exposed to B=>A

The vast majority of those exposed to experimental condition B=>A felt comfortable with the interactive robot B when they approached the robot or the robot approached them, whilst much fewer participants that were exposed to experimental condition A=>B felt comfortable with robot B [t (26) =2.253; p=0.033; p<0.05] (Figure 33).

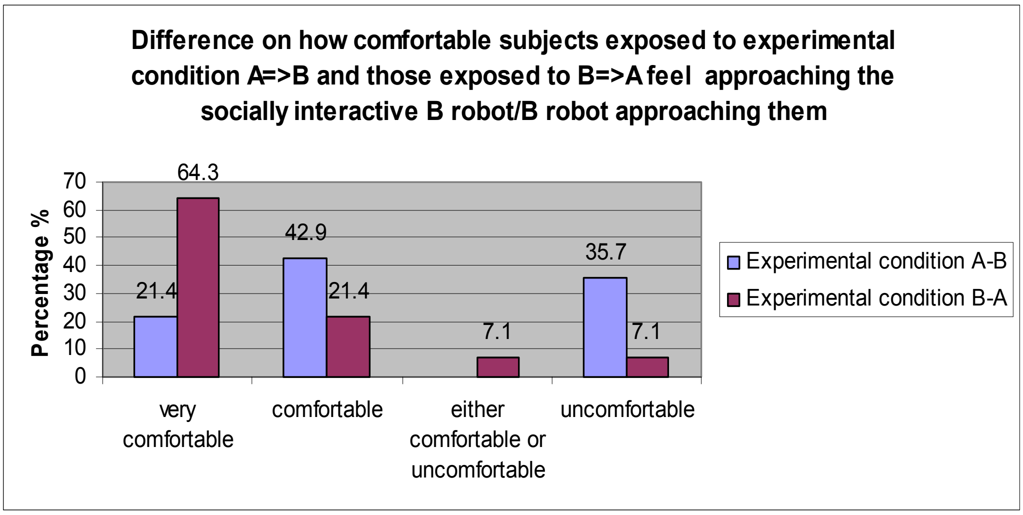

Figure 33: Difference on how comfortable subjects exposed to A=>B & those exposed to B=>A feel approaching the B Robot/B robot approaching them

3.14. Differences between responses of younger (<35) and older (>35) subjects

Differences on subjects' responses were examined between younger ones who are under 35 (14 subjects) and older ones who are over 35 (14 subjects); Independent-Samples T-tests (Two-tailed) were computed. Younger participants had more extensive technical knowledge of robots than older ones [t (26) =2.30; p=.03]. For example 14% of older subjects had extensive technical knowledge of robots compared to 0% of older subjects. Younger subjects perceived themselves as more excitement seeking compared to the older ones [t (26) =2.51; p=.02]. The majority of younger participants perceived the Socially Ignorant robot A to be more assertive in comparison with the perceptions of older ones that did not think it was very assertive [t (26) =2.43; p=.02]. For example 64% of younger participants perceived Robot A as being assertive compared to only 7% of the older subjects.

All of the younger participants thought the Socially Interactive robot B was active [t (26) =3.94; p=.001] compared to only half of the older ones; larger percentage of younger than older subjects perceived the interactive robot as assertive [t (26) =2.70; p=.01]. Only the younger subjects suggested they would like to have the future robot companion in the home as a friend, compared to none of the older ones [t (26) =2.69; p=.01]. Younger subjects preferred a Socially Interactive robot to pay attention to what they were doing more than older ones [t (26) =2.07; p=0.05]. Only a few younger subjects, compared to none of the older ones, would feel paranoid talking with a robot [t (26) =2.18; p=.04]

Finally, only the younger subjects perceived the Socially Interactive robot B as an extrovert compared to none of the older ones who either were undecided or thought of robot B as an introvert [t (26) =2.39; p=.03]

3.15. Differences on subjects' responses between 1st & 2nd robot exposure

Without taking into consideration the different personalities attributed to the robots by the researchers (Socially Ignorant A or Socially Interactive B), the subjects' responses after their first session with the robot were compared to their responses after they were exposed to the robot for the second time; Paired-Samples T-tests (Two-tailed) were computed to see if there were any significant differences (Habituation Effect).

Subjects described the robot they saw the second time as more aggressive than the same robot they had been exposed to the first time [t (27) =-2.42; p=.02]. Thus, as they get used to the robot they think it behaves more aggressively. In addition, as expected, the participants thought that the robot's behaviour was more predictable after their second exposure rather than when they interacted with the robot for the first time [t (27) =-2.06; p=0.05]. Therefore, as they got used to the robot they tended to believe that its behaviour was more predictable (Figure 34).

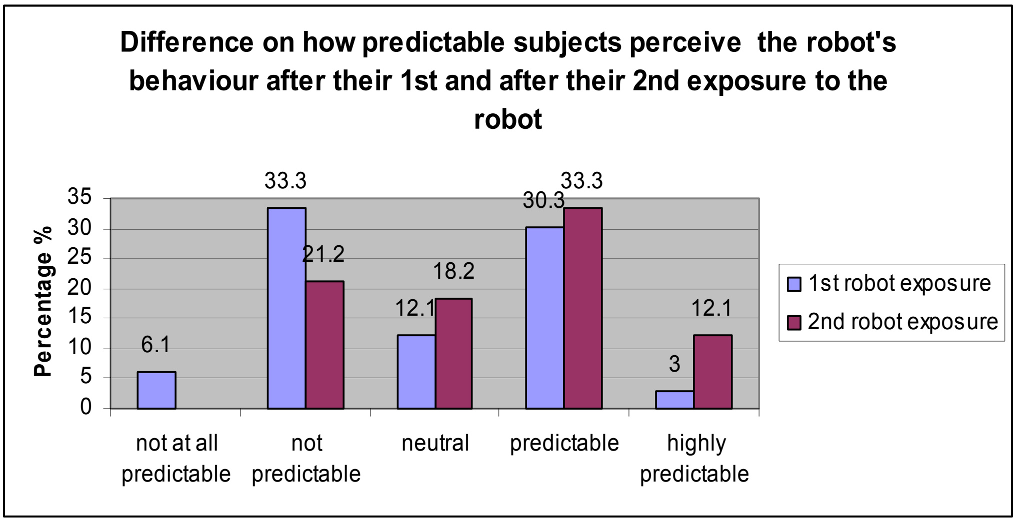

Figure 34: Difference on how predictable subjects see the robot's behaviour after their first and after their second exposure to the robot

3.16. Correlation between all subjects' and robots' personality characteristics

In addition, Pearson Correlation Coefficients were calculated in order to examine the relationship between subjects' and robots' personality characteristics overall.

- The results showed one significant positive linear relationship between subject's dominance and Socially Ignorant robot's A dominance [r (26) =0.44; p=.02]. This indicates that the more dominant the subjects, the more dominant they perceived the Socially Ignorant robot A to be (or vice-versa); so they assign one of their personality characteristics to the Socially Ignorant robot. No significant correlations were found between subjects and the Socially Interactive robot B.

3.17. Correlation between all subjects' and robots' personality types

- No significant correlations were revealed between subjects' and robots' personality types.

3.18. Correlation between males' perception of themselves & those of robots

- A significant positive linear relationship between males' anxiety and Socially Ignorant robot's A anxiety [r (14) =0.58; p=.03] was found. This indicates that the more anxious the male subjects, the more anxious they perceived the Socially Ignorant robot A (or vice-versa).
- A significant positive linear relationship was found between males' psychoticism and Socially Ignorant robot's A psychoticism [r (14) =0.55; p=.04]. This indicates that the more psychotic the male subjects, the more psychotic they perceived the Socially Ignorant robot A was (or vice-versa); so males assigned one of their personality characteristics and one of their personality types to the Socially Ignorant robot.
- No significant correlations were found between male subjects and the Socially Interactive robot B.

3.19. Correlation between females' perception of themselves & those of robots

- A significant positive linear relationship was reported between females' assertiveness and Socially Ignorant robot's A assertiveness [r (14) =0.66; p=.01]. This indicates that the more assertive the female subjects, the more assertive they perceived the Socially Ignorant robot A was (or vice-versa).
- Another significant positive linear relationship was found between females' dominance and Socially Ignorant robot's A dominance [r (14) =0.58; p=.03]. This shows that the more dominant the female subjects, the more dominant they perceived that the Socially Ignorant robot A was (or vice-versa); so females assigned two of their personality characteristics to the Socially Ignorant robot. No significant correlations were found between female subjects and the Socially Interactive robot B.

3.20. Correlation between students' perception of themselves & those of robots

- A significant positive linear relationship was found between students' vulnerability and Socially Ignorant robot's A vulnerability [r (11) =0.73; p=.01]. This indicates that the more vulnerable the students, the more vulnerable they perceived the Socially Ignorant robot A be (or vice-versa)
- A significant negative linear relationship was found between students' general activity level and Socially Ignorant robot's A general activity level [r (14) =-0.67; p=.02]. This indicates that the less active the students, the more active they perceived that the Socially Ignorant robot A was (or vice-versa).
- Three significant positive linear relationships were found between students' assertiveness, creativity, excitement seeking and Socially Interactive robot's B assertiveness [r (11) =0.64; p=.03], creativity [r (11) =0.64; p=.04], excitement seeking [r (11) =0.62; p=.04. All these indicate that the more assertive, creative and

excitement seeking the students, the more assertive, creative and excitement seeking they perceived that the interactive robot B was (or vice-versa)

- Significant positive linear relationships were found between students' psychoticism and Socially Ignorant robot's A psychoticism [r (11) =0.75; p=.007] as well as Socially Interactive robot's B psychoticism [r (11) =0.72; p=.01]. These indicate that the more psychotic the students, the more psychotic they perceived that Socially Ignorant robot A was, and the interactive robot B was (or vice-versa)

3.21. Correlation between staff's perception of themselves & those of robots

- Two significant negative linear relationships were found between staff members' excitement seeking, aggressiveness and Socially Ignorant robot's A excitement seeking [r (12) =-0.60; p=.04] and aggressiveness [r (12) =-0.76; p=.004]. These indicate that the more excitement seeking and aggressive the staff, the more excitement seeking and aggressive they perceived that the Socially Ignorant robot A was (or vice-versa)

3.22. Correlation between older subjects' perception of themselves & those of robots

- One significant negative linear relationship between older subjects' aggressiveness and Socially Ignorant robot's A aggressiveness was found [r (14) =-0.62; p=.02]. This indicates that the less aggressive the older subjects, the more aggressive they perceived the Socially Ignorant robot A was (or vice-versa)

3.23. Correlation between younger subjects' perception of themselves & those of robots

Five significant positive linear relationships were found between younger subjects' and Socially Ignorant robot's A for:

- assertiveness [r (14) =0.70; p=.005]
- anxiety [r (14) =0.64; p=.02]
- aggressiveness [r (14) =0.55; p=.04]
- impulsiveness [r (14) =0.57; p=.03]
- psychoticism [r (14) =0.68; p=.007]

All these indicate that the more assertive, anxious, aggressive, impulsive and psychotic the younger subjects, the more assertive, anxious, aggressive, impulsive and psychotic they perceived that the Socially Ignorant robot A was (or vice-versa).

3.24. Correlation between technology related subjects' perception of themselves & of robots

- Two significant positive linear relationships were found between technology related subjects' anxiety, aggressiveness and the Socially Ignorant robot A's anxiety [r (14) =0.51; p0.04], aggressiveness [r (14) =0.57; p=.04]. This indicates that the more anxious, and aggressive, the technology related subjects, the more anxious, and aggressive they perceived that the Socially Ignorant robot A was (or vice-versa).
- A significant negative linear relationship was found between technology related subjects' general activity level and Socially Ignorant robot's A general activity level [r (14) =-0.65; p=.01]. This shows that the less active the technology related subjects, the more active they perceived that the Socially Ignorant robot A was (or vice-versa).
- Two significant positive linear relationships were found between technology related subjects' anxiety, excitement seeking and Socially Interactive robot's B anxiety [r (14) =0.62; p=.02], and excitement seeking [r (14) =0.54; p=.055]. This indicates that the more anxious, and excitement seeking, the technology related subjects, the more anxious, and excitement seeking they perceived that the interactive robot B was (or vice-versa).
- A significant negative linear relationship was found between technology related subjects' shyness and interactive robot's B shyness [r (14) =-0.60; p=.02]. This shows that the less shy the technology related subjects, the more shy they perceived that the interactive robot B was (or vice-versa).

3.25. Correlation between technology non related subjects' perception of them & of robots

No significant correlations were found.

3.26. Correlation between subjects' (exposed to experimental condition A=>B, Socially Ignorant=>Socially Interactive) perception of themselves & those of robots

No significant correlations were found.

3.27. Correlation between subjects' (exposed to experimental condition B=>A, Socially Interactive => Socially Ignorant) perception of themselves & those of robots

- Two significant positive linear relationships were found between subjects' [that are exposed to experimental condition B (Socially Interactive) =>A (Socially Ignorant)] dominance and Socially Ignorant robot's A dominance [r (14) =0.67; p=.009], as well as Socially Interactive robot's B dominance [r (14) =0.69; p=.006]. This indicates that the more dominant the subjects exposed to experimental condition B=>A, the more dominant they perceived both the Socially Ignorant robot A and the Socially Interactive robot B (or vice-versa).

- A significant negative linear relationship was found between these subjects' tension and Socially Interactive robot's B tension [r (14) =-0.73; p=.003]. This shows that the more tense the subjects exposed to experimental condition B=>A, the less tense they perceived that the Socially Interactive robot B was (or vice-versa).

3.28. Personality Attribution

In this study we wanted to find out how far the subjects projected their own personality characteristics to the robot. More specifically, we investigated whether such attribution depends on the way the robot behaves. To this end, a measure for "Autonomy" and 12 characteristics of Eysenck's personality type classification were abstracted from the questionnaires of each of the 28 adult volunteers ($P_{i,j}^{sub}$, $i = 1 \ldots 28$, $j = 1 \ldots 13$). These characteristics can be grouped in two main clusters, one composing an introvert-extrovert dimension (General Activity, Assertiveness, Sociability, Dominance, Excitement Seeking) and the other a neuroticism – emotional stability factor (Vulnerability, Anxiety, Shyness, Tension). The attributes Aggressiveness, Creativity and Impulsiveness are taken together as reflecting psychoticism-related traits. They do not form a distinct group as they cannot be interpreted as polar opposites and – to some extent, can be present in all individuals.

The subjects were asked to rate the robot for the same 13 characteristics, both when it was operating in the "Socially Ignorant" and in the "Socially Interactive" mode ($P_{i,j}^{robot(ign)}$ and $P_{i,j}^{robot(int)}$ respectively). From these data we calculated the *difference* between the personality characteristics of each subject and how that same characteristic was evaluated to the robot by the subject. In case of no discrepancy, a subject would rate the robot as being identical to him/herself with respect to that particular personality attribute. To allow for meaningful comparisons, the differences were standardized to the score of the subject. In this way we obtained the differences

$$\Delta P_{i,j}^{sub,robot(ign)} = \frac{P_{i,j}^{sub} - P_{i,j}^{robot(ign)}}{P_{i,j}^{sub}}$$ for the Socially Ignorant robot

$$\Delta P_{i,j}^{sub,robot(int)} = \frac{P_{i,j}^{sub} - P_{i,j}^{robot(int)}}{P_{i,j}^{sub}}$$ for the Socially Interactive robot

for all traits (j) and each of the N subjects (i). We then computed mean discrepancy, its standard error and the 95% Confidence Limits (C) over the 28 subjects for each of the 13 characteristics discrepancies and for both modes of robot interaction:

Mode of Interaction:	Mean	Confidence Limits
Socially Ignorant	$\Delta \overline{P}_j^{sub,robot(ign)} = \frac{\sum_{i=1}^{N} \Delta P_{i,j}^{sub,robot(ign)}}{N}$	$C_j^{sub,robot(ign)} = \pm t_{0.05} \frac{S_j^{sub,robot(ign)}}{\sqrt{N}}$
Socially Interactive	$\Delta \overline{P}_j^{sub,robot(int)} = \frac{\sum_{i=1}^{N} \Delta P_{i,j}^{sub,robot(int)}}{N}$	$C_j^{sub,robot(int)} = \pm t_{0.05} \frac{S_j^{sub,robot(int)}}{\sqrt{N}}$

In figure 35, means of discrepancy and the corresponding confidence limits for the Socially Ignorant mode are plotted against those of the Socially Interactive style. The diagonal drawn in the plot indicates positions where the degree of discrepancy between self-evaluation and attribution would be the same for both modes of robot interaction (i.e. $\Delta\overline{P}_j^{sub,robot(ign)} = \Delta\overline{P}_j^{sub,robot(int)}$). Points that fall above the diagonal are characteristics that score relatively high for $\Delta\overline{P}_j^{sub,robot(ign)}$ and low for $\Delta\overline{P}_j^{sub,robot(int)}$.

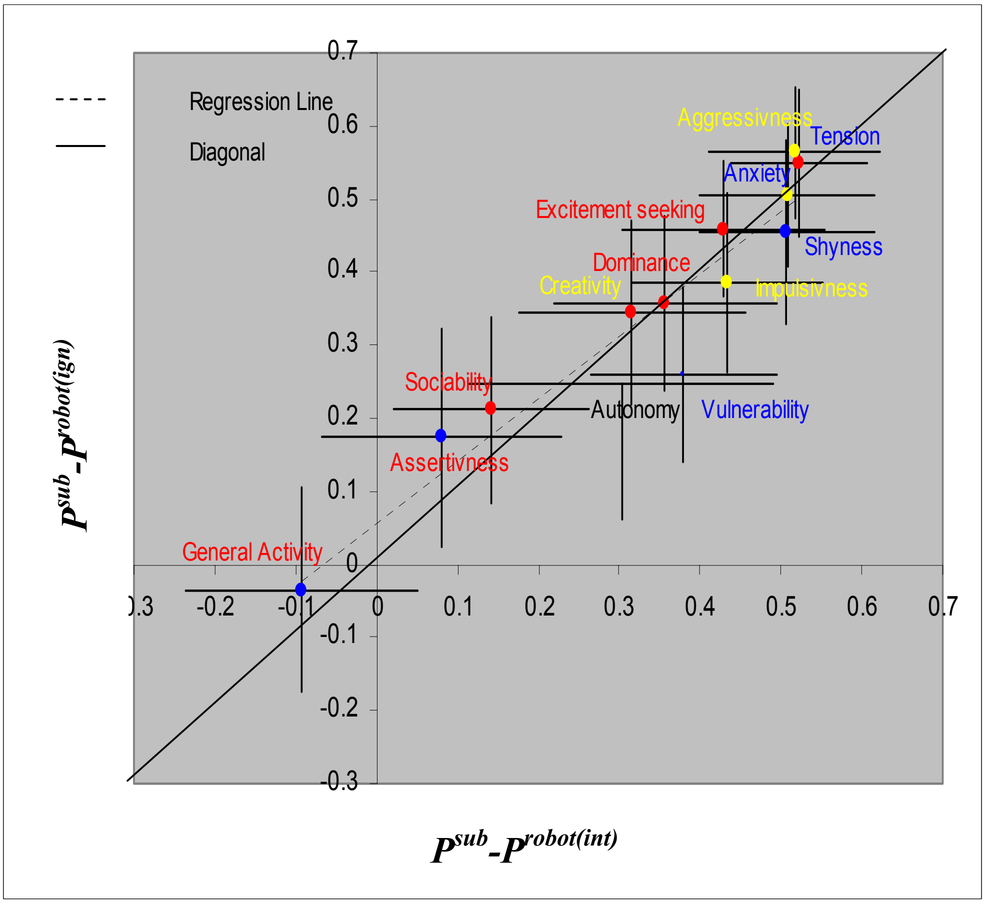

Figure 35. Discrepancies between values of personal characteristics and their attribution to two types of robots (Socially Ignorant and Socially Interactive). Points are the average discrepancies calculated over measurements of 28 subjects ± 95% Confidence Limits

The horizontal axis illustrates the difference between each subject's perceptions of themselves and their perception of the Socially Interactive Robot B in terms of personality characteristics. The vertical axis shows the difference between each subject's perceptions of themselves and their perception of the Socially Ignorant Robot A in terms of personality characteristics.

The plot shows the following interesting features:

1. The characteristics are relatively close to the diagonal. This means that the mean discrepancies measured for the Socially Ignorant robot are linearly related to those of the Socially Interactive robot. It also implies that the degree of attribution of personal characteristics to the robot does not depend strongly on the mode of robot interaction
2. The traits of the neuroticism-emotional stability and psychoticism factor form a cluster and show larger discrepancies (for both modes of robot behaviour) than those associated with the extra-introvert dimension. This means that subjects evaluated the

robot as being more similar to themselves with respect to extra-introvert traits than with neuroticism-emotional stability/psychoticism attributes.

3. Standard deviations are large; hence confidence intervals overlap for many trait discrepancies. This means that only a few of the trait discrepancies differ statistically among each other. Most outspoken is the low value of "General Activity". Furthermore, the three extro-introvert discrepancies of General Activity, Assertiveness and Sociability are on average smaller than those of neuroticism-emotional stability traits. This is especially true along the Socially Interactive axis.
4. The discrepancies of extra-introvert attributes are positioned either on (Dominance) or above the diagonal and therefore score relatively high for the Socially Ignorant style. In other words, the subjects rated the robot more similar to themselves with respect to extro-introvert characteristics when it operated in the Socially Interactive mode. For the neuroticist-emotional stability attributes we find the opposite trend: apart from "Tension", the discrepancies of these traits are either on or below the diagonal. This means that the subjects tend to identify the neuroticism-emotional stability side of their own personality with the Socially Ignorant robot rather than with the Socially Interactive robot.

4. SUMMARY OF MAIN FINDINGS

This section summarise the statistically significant findings.

Our test group consisted of twenty eight subjects, and was balanced for both for gender and whether they were drawn from Computer Science related departments. The group consisted of a mix of staff, students and researchers, and the age range was between nineteen and fifty-six years old. The majority of our 28 subjects were unfamiliar with, and had limited technical knowledge of robots.

Overall, our data shows no clear significant difference in the perception of the two robot personalities that we defined from the outset, apart from the following significant difference: Robot A (Socially Ignorant) was perceived by subjects as more vulnerable than Robot B (Socially Interactive). Both robot A & B were perceived as more emotionally stable, more introverted, and less psychotic than themselves. Most subjects felt very comfortable and enjoyed their interaction with both robots.

Our investigation into subjects' views on a robot companion in the home shows that more than one third (39%) of the subjects would like a robot as a companion at home. The roles they envisaged this robot to have were predominantly "assistant", "servant" and "machine", as opposed to friend. The preferred functionalities were household and other domestic tasks. An overwhelming majority of the subjects prefer a predictable and controllable robot that should behave considerately, including paying attention to the subject's activities, assist the subject, be polite etc.

In terms of differences between subject groups, we found e.g. that male subjects felt more in control of the ignorant robot's behaviour. Students would feel relaxed talking with robots compared to staff, and were confident operating robot in front of others, whereas staff reported that they would feel nervous. Experience with robots/technology resulted in more enjoyable interactions with robot A compared to no experience, and increased the judgement of robot B as impulsive. Younger participants had more extensive technical knowledge of robots, were less anxious about communicating with robots, and were more open to having a robot companion in the home compared to older subjects. They also perceived the Socially Interactive robot as extravert, whereas older subjects did not. Subjects reported that the same robot seen the second time was more aggressive and predictable compared to the first time.

The order in which the two robot personalities were presented to the subjects did matter: Participants exposed to exp. condition B=>A were more tense but said Socially Interactive robot B was non-aggressive and felt comfortable when it approached them. Those exposed to A=>B described robot B as aggressive and felt less comfortable with Socially Interactive robot B.

In order to evaluate correlations between subjects' and robots' personality characteristics and personality types (Eysenck), results show that overall, subjects did not assign their own personality characteristics and types to robots. However, there were some correlations between males, females, staff, students' personality characteristics and their perceptions of robot personality. For example, in terms of gender differences we found for males positive corrections between anxiety and psychoticism of the subjects and robot A. For females there were positive correlations between subjects' and robot A's personality in terms of assertiveness and dominance. Other such correlations were identified for staff/students, younger/older subjects, technology/non-technology related background; however the general interpretation of these findings is still under investigation.

5. DISCUSSION

It is clear that a certain amount of technology is already prevalent in the home environment, even for those subjects who are not based in a Computer Science department, since more than 80% of the subjects stated that they liked having computers at home. In addition, only 28.6% of the group remarked that they would not like to have a robot companion in their home, compared to 39.3% who stated that they would like a robot companion. This group is much smaller than those who stated that they were happy with a computer in their home environment. However, most subjects appeared to enjoy their time and were comfortable with the robots, enjoying the interaction. It is therefore possible that the subjects felt uncomfortable with the idea of a robot companion rather than the reality of the interaction.

When questioned about the most important behaviour to be displayed by a robot in the home, all of the subjects responded that the robot should be considerate towards others. This could be interpreted in the way in which the robot performs its actions, or the actual actions and behaviours themselves. In a follow-up question, the most popular definition of a 'considerate robot', was one which attended to the humans actions and was polite and unobtrusive. The second highest definition being to offer assistance and enquire if the human requires assistance. This creates a fine balance between a potential robot which enquires enough to perform as an aid efficiently and assist the user, and which does not bother the user with excessive enquiries.

Interestingly, 96.4% of the subjects also stated that the robot should be controllable. On one level, any technology for the home should be controllable, in that the user should be able to instruct the device to perform requested actions. However, at the same time, any device should not necessarily require constant supervision, or it ceases to be an aid and instead becomes at best an interface to a task, and at worst something which slows the user down.

Also high on the list of behaviours stated as desirable is the robot being predictable, with 89.3% selecting this trait. This conforms to more traditional research in that people are able to understand technology and devices which behave in a logical manner, particularly when such devices are installed into a persons' home environment.

When questioned about the future roles and behaviours of robots in the home, a clear divide emerged. All of the roles which are already, traditionally associated with robots were selected as well as the roles for future robots in the home, such as household assistant, gardener and security guard. More than fifty percent of the subjects selected these as roles to be performed in the future. However, roles such as looking after children, being a friend or being a mate were all selected by less than eighteen percent of the group. These are all roles which are considered within the 'human domain' and which only a human is able to perform. They are also roles which are the most difficult to prescribe specific actions to in advance, or to describe in any comprehensive way.

When the subjects experienced Socially Ignorant robot A and then Socially Interactive robot B, they felt that robot B was aggressive, and fewer subjects felt as comfortable with robot B. In contrast, most of those who experienced robot B first generally felt comfortable with the interactions with robot B when the distance between them and the robot was decreased, either by the movement of the robot, or by them moving, but they did describe themselves as more tense throughout the interaction.

When questioned about the Socially Ignorant robot, it was found that males generally felt more in control of this robot compared to the females, and while younger subjects found this robot to be more assertive, the older members of the group stated the opposite, that the robot seemed to them to be less assertive. In addition, the younger subjects generally had a more extensive knowledge of the technology and were more familiar with its use and operation. This may be due to general exposure to technology and the environment in which they are brought up. As a consequence of this, the younger subjects all viewed the Socially Interactive robot as active, and many stated that this robot was also more assertive. Also, only the younger subjects stated that they wanted a robot as a future companion in the home. In general, the younger subjects also wanted the robot to be more attentive to their actions, compared to the older subjects. This may provide an insight into the interactive role of a future robot companion, and the way in which these devices are viewed. For example, older subjects may view technology in general as something which is unobtrusive and which performs when required and does not intrude on other aspects of home life. However, younger subjects are more aware of devices which behave in a more ‘intelligent’ way, for example a television which suggests programs that you may like to watch, or computer programs which take a stronger role in their duties such as automatically correcting spelling or deleting email.

Other results appear to confirm this, as the younger subjects generally felt less uneasy talking to the robot and interacting with it in this way, while the older subjects were less inclined to talk to the robot, as this is not the method by which they are familiar with interacting with technology.

This divide between the older and younger subjects will need to be examined and addressed in more detail in the future. It can be seen that the way in which a robotic platform is to interact with its users will need to be complex and variable. Also there will inevitably be some degree of adaptation to be done by the users, which may be more difficult for the older users than the younger one.

After multiple exposures to the robot, the subjects stated that the second robot was more aggressive and more predictable than the first, even though the same robot was presented both times. This may be due to the experience of the situation, and the fact that the subjects were not facing a novel experience for the second set of trials. The fact that the subjects had interacted with a robot before could have made the second experience more logical and therefore predictable for them. However, this also presupposes that the robot device behaves in a predictable way, and one which is able to be understood with experience.

In general, when asked to judge the personality type of the robot, the subjects do not simply assign their own personality types, and instead prescribe a different set of traits. This may be to create a perceived divide between themselves and the robot. However, in many cases, robot A was attributed with more extreme traits, but along a similar axis to the personality traits of the subject. Therefore a male who described himself as anxious would describe robot A as being more anxious; a female who described herself as assertive is likely to describe robot A as more assertive, and a student which described themself as vulnerable would also describe robot A as being more so. This exaggeration of character trait may simply be a reflection of exactly what the subject is able to perceive in the behaviour of a robot, placing their own characteristics on that of the robot in an attempt to create a commonality. Possibly these particular traits are noticed and exaggerated in the subjects mind, because they are aware of those traits in themselves.

In general, it can be seen that there is a divide between the perceptions of, and interactions with, the robot by the older and younger subjects, including a difference between the ways in which they believe that robots will be used in a home environment in the future. The way in which subjects attribute character traits to the robot is mostly done with a different set of characteristics to those which they attribute to themselves. The exception to this is the fact that many subjects exaggerate their own traits when describing the behaviour of robot A.

6. RELATED WORK AND CONCLUSION

The findings from our initial study exploring people's perceptions of a robot companion in terms of gender, personality and age differences can be discussed in relation to some previous findings. Khan (1998) carried out a pilot study to explore how robots could be used for service purposes within the household. A number of different aspects were investigated including what appearance people wanted the robot to have, how the robot should behave, the preferred method of communication with the robot and what the robot should *not* do in the household. Khan's study reported that tasks respondents most wanted the robot to perform were polishing windows, cleaning and moving heavy things. The least wanted task that they wanted the robot to perform were baby sitting, cat/dog watching and reading aloud. This is similar to the current study where 96% of subjects stated that they would like the robot to perform household tasks compared to only 11% who wanted the robot to look after children.

The current study reported that only 29% of subjects wanted the robot to have a humanlike appearance. This corresponds with Khan's study where 19% of respondents wanted the robot to be humanlike compared to 57% who wanted to it be machinelike in appearance. Similar to the current study 82% of respondents wanted to communicate with the robot using human speech.

Khan's study reported that 69% of respondents thought it was a positive idea to have a service robot in the home compared to 23% who found it frightening. 76% of subjects thought it would be useful to have a robot in the home and 66% found it meaningful. The results of our study are slightly different where only 39% of subjects stated that they would like a robot as a companion at home. However, this difference could be attributable to the fact that our study is more about a robotic 'companion' rather than just a 'service' robot. Also, Khan's study relied on images of robots rather than live robotic interactions.

Finally, Khan found that people did not want the robot to be too smart, but be able to conduct limited actions according to its programs. Our findings are similar as 89% of subjects wanted the robot to be predictable and 96% wanted it to be controllable. According to subjects' comments, they also wanted to be able to instruct the robot and only wanted it to help them upon their request. They did want the robot to be roaming around the home.

A number of group differences e.g. age differences were revealed in our study. Mainly, younger participants were more accepting and less anxious of the idea of a robot companion compared to older participants. Younger subjects also perceived the robot as being more extravert compared to older participants. Older participants stated that they would feel paranoid talking to a robot in the home, whereas younger subjects were not concerned about communication with the robot. This is likely to be related to the finding that younger participants had more extensive knowledge of robots and future studies should attempt to statistically control the effect of experience to determine whether the difference remains. These results are comparable to those reported by Scopelliti et al. (2004) who reported that young people had strong familiarity with technology and a friendly idea of robots. Elderly participants on the other hand were the most frightened at the prospect of having a robot in the home and showed an element of distrust towards a robot in the home. Gender and educational level in comparison did not have a large impact on people's perceptions of a robot in the home.

We are not aware of any studies that have directly compared whether there is a link between personality attributes assigned to robots and the participants' personality styles. Our initial findings suggest that overall, subjects do not assign their own personality constructs to robots, but interestingly, some correlations were found between subjects' and robot personality.

A previous exploratory study, carried out with children, did find that children attributed personality constructs to robot images (Woods et al., 2004) but this could be due to the age of the subjects. The study by Goetz and Kiesler (2003) studied how a robot could make an impression on people and socially influenced their behaviour in terms of gaining people's acceptance and trust. Their results suggested that participants had more fun interacting with a playful robot and rated this robot's personality more positively, but cooperated more fully with a serious robot. However, they did not compare the participants' personality with their personality ratings of the robot. More research is needed in this area to be able to draw some firmer conclusions. In particular, it seems that individual differences, and group membership (e.g. gender, staff/students etc.) have an impact on how subjects perceive the robots they have been interacting with.

To conclude, regarding our research hypotheses, we found some supporting evidence:

- People do attribute personality characteristics to robots, and we found indeed statistically significant correlations between subjects' personality types and characteristics and those of robots, supporting Research Hypothesis 1 (RH1).
- We found statistically significant group differences, e.g. age and gender differences that had an impact on the personality characteristics that subjects attributed to the robots, supporting RH2.
- In terms of personality types and characteristics, our data shows no significant difference overall in the perception of the two robot behaviour styles that we defined a priori. The only exception was the perception of vulnerability: Robot A (Socially Ignorant) was perceived by subjects as more vulnerable than Robot B (Socially Interactive). Thus RH3 could not be confirmed overall, only with respect to vulnerability.

Future Work

In our future work on intentionality and attribution that contributes to CF-IA, more in depth studies are necessary in order to highlight how behaviour and appearance of the robot influences people's perception of robots. Also, the design of a robot's behaviour style is not trivial and merits further investigation. Our results documented in this report (and the related report (D3.1.1) show that there is no clear-cut distinction in the perception of the two robot behaviour styles A (Socially Ignorant) and B (Socially Interactive) that we used. Future work needs to investigate in more depth the design of these robot behaviour styles and their impact on people's perception of intentionality and personality types in robots. Such work will ultimately result in design guidelines that can inform HRI research and can be exploited by other partners in Cogniron with respect to the Key Experiments.

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APPENDIX 1

- **Information Sheet,**
- **Consent Form,**
- **Cogniron Introductory Questionnaire,**
- **Cogniron Subject Personality Questionnaire,**
- **Cogniron Robot Personality Questionnaire,**
- **Cogniron Final Questionnaire,**
- **NARS (Negative Attitude Towards Robot Scale) Questionnaire**

INFORMATION SHEET

‘cogniron- cognitive robot companion, study in July/August 2004.’

Purpose of Research:

As part of a European Robotics Project we are studying how to develop robots that will in the future be able to serve certain tasks in the home of humans. The project involving 10 European partners began in January 2004 and runs for 4 years. In July/August 2004 we are conducting an initial study involving humans in an “artificial living room” scenario where the performance of the robot will be studied. The study will take place in the Science and Technology Research Institute (STRI) at the University of Hertfordshire. A human-sized, but not humanoid robot, will operate in the same room as the participant is located. The trials will last about one hour and will be videotaped for research purposes.

The research has been approved by the Ethics Committee of the Faculty of Engineering and Information Sciences.

The research will involve some questionnaires. If you are asked to provide ratings, please do not dwell on your answers. We are interested in spontaneous reactions, so please answer with the first response that comes to your mind.

The study will treat all data collected on individual participants with full confidentiality. At no time throughout the whole course of the research project will your name or any other personal details that you provide be identifiable, i.e. your name will not appear in any internal or external publications. All evaluation work will be based on the participant numbers allocated to each subject. This ID code will form the basis of our evaluations, not your real name.

Participation in this study is entirely voluntary. If at any point you do not wish to continue with the study, you may withdraw, this will not reflect badly on you. The questionnaires provided do not have any right or wrong answers, nor should they be viewed as tests. However, you can decide not to answer certain questions in the questionnaires provided if you do not wish to.

CONSENT FORM

'Cogniron- cognitive robot companion, study in summer 2004.'

NAME OF Researchers:
Prof. Kerstin Dautenhahn, Christina Kaouri, Dr. Kheng Lee Koay and Michael L. Walters

(PLEASE INITIAL BOXES)

I CONFIRM THAT I HAVE READ AND FULLY UNDERSTOOD THE INFORMATION SHEET FOR THE ABOVE STUDY. I UNDERSTAND THAT MY PARTICIPATION IS VOLUNTARY AND THAT I AM FREE TO WITHDRAW AT ANY TIME, WITHOUT GIVING ANY REASON. I AGREE TO TAKE PART IN THE ABOVE STUDY. ☐

WE WOULD LIKE TO USE SOME OF THE VIDEO FOOTAGE FOR FUTURE CONFERENCES AND PUBLICATIONS. I CONSENT TO MY VIDEO FOOTAGE RECORDED DURING THE EXPERIMENTS TO BE USED FOR THIS PURPOSE. ☐

Name of PARTICIPANT:

____

Signature: ____________________________________

Date: ____________________________________

If you have any questions regarding the above study, please contact the coordinator, Prof. Kerstin Dautenhahn, K.Dautenhahn@herts.ac.uk (01707-284333)

Thank you.

COGNIRON Introductory Questionnaire

Participant No.……….

We would appreciate it if you could answer the following questions:

How to complete the questionnaire

Where categories are provided, e.g. for age and gender, please tick the appropriate box. Only tick one response unless stated otherwise.

A scale is used for some of the questions. Please circle or cross the number (1-5) that matches what you think e.g. circle no. 4 if you "think that this is quite unbelievable". Circle no. 3 if you can't tell the difference or can't make a decision.

Believable				Unbelievable
1	**2**	**3**	4	**5**

Personal Details

1. Gender: ☐ Male ☐ Female

2. Age:
   - ☐ Under 25
   - ☐ 26 – 35
   - ☐ 36 – 45
   - ☐ 46 – 55
   - ☐ 56+

3. Occupation:
   - ☐ Student
   - ☐ Researcher in academic institution
   - ☐ Academic/faculty staff (e.g. lecturer, professor)
   - ☐ Other, please specify ……………………………………………

4. Level of familiarity with robots:

Not at all familiar				Very familiar
1	2	3	4	5

5. Do you have any experience with robots? (private or professional):
   - ☐ yes
   - ☐ no

COGNIRON Introductory Questionnaire

If **YES**, what type of experience:

- ☐ at work
- ☐ as toys
- ☐ in movies/books
- ☐ in TV shows
- ☐ in museums/shows
- ☐ school

- Technical knowledge of robots:

Limited Knowledge				Extensive Knowledge
1	2	3	4	5

Thank you for completing this questionnaire!

COGNIRON Subject Personality Questionnaire

Participant No.………

We would appreciate if you could answer the following questions:

How to complete the questionnaire

Where categories are provided, e.g. for age and gender, please tick the appropriate box. Only tick one response unless stated otherwise.

A scale is used for some of the questions. Please circle or cross the number (1-5) that matches what you think e.g. circle no. 4 if you "think that this is quite unbelievable". Circle no. 3 if you can't tell the difference or can't make a decision.

Believable				Unbelievable
1	**2**	**3**	4	**5**

Could you tell us a bit more about yourself, i.e. how you see yourself in terms of different personality characteristics? (Note, this information will be treated confidentially and will not be linked to your real name in the evaluation. At no time throughout the whole course of the research project will your name or any other personal details you provide be identifiable.)

1) Sociability

Not at all Sociable				Very Sociable
1	2	3	4	5

2) Shyness

Not at all shy				Very Shy
1	2	3	4	5

COGNIRON Subject Personality Questionnaire

3) Vulnerability

Not at all Vulnerable — Very Vulnerable

1 2 3 4 5

4) General Activity Level

Inactive — Very Active

1 2 3 4 5

5) Assertiveness

Not at all Assertive — Very Assertive

1 2 3 4 5

6) Anxiety

Not at all Anxious — Very Anxious

1 2 3 4 5

7) Tension

Not at all Tense — Very Tense

1 2 3 4 5

8) Creativity

Not at all Creative — Very Creative

1 2 3 4 5

COGNIRON Subject Personality Questionnaire

9) Excitement-Seeking

Low excitement seeking				High excitement seeking
1	2	3	4	5

10) Dominance

Not at all dominant				Very Dominant
1	2	3	4	5

11) Aggressiveness

Not at all Aggressive				Very Aggressive
1	2	3	4	5

12) Impulsiveness

Not at all Impulsive				Very Impulsive
1	2	3	4	5

13) Autonomy

Prefer being told what to do				Prefer to decide myself what to do
1	2	3	4	5

Thank you for completing this questionnaire!

COGNIRON Robot Personality Questionnaire

Participant No.………

We would appreciate if you could answer the following questions:

How to complete the questionnaire

A scale is used for some of the questions. Please circle or cross the number (1-5) that matches what you think e.g. circle no. 4 if you "think that this is quite unbelievable". Circle no. 3 if you can't tell the difference or can't make a decision.

Believable				Unbelievable
1	2	3	(4)	5

Robot's Personality Characteristics

Based on your experience with the robot during the experiment, how would you describe the robot's personality based on the following characteristics?

1) Sociability

Not at all Sociable				Very Sociable
1	2	3	4	5

2) Shyness

Not at all shy				Very Shy
1	2	3	4	5

3) Vulnerability

Not at all Vulnerable				Very Vulnerable
1	2	3	4	5

COGNIRON Robot Personality Questionnaire

4) General Activity Level

Inactive — Very Active

1 2 3 4 5

5) Assertiveness

Not at all Assertive — Very Assertive

1 2 3 4 5

6) Anxiety

Not at all Anxious — Very Anxious

1 2 3 4 5

7) Tension

Not at all Tense — Very Tense

1 2 3 4 5

8) Creativity

Not at all Creative — Very Creative

1 2 3 4 5

9) Excitement-Seeking

Low excitement seeking — High excitement seeking

1 2 3 4 5

COGNIRON Robot Personality Questionnaire

10) Dominance

Not at all Dominant				Very Dominant
1	2	3	4	5

11) Aggressiveness

Not at all Aggressive				Very Aggressive
1	2	3	4	5

12) Impulsiveness

Not at all Impulsive				Very Impulsive
1	2	3	4	5

13) Autonomy

Seemed to do what it was told/ programmed to do				Seemed to make its own decisions
1	2	3	4	5

14) Intentionality

Did not behave intentionally				Behaved Intentionally
1	2	3	4	5

COGNIRON Robot Personality Questionnaire

15) Predictability of Behaviour

Not at all predictable

Highly predictable

1 2 3 4 5

16) Controllability

I did not feel at all in control of the robot's behaviour

I felt in control of the robot's behaviour

1 2 3 4 5

17) Considerateness

Did not behave considerately at all towards me

Behaved very considerately towards me

1 2 3 4 5

→
next page

COGNIRON Robot Personality Questionnaire

General Experience

1) **Did you feel comfortable or uncomfortable with the robot when you approached the robot or the robot approached you?**

Very comfortable — Very Uncomfortable

1 2 3 4 5

2) **Did you feel comfortable or uncomfortable being physically close to the robot?**

Very comfortable — Very Uncomfortable

1 2 3 4 5

3) **Did you feel comfortable or uncomfortable when you and the robot were moving in the same room?**

Very comfortable — Very Uncomfortable

1 2 3 4 5

4) **Did you feel comfortable or uncomfortable with the robot when you were sitting at a table?**

Very comfortable — Very Uncomfortable

1 2 3 4 5

5) **Overall, did you enjoy your interaction with the robot?**

Enjoyed very much — Didn't enjoy it all

1 2 3 4 5

Thank you for completing this questionnaire! We appreciate your cooperation!

COGNIRON Final Questionnaire

Participant No……….

We would appreciate if you could answer the following questions.

How to complete the questionnaire

A scale is used for some of the questions. Please circle or cross the number (1-5) that matches what you think e.g. circle no. 4 if you "think that this is quite unbelievable". Circle no. 3 if you can't tell the difference or can't make a decision.

Believable — Unbelievable

1 **2** **3** 4 **5**

What is a robot companion?

1. **Do you like computers/computer technology as part of your home environment?**

Like Very Much — Don't like at all

1 2 3 4 5

2. **Do you like the idea of having a robot as a companion at home?**

Like Very Much — Don't like at all

1 2 3 4 5

3. **What role do you think a future "robot companion in the home" should have (tick as many options as appropriate)?**

☐ Servant ☐ Buddy/Mate ☐ Assistant ☐ Friend
☐ Machine/appliance
☐ Other: ____________________

COGNIRON Final Questionnaire

4. What task(s) would you like this future robot to be able to carry out?

- ☐ Household (vacuuming etc.)
- ☐ Gardening
- ☐ Guarding the house/family
- ☐ Looking after children
- ☐ Entertainment
- ☐ Other (please specify):______________________________

5. How predictable should the behaviour of this future robot be?

Not at all predictable — Highly predictable

1 — 2 — 3 — 4 — 5

6. How controllable should the robot be, by you or other family members?

Not at all controllable — Highly controllable

1 — 2 — 3 — 4 — 5

7. How considerately should this future robot behave towards you or other members in the family?

Not considerate at all — Highly considerate

1 — 2 — 3 — 4 — 5

8. How human-like should the future robot companion *appear*?

Not human-like at all — Very human-like

1 — 2 — 3 — 4 — 5

COGNIRON Final Questionnaire

9. How human-like should the future robot companion behave?

Not human-like at all				Very human-like
1	2	3	4	5

10. How human-like should the future robot companion communicate?

Not human-like at all				Very human-like
1	2	3	4	5

11. With what speed should a considerate robot approach you?

Very slowly				Very fast
1	2	3	4	5

12. How close should a considerate robot come to you?

Not at all close				Very close
1	2	3	4	5

13. Should a considerate robot pay attention to what you are doing?

Not at all paying attention				Paying attention
1	2	3	4	5

COGNIRON Final Questionnaire

14. If you encounter a considerate robot, should it be polite and give way?

Not at all give way				Give way
1	2	3	4	5

15. Should a considerate robot try to find out if you need help before it helps you?

Will try to help me right away				Will try to find out if I need help
1	2	3	4	5

Your Feelings after the Session

1. What did you find most interesting about the robot during the experiment (please use back of page if necessary)?

…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
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…………………………………………………………………………………………
…………………………

2. What did you find most annoying about the robot during the experiment (please use back of page if necessary)?

…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
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…………………………

COGNIRON Final Questionnaire

3. Do you think that anything should be changed regarding the robot?

☐ Yes ☐ No

If yes, which of the following needs improvement (tick one or several boxes)?

☐ Appearance ☐ Speech ☐ Behaviour
☐ Other: ____

Can you explain in more detail how you think the robot should be changed?
……………………………………………………………………………………
……………………………………………………………………………………
……………………………………………………………………………………
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……………………………………………………………………………………
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4. Any other comments?

……………………………………………………………………………………
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…………………………

Thank you for completing this questionnaire! We appreciate your cooperation!

NARS (Negative Attitude towards Scale) Questionnaire

Participant number:________________

Directions:

This instrument is composed of 16 sentences describing attitudes towards robots.

Please judge these sentences ranging: (1) I completely disagree, (2) I disagree, (3) undecided, (4) I agree, (5) I completely agree.

There is no right or wrong answer, just give your first impression without taking too much time.

	disagree			agree
1. I have seen live robots before	1 2 3 4 5			
2. I would feel uneasy if robots really had emotions.	1 2 3 4 5			
3. Something bad might happen if robots developed into living beings.	1 2 3 4 5			
4. I would feel relaxed talking with robots.	1 2 3 4 5			
5. I would feel uneasy if I was given a job where I had to use robots.	1 2 3 4 5			
6. If robots had emotions, I would be able to make friends with them.	1 2 3 4 5			
7. I would feel comforted being with robots that have emotions.	1 2 3 4 5			
8. The word "robot" means nothing to me.	1 2 3 4 5			
9. I would feel nervous operating a robot in front of other people.	1 2 3 4 5			
10. I would hate the idea that robots or artificial intelligences were making judgments about things.	1 2 3 4 5			

NARS (Negative Attitude towards Scale) Questionnaire

	disagree				agree
11. I would feel very nervous just standing in front of a robot.	1	2	3	4	5
12. I feel that if I depended on robots too much, something bad might happen.	1	2	3	4	5
13. I feel that if I trust robots too much, something bad might happen.	1	2	3	4	5
14. I would feel paranoid talking with a robot.	1	2	3	4	5
15. I am concerned that robots would be a bad influence on children.	1	2	3	4	5
16. I feel that in the future society will be dominated by robots.	1	2	3	4	5

Thank you for completing this questionnaire!

APPENDIX 2

1) **Tables for: Subject Personality Frequencies and Percentages**
2) **Tables for: Robot A (Socially Ignorant) Personality Frequencies and Percentages**
3) **Tables for: Robot B (Socially Interactive) Personality Frequencies and Percentages**
4) **Tables for: Frequencies and Percentages for NARS Statements**

Tables for: Subject Personality Frequencies and Percentages

Sociability	Frequency	Percentage %
not sociable	2	7.1
neutral	9	32.1
sociable	**13**	**46.4**
very sociable	4	14.3
Total	28	100.0

Shyness	Frequency	Percentage %
Not at all Shy	4	14.3
not shy	6	21.4
neutral	**12**	**42.9**
shy	6	21.4
Total	28	100.0

Vulnerability	Frequency	Percentage %
not vulnerable	6	21.4
neutral	**19**	**67.9**
vulnerable	3	10.7
Total	28	100.0

General Activity Level	Frequency	Percentage %
quite inactive	1	3.6
neither inactive nor active	9	32.1
quite active	**16**	**57.1**
very active	2	7.1
Total	28	100.0

Anxiety	Frequency	Percentage %
not at all anxious	2	7.1
not anxious	**10**	**35.7**
neutral	8	28.6
anxious	6	21.4
very anxious	2	7.1
Total	28	100.0

Assertiveness	Frequency	Percentage %
not assertive	4	14.3
neutral	9	32.1
assertive	**14**	**50.0**
very assertive	1	3.6
Total	28	100.0

Tension	Frequency	Percentage %
not at all tense	2	7.1
not tense	**11**	**39.3**
neutral	8	28.6
tense	7	25.0
Total	28	100.0

Creativity	Frequency	Percentage %
not at all creative	1	3.6
not creative	2	7.1
neutral	4	14.3
creative	**18**	**64.3**
very creative	3	10.7
Total	28	100.0

Excitement- Seeking	Frequency	Percentage (%)
quite low excitement seeking	6	21.4
neutral	**10**	**35.7**
quite high excitement seeking	8	28.6
high excitement seeking	4	14.3
Total	28	100.0

Dominance	Frequency	Percentage %
not at all dominant	1	3.6
not dominant	9	32.1
neutral	**11**	**39.3**
dominant	6	21.4
very dominant	1	3.6
Total	28	100.0

Aggressiveness		Frequency	Percentage %
	not at all aggressive	3	10.7
	not aggressive	11	39.3
	neutral	**12**	**42.9**
	aggressive	2	7.1
	Total	28	100.0

Impulsiveness		Frequency	Percentage %
	not at all impulsive	1	3.6
	not impulsive	8	28.6
	neutral	**10**	**35.7**
	impulsive	8	28.6
	very impulsive	1	3.6
	Total	28	100.0

Autonomy		Frequency	Percentage %
	prefer being told what to do	1	3.6
	quite prefer being told what to do	1	3.6
	neutral	3	10.7
	quite prefer to decide myself what to do	**14**	**50.0**
	prefer to decide myself what to do	9	32.1
	Total	28	100.0

Tables for: Robot A (Socially Ignorant Robot) Personality Frequencies and Percentages

Sociability	Frequency	Percentage %
Not at all Sociable	2	7.1
not sociable	**11**	**39.3**
neutral	7	25.0
sociable	6	21.4
very sociable	2	7.1
Total	28	100.0

Shyness	Frequency	Percentage %
Not at all Shy	**13**	**46.4**
not shy	7	25.0
neutral	5	17.9
shy	2	7.1
very shy	1	3.6
Total	28	100.0

Vulnerability	Frequency	Percentage %
not at all vulnerable	4	14.3
not vulnerable	8	28.6
neutral	**10**	**35.7**
vulnerable	6	21.4
Total	28	100.0

General Activity Level	Frequency	Percentage %
quite inactive	4	14.3
neither inactive nor active	8	28.6
quite active	**11**	**39.3**
very active	5	17.9
Total	28	100.0

Assertiveness	Frequency	Percentage %
not at all assertive	4	14.3
not assertive	6	21.4
neutral	**8**	**28.6**
assertive	**8**	**28.6**
very assertive	2	7.1
Total	28	100.0

Anxiety	Frequency	Percentage %
not at all anxious	**15**	**53.6**
not anxious	5	17.9
neutral	6	21.4
anxious	2	7.1
Total	28	100.0

Tension	Frequency	Percentage %
not at all tense	**18**	**64.3**
not tense	3	10.7
neutral	6	21.4
tense	1	3.6
Total	28	100.0

Creativity	Frequency	Percentage %
not at all creative	8	28.6
not creative	**10**	**35.7**
neutral	2	7.1
creative	7	25.0
very creative	1	3.6
Total	28	100.0

Excitement- Seeking	Frequency	Percentage %
low excitement seeking	**11**	**39.3**
quite low excitement seeking	8	28.6
neutral	7	25.0
quite high excitement seeking	2	7.1
Total	28	100.0

Dominance	Frequency	Percentage %
not at all dominant	**9**	**32.1**
not dominant	6	21.4
neutral	**9**	**32.1**
dominant	4	14.3
Total	28	100.0

Aggressiveness	Frequency	Percentage %
not at all aggressive	**18**	**64.3**
not aggressive	5	17.9
neutral	4	14.3
aggressive	1	3.6
Total	28	100.0

Impulsiveness	Frequency	Percentage %
not at all impulsive	**10**	**35.7**
not impulsive	7	25.0
neutral	6	21.4
impulsive	5	17.9
Total	28	100.0

Autonomy	Frequency	Percentage %
seemed to do what it was told/programmed to do	**8**	**28.6**
quite seemed to do what it was told/programmed to do	7	25.0
neutral	5	17.9
quite seemed to make its own decisions	6	21.4
seemed to make its own decisions	2	7.1
Total	28	100.0

Intentionality	Frequency	Percentage %
did not behave intentionally	2	7.1
did not quite behave intentionally	1	3.6
neutral	5	17.9
quite behaved intentionally	9	32.1
behaved intentionally	**11**	**39.3**
Total	28	100.0

Predictability of Behaviour	Frequency	Percentage %
not at all predictable	1	3.6
not predictable	7	25.0
neutral	7	25.0
predictable	**9**	**32.1**
highly predictable	4	14.3
Total	28	100.0

Controllability		Frequency	Percentage %
	I did not feel at all in control of the robot's behaviour	6	21.4
	I did not feel in control of the robot's behaviour	5	17.9
	I felt neutral	**7**	**25.0**
	I quite felt in control of the robot's behaviour	6	21.4
	I felt in control of the robot's behaviour	4	14.3
	Total	28	100.0

Considerateness		Frequency	Percentage %
	did not behave considerately towards me	5	17.9
	behaved neutrally towards me	2	7.1
	behaved considerately towards me	6	21.4
	behaved very considerately towards me	**15**	**53.6**
	Total	28	100.0

Tables for: Robot B (Socially Interactive Robot) Personality Frequencies and Percentages

Sociability	Frequency	Percentage %
not sociable	**11**	**39.3**
neutral	6	21.4
sociable	**10**	**35.7**
very sociable	1	3.6
Total	28	100.0

Shyness	Frequency	Percentage %
Not at all Shy	**15**	**53.6**
not shy	8	28.6
shy	5	17.9
Total	28	100.0

Vulnerability	Frequency	Percentage %
not at all vulnerable	**9**	**32.1**
not vulnerable	7	25.0
neutral	8	28.6
vulnerable	4	14.3
Total	28	100.0

General Activity Level	Frequency	Percentage %
quite inactive	3	10.7
neither inactive nor active	4	14.3
quite active	**17**	**60.7**
very active	4	14.3
Total	28	100.0

Assertiveness	Frequency	Percentage %
not at all assertive	3	10.7
not assertive	5	17.9
neutral	5	17.9
assertive	**11**	**39.3**
very assertive	4	14.3
Total	28	100.0

Anxiety	Frequency	Percentage %
not at all anxious	**16**	**57.1**
not anxious	5	17.9
neutral	4	14.3
anxious	2	7.1
very anxious	1	3.6
Total	28	100.0

Tension	Frequency	Percentage %
not at all tense	**14**	**50.0**
not tense	8	28.6
neutral	5	17.9
tense	1	3.6
Total	28	100.0

Creativity	Frequency	Percentage %
not at all creative	**9**	**32.1**
not creative	6	21.4
neutral	4	14.3
creative	8	28.6
very creative	1	3.6
Total	28	100.0

Excitement- Seeking	Frequency	Percentage %
low excitement seeking	**11**	**39.3**
quite low excitement seeking	9	32.1
neutral	5	17.9
quite high excitement seeking	1	3.6
high excitement seeking	2	7.1
Total	28	100.0

Dominance	Frequency	Percentage %
not at all dominant	**10**	**35.7**
not dominant	5	17.9
neutral	9	32.1
dominant	4	14.3
Total	28	100.0

Aggressiveness	Frequency	Percentage %
not at all aggressive	**16**	**57.1**
not aggressive	6	21.4
neutral	4	14.3
aggressive	2	7.1
Total	28	100.0

Impulsiveness	Frequency	Percentage %
not at all impulsive	**10**	**35.7**
not impulsive	9	32.1
neutral	8	28.6
impulsive	1	3.6
Total	28	100.0

Autonomy	Frequency	Percentage %
seemed to do what it was told/programmed to do	**11**	**39.3**
quite seemed to do what it was told/programmed to do	7	25.0
neutral	1	3.6
quite seemed to make its own decisions	6	21.4
seemed to make its own decisions	3	10.7
Total	28	100.0

Intentionality	Frequency	Percentage %
did not behave intentionally	2	7.1
did not quite behave intentionally	2	7.1
neutral	5	17.9
quite behaved intentionally	**12**	**42.9**
behaved intentionally	7	25.0
Total	28	100.0

Predictability of Behaviour	Frequency	Percentage %
not at all predictable	1	3.6
not predictable	11	39.3
neutral	3	10.7
predictable	**12**	**42.9**
highly predictable	1	3.6
Total	28	100.0

Controllability	Frequency	Percentage %
I did not feel at all in control of the robot's behaviour	7	25.0
I did not feel in control of the robot's behaviour	**10**	**35.7**
I felt neutral	8	28.6
I quite felt in control of the robot's behaviour	1	3.6
I felt in control of the robot's behaviour	2	7.1
Total	28	100.0

Considerateness	Frequency	Percentage %
behaved neutrally towards me	3	10.7
behaved considerately towards me	12	42.9
behaved very considerately towards me	**13**	**46.4**
Total	28	100.0

Tables for: Frequencies and Percentages for NARS Statements

I have seen live robots before		Frequency	Percentage
	completely disagree	**13**	**46.4**
	disagree	6	21.4
	undecided	1	3.6
	completely agree	8	28.6
	Total	28	100.0

I would feel uneasy if robots really had emotions		Frequency	Percentage
	completely disagree	2	7.1
	disagree	3	10.7
	undecided	1	3.6
	agree	8	28.6
	completely agree	**14**	**50.0**
	Total	28	100.0

Something bad might happen if robots developed into living beings		Frequency	Percentage
	completely disagree	2	7.1
	disagree	5	17.9
	undecided	1	3.6
	agree	5	17.9
	completely agree	**15**	**53.6**
	Total	28	100.0

I would feel relaxed talking with robots		Frequency	Percentage
	disagree	4	14.3
	undecided	**9**	**32.1**
	agree	6	21.4
	completely agree	**9**	**32.1**
	Total	28	100.0

I would feel uneasy if I was given a job where I had to use robots		Frequency	Percentage
	completely disagree	**22**	**78.6**
	disagree	2	7.1
	undecided	3	10.7
	agree	1	3.6
	Total	28	100.0

If robots had emotions, I would be able to make friends with them		Frequency	Percentage
	completely disagree	**7**	**25.0**
	disagree	3	10.7
	undecided	**7**	**25.0**
	agree	6	21.4
	completely agree	5	17.9
	Total	28	100.0

I would feel comforted being with robots that have emotions		Frequency	Percentage
	completely disagree	**9**	**32.1**
	disagree	6	21.4
	undecided	7	25.0
	agree	3	10.7
	completely agree	3	10.7
	Total	28	100.0

The word 'robot' Means nothing to me		Frequency	Percentage
	completely disagree	**18**	**64.3**
	disagree	6	21.4
	undecided	2	7.1
	agree	1	3.6
	completely agree	1	3.6
	Total	28	100.0

I would feel nervous operating a robot in front of other people		Frequency	Percentage
	completely disagree	**11**	**39.3**
	disagree	**11**	**39.3**
	undecided	2	7.1
	agree	4	14.3
	Total	28	100.0

I would hate the idea that robots or artificial intelligences were making judgments about things		Frequency	Percentage
	completely disagree	**11**	**39.3**
	disagree	6	21.4
	undecided	1	3.6
	agree	7	25.0
	completely agree	3	10.7
	Total	28	100.0

I would feel very nervous just standing in front of a robot		Frequency	Percentage
	completely disagree	**23**	**82.1**
	disagree	4	14.3
	undecided	1	3.6
	Total	28	100.0

I feel that if I depended on robots too much, something bad might happen		Frequency	Percentage
	completely disagree	5	17.9
	disagree	**9**	**32.1**
	undecided	7	25.0
	agree	5	17.9
	completely agree	2	7.1
	Total	28	100.0

I feel that if trust robots too much, something bad might happen		Frequency	Percentage
	completely disagree	3	10.7
	disagree	7	25.0
	undecided	**10**	**35.7**
	agree	5	17.9
	completely agree	3	10.7
	Total	28	100.0

I would feel paranoid talking with a robot		Frequency	Percentage
	completely disagree	10	35.7
	disagree	**12**	**42.9**
	undecided	5	17.9
	agree	1	3.6
	Total	28	100.0

I am concerned that robots would be a bad influence on children		Frequency	Percentage
	completely disagree	7	25.0
	disagree	7	25.0
	undecided	**9**	**32.1**
	agree	3	10.7
	completely agree	2	7.1
	Total	28	100.0

I feel that in the future society will be dominated by robots		Frequency	Percentage
	completely disagree	8	28.6
	disagree	5	17.9
	undecided	**11**	**39.3**
	agree	3	10.7
	completely agree	1	3.6
	Total	28	100.0