UNIVERSIDADE DO ALGARVE

Predicting intention to work with social robots

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Tese apresentada para obtenção do grau de doutor em Psicologia

Trabalho efetuado sob a orientação de:
Professor Doutor Jean-Christophe Giger

2014

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Predicting intention to work with social robots

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Assinatura …………………………

Data…………………………………

“A mind is like a parachute. It doesn't work if it is not open.”

Frank Zappa

Acknowledgements

To all the accomplices who made this journey possible:

My supervisor: J. C. Giger

The University

The Students

My Friends

My Family

List of Publications and Conference Presentations

Publications:

Piçarra, N., Giger, J.-C-, Pochwatko, G., & Gonçalves, G. (under review). Validation of the Portuguese Version of the Negative Attitudes Towards Robots Scale.

Piçarra, N., Giger, J.-C., Gonçalves, G., & Pochwatko, G. (submitted). A Representação Social do Robô: uma análise estrutural [The social representation of robot: a structural analysis].

Conference presentations:

Piçarra, N., Giger, J.-C., Pochwatko, G., & Gonçalves, G. (2012, October). *The Robot Got the Looks. Social Robots Appearance as Predictor of Anthrpomorphism and Intention to Work*. Presentation at the Workshop on Motivational Aspects of Robotics in Physical Therapy, IEEE/RSJ International Conference on Inteligent Robots and Systems (IROS). Vilamoura, Portugal.

Piçarra, N., Giger, J.-C., Pochwatko, G. & Gonçalves, G. (2012, July). *Prédicteurs psychosociologiques de l'intention de travailler avec un robot social* [Psycho-sociological predictors of the intention to work with a social robot]. Presentationa at the 9e Colloque International de Psychologie Sociale en Langue Française. Porto, Portugal.

Piçarra, N., Giger, J.-C., Pochwatko, G. & Gonçalves, G. (2012, July). *Angoisse face à la mort, sens de l'immortalité symbolique, et attitudes face à la technologie comme prédicteurs de l'attitude envers les robots sociaux.* [Death Anxiety, sense of symbolic immortality, and attitudes toward technology as predictors of attitudes towards social robots.]. Presentationa at the 9e Colloque International de Psychologie Sociale en Langue Française. Porto, Portugal.

Piçarra, N., Giger, J.C. (2012, May). *O robô social: um parceiro de trabalho aceitável?* [Social robot: an acceptable work partner?]. Presentation at the VII Encontro de Investigação em Psicologia Social e das Organizações, ISCTE (Escola de Ciências Sociais e Humanas, Instituto Universitário de Lisboa). Lisboa, Portugal.

Piçarra, N., Giger, J.C., Pochatko, G. e Gonçalves, G. (2012, May). *Preditores das atitudes face aos robôs sociais. O papel das atitudes face à tecnologia* [Predictors of attitude towards social robots. The role of attitudes towards technology]. Poster presented at the XI Encontro de Psicologia no Algarve, Universidade do Algarve. Faro, Portugal.

Piçarra, N., Giger, J.C., Pochatko, G. e Gonçalves, G. (2011, May). *O Robô Humano: Efeitos do need for cognition, da tomada de perspectiva e das crenças na unicidade da natureza humana na antropomorfização de um robô social* [The human robot: effects of need for cognition, perspective taking and belief in human nature uniqueness in the anthropomorphization of a social robot]. Poster presented at the X Encontro de Psicologia no Algarve, Universidade do Algarve. Faro, Portugal.

Piçarra, N. (2010, December). *Inteligência Robótica. Robôs Sociais. Um novo campo de intervenção para a Psicologia?* [Robot inteligence. Social robots. A new field of intervention for psychology?]. Presentation at the Instituto Superior Manuel Teixeira Gomes, Portimão.

Resumo

Em 1998, uma parceria entre o Instituto de Robótica da Universidade de Carnegie Mellon e o Museu de História Natural de Carnegie deu vida ao SAGE. SAGE é um robô guia, cuja função é acompanhar os visitantes através do Hall dos Dinossauros, fornecendo-lhes informação multimédia. Ao fim de nove meses, os seus criadores (Nourbakhsh et al., 1999) reportavam 174 dias de operação sem supervisão, 135 dos quais sem qualquer erro. Muitos mais casos poderiam ser relatados de forma a ilustrar a crescente utilização de soluções robóticas autónomas orientadas para a interação com os seres humanos.

Esta nova geração de robôs recebeu a designação de robôs sociais (ou socializáveis) uma vez que sua construção tem sido orientada por um novo paradigma, o interface social. Ou seja, a construção de um robô social é orientada no sentido de proporcionar ao seu utilizador uma interação “natural”, através de uma presença física (que pode recorrer a formas mais ou menos humanoides), discurso verbal, utilização de gestos ou reconhecimento de estados afetivos.

Dadas estas características, é expectável que a crescente utilização de robôs socias em contextos profissionais, venha a colocar novos desafios organizacionais, obrigando à redefinição das competências de várias categoriais profissionais, bem como à redefinição de vários aspetos das relações laborais.

É dentro deste quadro que a presente investigação coloca a seguinte questão:

Como predizer a intenção de trabalhar com robôs sociais?

A pertinência desta questão prende-se com a necessidade de perceber que fatores sociocognitivos irão facilitar ou dificultar a adaptação a esta nova realidade.

De forma a estudar esta questão, vários modelos sociocognitivos, que têm recebido suporte empírico por parte da investigação acerca da intenção comportamental e a sua relação com o comportamento futuro são utilizados.

O modelo da ação raciocinada (Fishbein & Ajzen, 1975) afirma que o principal preditor de um comportamento é a intenção comportamental. Esta por sua vez é determinada pela atitude da pessoa acerca do comportamento em causa e da norma subjetiva (a norma subjetiva é definida como aquilo que a pessoa acha que alguém

significativo pensa que ele deveria fazer relativamente ao comportamento em questão). A atitude e a norma subjetiva são determinadas por crenças comportamentais e crenças normativas.

O modelo do comportamento planeado (Ajzen, 1985, 1991) acrescenta ao anterior modelo a variável controlo comportamental percebido. Desta forma o modelo pode ser também utilizado para estudar comportamentos que não estão completamente sob o controlo volicional da pessoa. O controlo comportamental percebido inclui avaliações objetivas dos recursos (pessoais e materiais) disponíveis, bem como avaliações subjetivas. Tal como a atitude e a norma subjetiva, também o controlo comportamental é determinado por crenças, neste caso designadas, crenças de controlo.

O modelo do comportamento dirigido por objetivos (Perugini & Bagozzi, 2001) afirma que, ao contrário do que é postulado pelos dois outros modelos, a motivação para a realização do comportamento não reside na intenção. Da mesma forma, a atitude, a norma subjetiva e o controlo comportamental percebido, embora sugiram uma razão para o comportamento, também não proporcionam a motivação para o realizar. O elemento motivacional seria proporcionado por uma outra variável, o desejo. Para além do desejo, estes autores propõem mais duas variáveis de caracter afetivo, as emoções antecipadas positivas e as emoções antecipadas negativas. Assim, embora a intenção comportamental continue a ser o principal preditor do comportamento, o efeito das outras variáveis, atitude, norma subjetiva, controlo comportamental percebido e emoções antecipadas, passa a ser mediado pelo desejo.

Qualquer um dos modelos anteriores tenta explicar o comportamento recorrendo ao menor número possível de variáveis possível (principio da parcimónia). Como tal prescrevem que todas as variáveis externas ao modelo terão sempre o seu efeito sobre o comportamento mediado pelas variáveis do modelo.

Com base na literatura e investigação sobre robótica e cognição social/ perceção social, alguns fatores externos foram escolhidos para que os seus efeitos sobre as variáveis dos modelos pudessem ser estudados. Os fatores escolhidos foram: a aparência do robô social (mecânico, humanoide, androide), a crença numa natureza humana única, a perceção de calor e competência (Fiske, Cuddy, Glick, & Xu, 2002), o antropomorfismo (Epley, Waytz and Cacioppo, 2007) e as atitudes negativas relativamente aos robôs (Nomura, Kanda, & Suzuki, 2004, July).

De forma a perceber qual a ideia contemporânea de robô, o estudo 1 visou a identificação da representação social de robô seguindo uma abordagem estrutural (Abric, 1993). O núcleo central da representação é dominado pelos temas máquina, tecnologia, futuro e ajuda.

Os estudos 2 e 3 testaram a estrutura da tradução portuguesa da escala de atitudes negativas relativamente aos robôs. A análise em componentes principais e a análise fatorial confirmatória identificaram que versão portuguesa era composta por dois fatores, atitudes negativas relativamente a robôs com características humanas e atitudes negativas relativamente a interações com robôs. O estudo 4 testou a validade nomológica da escala e o estudo 5 a validade preditiva.

O estudo 6 testou a validade psicométrica da escala de crença numa natureza humana única. Esta escala foi desenvolvida para esta investigação e visa avaliar o grau em que as pessoas reservam para si traços associados a uma natureza humana única (e.g. emoções, linguagem, moralidade), negando-os aos robôs sociais. Foram realizadas uma análise em componentes principais, que identificou os itens como pertencendo a um único fator e um estudo correlacional para avaliar a validade convergente e discriminante da escala.

Com o estudo 7 inicia-se a investigação da utilidade dos modelos sociocognitivos para a predição da intenção de trabalhar com um robô social num futuro próximo. Este estudo testa o modelo da ação raciocinada (MAR) e o modelo do comportamento planeado (MCP). Ambos os modelos explicaram a mesma proporção da variância da intenção de trabalhar com um robô social, 46%. Embora os modelos tenham apresentado um razoável poder explicativo, apenas a variável atitude (AT) apresentou (em ambos os modelos) um efeito estatisticamente significativo. O estudo 7 analisou também os efeitos das variáveis, aparência do robô social, calor (CA) e competência (CM) percebida, antropomorfismo (ANT), atitudes negativas relativamente a robôs com características humanas (ANR) e atitudes negativas relativamente a interações com robôs (ANI), nas variáveis atitude e controlo comportamental percebido (CCP). Não foi identificado qualquer efeito para a aparência do robô. O CA e ANR foram identificados como preditores positivos da quer de AT quer de CCP.

O estudo 8 analisou o modelo do comportamento dirigido por objetivos (COM) verificando que este explica 60% da variância da intenção de trabalhar com um robô social. A variável AT não apresentou efeitos diretos e indiretos estatisticamente significativos. A variável CCP não apresentou efeitos diretos significativos. Foi identificado um efeito direto de EP na intenção de trabalhar com robôs sociais. Todas as outras variáveis se comportaram de acordo com o postulado pelo modelo. Às variáveis externas analisadas no estudo 7, foi acrescentada a crença numa natureza humana única (NH). Foi estudado o efeito destas variáveis em AT, CCP, emoções positivas antecipadas (EP) e emoções negativas antecipadas (EN). Verificou-se que a aparência do robô afetava AT, EP e CCP. CO e ANI foram identificados como preditores positivos de AT. CA, CO e ANI foram identificados como preditores positivos de CCP. CA, CO e ANI foram identificados como preditores positivos de EP. CA e ANI foram identificados como preditores negativos de EN.

O estudo 9 comparou o poder preditivo dos três modelos estudados. O MAR explicou 37%, o MCP 42% e o COM 58% da variância da intenção de trabalhar com um robô social. Em resumo, o COM mostrou-se o modelo com maior poder preditivo. Não só explica maior percentagem da variância da intenção de trabalhar com um robô social, como o faz de forma mais completa, pois integra os efeitos de fatores motivacionais e emocionais. O estudo 9 voltou a identificar um efeito direto de EP na intenção de trabalhar com robôs sociais. Estes resultados sugerem a necessidade de investigar mais em pormenor o papel das emoções antecipadas na formação do desejo e intenção de trabalhar com robôs sociais.

Palavras chave: Robô social, modelo da ação raciocinada, modelo do comportamento planeado, modelo do comportamento dirigido por objetivos, aparência do robô, fatores sociocognitivos

Abstract

The growing number of robotic solutions geared to interact socially with humans, social robots, urge the study of the factors that will facilitate or hinder future human robot collaboration. Hence the research question: what are the factors that predict intention to work with a social robot in the near future. To answer this question the following socio-cognitive models were studied, the theory of reasoned action, the theory of planned behavior and the model of goal directed behavior. These models purport that all the other variables will only have an indirect effect on behavior. That is, through the variables of the model. Based on the research on robotics and social perception/ cognition, social robot appearance, belief in human nature uniqueness, perceived warmth, perceived competence, anthropomorphism, negative attitude towards robots with human traits and negative attitudes towards interactions with robots were studied for their effects on attitude towards working with a social robot, perceived behavioral control, positive anticipated emotions and negative anticipated emotions. Study 1 identified the social representation of robot. Studies 2 to 5 investigated the psychometric properties of the Portuguese version of the negative attitude towards robots scale. Study 6 investigated the psychometric properties of the belief in human nature uniqueness scale. Study 7 tested the theory of reasoned action and the theory of planned behavior. Study 8 tested the model of goal directed behavior. Studies 7 and 8 also tested the role of the external variables. Study 9 tested and compared the predictive power of the three socio-cognitive models. Finally conclusion are drawn from the research results, and future research suggestions are offered.

Keywords: Social robot, theory of reasoned action, theory of planned behavior, model of goal directed behavior, social robot appearance, socio-cognitive factors

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Aims and Overview

In 1998, a partnership between Carnegie Mellon University Robotics Institute and the Carnegie Museum of Natural History brought to life SAGE, an autonomous mobile robot guide. Its job is to provide visitors with educational information and guidance through the Dinosaur Hall exhibit area. After nine months of operation its creators report "174 days of service to the museum, with 135 of those days consisting of error-free, totally unsupervised operation" (Nourbakhsh et al., 1999, p.96). A few years later, Wada, Shibata, Saito, Sakamoto and Tanie (2005, April), reported on a one year study, conducted with three therapeutic seal robots in an elder nursing home. These seals, named PARO (http://www.parorobots.com) where designed to be used in therapy and activities with elders. Their results suggest that interactions with the robot seals improved mood and reduced depression symptoms. On the 29th of December of 2010 the website Daily Tech (McDaniel, 2010, December 29) reported on a four month pilot study using twenty nine egg-shaped, tele-operated English teaching robots. A year later, BBC News (2011, November 25) reported on a month trial due to start in a South Korean prison with three robot wardens. These three 150 cm robotic prison guards, are equipped with cameras and sensors and are expected to patrol the wards detecting risk behavior such has violence and suicide among the detainees and thus reducing the workload of the human guards. Researching on the use of robots in elder care, McColl and Nejat (2013) report on the use of the human-like socially assistive robot Brian 2.1. This assistive robot's aim is to provide cognitive and social stimulation and support during independent meal eating. The authors found that not only the elders thought the robot was engaging but also that 87% of the time they complied with its instructions. Museum guide, occupational therapist, teacher, warden or nursing home helper, these are all jobs that, although traditionally associated with a human presence, are now using robots. This growing trend in automating and roboticizing common everyday tasks and labor[1] as pushed robots from the confines of science fiction to the pages of leading international newspapers and newsmagazines. For example, Thomas Friedman asks in the New York Times "How did

[1] Erik Brynjolfsson and Andrew Mcafee, on their recent book "The second Machine Age" (2014), provide a throughout account on how computers and robots are getting increasingly better at what was thought to be exclusively human tasks, from driving to translating or even at playing jeopardy, the trivia contest.

the robot end up with my job?" (Friedman, 2011, January 10). The Economist reports on the development and use of robots to collaborate and work alongside humans (2013). In Foreign Affairs, Brynjolfsson, Mcafee & Spence (2014), point that "machines are substituting for more types of human labor than ever before".

If opinions diverge about the effects of the automation of work, they tend to converge when it comes to the need to accept the idea of a future, living with robots and automation (see Brynjolfsson & Mcafee, 2012; 2014; Manjoo, 2011, September 26). If the first question, how robots will impact the job market, belongs to the realm of economics, the second question, how is going to be our lives with robots, is already addressed by psychology. As early as the 80's, researchers like Argote, Goodman and Schkade (1983) and Shenkar (1988), were pointing to the disruptive impact of automation and industrial robots, both in job definition and organizational arrangements, given its ability to "perform tasks in a manner analogous to the human operation" (Shenkar, 1988, p. 103). Nevertheless, this line of research has focused mainly on the effects of automation in the context of industrial organizations and monotonous, dull and dangerous tasks, thus leaving unanswered the questions currently raised by the increasing number of assistive social robots deployed to perform tasks like the ones mentioned above, providing human support and supervision. However, two aspects were made clear by this early research: one, automation his producing profound changes in the ways we work and produce; two, the question is not do people want to work with robots? But how will people work with robots?

The present research follows that second line of reasoning and thus, aims to explore what are the determinants of the intention to work with social robots. That is, given the growing number of professional areas targeted by robotics, and the successful deployment of assistive robots designed with social interactions in mind, i.e. social robots, what are the socio-cognitive factors that will hinder or facilitate people's intention to work/ collaborate with a social robot.

This thesis is organized in three parts. In part 1, theoretical underpinnings will circumscribe and clarify the constructs and definitions used along the research. It starts by defining the concept of robot, social robot and its disruptive character. Next an overview of the socio-cognitive models, that is, the theory of reasoned action (Fishbein &

Ajzen, 1975), the theory of planned behavior (Ajzen, 1985), the theory of self-regulation (Bagozzi, 1992) and the model of goal directed behavior (Perugini & Bagozzi, 2001), is offered. Some possible determinants of the variables of the behavioral models are reviewed, namely negative attitudes towards robots (Nomura, Kanda, & Suzuki, 2004, July), belief in human nature uniqueness (elaborated for the purpose of this research), the stereotype model of warmth and competence (Fiske, Cuddy, Glick, & Xu, 2002), psychological anthropomorphism (Epley, Waytz & Cacioppo, 2007) and social robot appearance (Nishio & Ishiguro, 2011). Finally a summary of the hypotheses to be tested in Part 2: empirical research, is offered.

Part 2: Empirical research, will present the empirical results of the research. Study 1 aims to identify the current social representation of robot. Study 2 to 6 aim to investigate the psychometric qualities of two scales. Study 2 and 3 tests the structure of the Portuguese version of the negative attitude towards robots scale using a principal component analysis and a confirmatory factor analysis, respectively. Study 4 teste the nomological validity, while study 5 tests the predictive validity of the Portuguese version of the negative attitude towards robots scale. Study 6 tests the psychometric qualities of the belief in human nature uniqueness using for that purpose a principal component analysis and a bivariate correlation. Study 7 aims to test whether the theory of reasoned action and the theory of planned behavior allow the prediction of the intention to work with a social robot in the near future. It also studies the role of robot appearance, perceived warmth, perceived competence, anthropomorphism and negative attitudes towards robots as possible determinants of the attitude towards working with robots and perceived behavioral control. Study 8 aims to test whether the components of the model of goal directed behavior allow the prediction of the intention to work with a social robot in the near future. It also studies the role of robot appearance, belief in human nature uniqueness, perceived warmth, perceived competence, anthropomorphism and negative attitudes towards robots as possible determinants of the attitude towards working with robots, positive anticipated emotions, negative anticipated emotions and perceived behavioral control. Finally, Study 9 revisits the models studied using a larger sample, providing a comparison of their explanatory power.

Finally in part 3, research results are discussed and conclusions are drawn.

Part 1: Theoretical Underpinnings

Chapter 1: The Social Robot

1. Definition and Typology

1.1 Definition of robot.

A quick look at the Oxford dictionary (2010) teaches us that a robot is “a machine that can perform a complicated series of tasks automatically”. In more technical terms, the International Federation of Robotics (IFR) describes and defines, on their web site (www.ifr.org), two types of robots, industrial and service robots. The first is defined as “an automatically controlled, reprogrammable, multipurpose manipulator programmable in three or more axes, which may be either fixed in place or mobile for use in industrial automation applications” (www.ifr.org/industrial-robots). The second has the following definition: “a service robot is a robot that performs useful tasks for humans or equipment excluding industrial automation application” (www.ifr.org/service-robots). This definition is further decomposed into personal service robots, “used for a non-commercial task, usually by lay persons” (www.ifr.org/service-robots) and professional service robots “used for a commercial task, usually operated by a properly trained operator” (www.ifr.org/service-robots).

Although the idea of automatic or autonomous mechanisms can be traced back to ancient Greece (see Les Cahier Science et Vie, nº 132, 2012, October, for a brief history of technology) the word robot was coined only at the dawn of the XX century. Deriving from the Czech word *robota*, meaning slave, the expression was first used in Karel Capek theatrical play Rossum Universal Robots (R.U.R), a critique to technology, taylorism, communism and the alienation of the factory worker. Although in the play, robots are presented as artificial people akin to what would be called today an android, the word ended up meaning an automatic programmable machine, whose upmost representative is the industrial robot.

1.2 Types of robots.

Industrial, assistive, surgical, autonomous, tele-operated, social… the growing diversity of applications has increased the difficulty of categorizing robot type. The above mentioned IFR's classification groups robots by function specifying two broad categories: industrial and service robots. Industrial robots are further classified by mechanical structure into: articulated robots, cylindrical robots, linear robots, parallel robots and SCARA robots (http://www.ifr.org/industrial-robots/products/).

Service robots are divided in two broad categories, according to type of operator: personal/ domestic robots and professional service robots. These two categories are further divided by area of application. Personal/ domestic robots comprise the following categories: robots for domestic tasks, entertainment robots, handicap assistance, personal transportation and home security and surveillance. The category list for professional service robots is even longer, comprising the following categories: field robotics, professional cleaning, inspection and maintenance systems, construction and demolition, logistic systems, medical robotics, defense, rescue and security applications, underwater systems, mobile platforms in general use, robot arms in general use, public relation robots, special purpose, customized robots and humanoids (http://www.ifr.org/service-robots/products/).

Garcia, Jimenez, de Santos and Armada (2007) follow a different focus in their review, grouping robots by research area. They differentiate three broad areas: a) robot manipulators, where they include industrial, medical, rehabilitation, refueling, picking and palletizing robots; b) mobile robots, where they consider terrestrial, underwater and aerial vehicles; c) and biologically inspired robots, where they include walking, humanoid robots and other biologically inspired robots.

Both of the above classifications are largely rooted on engineering and technical solutions. Kaplan (2005, October), on the other hand proposes a different approach, arguing that the central question is not the functions we can envision for robots, but the value of the interaction provided. Thus, for Kaplan a robot should be defined by three general properties: 1) being a physical object; 2) functioning autonomously; and 3) being situated. Libin and Libin (2004), like Kaplan, argue that robot development should be centered on human needs. Based in this premise they propose a classification based on the type of support activity performed by the robot: assisting robots and interactive stimulation robots. Assisting robots are defined as mechanical in appearance, able to perform physical movements and to execute specific tasks, performing in hazardous jobs, expanding human sensory capabilities and helping in daily domestic chores. Among them are, industrial, research, military, medical and service robots. Interactive stimulation robots have the purpose of performing social, educational, rehabilitation, therapeutic and entertainment activities while engaging in complex interactions with humans. Although they consider that this last type of robot will tend to exhibit human features, it can also be inspired in other living animals (e.g. PARO Therapeutic Robot, www.parorobots.com). Among these are social, educational, rehabilitation and recreational robots.

In short, two large groups of robots can be devised, industrial robots and service robots. The first type is used in production activities; the second type is used for general assistive activities outside the production environment (e.g. domestic tasks, maintenance, health, security, education and entertainment). While some authors focus on engineering and technical aspects (e.g. Garcia, Jimenez, de Santos and Armada, 2007) others are turning the focus to the category of interaction (supportive, therapeutic, emotional) the robot provides to its user (e.g. Kaplan, 2005; Libin & Libin, 2004).

1.3 Presence of robots/ forecast.

Since the installation of the first industrial robot in the early 60s, the number of robots has grown exponentially. From the first robotic arms, that were little more than automated cranes, to robots that paint, weld and perform precision cuts, its use has expanded and diversified. From the motor vehicle industry to aeronautics, from medicine to agriculture, the number rose from 3000 industrial robots in 1973 to 66000 in 1983 and 605000 in 1995 (Gout, 2009). The IFR (2012) estimates that the number of operational multipurpose industrial robots in 2010 to be around 1.059.162 and forecasts that in 2015 it will be 1.575.500.

In 2010, Japan, The Republic of Korea and Germany where the most automated countries in the world, with respectively 306, 287 and 253 robots per 10.000 persons employed in the manufacturing industry. The average estimated density for the whole world is about 50 industrial robots per 10.000 manufacturing industry workers.

Nowadays robots are not confined to factories and have spread to other environments. Sales for professional and personal/domestic service robots in 2003 reached a total of 537.019 units (UNECE, 2005). In 2010, personal household robots, alone, represented 1.500.000 sold units. Entertainment and leisure robots sold 800.000 units and professional service robots sold 15.027 units. Of these professional service robots, 40% were defense applications, 31% were field robots and 6% were medical robots (IFR, 2012). Projections for the period of 2012-2015 suggest the number of professional service robots could reach 93.800 units and personal service robots could reach more than 15 million units. Robots for domestic tasks could reach close to eleven million units, entertainment robots close to 4.7 million units and assistance robots for the elderly and handicapped could reach 4.600 units (IFR, 2012).

In line with this growing presence of robots, the Japan Robot Association, in their "report on technology strategy for creating a robot society in the XXI century", proposes the extension of the expression robot to robot technology, defining it in the following way: "… robot technology refers to a much wider concept of robots as intelligent systems utilizing robot technology to provide useful functions in real-world situations" (Japan Robot Association, 2001, May). Their intent is to underline the shift from an industrial centered robotics to a service centered robotics with an emphasis on human needs. No longer limited to the automated heavy lifting crane, tirelessly laboring in the factory, robots are expected to become a regular presence in offices, schools, hospitals and households. Within this new paradigm creations like the Aibo (www.sony-aibo.co.uk), NAO (www.aldebaran.com) and Lego NXT (www.lego.com/en-us/mindstorms/?domainredir=mindstorms.lego.com) are crossing the boundaries between entertainment, social support and learning.

1.4 The social robot.

With a general overview of the current state of robotics sketched it is time to focus on the type of robot that is the concern of this research, the social robot.

Originally the term social robot was coined as a reference to small autonomous units used to replicate the behavior of social insects. Social robots, or swarm robots, are groups of very simple autonomous robots, operating according to a limited set of rules in a determined environment (Fong, Nourbakhsh & Dautenhahn, 2003). These social robots were a practical application of what biology had learned about group behavior in insects, birds and fish, that exhibit what seemed very complex behavior patterns, but presented an apparent limited information processing capacity. Although some authors (e.g. Breazeal, 2003) distinguish social robots (robots that interact with other robots) and sociable robots (robots that interact with people), the expression social robots, has progressively been adopted as meaning robots that are designed to interact with people.

In the preface of the first issue of the International Journal of Social Robotics, Ge and Matarić (2009) provide the following definition of this area of robotics: "social robotics is the study of robots that interact and communicate among themselves, with humans, and with the environment, within the social and cultural structure attached to their roles". Elaborating on the characteristics of a social robot Fong et al (2003) propose that it should:

- express and/or perceive emotions;
- communicate with high-level dialogue;
- learn/recognize models of other agents;
- establish/maintain social relationships;
- use natural cues (gaze, gestures, etc.);
- exhibit distinctive personality and character;
- learn/ develop social competencies.

This set of features comes together to form a social interface. "A social interface encloses all the designed features by which a user judges the robot as having social qualities" (Hegel et al, 2009). The implementation of these features follows a continuum, from minimum interactivity, to a complete social presence. Social robots could then be organized, given the set of interacting capabilities displayed, into the following categories (Breazeal, 2003):

Socially evocative: designed in a way as to encourage anthropomorphizing[2] in order to facilitate interaction, but not exhibiting social behaviors.

Social interface: uses human modalities of communication, voice, facial expression, but their interaction capabilities are limited.

[2] Anthropomorphism can be shortly defined as the attribution of human psychological traits to non-human agents. The concept will be further discussed in Chapter 3.

Socially receptive: robot behavior can change in response to human behavior. Although exhibiting some learning, these robots do not initiate interactions, only reacting to solicitations.

Sociable: besides changing their behavior in response to human behavior, these robots can start an interaction, they are socially participative.

In short, a social robot can be defined as a robot endowed with a social interface. This social interface would allow the robot to, among other things, use natural language, understand physical queues like gestures and gaze and express/ recognize emotions while operating autonomously.

1.5 The disruptive character of robots and social robots.

Although an industrial robot can be seen as an increment to the already existing industrial machinery, the fact is that industrial robots pose a series of challenges to workers, organizations and society. By replacing human workers in a series of task, robots induce the redefinition of job categories and organizational status. As Argote et al. (1983) point: “while robots may be viewed as another advance in automation, we believe that workers may view robots as qualitatively different from other forms of automation. Workers have been exposed to robots with glorified capabilities on television and in the movies. In addition, a robot often directly takes the place of a worker. We think these factors combine to make the introduction of a robot a very salient and possibly threatening event for worker's”. Shenkar (1988) offers a summary of some possible consequences of automation (robotics) on human employment: 1) displacement (this will be more relevant for lower skilled jobs. Although some argue that robotics will create new jobs, these will hardly equal the number of jobs lost, and the new jobs will be created at other points of the production cycle); 2) blocked promotion; 3) decrease in social interaction; 4) change in extrinsic rewards; 5) change in intrinsic rewards. Argote et al. (1983), also assert that automation will have a profound effect on job definition and workers perception of their role. Their research results, showed a profound change in the tasks of the workers now responsible for operating an industrial robot. The focus of the task changed from mainly manual to cognitive (monitoring the functioning of the machines and programming the robot), with operators reporting higher levels of stress and felt responsibility, while at the same time reducing interactions with co-workers given the more demanding cognitive tasks. The operators also reported that, although the robot eliminated heavy work, the job was now more boring, thus raising the question of motivation and worker preferences.

Unlike computers and industrial robots, social robots given their physical and social presence create a sense of agency akin to that of a living entity. As Young et al. (2011) point out, "robot's social and physical presence, and their tendency to evoke a sense of agency, creates a complex interaction context very different from that of interaction with other technologies and artifacts", and thus may require a new social category altogether[3]. Social robots fall outside of lay people's categories for machines altogether, the idea of a robot endowed with emotions, "personality" and perhaps human form, belongs to the category of discontinuous innovations[4] (Bagozzi & Lee, 1999). Thus, if the industrial robot brought a series of challenges to the organization of labor, the social robot will further those challenges to the organization of social life, as it permeates the boundaries of what is exclusively human.

Research on innovation acceptance has shown that apart from a small group of early adopters (Rogers, 2004) most people will tend to take some time incorporating "innovations" in their lives. This unwillingness to adopt the "new", called innovation resistance (Sheth, 1981), was initially seen as a consumer's reprehensible attitude, as innovation was equated with progress and improvement. Research has shown otherwise, suggesting that the common response to innovation is not enthusiasm but ambiguity (Rindova & Petkova, 2007) and anxiety (Fagan, Neill, & Wooldridge, 2003). In fact it is the early adopter that seems to be indiscriminately adopting innovations without pondering on their intrinsic value (Sheth, 1981). These results have led researchers to underline the need to understand innovation resistance (Sheth, 1981, Ram 1987), as a dynamic process resulting from the interplay between the characteristics of the innovation, the characteristics of the user and the propagation mechanism (Ram, 1987).

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[3] Anderson (2003) offers an account on how technology is challenging assumptions about "human nature" and self-identity.

[4] An innovation may assume three forms, improves an existing product, introduces new attributes to an existing product, or is an entirely new product. Continuous innovations consist in the introduction of changes in existing products. Discontinuous innovations refer to entirely new products (Bagozzi & Lee, 1999).

Reviewing the literature on the subject, Kleijnen, Lee and Wetzels (2009) identified the following set of factors as responsible for consumer resistance (or acceptance) of innovations:

- traditions and norms,
- existing usage patterns,
- perceived image,
- physical risk,
- economic risk,
- functional risk,
- and social risk.

Drawing on reviewed literature and their own research, Kleijnen et al. (2009) argue that these factors will weight differently in the adoption decision and that their combination will lead to three different stances: rejection, postponement or opposition to the innovation in question.

Although it can be argued that, social robots albeit representing a discontinuous innovation, will have its use determined by the factors identified by Kleijnen et al. (2009) as shaping the use of innovations, one central aspect must be taken into account: the professional use of social robots will follow the same pattern as the deployment of industrial robots in factory plants. That is, workers will not be asked if they want to work with social robots, instead they will be instructed to work with it[5]. As such the focus on product value and function, provided by most research on innovation does not account for the deliberative process that workers will have to engage when confronted with the presence of their automated partner. As Bagozzi and Lee (1999) pointed out the problem of acceptance (or rejection) of innovations must be viewed in the wider context of the person's goals, desires and life expectations. Consequently, we suggest that besides accounting for the actual technical dexterity, professional deployment of social robots will have to manage a series of expectations from both workers and employers: the social robot will reduce down time, it will turn the job into a boring endeavor, it will reduce the

[5] In other contexts, like the use of entertainment or domestic robots, product value will probably have a different weight. Also in the decision to use, personal preferences will probably play a more significant role. Nevertheless, the focus of this research is on the use of social robots at work, where the option of not using may not be available.

workload, it will increase responsibility, it will increase the number of steps to perform a task, it will make workers lazy, and so on.

In short, although technology is frequently equated with innovation, and innovation is seen as synonymous of progress, research suggests a somewhat different picture. That is, the introduction of innovations seems to be frequently associated with anxiety and a complex decision process that takes into account the person’s beliefs, values, goals and expectations. Social robots, given its disruptive character, both in terms of definition and of tasks performed require an attentive look at the socio-cognitive factors associated with attitudes, beliefs and social determinants of behavior.

Chapter 2: Determinants of Behavior

1. Overview

As pointed in the previous section, the introduction of social robots in the work place will confront workers with a significant challenge not only at a professional level, but also at a personal level. It is then of the upmost importance to understand what are the socio-cognitive factors that may underlie and determine people's intention to work with a social robot, since this will allow the development of organizational strategies to promote a smoother transition to this new environment.

This chapter opens with the operational definitions of overt behavior and behavioral intention. Then follows with the description of four socio-cognitive models, the theory of reasoned action, the theory of planned behavior, the theory of self-regulation and the model of goal directed behavior.

2. From thoughts to actions

2.1 Overt Behavior

Although behavior underlies all research in psychology, defining it may turn into a daunting task given the almost unlimited diversity and complexity of forms that human action assumes. For the purpose of this research behavior is defined as: an action that is clearly visible and understandable by the observer, *i.e.* overt behavior. Following Fishbein and Ajzen's (1975) operationalization: "the term behavior will be used to refer to observable acts that are studied in their own right"[6]. That is, there is no other meaning attributed to that behavior, there is no symbolic or representative attribution and no underlying qualities of the actor to be inferred from the behavior in question. Importantly, the measurement of the behavior to be studied should bear in mind four elements: the action, the target, the context and the time (Ajzen & Fishbein, 1977). That is, the action to be performed, the target of that action, the context where the action will take place and the time when the action will occur.

[6] It should be noted however that this does not mean that the behavior in question cannot in other circumstances be used as an indicator of beliefs, attitudes or intentions (Fishbein & Ajzen, 1975).

2.2 Behavioral Intention

What compels a person to act? "A great many behaviors of everyday life may be considered under volitional control in the sense that people can easily perform these behaviors if they are inclined to do so" (Ajzen, 1985). That is, unless the occurrence of some unexpected and unforeseen event, people are expected to act in conformity with their intentions. Thus, intention to perform a behavior (Behavioral Intention) has been identified by research in social psychology as the proximal psychological determinant of overt behavior (Fishbein & Ajzen, 1975; Bagozzi, Baumgartner & Yi, 1989; Webb & Sheeran, 2006 for a review)[7].

However it should be noted that although intention is the proximal determinant of overt behavior, not all intentions lead to actions. The behavior in question should be under some volitional control, that is, the person should have some of the necessary abilities and resources to carry on the action. And intention should correspond to behavior in terms of action, target, context and time (Fishbein, 1997).

In short, behavioral intention (BI) can be said to have a provisional character. When a person declares he has the intention to perform a given act (e.g. working with social robots in the near future), what that person is doing is assigning a subjective probability to the action. Intention then, constitutes a plan of action in pursuit of the behavioral goal (Ajzen, 1985). "Intentions are assumed to capture the motivational factors that influence a behavior; they are indications of how hard people are willing to try, of how much of an effort they are planning to exert, in order to perform the behavior. As a general rule, the stronger the intention to engage in a behavior, the more likely should be its performance" (Ajzen, 1991, p.181). Assessing a person's readiness to act, that is behavioral intention, would be done through questions like: does she intends to engage, expects to engage, is planning to engage, will try to engage and is willing to engage in the target behavior. "These various expressions of behavioural readiness are best considered manifest indicators reflective of the same latent underlying construct, *i.e.* intention" (Ajzen, 2011, p.1122).

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[7] Studies conducted under the technology acceptance model (TAM) framework have also shown that intention to use a technology is the best predictor of its effective use (Venkatesh & Davis, 2000; see King & He, 2006 for a meta-analysis).

To sum up, behavioral intention is a measure of how willing a person is to perform a behavior.

The next section presents the four behavioral models mentioned above, the theory of reasoned action, the theory of planned behavior, the theory of self-regulation and the model of goal directed behavior.

3 Theory of Reasoned Action (TRA)

3.1 Description of the model

According to Fishbein and Ajzen's (1975) the theory of reasoned action (TRA) main purpose is to predict behavioral intention (BI), which is considered the most proximal determinant of behavior. As described above, behavioral intention provides an indication of the effort a person his willing to put in order to perform a certain behavior. That is, intention somehow encapsulates the motivation to perform an action.

Behavioral intention is the combined product of attitude and subjective norm towards the target behavior (i.e. the behavior to be performed). All the other variables (e.g. demographic variables, personality traits or general attitudes) would exert their influence on BI indirectly through attitude and subjective norm (see Figure 2.1).

In the TRA attitude is defined as attitude towards a behavior, "the individual's attitude toward performing a particular act in a given situation with respect to a given object…" (Ajzen & Fishbein, 1969, p. 402). Attitude embodies a favorable or unfavorable appraisal; an evaluative stance towards the behavior and its expected consequences (e.g. enjoyable vs. unenjoyable, desirable vs. undesirable, good vs. bad, pleasant vs. unpleasant). That is, a person expects behavior X to produce outcome Y and thinks that outcome Y is desirable (or undesirable).

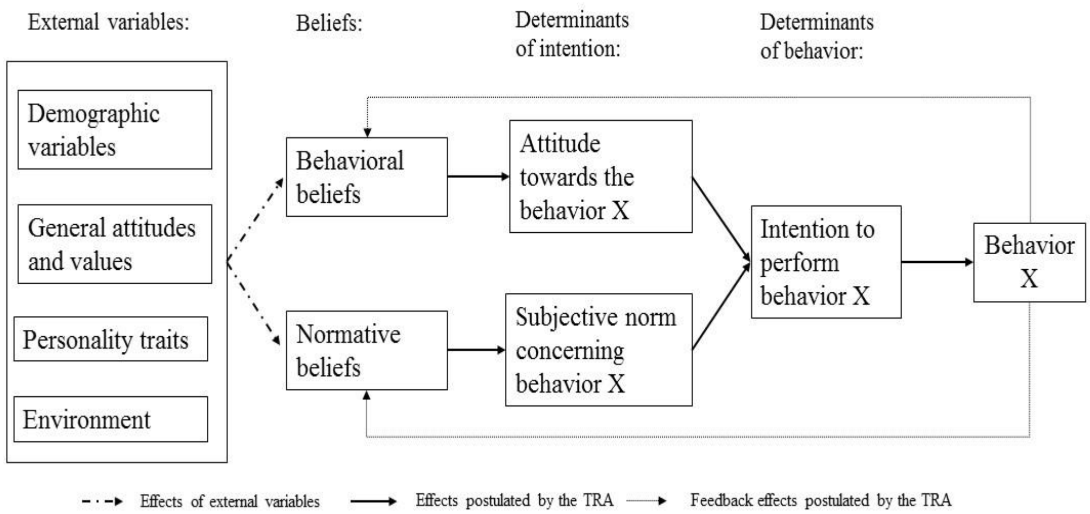

Figure 2.1. The theory of reasoned action (based on Ajzen &Fishbein,1973; Fishbein & Ajzen,1975).

Attitude towards a behavior is determined by a person's subjective expectation of a behavior producing a certain outcome, and the subjective value attributed to that outcome, that is, attitudes are determined by a set of behavioral beliefs (Azjen, 1985). Attitudes are expected to form automatically from this attribution of outcome probability and value to a behavior, encapsulating both expectancies towards the consequences of the behavior and an evaluation of those consequences. It is the combination of these beliefs about behavior outcome, their strength and their value, that produces a more favorable or unfavorable attitude, in what Fishbein and Ajzen (1975) have termed the expectancy-value model of attitude. "Generally speaking, we form beliefs about an object by associating it with certain attributes, i.e., with other objects, characteristics, or events. In the case of attitudes toward a behavior, each belief links the behavior to a certain outcome, or to some other attribute such as the cost incurred by performing the behavior. Since the attributes that come to be linked to the behavior are already valued positively or negatively, we automatically and simultaneously acquire an attitude toward the behavior" (Ajzen, 1991, p. 191). For example, has a person learns about the capabilities of a social robot, she comes to expect it to be compliant with work requests, arrive on schedule and work without pauses. These are aspects that will lead to an increased productivity, something this person values. As such, she will display a favorable attitude towards working with the social robot. That is, the behavior of working with a social robot is expected to increase productivity (behavioral belief) and thus is valued favorably (positive attitude towards working with social robots). It is important to note however, that not all beliefs contribute equally to attitude; a person attends only to a small set of salient beliefs when forming attitudes. As the person gathers more information, beliefs will tend become more or less salient or even change the evaluative direction, thus influencing attitudes. “From an expectancy- value perspective, therefore, attitudes have an emergent quality. They develop in the course of acquiring information about the attitude object, and they keep evolving as existing beliefs change and new beliefs are formed” (Ajzen & Fishbein, 2000, p. 6).

Although beliefs are formed on the basis of the information a person gathers about the world, and attitudes emerge automatically and are consistent with the accessible beliefs, it should not be inferred that beliefs are strictly rational assumptions. In spite of being generally accurate, beliefs are prone to biases and motivational processes, which result in information selection and inaccuracy (Ajzen & Fishbein, 2000). That is, even though there is coherence and logic to the process of attitude formation, the set of beliefs underlying an attitude may not reflect a very reasonable and objective view of reality. In addition, even when beliefs are accurate, their salience may lead to an attitude that may seem, to an outsider, not very reasonable. For example, when asked almost everyone would agree that smoking is damaging to he’s health. However a person can also believe that smoking relaxes her. At the same time she has the evidence of her uncle that, although an inveterate smoker, lived until he was 98. Given the salience of these two latter beliefs, this person might dismiss the information about the risks of smoking, valuing more the relaxing effect of a cigarette at the end of the day.

In short, accessible (salient) behavioral beliefs lead to the formation of an attitude towards a target behavior, which in turn helps the formation of a behavioral intention to perform the behavior, which in turn will lead to the performance of the behavior (see figure 2.2) .

One final consideration about attitudes in order. One of the aims of the TRA was to account for the rather low attitude-behavior correlations found by research. As Ajzen

(1982) points out the measurement of people's attitudes towards general classes of objects, like social class or institutions, revealed itself a poor predictor of individual overt behaviors. That is, although an attitude was defined as an evaluative judgment, leading to a predisposition to respond in a favorable or unfavorable manner to an object, attitude per se rarely resulted in a readiness or willingness to act in a certain way. Attitudes, in spite of being related to the totality of a person intentions and behavior towards an object, may have little or no relation to a single belief, intention or behavior (Ajzen, 1982). In fact, research results support the argument that a behavior is determined by the intention of performing that behavior and that intention in turn, is determined by attitude towards performing the behavior (e.g. Ajzen & Fishbein, 1969; 1970; 1972; 1977). For example, a person can hold a positive attitude towards voting, but may not intend, or be willing to vote for the election of the best athlete of the year.

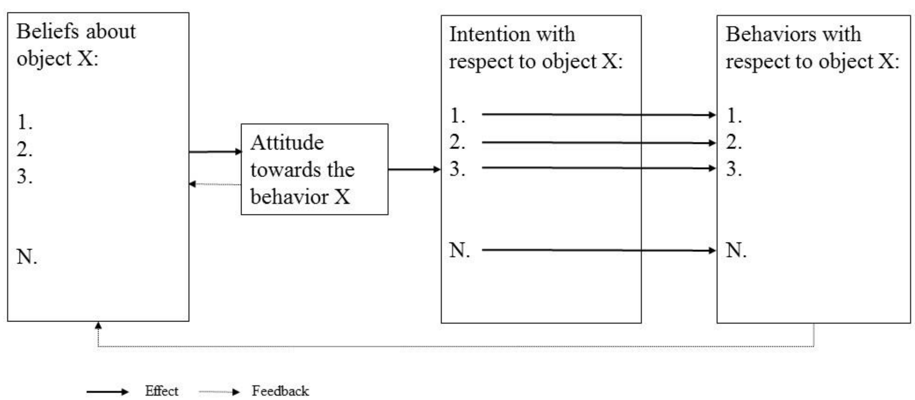

Figure 2.2. The relation beliefs, attitude, intention, behavior. (adapted from Fishbein & Ajzen, 1975, p. 15).

The subjective norm can be understood as the perceived social pressure to perform (or not) a certain action. In its initial conception, the normative component included: the person's perception of what others think his behavior in a certain situation should be (normative beliefs), his personal beliefs about how he should behave in a certain situation (personal normative beliefs), and the motivation to comply with those norms (Ajzen & Fishbein, 1969). Further research led the authors to abandon the concept of personal normative beliefs and motivation to comply since these components did not bring relevant contributions to the model (see Ajzen & Fishbein, 1970). A person's normative beliefs are a function of the perceived attitude of the relevant others toward the behavior or object in question. "For example, just as a person's attitude toward a given behavior was related to his beliefs about the consequences of performing that behavior and his evaluation of those consequences, his perception of attitudes of relevant others was related to his perception of their beliefs about the consequences of performing the act and his perception of their evaluation of those consequences" (Ajzen & Fishbein, 1972, p. 8). For example, a person who believes that her parents will approve of her working with a social robot, and values the approval of her parents, will display a favorable subjective norm towards working with a social robot. Likewise, a person who believes her supervisor will value a flawless operation of a social robot, will be more willing to put an extra effort in studying the technical and operational manual in order to collaborate more efficiently with it.

Normative beliefs, as viewed in this model, are more restrictive than the concept of social norms, "it refers to a specific behavioral expectation attributed to a given social agent. While a social norm is usually meant to refer to a rather broad range of permissible, but not necessarily required, behaviors, NB refers to a specific behavioral act the performance of which is expected or desired under the given circumstances." (Ajzen & Fishbein, 1972, p. 2)

In summary, the TRA deals with the prediction of a specific behavioral intention (BI) in a well-defined circumstance, and assuming the person has complete control over performing the behavior. The model includes a personal (attitudinal) factor and a social (normative) factor. The attitude towards a specific behavior is a function of the behavior's perceived consequences and their value for the person. The normative beliefs are the person's beliefs about the expectations of significant others about performing the specific behavior. All other variables have their effect on BI mediated by the attitudinal and normative factors. "It follows that a single act is predictable from the attitude toward that act, provided that there is a high correlation between intention and behavior." (Ajzen & Fishbein, 1977, p.888).

3.2 Predictive power of the TRA

Since it was first formulated the TRA has been used both in theoretical and applied research, receiving empirical support and proving itself useful in a diverse number of settings, from health behavior (e.g. Beadnell et al., 2008 use the TRA to predict heterosexual men's intention to use condom), to education (e.g. Vincent, Peplau, & Hill, 1998 use the TRA to predict career behavior) and business ethics (e.g. Kurland, 1995 uses the TRA to predict insurance agent's ethical intentions towards their clients). Ajzen (1985) reviewing empirical results supporting the TRA, found correlations between intention and actual behavior ranging from .55 to .96. Attitude toward behavior was found to account for 19% to 74 % of the observed variance and subjective norm for 13% to 70% of the observed variance of intention to perform the behavior. Sheppard, Hartwick and Warshaw (1988) conducted a meta-analysis of the TRA and reported a frequency-weighted average correlation of .53 between intention and actual behavior, based on 87 separate studies, with a total of 11556 participants, at a .001 level of significance. The frequency-weighted average correlation between attitude, subjective norm and intention was .66, based on 87 separate studies, with a total of 12624 participants, at a .001 level of significance. These results support the overall predictive value of the TRA. The TRA has also been used to predict several technology related behaviors like the use of a word processor software (Davis, Bagozzi & Warshaw, 1989[8]), acceptance of an expert systems for accountants (Liker & Sindi, 1997), use of internet banking (Yousafzai, Foxall, & Pallister, 2010[9]) and software piracy (Aleassa, Pearson and McClurg, 2011). Davis et al., (1989) and Yousafzai et al., (2010) measured actual behavior. The first found that intention predicted 12% (Time 1) and 40% (Time 2 – 14 weeks later) of the variance of actual use of the word processor; the latter that intention predicted 37% of the variance of actual use of internet banking. Davis et al., (1989), Yousafzai et al., (2010) and Aleassa et al., (2011), found that attitude towards the behavior and subjective norm predicted the variance of intention to use a word processor (Time 1= 32%; Time 2= 26%), to use internet banking (47%) and to use pirated software (15%) respectively.

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[8] Provides a comparison with the technology acceptance model - TAM

[9] Provides a comparison with TPB and TAM

The practical value of the TRA resides in, not only allowing the study of the factors conducing to behavior, but also, based on these factors, develop empirically supported interventions. These interventions however, must take into account some principles (Fishbein & Ajzen, 1975): first even though an intervention can aim towards a belief, an attitude, a subjective norm, an intention, or a behavior, only proximal beliefs (i.e. beliefs directly corresponding to an object attribute association) can be targeted for direct effects. That is, attitudes, subjective norms, intention and actual behavior will only be affected indirectly. Second, it is essential that beliefs targeted for change are primary beliefs, that is, the beliefs that determine the variable of interest. Change in primary beliefs can be achieved by either exposing the person directly to new information about the object (active participation), or using an outside source to convey the new information about the object (persuasive communication). Third, the further the target of the intervention, the higher the number of intermediate effects. That is, when the target for change is a primary belief, there is a direct effect. If the target for change is attitude, there is a direct effect on the primary belief and an indirect effect on attitude. If the target of change is intention, there is a direct effect on the primary belief, an indirect effect on attitude and an indirect effect on intention, what Fishbein & Ajzen, (1975) call a multiple-step chain. The same reasoning applies to attempting to change behavior. In order to build an effective intervention it is essential to have a reasonable knowledge of the expected chain of effects.

4 Theory of Planned Behavior (TPB)

4.1 Description of the model

One of the central contentions of the previously presented TRA is that the model is only fit to predict behavior that is under volitional control. In order to overcome this limitation Ajzen (1985, 1991) advanced the theory of planned behavior (TPB). According to it, the proximal determinant of behavior would be the intention to perform that behavior. Intention (or behavioral intention) in turn, would be determined by the attitude towards the behavior, subjective norm and perceived behavioral control.

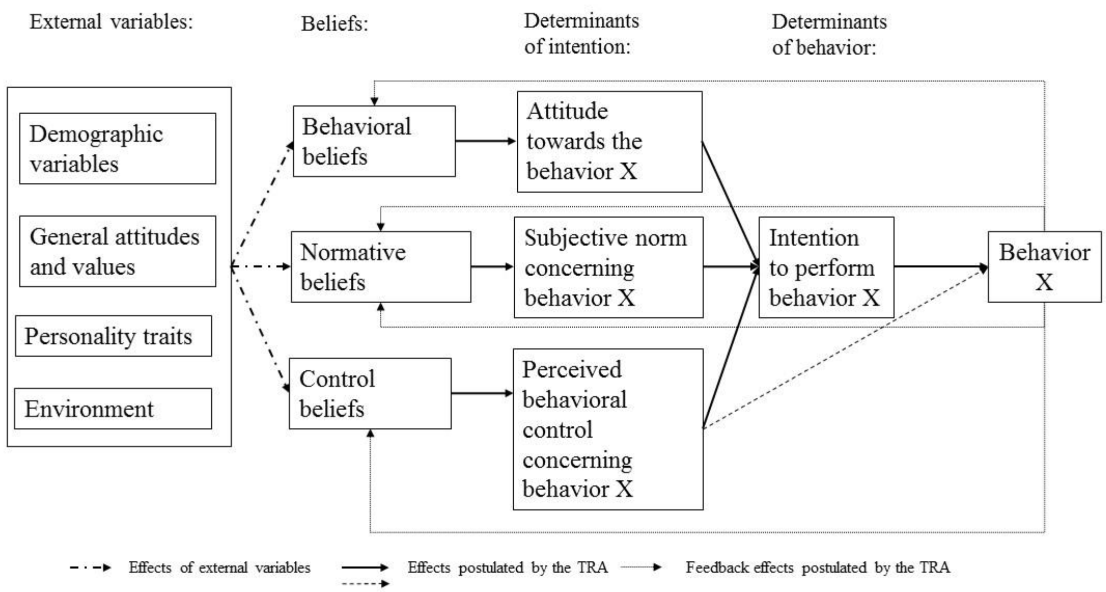

Figure 2.3. The theory of planed behavior (based on Ajzen, 1985, 1991)

Attitude towards the behavior and subjective norms are defined like in the TRA. Attitudes provide the evaluative, while subjective norms provide the normative components that lead to intention. However, in order to perform a behavior a person also needs personal competencies and material resources[10]. This perception of how easy or difficult it will be to perform a particular behavior is called perceived behavioral control (PBC). “Perceived behavioral control in the theory of planned behavior refers generally to people’s expectations regarding the degree to which they are capable of performing a given behavior, the extent to which they have the requisite resources and believe they can overcome whatever obstacles they may encounter” (Ajzen, 2002, p. 676). PBC accounts both for internal or external, real or imagined obstacles and resources. They are the person’s perception of the factors that might facilitate or hinder the performance of the behavior. That is, PBC can result from realistic and “not so realistic” evaluations. A high level of perceived behavioral control strengthens the intention, increasing effort and perseverance, thus affecting behavior through BI. When PBC is an accurate measure of the person’s control it can be used as an additional direct measure of behavior (Ajzen,

[10] It should be noted that the evaluation of the available personal and material resources is done against the backdrop of past experience.

2002). A meta-analysis of the TPB conducted by Notany (1998) confirms that PBC is related both to intention and behavior, although showing a stronger relation with the first.

PBC refers to an efficacy expectation, *i.e.*: “I will be able to perform behavior X” and not to an outcome expectancy, *i.e.*: “the performance of behavior X will likely lead me to outcome Y”. Although showing some similarities with the concept of self-efficacy, PBC is conceptually different. Self-efficacy is defined by Bandura as “people’s beliefs about their capabilities to exercise control over their own level of functioning and over events that affect their lives” (Bandura, 1991, p. 257). PBC on the other hand, is focused on the ability to perform a specific behavior. PBC should also be contrasted with the concept of locus of control. This last one is “the extent to which they view rewards, punishments, or other events in their lives as caused by their own actions or by factors beyond their control” (Ajzen, 2002, p. 675).

In short, according to the TPB, behavior is a function of intention, which is the combined expression of attitude, subjective norms and perceived behavioral control. The relative importance of these three will vary across situations, behaviors and time. PBC can also be used, together with behavioral intention, as a direct predictor of behavior.

4.2 Predictive power of the TPB

Like the TRA, the TPB has received ample empirical confirmation of its usefulness, both in theoretical and applied fields of research. Ajzen (1991) reviews empirical evidence for the prediction of behavior using BI, PBC and the TPB. Regression analysis results showed that BI and PBC accounted for 23% to 84% of the variance of actual behavior (sample of 12 studies). Attitude towards behavior, subjective norm and perceived behavioral control account for 43% to 94% of the variance of intention (sample of 16 studies). Armitage and Conner (2001) conducted a meta-analysis of the TPB using 185 independent studies. The authors reported that TPB accounts for 27% of the variance of behavior and 39% of the variance of intention. PBC was also found to account for a significant percentage of the variance of behavior and intention, independently of attitudes towards behavior and subjective norm, thus supporting the inclusion of PBC in the model. Ajzen (2011, 2012, 2014), report on recent theoretical and empirical progresses, while responding to some criticisms to the model. The TPB has been found useful in the prediction of behaviors like: exercise (see Blue, 1995; Godin, 1994 for reviews[11]), health related behaviors (see Cooke & French, 2008[12]; Godin & Kok, 1996; McEachan, Conner, Taylor, & Lawton, 2011), sexual behavior (Albarracín, Johnson, Fishbein, & Muellerleile, 2001[13]) buying behavior (Cannière, Pelsmacker, & Geuens, 2009) and consumer adoption intentions (Taylor & Todd, 1995).

The TPB has also been applied to behaviors related to the use of technology, namely, intention to use a spreadsheet software (Mathieson, 1991[14] - $R^2_{adj} = .60$), online shopping (Hansen, Jensen and Solgaard, 2004[15]), e-commerce adoption (Grandón, Nasco and Mykytyn, 2011[16]), use of social networking sites (Baker & White, 2010), digital piracy (d'Astous, Colbert & Montpetit, 2005; Kwong & Lee, 2002; Liao, Lin & Liu, 2010; Yoon, 2011, 2012) and acceptance of social robots (Tay, Jung & Park, 2014). Albeit several of these studies use modified versions of the TPB (e.g. Baker & White, 2010; d'Astous, Colbert & Montpetit, 2005; Kwong & Lee, 2002, January; Liao, Lin & Liu, 2010; Yoon, 2011), results generally support the TPB model, with attitude towards behavior, subjective norm and perceived behavioral control explaining between 35% and 81% of behavioral intention variance.

The three principles that interventions should take into account, mentioned above for the TRA, are also applicable to the TPB. Quine, Rutter & Arnold (2001) provide a good example of its application. The authors designed an intervention aimed at increasing the number of youngsters using helmet when riding their bikes to school. Their intervention targeted behavioral beliefs about helmet use, normative beliefs and control beliefs (identified in a previous research). The group of 97 participants was divided, with half receiving a booklet with information directed at the primary beliefs, and half receiving information regarding cycling proficiency and bicycle maintenance. Beliefs were measured before the intervention, right after the intervention and five moths latter. Results showed that behavioral, normative and control beliefs, relative to wearing a helmet, become more positive in the experimental group than in the control group. At

[11] Both papers provide comparisons with the TRA.
[12] Provides a comparison with the TRA
[13] Meta-analysis of the TRA and TPB applied to condom use.
[14] provides a comparison of TPB and TAM
[15] Provides a comparison with the TRA.
[16] Provides a comparison with the TRA.

five month follow up there was significant behavioral effect, with 25% of the experimental group wearing helmet when cycling to school, while none of the participants in the control group did it. Other example is Kazemi and Forward (2009). Their intervention focused on helmet use, among adults, when cycling to work. Beliefs were measured before and after the intervention. The intervention was based on a one hour informative session presenting the health benefits of cycling, but also the risks and consequences of accidents when not wearing helmet (behavioral and normative beliefs). Participants were also offered the opportunity to sign for a free cycling helmet (control beliefs). Results show that the intention to wear a helmet when cycling to work increased in the experimental group after the intervention.

5 The Theory of Self-Regulation (TSR)

5.1 Description of the model

Bagozzi (1981), like Ajzen and Fishbein (1977), found that attitudes do not affect behavior directly, having its effect mediated by intention. “Using measures of actual blood donation behavior at two points in time as criteria, we found that attitudes influence behavior but do so in an indirect manner only through their impact on intentions, as Fishbein has long argued” (Bagozzi, 1981, p. 607). Further researching the attitude-intention-behavior relationship Bagozzi (1992) contends that not only attitude and subjective norm are not direct determinants of intention, but also that intention per se does not lead to action. Attitudes are have been defined as an evaluative appraisal, favorable or unfavorable, towards an object, or in the case of the TRA and TPB, towards behaving in a certain way relatively to a certain object. That is, a person believes that acting in a certain way towards a certain object will result in a desirable (or undesirable) outcome. Although this favorable (or unfavorable) stance towards a behavior provides a reason for acting, it does not provide a motive. “In and of themselves, evaluative appraisals such as those found in attitudes do not imply motivational commitments. In contrast, the existence of a desire, in the presence of a belief that one can act, is a sufficient motivator to activate an intention and does not require a positive evaluation” (Bagozzi, 1992, p. 184). Drawing an example: a person might have a favorable attitude towards using robots at work, but have no wish to do so. Likewise a person may have an unfavorable attitude towards the use of robots at work, since she views it as resulting in lower employment rates, but feel compelled to do so, in order to secure her job.

In short, in order to transform an attitude toward behavior A, into an intention to perform behavior A, it is necessary a motivational “push”, that is, a desire to perform behavior A. “The missing motivational link in the attitude-intention relationship seems to be related to the subjective experience of desiring to perform an action” (Bagozzi, 1992, p.184).

Desire is defined by Perugini & Bagozzi, (2004b, p.71) as “a state of mind whereby an agent has a personal motivation to perform an action or to achieve a goal”. Desire differs from attitude in several aspects. Desire implies a motivational commitment to act, refers to a future act, and has a limited duration (i.e. once satisfied loses its motivational effect). Attitudes on the other hand provide only a reason to act, not a motive. May refer to past present or future behaviors and are persistent over time. Further detailing on the formation of desire, Bagozzi (1992) distinguishes appetitive desire and volitive desire. The first would be directed towards activities of consuming (e.g. desire for a drink) and would not be based on a reason per se. The second would be based on reasons (e.g. desire to exercise). Attitudes would lead to intentions either by freeing up an appetitive desire or by stimulating a volitive desire. Bagozzi (1992) further contends that, occasionally, desires could lead to intentions even without the contribution of attitudes.

This redrawing of the attitude - intention relation assumes also a critique to the way intentions are conceptualized. Both the TRA and TPB assume that motivation is captured by the concept of intention (Ajzen, 1991), Bagozzi (1992) argues differently. According to him, desire represents the first step towards the decision to act, drawing on emotional, evaluative and social cues. Intention on the other hand would be more closely connected to behavior; concerning a plan of how to perform the behavior. If, on one hand, the intention to perform a behavior requires a desire to do so, on the other hand, a desire does not imply intention to act. A person will not intend to work with a social robot, unless she desires to do so. Likewise, a person may desire to work with a social robot, but since it lacks the expert skills to do so, she will have no intention to do so. This self-efficacy evaluation is crucial for a desire to become an intention, even though desire per se does not imply necessarily that a person has the skills or material means to accomplish it.

Desire, thus, differs from intention in the following (Perugini & Bagozzi, 2004b): 1) perceived performability, intention to perform an action is generally associated to a reasonable level of confidence in the capacity to perform that action. Desire for an action does not entail capacity to perform that action; 2) action connectedness, intentions imply some form of planning and commitment and are strongly connected to outcome and goals. Intention implies a plan of action (how, when and where). Desires do not require the specification of a plan of action, they form a pre-intention phase, with a high level of abstraction; 3) temporal framing, although there is no final rule, desires are generally associated with an undefined time, and intentions are generally associated with shorter term plans that involve opportunity and resources.

In sum, desire is conceptualized in more abstract terms and over longer time periods. It is less specific, and thus, opened to more than one way of fulfillment, unlike intention that is generally connected to an action or goal. Desire is less affected by perceived feasibility than intention, as it requires only an abstract conceptualization of the goal. Intention, on the other hand, needs to take in consideration practical questions, like resources and alternatives. Feasibility, like self-efficacy, is central in the transformation of a desire into an intention.

The discriminant validity between desire and intention and the role of desire as mediator of the effects of attitude towards behavior, perceived behavior control and subjective norm has received empirical support. Perugini and Conner (2000), studied body weight regulation and study effort. They report that desire and intention achieve discriminant validity using a confirmatory factor analysis (CFA). They also found desire to predicted intention (β = .85), while perceived behavioral control was found to be a significant predictor of desire (β = .34). No effects were found for attitude towards behavior or subjective norm. Perugini and Bagozzi (2001) studied intention to diet, to exercise and study effort. The authors report discriminant validity between desire and intention using a CFA. Intentions predicted 25% of actual dieting behavior, 46% of actual exercising behavior and 24% of actual studying behavior. Desire was found to have a significant effect on intention, predicting 74% of the intention to diet, 78% of the intention to exercise and 53% of the intention to study. In the studies about dieting and exercising, only subjective norm and perceived behavioral control were found to have a significant effect on desire. In the study about studying effort, all three variables had significant effects on desire. Perugini and Bagozzi (2004b), focused on the distinction between desire and intention. They asked participants to mention a desire or intention and afterwards to rate it according to expected temporal completion, perceived feasibility, expected likelihood of execution and expected likelihood of achievement. Participants reported that they expected desires to be implemented later in time, be less feasible, and to have a lower probability of execution and achievement than intentions, which supports the theoretical criteria presented above, to distinguish desire and intention.

Besides introducing a motivational component, desire, in the attitude-intention-behavior relationship, Bagozzi (1992) offers a few more critiques to how the TRA and TPB variables are conceptualized. Concerning subjective norm, he contends that motivation to comply covers only a small part of the possible emotional response range. Subjective norms imply a dynamic interplay between one's emotional responses, the other's expected emotions and the ability to take the perspective of the other, i.e. normatively based emotions. He also argues that normative experiences are conditioned by social context, distinguishing when a person is an independent agent, is part of a group and part of a formal organization.

The concept of intention is also further specified with the distinction of present oriented, future oriented and goal oriented intention. Present oriented intention refers to a decision to act immediately (e.g. a person is using he's laptop computer to write an essay). Future oriented intention implies a decision to act later and can be non-contingent (e.g. a person will use his laptop computer to write an essay) or contingent (e.g. a person will write his essay on a laptop computer, if someone lends him one). Goal oriented intention implies a set of behaviors that will lead to a desired outcome (e.g. in order to write he's essay on a laptop computer, a person will have to ensure that he has a place to sit, he's personal notes, the laptop has a word processor, enough battery and so on). That is, goal intention implies decisions regarding means, instrumental acts, personal abilities and situational factors.

Finally, Bagozzi (1992) emphasizes the dynamic, self-regulatory character of behavior. That is, unlike the TRA and the TPB which conceptualize the determinants of behavior as following a relatively linear path towards action, the TSR underlines the motivational, affective and instrumental aspects of striving towards a goal behavior.

In short, in order to understand the chain of events the follow from attitude – intention - behavior, Bagozzi (1992) proposed the theory of self-regulation of attitudes, intentions and behavior (TSR). Contrary to the TRA and TPB, the TSR argues that attitudes, subjective norm and intention although necessary are not sufficient to explain behavior. While the TRA and TPB argue that the motivation to act is encapsulated by behavioral intention, the TSR proposes that the motivational "push" to act is provided by desire. A favorable attitude will only become an intention if a person desires to perform the behavior in question, that is, only if a person as the desire to pursue a goal behavior perceived as valuable. Behavioral intention would encompass a set of decisions regarding opportunities and resources, thus underlining the self-regulatory character of behavior.

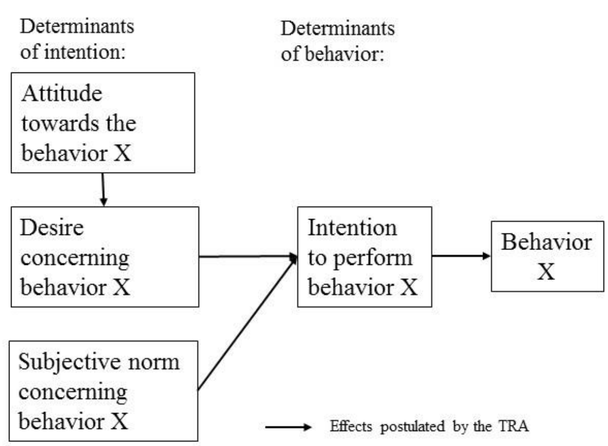

Figure 2.4. Theory of self-regulation (adapted from Leone, Perugini & Ercolani, 1999, p. 163)

Leone, Perugini & Ercolani (1999) provide a comparison of the TRA, TPB and TSR (see figure 2.4 for model). Their results confirm the limitations of the TRA, since it does not account for motivational and self-efficacy variables. The TRA model predicts 40% of intention, while the TPB and TSR predict respectively 52% and 68% of intention. Expanding the three models using past behavior, they conclude that it has a significant effect on the predictive power of the TRA, but little effect on the TPB and TSR. These two models seem to already account for the effects of past behavior through perceived behavioral control and desire. The authors also note that, both TPB and TSR predict intention, although they do it from two distinct perspectives. While the TPB focus on self-evaluation (attitudes, subjective norms, perceived behavioral control), the TSR focus on motivation (attitudes, subjective norms, desire), thus offering an alternative explanation for the attitude – behavior relationship.

The interest of the TSR resides in two key aspects. First and foremost: the introduction of desire and its motivational character. Second: the reconceptualization of behavioral intention in terms of goal striving. These ideas are both crucial to understand the model of goal directed behavior presented below. In a certain way the TSR can be viewed as an intermediary steep towards the model of goal directed behavior.

6 Model of Goal Directed Behavior (MGB)

6.1 Description of the model

Like the TRA, TPB and TSR, presented above, the aim of the model of goal-directed behavior (MGB, Perugini & Bagozzi, 2001) is to explain and clarify the attitude – intention - behavior relationship, while at the same time overcoming the limitations of the aforementioned models (see figure 2.5).

Briefly, the TRA only accounts for behavior under complete volitional control. Although the TPB accounts for controllability, according to Bagozzi (1992) neither the TRA nor the TPB take into account motivational or affective elements. The TSR, presented in Leone et al. (1999), accounts for desire (motivational element) but does not account for affective elements. The MGB draws from all these three models, while trying to account for the above mentioned limitations.

The MGB, like the TRA and the TPB, recognizes the role of attitude towards the behavior, subjective norms and perceived behavioral control in determining intention to perform the behavior. However, like the TSR, introduces desire as a mediating motivational variable. The concept of intention, like in the TSR, includes the formation of goals. That is, intention is not operationalized only as the performance of a behavior, (e.g. I intend to exercise) but the performance of the behavior is viewed as pertaining to goal achievement (e.g. I intend to exercise because it will make me healthier). In spite of this reconceptualization intention is still defined as the most proximal determinant of behavior.

Besides these variables, already present in the TRA, TPB and TSR, the MGB includes an affective component, (positive and negative) anticipated emotions and a proxy of habit, past behavior.

Although representing an evaluation, anticipated emotions are distinct from the evaluative component of attitudes. First, anticipated emotions do not focus on the behavior per se, like attitudes, but on the achievement, or not, of a personal goal through that behavior. Anticipated emotions are pre-factual appraisals, i.e. "a decision maker imagines the affective consequences of goal attainment and goal failure before deciding to perform instrumental acts" (Perugini & Bagozzi, 2001, p.82). Second, anticipated emotions are not dispositional states, but a dynamic self-regulation process in response to achieving, or not a desired goal. While attitudes are relatively stable and non-contingent, anticipated emotions are contingent to one's appraisal of goal achievement or failure and thus sensible to contextual changes. In detailing the role of emotions in the decision process, Bagozzi, Baumgartner & Pieters, (1998)[17] contend that the appraisal of a goal results in a set of anticipatory emotions (positive and negative) which are the result of anticipated success or failure in goal achievement. These emotional responses to anticipated success or failure play a key role in the volitional process and goal-directed behavior, both motivational and regulatory. Baumgartner, Pieters and Bagozzi (2008, p. 685) further distinguish between anticipatory and anticipated emotions. "Anticipatory emotions are currently experienced due to the prospect of a future event (e.g., hope or fear). Anticipated emotions, on the other hand, are expected to be experienced in the future if certain events do or do not occur (e.g., anticipated joy or regret)". The authors found that anticipatory and anticipated emotions independently motivate goal-directed behavior; however research results suggest that anticipated emotions have a stronger motivational effect than anticipatory emotions. Also, negative emotions seem to be more influential of behavioral intentions than positive emotions. Previous research by Leone,

[17] In this paper the authors detail the role of emotions in goal appraisal and pursuing, in what they call the emotional goal system. See also Bagozzi and Le (1999) for an account of the role of emotional processes in goal setting and goal striving processes.

Perugini and Bagozzi (2005) had already suggested differential effects for negative and positive emotions on decision making and action planning. Baumgartner et al. (2008) also point that the simulation of future expected emotions may alter the present felt emotion, thus playing a role in self-regulation of goal pursuing. In the MGB anticipated emotions are expected to influence intention indirectly, through their effect on desire (see figure 2.5).

Past behavior is hypothesized to have an effect on desires, intention and behavior, since “frequent performance of a behavior may bring subsequent behavior under the control of habitual processes” (Conner & Armitage, 1998, p.1436). Perugini & Bagozzi (2001) describe two processes through which past behavior frequency influences intention and future behavior. When a behavior is well practiced in a constant environment, thus forming a habit and directly influencing future behavior. When behavior is neither well practiced nor performed in a constant environment, but its familiarity will result in a favorable intention towards it. Perugini and Bagozzi (2001) also distinguish behavior frequency and behavior recency. That is, the behavior happened very often in the person’s life (frequency), and the behavior was recently initiated (recency). Thus, a past behavior can be frequent, but not recently performed, and a past behavior may not be very frequent, but was recently performed. Past behavior frequency is expected to affect desire, intention and future behavior, while past behavior recency is expected to affect only future behavior (see figure 2.5).

For the purpose of this research past behavior will not be investigated. Given the still limited number of opportunities to perform real life interactions with social robots, measuring past behavior frequency or recency would reveal itself pointless. As an alternative, participants were asked how familiar they were with the concept of social robots and if they had already seen the social robots presented in the research.

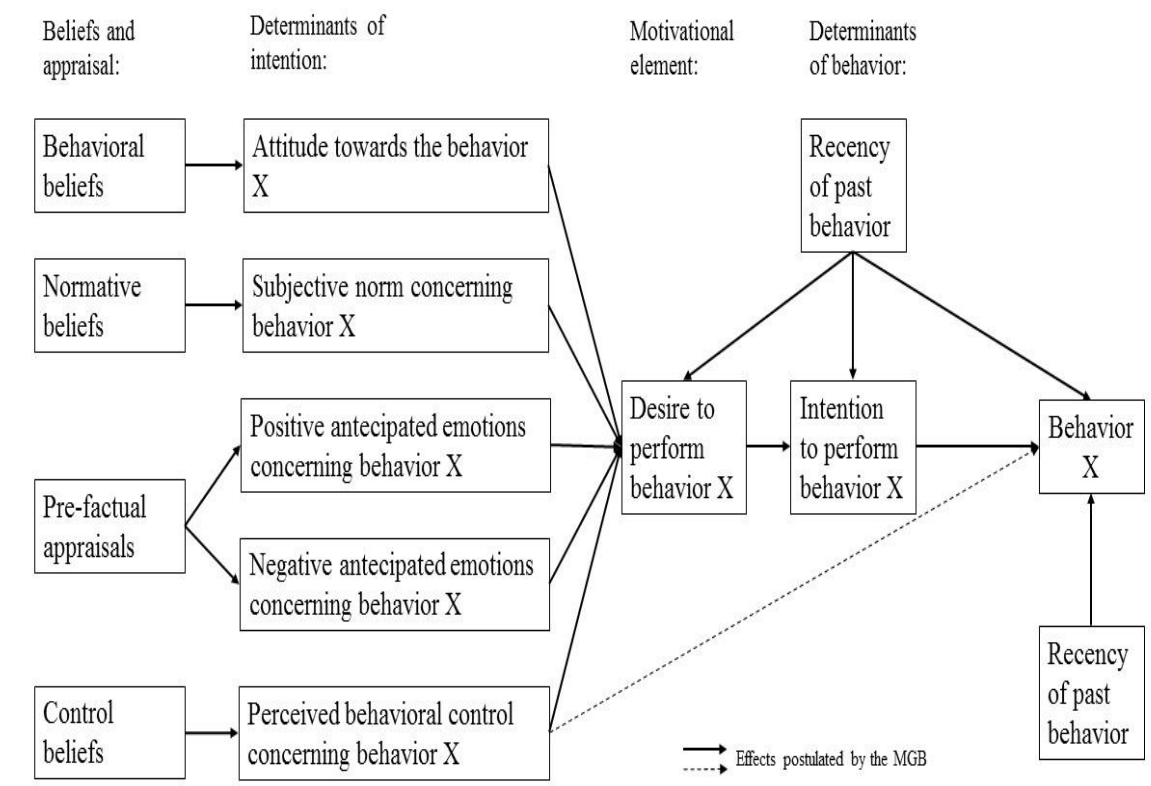

Figure. 2.5. The model of goal directed behavior (adapted from Perugine & Bagozzi 2001, p.80). External variables are omitted for simplicity.

In short, the MGB, like the other socio-cognitive models, contends that intention is the most proximal determinant of behavior. Intention, in turn is determined by desire, which turns the appraisals afforded by attitude towards the behavior, subjective norm, perceived behavioral control and anticipated emotions into an intention to act. The MGB concedes that in certain circumstances, that is, when perception of control and real control coincide, perceived behavioral control will affect behavior directly. The model also postulates that past behavior is a determinant of future behavior. Frequency of past behavior will affect desire, intention and behavior, while recency of past behavior will affect only behavior.

6.2 Predictive power of the MGB

The MGB has been successfully used to predict several behaviors (see Perugini & Bagozzi, 2004a for a review), like weight control (Perugini & Conner, 2000; Perugini & Bagozzi, 2001), time spent studying (Perugini & Conner, 2000, Perugini & Bagozzi, 2001), information search prior to decision (Taylor, 2007), drinking soft drinks (Richetin, Perugini, Adjali, & Hurling, 2008[18]), drinking responsibly (Fry, Drennan, Previte, White and Tjondronegoro, 2014), environmental issues (Song, Lee, Kang & Boo, 2012), and travel intentions (Lee, Song, Bendle, Kim & Han, 2012; Kim, Lee, Lee & Song, 2012). Results generally confirm the relations posited by the model, with intention predicting 14% to 46% of the variance of actual behavior. The mediating role of desire is also confirmed, with this variable predicting 38% to 79% of the variance of intention. The direct effect of perceived behavioral control on intention was also confirmed (e.g. Fry et al., 2014; Kim et al., 2012; Lee et al., 2012; PBC → Intention: β= .18; β= .26; and β= .25 respectively.

The MGB has also been applied to behaviors related to the use of technology, namely, learning to use a software package (Leone, Perugini & Ercolani, 2004[19]), online social interactions (Bagozzi, Dholakia & Pearo, 2007) and digital piracy (Taylor, Ishida & Wallace, 2009).

Leone et al., (2004), studied two behaviors related to learning to use the software package, studying the handbook and practicing with the software. Results show that intention had a significant effect on both actual study using the handbook and actual practice with the software (β= .25). Past behavior frequency and recency had significant effects on actual behavior (β= .20 and β= .22 respectively). The effect of PBC on actual behavior was marginal. Desire had a strong effect on both intention to study using the handbook and to practice with the software (β= .67). The model predicts respectively 58% and 38% of the intention to study using the handbook and to practice with the software. Desire to study using the handbook and desire to practice with the software are predicted by PAE (β= .21), SN (β= .23) and PBC (β= .25). Studying the handbook is also predicted by attitude (β= .37). The model explains 48% of the variance of desire to study using the handbook and 24% of the desire to practice with the software.

[18] Provides a comparison between the TPB, MGB and EMGB. Perugini and Conner (2000; see also Perugini & Bagozzi, 2004) proposed an extended version of the MGB, the EMGB, which introduces the variables goal desire and goal perceived feasibility. The first would influence desire; the second would influence perceived behavioral control. Several studies provide support to this extended version. Shiu, Hassan, Thomson and Shaw (2008) and Thomson, Shaw and Shiu (2008) used it to study smoking cessation.

[19] Provides a comparison with the TPB.

The study of online social interactions conducted by Bagozzi et al., (2007), also measured actual behavior and relied on a modified MGB model (added variables: group norm and social identity). The authors found that intention was a positive predictor of participation in online interactions (high-interactivity group[20]: β= .50; low-interactivity group: β= .26), offline interactions with family (low-interactivity group: β= .18), offline interactions with friends (low-interactivity group: β= .19), interaction with neighbors (low-interactivity group: β= .18) and reading books (high-interactivity group: β= .16), and a negative predictor of telephone use (high-interactivity group: β= -.17), television use (low-interactivity group: β= -.17), and radio use (high-interactivity group: β= -.13). Desire and PBC had significant effects on intention (Desire: high-interactivity group: β= .52; low-interactivity group: β= .79; PBC: high-interactivity group: β= .40; low-interactivity group: β= .18). Desire, in the high-interactivity group, was predicted by attitude (β= .17) and negative anticipated emotions (β= .17), while desire, in the low-interactivity group, was predicted by positive anticipated emotions (β= .19), negative anticipated emotions (β= .24) and perceived behavioral control (β= .20).

Taylor et al., (2009) studied intention to engage in digital piracy of music and movies, using a modified version of the MGB. Participants in the study were divided in two main groups, music and movies. These two groups were divided in comfortable seeking free music/ movies vs. uncomfortable seeking free music/ movies. These subgroups were further divided in self vs. share. Their results are consistent with results in other areas of research, supporting the role of desire as predictor of intention. Desire and frequency of past behavior explained 67% of intention to engage in digital piracy for the subgroups: comfortable seeking free movies to share and not comfortable seeking free movies to share. Desire, perceived difficulty[21] and frequency of past behavior explained intention to engage in digital piracy for the subgroups: comfortable seeking free movies for self (64%), comfortable seeking free music for self, to share (59% and 68% respectively) and, not comfortable seeking free movies for self (65%). Desire, perceived

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[20] Bagozzi et al., (2007) divided participants according to the level of communication interactivity provided by the information system: high interactivity (real-time online chat rooms, Web-based chat rooms, and MUDs); low interactivity (e-mail lists, Web site bulletin boards, and Usenet newsgroups).

[21] Variable not part of the original MGB.

behavioral control, perceived difficulty[22] and frequency of past behavior explained intention to engage in digital piracy for the subgroups: not comfortable seeking free music for self (60%), to share (54%).

7 Conclusion

All the above models have proved their usefulness as predictors of behavioral intention and provide valuable information as to what are the proximal determinants of it. According to the TRA and TPB, intention is the proximal determinant of behavior. The TSR and the MGB also consider intention the proximal determinant of behavior, but consider a previous step, desire. Desire to achieve a certain goal sets in motion an intention to act, in order to achieve the desired goal. All four models consider attitude and subjective norm as antecedent variables of intention, although the TRA and the TPB, propose a direct relation, while the MGB propose that these variables have their effect on intention mediated by desire. The TSR proposes a mediated effect only for attitude. Both the TPB and the MGB take into account the person's subjective evaluation of how difficult (or easy) the performance of the behavior will be. Although it can be argued that attitude, subjective norm and perceived behavioral control, already account for affect, the MGB proposes two more measures, positive anticipated emotions and negative anticipated emotions. However these two measures should not be confused with measures of emotions. Anticipated emotions refer to how a person anticipates she will feel when achieving her goal.

The comprehension of the inner workings and inter-dynamics of the determinants of desire and intention is crucial for the planning and implementation of a real life intervention. It is through the variation of the weights and direction of these variables that we can increase (or decrease) the desire and intention to perform a target behavior. For example, in order to increase someone's intention to work with social robots, it may be necessary to develop her sense of perceived behavioral control, because although the person has a favorable attitude towards working with social robots, she thinks that she is unskilled in handling technology and thus will find arduous operating it. Other person

[22] Variable not part of the original MGB.

may think she has the necessary skills, but since she has a negative attitude towards working with social robots, she does not desire to do so.

The TRA and the TPB also advance an explanation of how attitude, subjective norm and perceived behavioral control are formed, by describing the dynamics underlying behavioral beliefs, normative beliefs and control beliefs. The TSR introduces a motivational element in the model, desire. The MGB, through positive anticipated emotions and negative anticipated emotions, proposes not only an additional motivational element, but also a self-regulatory mechanism. Table 2.1 provides an overview of the determinants of behavior proposed by the models reviewed above.

By defining the determinants of behavior and behavioral intention all these models afford us with a blueprint not only for the theoretical exploration of the cognitive mechanisms underlying behavior, but also for the production of meaningful interventions in real life settings.

Table 2.1
Summary of the socio-cognitive model's variables

Model	Beliefs	Distal determinant	Motivational determinant	Proximal determinant
TRA	- Behavioral beliefs - Normative beliefs	ATW SN		BI
TPB	- Behavioral beliefs - Normative beliefs - Control beliefs	ATW SN PBC		BI
TSR	- Behavioral beliefs - Normative beliefs	ATW SN	DES	BI
MGB	- Behavioral beliefs - Normative beliefs - Control beliefs Emotional Appraisal	ATW SN PBC PAE NAE	DES	BI

Notes: TRA= theory of reasoned action; TPB= theory of planned behavior; MGB= model of goal directed behavior; ATW= attitude towards the behavior; SN= subjective norm; PBC= perceived behavioral control; DES= desire; PAE= positive anticipated emotions; NAE= negative anticipated emotions; BI= behavioral intention.

Chapter 3: External factors affecting attitude towards working with robots, perceived behavioral control, positive anticipated emotions and negative anticipated emotions

1. Overview

According to the socio-cognitive models reviewed in the previous chapter, variables like socio-demographic status, general attitudes and personality traits are expected to influence behavior only indirectly, having their effects mediated by the variables identified by the models. The following section presents the theoretical framework and describes empirical research that justifies the assumption that socio-cognitive factors like belief in human nature uniqueness, attitudes towards robots, perceived warmth, perceived competence and anthropomorphism, and social robot's appearance affect the determinants of behavior.

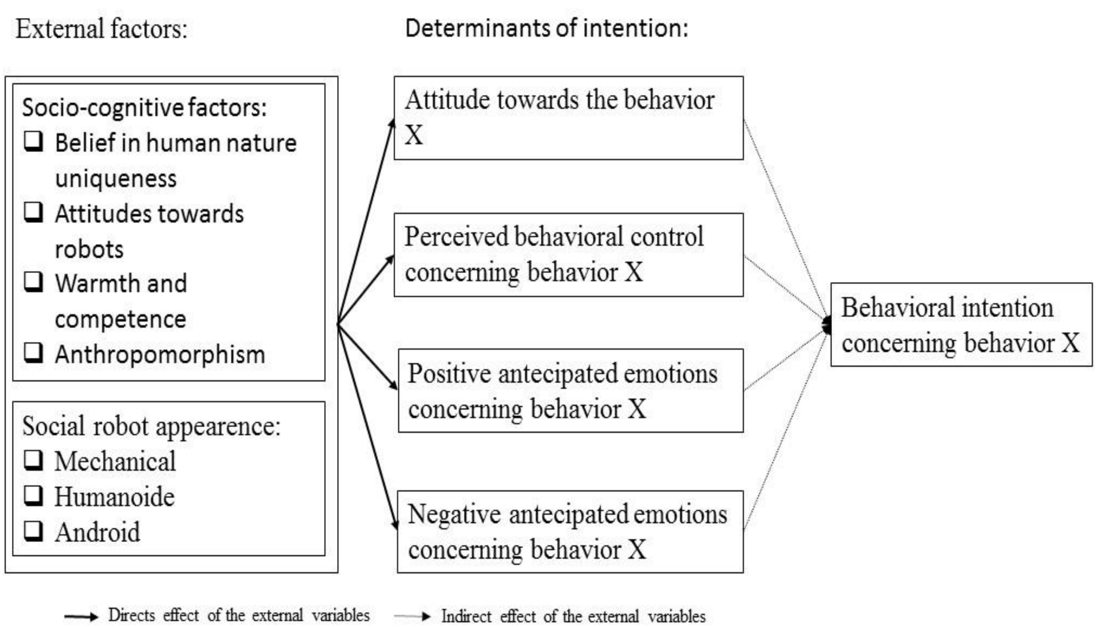

Figure 3.1. External factors affecting behavioral intention

2. Socio - Cognitive Factors

The capacity to organize the world into meaningful units plays a key role in human cognition. By dividing objects into groups, the process of categorization affords the human mind with a cognitively economical way of learning, perceiving, remembering and recognizing the world (Eysenck & Keane, 2005). Categories inform not only about appearance, but also about function and quality and are not limited to inanimate objects, like chairs or pencils, but extend to everything that surrounds us, playing a major role in making sense of ourselves and others (humans and non-humans). At a social level, concepts like family, coworker, neighbor, socialist, foreigner, inform not only about the superficial similarities of their members, but also offer predictions about their behavior, intention and status. They represent social categories, anticipating, attributing, and evaluating the intentions of the others and defining the self. These processes play a key role in two fundamental mechanisms of social life, social perception and social cognition. Social perception is the process by which people make sense of the behavior, words and actions of other persons. Social cognition is the process by which people make sense of social events. These may include, or not, other persons. (Bordens & Horowitz, 2008).

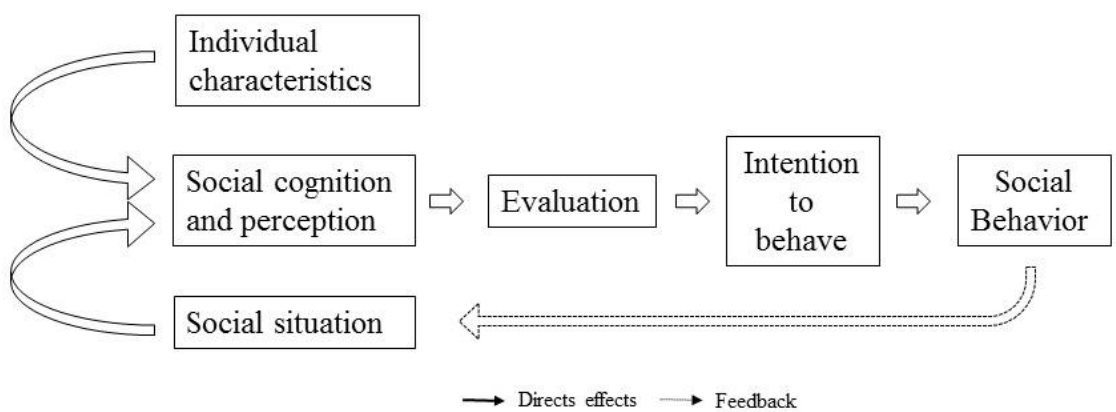

Figure 3.2. Expanded model of social behavior (adapted from Bordens & Horowitz, 2008).

In chapter 1, while describing the different types of robots, it was underlined that that a new type of service robot was being devised, the social robot. Among its chief characteristics, being endowed with a social interface is the most significant. That is, social robot designers intend that their creations can mimic social cues, from gaze to affective responses, in order to facilitate interactions with users. Since researchers where already cautioning about the potential social impacts of automation and industrial robotics (see Shenkar, 1988), given the socio-centric approach of social robots, it is expectable to anticipate even greater changes, since service robots are not confined to closed factory environments. Research with robotic appliances like Romba[23] have already demonstrated that, even without displaying social features, its presence in the household is enough to change the pattern of interactions and daily tasks performed by the family (see Fink, Bauwens, Mubin, Kaplan, & Dillenbourg, 2011; Forlizzi, 2007; Sung, Grinter, Christensen, & Guo, 2008).

These results underline the need to take into account the socio-psychological factors that underlie social interactions, when studying human robot interactions. In the following sections the belief in human nature uniqueness, the stereotype content model and the three factor theory of anthropomorphism are reviewed in order to understand how perceived warmth, competence and anthropomorphism can affect the determinants of intention to work with social robots.

2.1 Belief in human nature uniqueness.

2.1.1 Essentialism.

As mentioned earlier in this chapter, the ability to devise the world into meaningful clusters of objects (categories) is a fundamental cognitive task, both for learning the new and recollecting the old. Earlier attempts to systematically explain how categories are built and what underlying properties an object must possess in order to be included in it can be traced back to Greek philosophy. According to Aristotle, each concept (category) would comprise a set of necessary and defining features (essential features or essence) and these would define their members. Later on, philosophers proposed that some concepts (objects) had a set of necessary microstructures, essence, from which their observable properties arose and made them what they are, calling this objects natural kinds (see Haslam, 1998 for a review of the concept of essence). The concept of essence also played a major role in biological thinking, and until the rise of

[23] Roomba is a robot vacuum cleaner built by IRobot. www.irobot.com

Darwinian thought was the consensual explanation for what defines a species as a species (see Devitt, 2008 and Ereshefsky, 2010 for a contemporary discussion of the concept of essence from a biological standpoint). Although a flawed concept from a biological perspective, the idea of an underlying essence, that turns things into what they are, seems pervasive in everyday thinking (Barret, 2001). Despite this, only recently the idea that categories have an underlying essence felt under the scrutiny of psychology. One of the first proponents of psychological essentialism was Medin and Ortony (1989). From a psychological standpoint, they argue, the discussion should focus not on the qualities of the object per se, but on the subjective representations people make of them. That is, psychological essentialism "…would be not the view that things have essences, but rather the view that people's representations of things might reflect such a belief" (Medin & Ortony, 1989 p.183). Thus, while building categories people ascribe an underlying nature or essence to those same categories. This essence is what makes things what they are, that is, they have causal consequences and they produce kind-specific properties. As a result, the surface aspects of a representation (i.e. list of properties people use when describing an object) would be constrained and sometimes generated by a deeper set of qualities that people believe are attributable to the object (or category of objects).

Two notes of caution should, nevertheless, be introduced here. First, psychological essentialism does not entail that a person has any knowledge (conscious or unconscious) or theory about what an essence is. Second psychological essentialism should not be confused with the classical philosophical concept of essence, "… on our account people may sometimes believe that necessary and sufficient conditions are a consequence of the essential nature of the thing in question, rather than the essential nature itself." (Medin & Ortony, 1989, p. 184). That is, although a person is familiar with the categories fish and mammals, and ascribes to each of them an essentialized set of features, that person is also aware that whales and dolphins, although exhibiting superficial features that could be attributed to fish, are in their "essence" mammals.

Not only essentialist thinking seems to be pervasive in adults, it also seems to follow a developmental path. Gelman and Wellman (1991) report that children as young as 3 years are already aware of the distinction between outside and inside characteristics of objects and animals. Gelman, Heyman & Legare (2007), showed that as children grow older they make less use of essentialist reasoning. They also report qualitative changes in the structure of essentialist beliefs, suggesting that essentializing is a default way of reasoning about categories that is later replaced by more complex ways of reasoning. Rhodes and Gelman (2009) report that children at age 5 are already able to distinguish between natural and conventional categories and that these are essentialized differently. Rhodes (2012), argues that social categorization is not simply a matter of intuitively applying natural kinds to social categories, since children, although aware of physical cues, seem to be very selective in their use as a criterion for category inclusion (see Rhodes, 2012 for a theoretical model on the development of social categorization). Other lines of enquiry are taking this developmental approach even further by exploring the evolutionary origins of psychological essentialism (see Barret, 2001).

Research in social psychology is uncovering the role of psychological essentialism in group identity, stereotypes and social categorization (see Prentice & Miller, 2007; Yzerbyt, Rocher & Schadron, 1997 for reviews). Essentialized categories not only help defining the identity of the in and outgroup, but also legitimize their existence, while rationalizing the actions taken towards the outgroup. That is, essentialized categories not only provide information about their members, but also legitimize the courses of action taken towards them. For example Yzerbyt, Rogier & Fiske (1998), showed that when a group was presented to the participants as an entity, rather than just a group of people, they tended to attribute the behavior of members more to group underlying features than to the situation. That is, salience of group entitativity[24] biased individual's behavior explanations, downplaying the effects of the situational constraints on the observed behavior.

In a latter study Yzerbyt, Dumont,Wigboldus and Gordijn (2003) observed the effects of categorization and group identification on emotional and behavioral responses to harmful behavior. For that purpose participants were divided by to conditions: same group as the victims; and different group, with both groups being part of a larger common

[24] Entitativity can be defined as: "…the extent to which a collection of individuals is actually perceived as a group, as a single and unified entity…" (Svirydzenka, Sani & Bennett, 2010, p. 611). Yzerbyt, Corneille and Estrada (2001) argue that entitativity and subjective essentialism mutually reinforce each other. That is, the perception of a group as an entity suggests the existence of an underlying order, while the prior belief in underlying explanations encourages the search for similarities and regularities within group members.

group. Their results show increased emotional anger responses and concomitant offensive action tendencies when participants saw the victims as being part of the same group, or when participants highly identified with the common larger group. That is, identification with the victim group led to an emotional and behavioral attunement. Similar results were obtained by Dumont, Yzerbyt, Wigboldus, & Gordijn (2003) in a study about fear reactions in the context of the terrorist attacks against the World Trade Center in New York on September 11, 2001. Participants that were in the condition that emphasized group identity with the victims reported more fear and fear related behavioral tendencies than participants on the out-group condition.

Studying the effects of psychological essentialism on in-group favoritism bias Leyens et al. (2001) discovered that people chose more secondary emotions (i.e. emotions that are thought to be distinctive of the human species) for their group than for the out-group, independently of the status of the origin group. Further elaborating on this idea Leyens et al. (2003) explored the denial of secondary emotions to out-group members, what they called infra-humanization. This privileged link between the attribution of secondary emotions (uniquely human emotions) and in-group membership was further confirmed by Boccato, Cortes, Demoulin and Leyens (2007). Their results showed that, while participant's reaction time to primary emotions did not differ, reaction time to secondary emotions was faster when these were associated to the ingroup.

Haslam, Rothschild, and Ernst (2000), furthering the idea of essentialized categories, found that people devise social categories in two distinct ways, those that are discrete, immutable, stable, necessary and natural (akin to "natural kinds") and those that are uniform, informative, inherent and exclusive (akin to entitativity). Analysis of their data showed that while categories like gender or race where perceived as natural, categories like homosexual or AIDS patient where perceived as entitative. This different origin attribution entailed different judgmental stances towards the categories in question as Jayaratne et al., (2006) found out. In their research they studied the relation between lay theories about the genetic origins of race and sexual orientation and attitudes towards Blacks and homosexuals. Their results showed that the more people endorsed a "genetic" view of race the greater the level of racial prejudice reported. Otherwise, the more respondents endorsed a "genetic" view of sexual orientation the lower the level of prejudice towards homosexuals reported. These results point in a similar direction to those of a previous study by Haslam et al. (2002). Studying the link between essentialist beliefs and prejudiced attitudes, these authors found that although essentialist beliefs predicted an anti-gay attitude, they did not predict a generalized disposition towards sexism or racism. That is, prejudice and essentialism although related were dependent of category and context.

This category dependency has been further confirmed by research. Lindquist, Gendron, Oosterwijk, & Barrett (2013), found that categories that seem to be more related to the body (e.g. hunger) are more essentialized than those thought to exist in the mind (e.g. memory).

Context dependency has been further studied through group affiliation. Prentice and Miller (2006) studied how group membership can change the value of new information. By dividing participants in three conditions: 1) similar to the other gender in a new attribute; 2) different from the other gender in the new attribute; 3) only learned how much of the attribute they had; the authors found that those who learned that the attribute distinguished them from the other gender, thought it to be more informative. Also, participants in the second condition were found to make stronger inductive inferences based on the attribute. This is in line with the results of Haslam, Bastian and Bissett (2004) study on the relation between essentialist beliefs and personality. The authors found that the personality characteristics that were more essentialized were those perceived as more desirable, prevalent and emotionally based. Essentialized characteristics were perceived as particular important in defining a person’s identity, forming impressions and communicating about a third person.

The relation of essentialism and group affiliation (social identity) has received further attention in the context of migration. Chao, Chen, Roisman and Hong (2007) found that stronger essentialist beliefs about race were associated with more cognitive difficulties in rapidly changing between cultural frameworks and with more emotional reactivity when discussing issues related to bicultural identities. Bastian and Haslam (2008) found that differences in individual essentialist beliefs predict negative bias towards recently arrived immigrants. Essentialist beliefs were also found to interact with social identity in predicting bias towards immigrants. Results also suggest that immigrants that hold essentialist beliefs do not perceive the new cultural identity as an important self-guide. Pehrson, Brown, and Zagefka (2009) found similar results.

Zagefka, Pehrson, Mole and Chan (2010), found that essentialist beliefs regarding in-group and out-group, in the contexts of historic intergroup atrocities, are related to feelings of collective guilt and willingness to forgive.

Eyssel and Kuchenbrandt (2012) studied the effects of ingroup bias in the context of human robot interaction. For that purpose, the authors assigned participants to two conditions. In the ingroup condition, participants saw an image of a robot with a German name and supposedly produced at a German University, in the outgroup condition, participants saw an image of a robot with a Turkish name and supposedly produced at a Turkish University. Both groups were asked to rate the robot in terms of mind attribution, warmth (used as measures of anthropomorphism), psychological closeness, contact intentions, and design. All of the participants were of German origin. There was an evident preference for the robot in the ingroup condition, which received higher ratings in all the measures, thus confirming the preference for the ingroup.

In short, psychological essentialism not only offers a cognitive tool for describing, organizing and making predictions about the world and its inhabitants, but also plays a role in self-identity and group affiliation, and thus in social interactions. Essentializing a category, or a member of that category will, on one hand facilitate interactions by making events more predictable, but on the other hand, if too inflexible, will hinder interactions since it will not account for alternative courses of action. Among other factors, essentialism seems to be affected by developmental factors, group membership salience and context. As a result of essentialism people seem to display different affective responses towards outgroup members, or members of certain categories, than they display towards their ingroup members. This ingroup – outgroup affiliation induces a differential attribution of responsibility, guilt and moral worth. Finally, ingroup – outgroup affiliation also constrains the attribution of human qualities to other groups and categories, with secondary emotions (i.e. emotions that are thought to be distinctive of the human species) reserved for the ingroup.

2.1.2 Belief in human nature uniqueness.

The concept of belief in human nature uniqueness draws from the above research. It asserts that people, will reserve for themselves the core of what is thought to be human essence (e.g. emotions that are thought to be distinctive of the human species), when interacting with technology. Although research results suggest that people "mindlessly apply social rules" (Nass & Moon, 2000, pag.82) to their interactions with some technological gadgets (e.g. computers; see Nass, Steuer & Tauber, 1994), it is reasonable to expect this interactions to be tainted by the same processes observed in intergroup social relations. Essentialist beliefs are associated with the enhancement of the standing, power and social value of the in-group. Consequently, people holding essentialist beliefs might be more sensitive to the blurring of the frontiers of humanness induced by social robots. Those who perceive social groups as stable, unchangeable (vs. alterable by human action), fixed at birth, and due to biological (natural) differences (vs. due to environmental and developmental factors) are more likely to deny human features to robots and consider them with suspicion.

In order to gauge to what extent people withhold for themselves these uniquely human features (e.g. language, emotions or consciousness) and how this impacts human-robot interactions and the intention to work with social robots in the near future, a new scale was created, the belief in human nature uniqueness scale (BHNU). The psychometric properties of this scale are investigated in study 6 of Part 2: empirical studies.

The measurement of a construct like belief in human nature uniqueness, allows the comprehension of how a person's concept of what is the essence of a human-being intertwines with how "human" she thinks a robot can be. That is, a person who holds a stronger sense of the uniqueness of humans, may be less sympathetic to the "humanization" of social robots, which could have an impact on her willingness to accept and work with it.

2.2 Attitudes towards robots.

2.2.1 Attitudes.

As people go about their daily lives, streaming across events, objects and other people, they automatically emit evaluative judgments, god or bad, desirable or undesirable, acquiring in the process a set of beliefs, i.e. they build a subjective probability of the object, event or person having certain properties (Ajzen & Sexton, 1999). This ongoing collection of beliefs (i.e. evaluative and probabilistic information about an object's qualities) will give rise to a general favorable or unfavorable disposition towards the said object,[25] to an attitude. In short, attitudes form a fairly stable evaluative tendency towards an object, thus producing a certain approach or avoidance predisposition.[26] However, as Ajzen and Fishbein (1977) pointed out, this predisposition should not be mistaken for a prescription for a specific course of action. That is, a positive evaluation of an object, although necessary, is not always sufficient condition for acting towards that object.

Besides being systematically studied by social psychology (see Ajzen & Fishbein, 1977; Kraus, 1995; Glasman & Albarracín, 2006 , for reviews), attitudes have also been extensively used in the area of human-computer interaction (HCI), with the production of several attitudes scales (see Garland & Noyes, 2008 for a brief review of attitude scales used in HCI). In the area of human-robot interaction (HRI) attitudes have also started to garner some interest. Riek et al. (2010, March) studied attitudes towards humanoid robot Ibn Sina in an Arabic population (see also Mavridis et al. 2012) and proposed the culture education and domestic attitudes towards robots scale (CEDAR). Broadbent et al. (2009), developed the robot attitude scale (RAS) in order to assess elders (and there caretakers) attitudes towards a care robot at a nursing home (see also Broadbent et al. 2012; Stafford, MacDonald, Jayawardena, Wegner, & Broadbent, 2013). Nomura Kanda and Suzuki (2004, July) have proposed the concept of negative attitudes towards robots, as a

[25] Object is used here in the most general sense and can account for a person, an institution or a behavior.

[26] Personality trait and values are two neighboring concepts that are frequently confused with attitude. A personality trait gives rise to a typical and stable action tendency, but unlike attitudes do not involve an evaluative tendency towards a specific object (e.g. being introverted vs. being extroverted). They are a general action tendency without a specific domain. Values, like attitudes, also have an evaluative character. But these evaluations are not object specific; they are general and abstract, with a normative character (e.g. honor, loyalty).

psychological factor that could prevent people from interacting with social robots, and developed the Negative Attitudes Towards Robots Scale (NARS; see also Nomura, Kanda, & Suzuki, 2006; Nomura, Kanda, Suzuki, & Kato, 2004; Nomura, Suzuki, Kanda & Kato, 2006, July).

General attitudes towards robots are of interest not as much because they will produce accurate predictions of interactions, but because they can influence, by creating a favorable or unfavorable evaluative tendency, other variables that have already been identified as determinants of behavioral intention, like attitudes toward the target behavior, perceived behavioral control, or anticipated emotions. For this reason the following section reviews in some detail the researched already conducted using the NARS (Nomura et al., 2004, July).

2.2.2 The negative attitudes towards robots scale (NARS).[27]

The NARS (Nomura et al., 2004, July; 2006; Nomura, Kanda, Suzuki, & Kato, 2004) was elaborated to assess psychological reactions evoked in humans by human-like and non-human-like robots, gauging the extent to which people feel unwilling to interact with it. Its 14 items are divided in three subscales: the negative attitudes towards interacting with robots (NARS-Interaction), towards the social influence of robots (NARS-Social Influence) and towards emotions in interaction with robots (NARS-Emotion).

Since its elaboration, the NARS has been used to study various dimensions of HRI. First, the NARS was administered to predict verbal and behavioral reactions to social robots in live HRI studies (e.g., Nomura et al., 2004, July; Nomura, Kanda, Suzuki & Kato, 2008; Nomura, Shintani, Fujii & Hokabe, 2007). Studies have provided mixed results. For example, the subscales of the NARS predicted behavior toward robots, such as time spent talking with and touching it, differentiating participants according to gender (Nomura et al., 2008), but they failed to predict the physical distance allowed by participants between them and a robot (Nomura et al., 2008). Moreover, the Robot

[27] This section is a partial adaptation of the following paper: Piçarra, N. Giger, J.-C., P, Pochwatko, G. & Gonçalves, G (under review). Validation of the Portuguese Version of the Negative Attitudes Towards Robots Scale.

Anxiety Scale (Nomura, Suzuki, Kanda, & Kato, 2006) turned out to be, under some conditions (e.g., according to gender), a better predictor of behaviors than the NARS (Nomura et al., 2007).

Second, the NARS has been used to : 1) measure attitude towards social robots (Nomura et al., 2004, July; Nomura, Kanda, Suzuki, Yamada, & Kato, 2009); 2) measure the effect of attitudes towards robots on the perception of robots' behavior (Syrdal, Dautenhahn, Koay & Walters, 2009, April; Cramer, Kemper, Amin, Evers, & Wielinga, 2009; Cramer, Goddijn, Wielinga & Evers, 2010); 3) measure the effect of interacting with robots on attitudes towards robots (Weiss, Bernhaupt, Tscheligi & Yoshida, 2009, April), 4) measure the evaluations of different types of robots (Nomura, Suzuki, Kanda & Kato, 2006, July; Syrdal et al., 2009, April), 5) compare different social groups and cultures on their attitudes towards robots (Bartneck, Nomura, Kanda, Suzuki & Kato, 2005, April; 2005, July; Bartneck, Suzuki, Kanda & Nomura, 2007; Weiss, Igelsbock, Wurhofer & Tscheligi, 2011; Halpern & Katz, 2012), and 6) predict social acceptability of robots (Nomura, Kanda, Suzuki, Yamada, & Kato, 2009).

Overall, the results of studies using the NARS indicate that, although its capacity to predict in situ human behaviors towards robots is still under debate, it still remains a useful tool to study the social representation and perception of robots as well as the acceptance of social robots. Moreover, inversely to other existing scales that focus on interaction with a specific type of robot, set of tasks, and context, like the CEDAR scale (Riek et al., 2010, March) or to the Robot Attitude Scale (Broadbent et al., 2009), the NARS has the advantage to provide a general measurement of the attitude towards robots. Indeed, despite focusing on attitude towards robots with human traits (e.g., emotions, intentions, language), the NARS does not make any specific assumptions on how the robot should look and where and how it should operate. As such, the NARS is a general and easy-to-administer measurement of the attitude towards social robots, independent of the type of robot or context, and offers the possibility of being used both in real and imaginary interactions.

As it was already mentioned, the interest of general attitudes towards robots resides in the fact that by creating a favorable or unfavorable evaluative tendency (i.e. sets of beliefs about objects), they will influence other factors more directly related to the intention to work with social robots. A more positive general attitude towards robots could lead to a more positive attitude towards working with robots, a higher perceived behavioral control and an increase in positive anticipated emotions (with a decrease in negative emotions). A more negative general attitude towards robots will result in the contrary effect.

2.3 Perceived warmth and competence. The stereotype content model.

Although generally operating by the same means as the categorization of objects, social categorization differs from it in one crucial aspect: it always considers the status of the person as a member, or non-member, of the social category in question (Bodenhausen, Kang, & Peery, 2012). That is, besides having the epistemic function of organizing the social world, social categories play a role in the construction and maintenance of a sense of identity and belongingness (or alienation) to the group (see Macrae & Bodenhausen, 2000 for a review of the role of categories in social cognition).

According to the framework of the Stereotype Content Model (SCM; Fiske, Cuddy, Glick, & Xu, 2002; Fiske, Cuddy & Glick, 2007; Cuddy, Fiske & Glick, 2007), the construction of social categories afforded by social perception tries to answers two complementary key questions: 1) do outgroup members have good (vs. bad) intentions towards me and my group? 2) can outgroup members enact their intentions? The answer to these two questions is structured by two fundamental dimensions. The warmth dimension (which comprises traits like morality, trustworthiness, sincerity, kindness and friendliness), assesses the other's intentions towards the person or in-group. The dimension of competence (which comprises traits like efficacy, skill, creativity, confidence and intelligence), assesses the others capability to perform their intents (Fiske et al., 2002). Perceived levels of warmth and competence permit the differentiation of groups and their members according to the following four judgments: The other can be seen as warm and competent, warm but not competent, not warm but competent and neither warm nor competent. While the first judgment, warm and competent, is reserved for in-group members, the last one, neither warm, nor competent is reserved for extremely disliked and despised[28] out-groups (e.g. drug addicts and homeless). The other two constitute what the authors call the mixed stereotype content or ambivalent stereotypes (Fiske et al., 2002), i.e. judgments about the out-group, include opposite valences for warmth and competence. The out-group is seen as incompetent but warm, and thus does not constitute a threat, leading to paternalistic stereotypes, or the out-group is seen as competent but not warm, thus comprising a threat, leading to envious stereotypes (Fiske, Xu & Cuddy, 1999).

These judgments would in turn be closely linked to emotions and behaviors towards the person or group in question, what Cuddy et al., (2007) call the behaviors from intergroup affect and stereotypes map (BIAS). Indeed, research has shown that to each of this judgments corresponds a signature emotion, admiration (warm and competent), pity (warm but not competent), envy (not warm but competent) and contempt (neither warm nor competent). Behaviorally, the warmth dimension, being an appraisal of the others intentions is linked to active behaviors (active facilitation, active harm), and the competence dimension, being an appraisal of the others capability to act is linked to passive behaviors (passive facilitation, passive harm). There were also identified links between the signature emotions and behavioral patterns. Admiration elicits both active and passive facilitation, while contempt elicits both active and passive harm. Pity and envy result in ambivalent combinations of behavior (for a review see Cuddy, Fiske and Glick, 2007). Figure 3.3 shows the relations between perceived warmth and competence, emotional eliciting and behavioral response.

[28] For a neuropsychological account of disgust in the context of social perception see Harris and Fisk (2006).

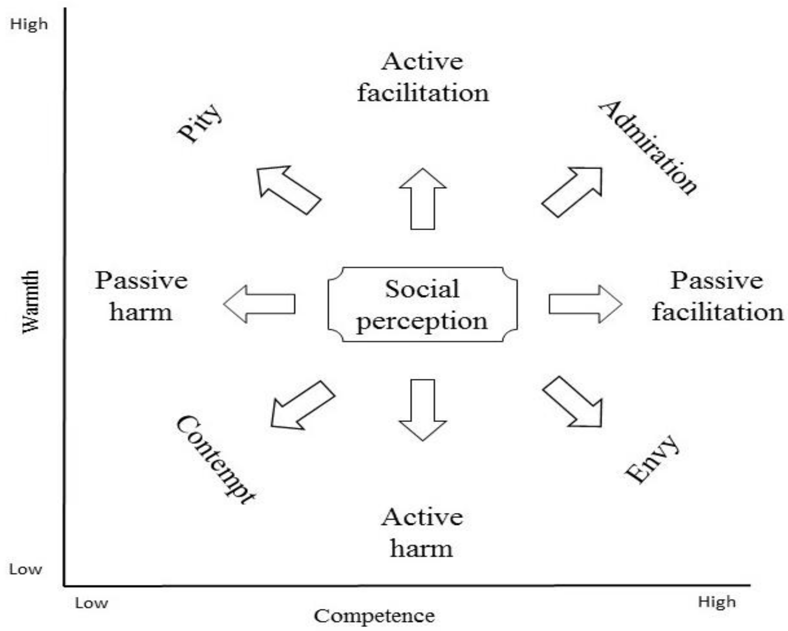

Figure 3.3. Emotional and behavioral responses in the warmth and competence space (adapted from Cuddy, Fiske & Glick, 2007, p. 634)

Further studying these ambivalent combinations of behaviors and emotions, Becker & Asbrock (2012) suggest that what leads to active harm (or active facilitation) or passive harm (or passive facilitation) is a consequence of the subjective salience of the dimensions of warmth and competence. That is, a group perceived as competent but cold, is more likely to receive passive facilitation, if their competence is more salient, while a group perceived as warm but incompetent, will more likely receive active facilitation, if their warmth is more salient. Researching on this compensatory effect, (i.e. a group being judged as warm but incompetent, while the other is judged the opposite, competent but not warm), Kervyn, Yzerbyt, Demoulin and Judd (2008) report on series of experiments where Belgium participants were asked to rate, for warmth and competence, Belgiums, Italians and Germans. Participant's rated themselves as warmer than Germans, but not as warm as Italians. On the other hand, they rated themselves not as competent as Germans, but as more competent than Italians, thus suggesting that judgments are not static, but respond to context. That is, a judgment about a group will vary depending on the group to which the comparison is made. According to the authors, the presence of a comparative context is essential for the compensatory nature of social perception to emerge, being absent when no group comparisons are involved.

The effect of the warmth and competence judgments' on social perception also operates at an individual level. Research suggests that these effects are influenced by social structural context. That is, the perceived role of the other as a competitor and he's social status predicts perception of competence and warmth. Someone perceived as a competitor is perceived as less warm, while someone of higher social status is perceived as more competent (Russell & Fiske, 2008).

Although the content of a stereotype and the group targeted by a stereotype might be influenced by cultural differences, warmth and competence, as a universal structural dimension of social perception, has received some cross-cultural validation (Cuddy, Fiske, Kwan, Glick, Demoulin, Leyens et al, 2009).

In short, the category of warmth and competence allows us to navigate both at a group and individual level, offering a set of behavioral – affective responses and predispositions towards the other. For example, perceiving someone as warm, will elicit positive emotions and a behavioral tendency towards that person, which in turn may create a more favorable attitude towards working with her. On the other hand if someone who was perceived as warm, is also perceived as incompetent, although she still elicits positive emotions, given your beliefs about the importance of performing flawlessly at work, a negative attitude towards working with her will emerge, or the perceived sense of behavioral control will decreased, as that person repeatedly fails to complete her part in the mutual assignments.

Some research results are suggestive of the role of social perception in human robot interaction. In their experiment, Hinds, Roberts and Jones (2004) asked participants to collect a set of parts that would be used, by another team, to assemble various objects. To accomplish the task they would work with a partner. Their partner knew about the location of the parts and could carry them, while the participants received a list with the necessary parts. This division of tasks intended to create a sense of interdependence while performing the task. The experimenters controlled for work partner type (human, human-like robot or machine-like robot) and status (subordinate, peer or supervisor). The robot was tele-operated in order to look appear autonomous. Their results showed that participants relied more on the human partner then on the robot partners (there was no significant difference between the human-like and machine-like robot). However participants reported lower levels of responsibility when working with the human-like robot. Reliance was also higher when the robot was presented as peer, than as subordinate or supervisor. Interestingly when the robot was presented as supervisor, it received less credit for the work done and was more likely to be blamed for mistakes, than the peer and the subordinate robot. Although the study does not use explicit measures of competence, the effect of the robot's perceived status are in line with what would be expected from in the framework of the stereotype content model.

Lee, Lau and Hong (2011), on the other hand, used explicit measures of warmth and competence. In their study, the authors compared three robot appearances: human-like, animal-like and machine-like. Although participants perceived the human-like and animal-like robots as warmer than the machine-like robot, they attributed similar levels of competence to the three robots. The attribution of warmth and competence was found to be associated with the occupational suitability of the robots, with warmth associated with people oriented occupations, and competence associated with task oriented occupations.

Waytz and Norton (2014) found similar effects. Questioning about people's acceptance of botsourcing[29], the authors found that participants support it more for cognition- versus emotion-oriented jobs, since the last are associated with what is seen as an essential human capacity: to experience emotions.

How can the stereotype content model be informative about the intention to work with social robots? Research on robotics has attempted to create more acceptable robots by varying its appearance. The assumption is that more humanoid robots will automatically elicit social responses from humans, thus facilitating interaction and acceptance. The production of a social robot that is perceived has having a high level of warmth is expected to elicit a positive affective response and a favorable behavioral tendency, which in turn can lead to a more favorable attitude towards working with it. Conversely, if the social robot is perceived as very competent, a negative affective response and an unfavorable behavioral tendency may follow, as the person sees himself has having very little perceived behavioral control over a shared task.

Figure 3.4 shows the relations between perceived warmth and competence, emotional eliciting and behavioral response when the social agent is a social robot.

[29] Botsourcing can be generally defined as the allocation of human jobs to robots or automated systems.

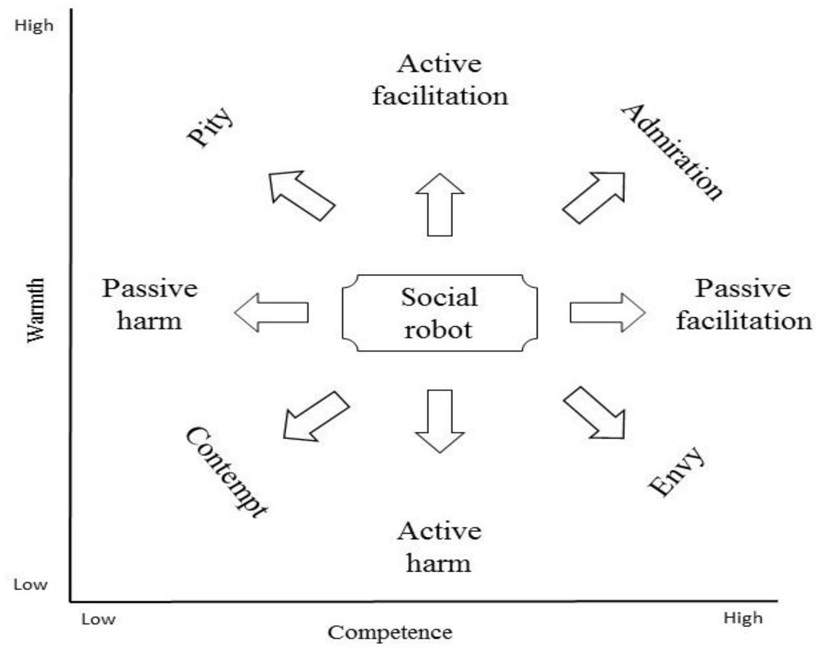

Figure 3.4. Suggested emotional and behavioral responses towards a social robot in the warmth and competence space.

2.4 Anthropomorphism.

2.4.1 The three-factor theory of anthropomorphism.

Anthropomorphism is a spontaneous and efficient way for people to establish relationships with artifacts and non-human living beings (Vidal, 2007). In spite of this, it has been viewed with suspicious and frequently characterized as a cognitive flaw or deficit. In early 19th century the term was used as a reference to the improper use of human mental states in the description of animal's behavior, denoting a categorical mistake, a fallacy improper for scientific research (Schilhab, 2002). Later in the 70's of the XX century the term was used in child development and in psychiatry, meaning either a lesser form of reasoning or a clinical symptom.

In a review of literature encompassing the years of 1893 until 2007, Kwan and Fiske (2008) identified 96 articles using the term "anthropomorphism", of these, only 25 where empirical studies, the remaining where conceptual discussions. The authors conclude by pointing to how fragmented research on this topic has been and to the absence of the theme in social psychology research.

In short, research on anthropomorphism has focused on how frequent and accurate anthropomorphic descriptions are, while considering it an invariant and automatic process. Nevertheless no explanations are provided about the "inner workings" of anthropomorphism besides that it is a flowed (or "primitive") form of reasoning.

In an attempt to overcome this, Epley, Waytz and Cacioppo (2007) have proposed a psychological account of anthropomorphism, the three-factor theory of anthropomorphism. With it they expect to explain and predict the variability in the tendency to anthropomorphize nonhuman agents. "Imbuing the imagined or real behavior of nonhuman agents with humanlike characteristics, motivations, intentions, and emotions is the essence of anthropomorphism. These nonhuman agents may include anything that acts with apparent independence, including nonhuman animals, natural forces, religious deities, and mechanical or electronic devices" (Epley et al., 2007, p. 864). But unlike previous accounts of anthropomorphism, the three-factor theory conceives it as a case of inductive inference[30]. That is, when reasoning about non-human agents, people draw inferences based not only on the agent's actual behavior, but also on the homocentric knowledge (i.e., self-knowledge and knowledge about other humans) that is accessible at the time of judgment. Epley et al. (2007) suggest that people use homocentric knowledge as a starting point, when it is, either chronically or situationally, accessible and applicable, and then correct the representation by adding abstract knowledge when they have the resources and the motivation to do it. "Anthropomorphism involves going beyond behavioral descriptions of imagined or observable actions (e.g., the dog is affectionate) to represent an agent's mental or physical characteristics using humanlike descriptors (e.g., the dog loves me)" (Epley et al., 2007, p. 865).

The three fundamental psychological determinants of anthropomorphism are: self-knowledge (cognitive element), effectance and sociality (motivational elements). This psychological determinants would in turn be influenced by a set of independent variables, namely: dispositional variables (individual differences that affect how chronically active

[30] The inductive inference process can be decomposed in three parts: 1) the activation of knowledge about humans when making inferences about non-humans; 2) the correction and adjustment of anthropomorphic representations with knowledge about nonhuman agents; 3) and applying these anthropomorphic representations to nonhuman agents.

some knowledge representations and motivational states are); situational variables (transitory environmental conditions that alter the accessibility of knowledge representations as well as the level of effectance and sociality motivation) and developmental and cultural variables (that alter the content of representations and the strength of effectance and sociality motivations throughout the developmental path and socio-cultural contexts). See figure 3.5 for a summary of the model.

Self-knowledge is fundamental, not only for distinguishing ourselves from others, but also to be able to simulate and comprehend others behaviors, thus attributing them agency. Understanding how knowledge about human and non-human agents is acquired, activated, applied and corrected is a key to understand anthropomorphism, since the accessibility of knowledge, about the self and the other, is the first step in the process. “A person’s own knowledge and phenomenological experience are so automatically accessible and richly organized that they continue to serve as an automatic base for induction that needs to be overcome and corrected when reasoning about others, rather than being a childhood tendency that is outgrown.” (Epley et al, 2007, p. 868).

Effectance is the need to interact, explain and predict the surrounding world. This motivation reduces the uncertainty about the world. Anxiety about uncertainty may lead to more anthropomorphism. Higher effectance motivation will lead to more anthropomorphism and vice versa. This effect of effectance motivation may be heightened by two factors: uncertainty regarding the behavior of the non-human agent; and incentives for understanding and predicting the behavior of the non-human agent (high incentive more anthropomorphism and vice versa). Effectance motivation is also affected by dispositional factors. One of these factors is need for closure (NFCLOSE) that is the extent to which a person desires an answer to a question compared to ambiguity and confusion). People high on NFCLOSE tend to rely on early and immediately accessible information when making judgments. It is then to expect that when forming an impression based on egocentric knowledge, people high on NFCLOSE will tend to anthropomorphize more, as they are less likely to keep searching for new information. Another dispositional influence is desire for control (the extent to which a person is motivated to see himself in control of events in is life). People high in desire for control tend to use more concepts like intentions and desires, which in turn will probably lead to an increase of anthropomorphism. Situational influences will also affect effectance motivation. An agent that one expects to interact actively in the future will probably be more anthropomorphized, as there is an increased incentive in trying to understand it. Other situational incentive to anthropomorphism is when behavior violates expectancies.

Sociality is the need to connect to other humans. In the absence of social connections anthropomorphism, by attributing humanness to non-human agents, may provide surrogate companionship. A god example of this is the relations people develop with their pets. Sociality motivation operates in two distinct ways: it increases the accessibility of social cues (human characteristics and traits); and increases the search for sources of social connection. Both may increase anthropomorphism. Chronic loneliness (dispositional influence) and social disconnection (situational factor) may both increase the tendency to anthropomorphism. Attachment style (developmental influence) may also impact sociality as it may affect the sense of social connectedness. Living in individualistic vs. collectivist cultures (cultural influence) may also impact levels of anthropomorphism.

Dispositional influences. As it was mentioned, knowledge about the self is readily available, thus making it the default starting point of the inductive inference process. A person's motivation, or willingness, to go more or less beyond this first reasoning is called need for cognition (NFC). "Those who are high in need for cognition tend to enjoy engaging in effortful thinking and are more likely to overcome readily accessible defaults in judgment more than those low in need for cognition." (Epley et al. 2007, p. 869). Hence a person rated high on NFC will probably engage in an effort to complement and correct the initial egocentric information about the external agent and thus be less prone to anthropomorphism, while a person rated low on NFC will probably be more prone to anthropomorphism.

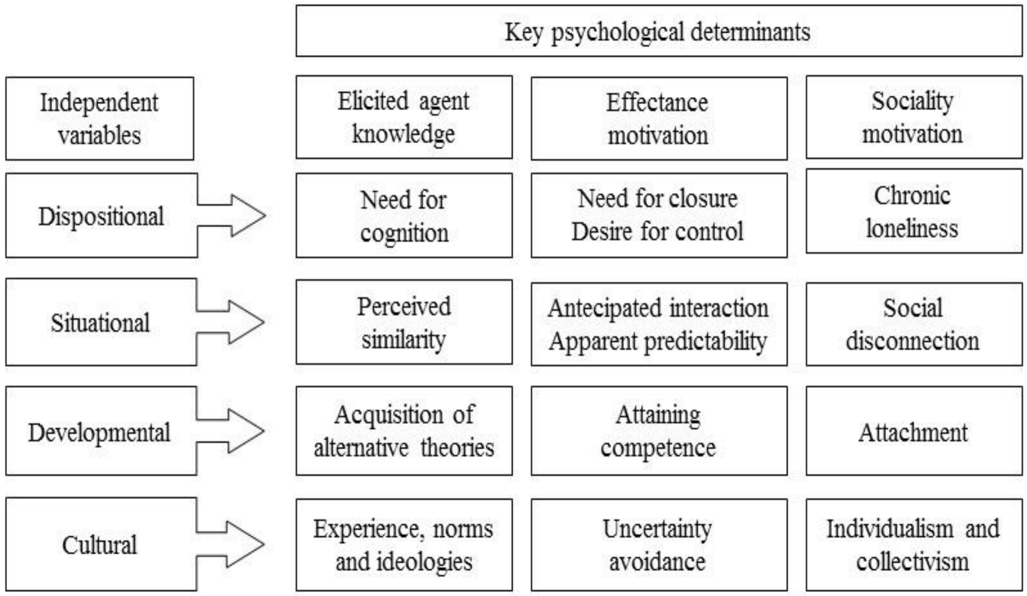

Figure 3.5. The three-factor theory of anthropomorphism (adapted from Epley, Waytz and Cacioppo, 2007, p.867)

Situational influences. People tend to rely more on egocentric knowledge if the target is perceived as similar to them. This similarity may assume two forms: 1) similar motion, that is, nonhuman agents that move at a speed similar to that of humans are attributed mental states; 2) and similar morphology, that is, the more similar in appearance, the more people use themselves as a reference.

Developmental influences. Anthropomorphism is expected to follow a developmental course. That is, as the representation of the self, other humans and nonhuman agents becomes more complex with age, the level of anthropomorphism diminishes. This however seems to be the result of further correction of egocentric biases by adults and not a lesser use of automatic egocentric interpretations.

Cultural influences. Different cultures afford people with different representations of what is to be human, animal or an inanimate object. They also afford people with different levels of familiarity with technology and nature. As such, it is expected that culture will influence the accessibility of egocentric knowledge in the inductive inference process.

Some of the proposals of the three-factor theory of anthropomorphism have already received empirical confirmation. Epley, Akalis, Waytz and Cacioppo (2008) found that loneliness was significantly correlated with the anthropomorphic mental state ratings; that participants in the social disconnected condition reported higher belief in supernatural beings, than those in the social connected condition; and that participants in the social disconnected condition chose more traits related to social connection when describing their pets, than those in the social connected condition. Epley, Waytz, Akalis and Cacioppo (2008) also found empirical evidence for the effects of sociality motivation, with participants who rated higher on social disconnect, attributing more supportive anthropomorphic traits to their pets. They also found effects for effectance motivation, due to both dispositional and situational influences. Participants who rated higher on desire for control, attributed more anthropomorphic traits to the dogs show in a video. The dog that exhibited a more unpredictable behavior induced higher attribution of anthropomorphic traits by the participants. Waytz, Morewedge, Epley, Monteleone, Gao and Cacioppo (2010) found further evidence for effectance motivation, by manipulating perceived unpredictability and incentives for mastery.

However anthropomorphism is more than the attribution of human mental states, like emotions, whishes or desires. Attributing a “mind” to a non-human agent entails: attributing it moral worth, since it has a conscious experience; attributing it responsibility, since it acts intentionally; and attributing it social normativity, since it has the capacity to evaluate and judge back the one perceiving him (see figure 3.6).

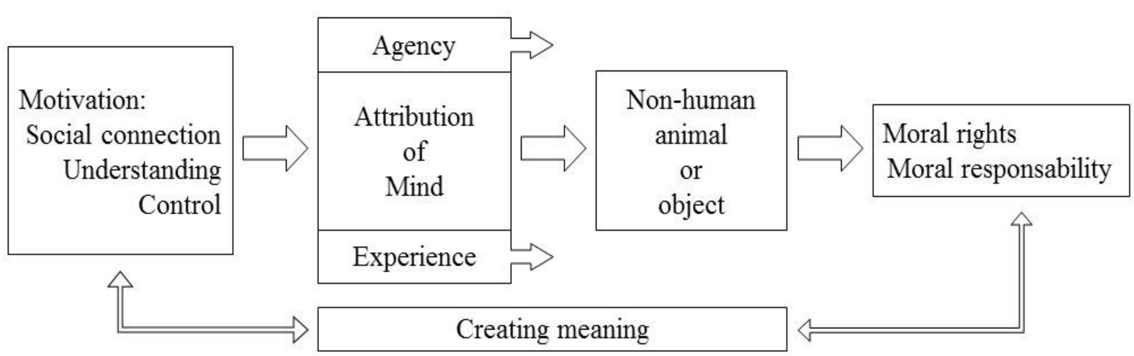

Figure 3.6. The process of attributing humanlike motives, intentions and feelings (mind) to the real, or imagined, behavior of a nonhuman agent (adapted from Waytz, Gray, Epley, and Wegner, 2010, p.384).

These effects have received some empirical confirmation. Waytz, Cacioppo & Epley (2010) results suggest that individual differences in the level of anthropomorphization ascribed to nonhuman agents predict level of moral care and trust in these agents. That is, participants with higher individual ratings on the anthropomorphism scale, showed more moral concern for nonhuman agents and more trust in technological agents to make important decisions. The same effect was found for social normativity, with participants with higher individual ratings on the anthropomorphism scale, showing more social desirable responses to a questionnaire conducted by an anthropomorphized computer interface. "Individual differences in anthropomorphism matter for creating an empathic connection with nonhuman agents, for judgments of responsibility and culpability, and for creating social influence" (Waytz et al., 2010, p. 220).

A similar social influence effect was also found by Chartrand, Fitzsimons & Fitzsimons (2008). In the first part of their experiment they showed participants photos of dogs and cats. As expected dogs where more associated with loyalty than cats. In the second part, participants were assigned a task where they were primed either with images of dogs or cats. Afterwards they were presented with a set of scenarios representing interpersonal situations designed to evaluate the level of loyalty towards a friend. Their results show that those primed with dog images showed higher level of loyalty to friends. That is, participants behaved in accordance to the anthropomorphic trait generally attributed to dogs. Given these results, the authors argue that exposure to an anthropomorphized non-human object or animal will make people more prone to exhibit the behavioral trait associated with it.

Following a related line of research, Haslam, Kashima, Loughnan, Shi, and Suitner (2008), compared how participants from three different countries (Australia, China and Italy), rated animal, robots and supernatural beings in terms of primary emotions, secondary emotions, wishes, intentions, thoughts and perceptions, compared to humans. There was an overall cross-cultural agreement on what differentiates humans from animals, robots and supernatural beings. Robots were found to differ from humans on core human nature traits of emotionality and desire, and animals to differ on traits of higher cognition and secondary emotions, that is, unique human traits. Supernatural beings differ from humans on cognitive and perceptive traits, which they possess at a higher level.

In short, the attribution of anthropomorphic traits to non-human animals and inanimate objects is determined by elicited agent knowledge, effectance motivation and sociality motivation and is influenced by dispositional, situational, developmental and cultural factors. Dispositional and situational factors like loneliness or unpredictability were found to induce higher levels of anthropomorphism. On the other hand, level of anthropomorphism was shown to predict degree of moral care, responsibility and trust, not only towards a nonhuman agent, but also towards human agents. The kind of psychological trait attributed to non-human agents also seem to vary depending on the category assigned to the agent, with unique human traits (secondary emotions and cognition) and naturally human traits (primary emotions and desire) being attributed differently. Overall, different lines of research seem to converge on the recognition that anthropomorphism plays an important role in perceiving the other and in social interactions. As such, perceived anthropomorphism can be an important factor underlying the formation of an attitude towards working with social robots, the sense of perceived control in operating a social robot and in foreseeing the emotional state elicited by achieving working with a social robot.

3. Social Robot Design and Appearance

There is a generalized confidence that building robots with human features and behaviors will enhance their interactions with humans (see Duffy, 2003 and Vogeley & Bente, 2010). In fact research in psychology has shown that physical appearance plays a significant role in social interactions. From inferring traits like attractiveness, likeability, trustworthiness, competence, and aggressiveness, based on a 100-Ms Exposure to a face (Willis & Todorov, 2006), to the biasing effects of physical attractiveness in court verdict decisions (Castellow, Wuensch & Moore, 1990; Kulka & Kessler, 1978), or inferring personality traits based on zero acquaintance, or minimal information (Albright, Kenny & Malloy, 1988; Nauman, Vazire, Rentfrow & Gosling, 2009), physical traits have been associated to a series of inferential deductions related to social interactions and decision making.

Research also suggests that people infer other's intention and personality by observing their behavior, even if information about physical appearance is unavailable (e.g. the other person is far away; see Thoresen, Vuong & Atkinson, 2012), with researchers suggesting that the recognition of biological movement may underlie higher mental processes, like the attribution of a "mind" to others (Blackemore & Decety, 2001; Iacoboni, 2009). The study of biological movement is based on a simple protocol: an actor with lights attached to the main joints is filmed moving in a dark environment. The film with the moving dots is shown to a group of participants with no previous knowledge of the content of the film. Participants are asked to identify the behavior performed (see Johansson, 1973 for early studies). The application of this methodology has shown that people can recognize gender, personality traits, emotions and complex actions like dancing (Blakemore & Decety, 2001). This capacity has an early onset, with three months old babies being able to discriminate between a display showing random moving dots from moving dots representing a walking person (Blakemore & Decety, 2001) and 12 month infants being able to recognize biomechanically correct (and incorrect) arm movements (Morita et al., 2012). This capacity of recognizing biological motion plays a key role in the attribution of intention (and other mental states, like feelings) to other's actions. As Blakemore and Decety (2001, p.566), point out "the brain is a powerful simulating machine, designed to detect biological motion in order to extract intentions from motion and to predict the future actions of other animate beings."

In short, research as confirmed not only the importance of physical appearance, but also suggests that physical presence and body motion play a significant role in inferring other's intentions and capabilities. As such, the design of a social robot should not be discarded as a potential factor influencing the determinants of behavioral intention.

The following sections offer a brief overview of research focusing on robot appearance, features and design. It is organized following two major themes: 1) robot appearance/ aesthetics: concerned with robot form (more or less humanoid appearance) and features (e.g. voice); and 2) robot perceived animacy: concerned with robot motion.

3.1 Social robot appearance/ aesthetics.

The study of robot appearance in robotics literature falls frequently under the label of anthropomorphism, being the term loosely applied to the fact that some (or all) of the robot traits are design to look human. This use of the label anthropomorphism is misleading, since anthropomorphism is a cognitive process, which involves the attribution of humanlike, motivations, intentions or emotions to the real, or imagined, behavior of a nonhuman agent, independently of their appearance (Epley et al, 2007). In order to distinguish the use of the term anthropomorphism in robotics literature from the concept as it is used in social and life sciences, the term anthropomorphic form (Disalvo &Gemperle, 2003) will be used henceforth. Disalvo and Gemperle (2003)[31] define an anthropomorphic form as: a non-living object that reflects human-like qualities, including physical characteristics, like shape and size, as well as qualities of behavior and interaction. That is, an anthropomorphic form is the product of design, while anthropomorphism is the product of a cognitive process.

The question of whether human-machine interfaces should be given human physical traits, is far from being closed (Duffy, 2006; Ishiguro, 2006) and there is a consistent effort by researchers to identify its usefulness in human-robot interaction. The assumption is that by looking more human like, the robot will elicit social behaviors from its users, thus leading to more fluid and efficient interactions.

Research has shown that variables like the robots voice (Powers & Kiesler, 2006; Sims et al., 2009; Tamagawa, Watson, Kuo, MacDonald & Broadbent, 2011), smile (Blow, Dautenhahn, Appleby, Nehaniv & Lee, 2006), face traits (Tamagawa et al., 2011; DiSalvo, Gemperle, Forlizzi & Kiesler, 2002), gestures (Sugiyama et al., 2006), presence of limbs (Syrdal, Dautenhahn, Woods, Walters & Koay, 2007), height (Lee et al, 2009; Walters, Koay, Syrdal, Dautenhahn & Boekhorst, 2009), whole body shape (mechanical vs humanoid) (Syrdal et al., 2007; Bartneck, Kanda, Mubin, & Al Mahmud, 2009; Ellis et al, 2005) and gender (Powers et al., 2005) have an influence in the perception of the robots intelligence, competence and friendliness. People also seem to take into account

[31] Disalvo and Gemperle (2003) ascribe four functions to the use of anthropomorphic form in design: 1) keeping things the same; 2) explaining the unknown; 3) reflecting product attributes; and 4) reflecting human values.

robot appearance when asked what jobs a robot should perform (Li, Rau & Li, 2010; Ray, Mondada, & Siegwart, 2008; Nomura, Kanda, Suzuki & Kato, 2005; Hegel er al., 2007).

This results, should however be read with some caution, since there are other results pointing in the opposite direction. For example, Broadbent, Lee, Stafford, Kuo & MacDonald (2011), found that people who thought of robots as having human form, showed greater increases in blood pressure readings and negative emotions, after having their pressure measured by a robot, than those who thought of mechanical robots. Carpenter, Eliot & Schultheis (2006), found that although people saw a humanoid robot performing house chores as acceptable, they felt uncomfortable with the idea of interacting socially with it (see also Carpenter et al., 2009).

In short, research results generally support the premise that robot appearance/ aesthetics is relevant for human-robot interactions, impacting user's perception not only of robot capabilities, but also of the kind of task it should perform. It should be noted however that research also suggests that a humanoid solution may not be an adequate solution for some contexts.

3.2 Social robot perceived animacy.

Being the purpose of social robots the creation of engaging social partners, the question of how lifelike, animated, the robot looks is another important question, the assumption being: the more "animated" (lifelike) a social robot is perceived the more the user will engage it. Using the framework of motor-interference/ resonance (Brass, Bekkering & Prinz, 2001; Kilner, Hamilton & Blakemore, 2007) the perception of robot movement has served as a benchmark for robots animacy. That is, if watching a robot perform an action produces the same kind of interference as watching a human perform, it can be said that the robot conveyed a sense of biological motion. Hence the above mentioned role of biological motion in inferring other's intentions can be transferred to human-robot interaction.

Research on robot movement has produced some suggestive results. Kupferberg, Glasauer, Huber, Rickert, Knoll & Brandt (2011), studied the effects of different types movement (biological vs mechanical) and observed agent type (industrial robot, humanoid robot and other human) concluding that "a humanoid robot with a limited human likeness in its appearance may trigger the same type of implicit perceptual processes as a human agent, given that it moves with a quasi-biological velocity" (Kupferberg et al.,2011, p. 343). The authors also note that motor interference was not observed when using a mechanical robot moving at constant speed. These results replicate Oztop, Franklin, Chaminade and Cheng (2005) results. They found that observing the actions of a humanoid robot or a human agent, resulted in motor interference, while watching a robotic arm did not. Nomura and Nakao (2010) studying the use of robot movement to convey different affective states (anger, sadness and pleasure), found a similar effect. They found that different states were associated with different magnitude and speed of performance of movements. However they did not studied if magnitude and speed were related to biological movement. Interestingly, their results showed that perception of movement and emotion was related to age group, with young students and elders focusing on different parts of the robot in order to identify the different emotional states. Research by Salem, Kopp, Wachsmuth, Rohlfing & Joublin (2012), also found behavior to play a significant role in human-robot interaction. Their results show that both multimodal (verbal and gestures) communication conditions (congruent and incongruent) rate higher in terms of participant's impression of the robot, than the unimodal verbal condition, indicating that it is advantageous to accompany robots verbal behavior with gestures, as this produces more effective interactions and a more positive perception of the robot.

In short, these results suggest that the significance of robot movement will depend on how biological-like it is. If the robot can convey biological-like body movements, enhanced interactions with humans may be expected. However, these results also point to the importance of robot global appearance (motor interference was observed with more humanoid robots), and human user characteristics. As Nomura and Nakao (2010) showed, differently aged participants relied in very different observation patterns to interpret the robot movements (for a review of the use of motor-interference/ resonance in HRI see Sciutti et al., 2012).

3.3 Social robot appearance in the context of the socio-cognitive models.

As exposed earlier, all the behavioral models presented assume that variables like socio-demographic status, general attitudes and personality traits (external variables) will have their effects on intention to perform a behavior mediated by the model's internal variables. Thus, in line with this reasoning it is proposed that the social robot appearance will have an effect on attitudes toward working with a social robot, perceived behavioral control and anticipated emotions.

For the purpose of this research one particular aspect of robot appearance is taken into account: how human a social robot looks like, that is, at a first glance does the robot generally resembles a human. The following typology is proposed:

- Mechanical, the robot has some traits that may remind human aspects (e.g. a round shape on top of its main structure in order to evoke a head. A pair of round orifices in order to evoke a pair of eyes) but is clearly a mechanical object.
- Humanoid, the robot design is clearly inspired by human form and motion (e.g. the shape of the extremities of the robot clearly reminds a pair of hands. The robot moves by using a pair of legs instead of wheels). Although in general the humanoid appearance is easily recognizable, there is not an attempt to emulate a human being in detail.
- Android, the main goal here is to produce an accurate replica of a human. The robot forms and function are not only inspired, but try to replicate in detail a human being (e.g. the robot's head will exhibit hair. The structure of the robot will be covered in material that tries to recreate skin touch).

Following from the research results presented above it is reasonable to expect that as the social robot's appearance moves from mechanical to android, people's perception and expectations will change and thus, attitudes toward working with social robots, perceived behavioral control and anticipated emotions will also change.

4. Summary

The above section presented the theoretical basis and the empirical results of research on factors that are expected to influence the determinants of intention to work with a social robots in the near future.

Drawing on research on social perception/ social cognition, belief in human nature uniqueness, attitudes toward robots, perceived warmth, perceived competence and anthropomorphism are posited as factors that will have a direct effect on attitude towards working with a social robots, perceived behavioral control and anticipated emotions. A stronger belief in human nature uniqueness is expected to produce a less favorable attitude towards working with a social robot, reduce perceived behavioral control and positive anticipated emotions. Social robots clearly challenge the core of the social representation of robot, and thus, may generate some discomfort and anxiety. Given this, a stronger belief in human nature uniqueness is expected to also increase negative anticipated emotion. Attitudes towards robots, perceived warmth, perceived competence and anthropomorphism are all expected to have positive effects, contributing to a more positive attitude towards working with a social robot, a higher sense of perceived behavioral control, a higher level of positive anticipated emotions and a lower level of negative anticipated emotions. Attitudes towards robots are expected to create a generally positive stance towards robots, while warmth, competence and anthropomorphism may function as facilitators of interactions. That is a social robot perceived as warm and competent may elicit in the human partner a sense of a partner that is available for cooperation, and will put an effort in the pursuit of the task assigned.

Drawing on research in robotics, it is posited that the appearance of the social robot will have an effect on attitude towards working with a social robots, perceived behavioral control and anticipated emotions. For the purpose of this research, three different appearances are used: mechanical, humanoid and android. It is expected that as the robot appearance becomes more humanized, the attitude towards working with a social robot becomes more positive, the sense of perceived behavioral control becomes higher, and positive anticipated emotions increase while negative anticipated emotions decrease. That is, a more humanized robot, will provide a more intuitive interface for interaction and thus increase the sense of control, the level of positive emotions and the attitude towards working with a social robot.

Table 3.1 presents a summary of the factors though to affect the determinants of intention and their measures.

Table 3.1
External variables, respective measures and expected effect

Variables	Theoretical model	Measure	Expected direct effect on
Socio-cognitive factors	- Essentialism - Attitudes towards robots - Stereotype content model - Three-factor theory of anthropomorphism	- Belief in human nature uniqueness - Negative attitude towards robots scale - Warmth/ competence - Perceived anthropomorphism	ATW PBC PAE NAE
Social robot appearance	- Uncanny valley	- Mechanical - Humanoid - Android	

Note. ATW= attitude towards working with a social robots; PBC= perceived behavioral control; PAE= positive anticipated emotions; NAE= negative anticipated emotions.

Chapter 4: Summary, Hypotheses and Overview

Summary and hypotheses

Social robots are robots capable of eliciting social responses from people, by perceiving and expressing emotional states, using non-verbal social cues or communicating in natural language. Although the social robot's social interface will vary in the degree of complexity and engagement afforded, it will change profoundly the way we interact and think about technology. If industrial robots, albeit having limited skills and mobility have redefined the way people work in factory plants than social robots, given its motor dexterity and ability to participate in a social context, will pose an even larger challenge and cannot be seen as just another innovation.

Although discussions about the future of robots always include a reference to entertainment robots (Graf & Barth, 2002), it is much more reasonable to expect that the large scale use of social robots starts within factories and offices. Thus, similar to what happened with industrial robots (Argote et al., 1983) and personal computers (Culpan, 1995), there will be a need to understand what factors will facilitate or hinder the people's willingness to work with social robots in the near future.

The TAR, TPB and MGB were develop to explain and predict behavior using a limited set of variables. In fact all three models accept that the proximal determinant of behavior is behavioral intention. This assumption has received ample empirical support (see Webb and Sheeran, 2006 for meta-analysis) as long as the following four elements of behavior are taken into account: action, target, context and time (Ajzen & Fishbein, 1977). That is, in order to be a reliable predictor of behavior, intention must account for these four elements. Applying this principle to the focus of this research, i.e. predicting the intention to work with a social robot in the near future, intention should account for these four elements: the action itself (i.e. working), the action towards a specific target (i.e. with a social robot) the action performed in a given circumstance (i.e. work place) and the action performed at a given moment (i.e. in the near future). See figure 4.1.

Figure 4.1. The four elements of behavioral intention (Asimo picture retrived from http://www.cnet.com/news/asimo-does-bottles-lovey-dovey-hand-gestures/).

Although the three socio-cognitive models agree on what is the proximal determinant of overt behavior they differ in the definition of what are the determinants of behavioral intention. The TRA (Fishbein & Ajzen, 1975) argues that intention is determined by attitude towards the target behavior and subjective norms regarding that same target behavior. These definition limits the range of its applicability, since it can only be applied to behaviors over which the person as complete control. The TPB (Ajzen, 1985) was developed to account for this limitation by adding a third determinant, perceived behavioral control. The MGB (Perugini & Bagozzi, 2001), not only proposes new variables, but also argues for a different chain of events. Intention is directly determined by desire to perform the target behavior. That is, according to the MGB, attitude towards the behavior, subjective norm and perceived behavioral control, although providing a reason to act, do not provide a motive to do so. Hence it is posited that their effect on intention is mediated by desire (the motivational element). The MGB also introduces an emotional element, positive and negative anticipated emotions. These anticipated emotions would also have their effect on intention mediated by desire. The MGB, like the TPB contends that under specific circumstances (when perceived behavioral control is equivalent to actual control), perceived behavioral control will have a direct effect on behavior (or behavioral intention).

Empirical research has provided support to the contentions of the TRA (see Sheppard et al., 1998 for a meta-analysis), TPB (see Armitage and Conner, 2001 for a meta-analysis) and MGB (see Perugini & Bagozzi, 2004 for a review).

In short, all three socio-cognitive models provide an account of the proximal determinants of behavioral intention and the processes underlying them, thus providing several avenues for intervention and behavioral change (e.g. Bledsoe, 2006; Kazemi & Forward, 2009).

Given the proven explaining value of these models and the already mentioned need to understand people's future behavior towards social robots, it is posited that: 1) all the three models, TRA, TPB and MGB can be used to predict the intention to work with a social robot in the near future; 2) these models are useful to determine which factors (attitude towards working with social robots, subjective norm, perceived behavioral control or anticipated emotions) facilitate or hinder the intention to work with a social robot; and 3) by focusing in a limited number of variables the models allow the development of affordable and empirically testable interventions.

Although the original MGB model posits a direct relation between PBC and actual behavior, research results show that this direct effect can also be posited between PBC and intention (see Taylor, Bagozzi and Gaither, 2001; Fry et al., 2014; Kim, Lee, Lee & Song, 2012; and Lee, Song, Bendle, Kim & Han, 2012). As such, the model used in the research considers that intention may be directly affected by perceived behavior control and desire.

Figure 4.2 shows a summary of the variables used in the research.

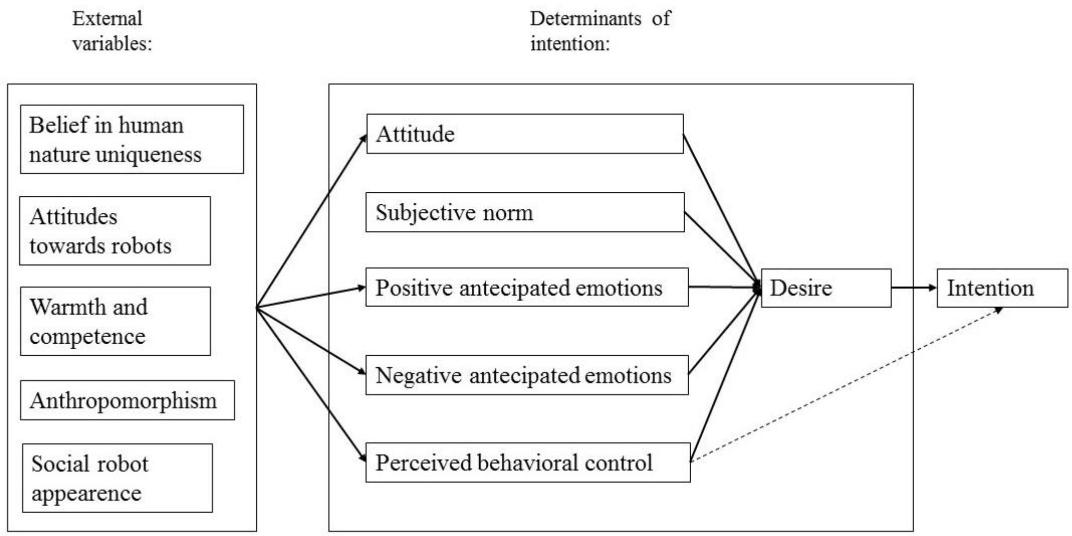

Figure 4.2. Summary of the variables used and their relations.

In Part 2: empirical research, the following hypothesis are tested:

H1: Intention to work with social robots is a function of attitude towards working with a social robot and subjective norms (i.e. the theory of reasoned action). A more positive attitude and subjective norms towards working with a social robot will lead to a stronger intention to work with a social robot (Study 7 and Study 9 test this hypothesis).

H2: Intention to work with social robots is a function of attitude towards working with a social robot, perceived behavioral control and subjective norms (i.e. the theory of planned behavior). The more positive the attitude and subjective norms towards working with a social robot and the stronger the perceived behavioral control, the stronger will be the intention to work with a social robot (Study 7 and Study 9 test this hypothesis).

H3: Intention to work with a social robot in the near future is a function of desire. Desire is determined by attitude towards working with robots, anticipated emotions, perceived behavioral control and subjective norms. The effect of these latter variables on intention is mediated by desire (i.e. the model of goal directed behavior). An increase in desire will lead to a stronger intention to work with social robots. An increase in attitude towards working with robots, positive anticipated emotions, subjective norm and perceived behavioral control will lead to a stronger desire to work with social robots. An increase in negative anticipated emotions will lead to a decrease in desire (Study 8 and Study 9 test this hypothesis).

All the three socio-cognitive models aim to present a parsimonious account of behavior and thus, assume that all the other factors, like socio-demographic status, attitudes and values or personality traits, will have their effects on behavior mediated by the model. In chapter three, a set of socio-cognitive factors (belief in human nature uniqueness, attitudes towards robots, perceived warmth and competence, and perceived anthropomorphism) and social robot appearance, were presented under the assumption that given their role on social behavior, they could have a direct effect on the determinants of intention and thus, an indirect effect on behavior.

The belief in human nature uniqueness, draws from the concept of essentialism. Recent research results suggest that the ingroup bias is extensible to the perception of social robots (Eyssel & Kuchenbrandt, 2012). Nomura et al. (2004, July) proposed the concept of negative attitudes towards robots. Subsequent research showed that the NARS could be used to predict time spent talking with a social robot (Nomura et al., 2008). The attribution of warmth and competence was found to be associated with the occupational suitability of the robots, with warmth associated with people oriented occupations, and competence associated with task oriented occupations (Lee, Lau and Hong, 2011). Haslam, Kashima, Loughnan, Shi, and Suitner (2008), compared how participants rated animal, robots and supernatural beings in terms of primary emotions, secondary emotions, wishes, intentions, thoughts and perceptions. Robots were found to differ from humans on emotionality and desire (core human nature traits), and animals to differ on traits of higher cognition and secondary emotions (unique human traits). The authors thus conclude that the anthropomorphization of robots will consist in the attribution of human natural traits, like mood.

From inferring traits like attractiveness, likeability, trustworthiness, competence, and aggressiveness, based on a 100-Ms exposure to a face (Willis & Todorov, 2006), to the biasing effects of physical attractiveness in court verdict decisions (Castellow, Wuensch & Moore, 1990), physical traits have been associated to a series of inferential deductions related to social interactions and decision making. In engineering the appearance of an object is frequently used to convey function and value (Disalvo &Gemperle, 2003). Research on social robots appearance and design suggests that it affects not only people's perception its capabilities (e.g. DiSalvo, Gemperle, Forlizzi & Kiesler, 2002) but also the type of job it should perform (e.g. Li et al., 2010).

The study of the effects of the external variables will focus solely on socio-cognitive individual factors (attitude towards working with a social robot, perceived behavioral control, anticipated positive emotions and anticipated negative) and will not account for any effects on subjective norms. Subjective norms were defined as the valuing (or devaluing), by significant ones, of a person's performing (or not) a certain action. That is, subjective norms draw on the beliefs a person has about a significant other's beliefs. As such it is posited that there are no theoretical reasons to expect a direct effect of the individual socio-cognitive factors studied and social robot appearance on subjective norms. That is not to say that these variables do not have indirect effects on subjective norms, but since the focus of the research is on predicting intention to work with social robots, it was considered a detour to pursue the indirect determinants of subjective norm.

Figure 4.2 shows a summary of the external factors and how they interact with the determinants of intention.

In Part 2: empirical research, the following hypothesis are tested:

H4. The level of belief in human nature uniqueness will affect the attitude towards working with social robots, perceived behavioral control and anticipated emotions. The stronger the belief in human nature uniqueness, the less favorable the attitude towards working with it, the lower the level of positive anticipated emotions, the higher the level of negative the anticipated emotions and the weaker the perceived behavioral control (Study 8 tests this hypothesis).

H5. The general attitude towards social robots will affect the attitude towards working with the social robot, perceived behavioral control and anticipated emotions. The more favorable the general attitude towards social robots, the more favorable the attitude towards working with the social robot, the stronger the perceived behavioral control, the higher the level of positive anticipated emotions, and the lower the level of negative anticipated emotions (Study 7 and Study 8 tests this hypothesis).

H6. The level of warmth and competence attributed to the social robot will affect the attitude towards working with social robots, perceived behavioral control and anticipated emotions. The higher the level of warmth and competence attributed to the social robot, the more favorable the attitude towards working with it, the stronger the perceived behavioral control, the higher the level of positive anticipated emotions and the lower the level of negative anticipated emotions (Study 7 and Study 8 tests this hypothesis).

H7. The level of anthropomorphism attributed to the social robot will affect the attitude towards working with the social robot and the perceived behavioral control. The higher the level of anthropomorphism attributed to the social robot, the more favorable the attitude towards working with it and the stronger the perceived behavioral control (Study 7 tests this hypothesis).

H8. The appearance of the social robot will affect the attitude towards working with it, perceived behavioral control and anticipated emotions. The more humanlike the social robot, the more positive the attitude towards working with it, the higher the level of perceived behavioral control, the higher the level of positive the anticipated emotions, and the lower the level of negative anticipated emotions (Study 7: mechanical vs. android; Study 8: Mechanical, Humanoid or Android test this hypothesis).

1 Overview of the empirical studies

In chapter 5, study 1 is aimed at determining the current social representation of robot in a Portuguese sample and thus, offering a first framework for what people think about robots and how the concept of social robot fits into it.

Chapter 6, is dedicated to the study of the psychometric qualities of the negative attitudes towards robots scale (NARS) and the belief in human nature uniqueness scale (BHNU). Studies 2 and 3 test the structure of PNARS using respectively a PCA and CFA. Study 4 tests the nomological validity and study 5 tests the predictive power of PNARS. Study 6 aims to explore the structure, reliability convergent and discriminant validities of the BHNU.

Chapter 7 studies the intention to work with social robots in the near future using the TRA, TPB and MGB. The effects of socio-cognitive external factors and the appearance of social robots in the determinants of intention is also studied. Study 7 uses the TRA and TPB to investigate the intention to work with social robots in the near future. The effects of robot appearance, perceived warmth and competence, perceived anthropomorphism and attitudes towards robots on attitude towards working with social robots and perceived behavioral control are also studied.

Study 8 uses the MGB to investigate the intention to work with social robots in the near future and its determinants. The effects of robot appearance, perceived warmth and competence, belief in human nature uniqueness and attitudes towards robots on attitude towards working with social robots, perceived behavioral control and anticipated emotions are also studied.

Finally, study 9 offers a comparison of the three socio-cognitive models in order to appreciate their different contributions to the understanding of the intention to work with social robots in the near future.

Part 2: Empirical studies

Chapter 5: The Social Representation of Robot

1. Overview

It was mentioned in the introduction that social robots have the potential to be a disruptive technology, and that the general public may be unaware of its potential and challenges. Given this state of affairs, it is only reasonable that prior to asking, what factors predict the intention to work with a social robot in the near future, one asks, what is the current lay understanding of what is a robot. Thus, this study aims to explore the current social representation of robot in order to understand how the social robot will fit (or misfit) it.

2. Defining Social Representation

When Serge Moscovici, in the early sixties, set forward the theory of social representations, he wanted to tackle the question of how lay people in modern, ever changing, societies accommodated the ever growing body of technical and scientific knowledge placed at their disposal by the social media (radio shows, television and newspapers), and turned it into their daily life practices. In other words, he wanted to know how common knowledge is formed, how individuals in social interaction, build theories about social objects and thus make possible communication and the organization of behavior (Vala, 1993). The social representation is a form of knowledge that intents to transform what is strange into something familiar, by anchoring novelty to already existing and stable knowledge structures (Moscovici cited in Wachelke & Camargo, 2007).

3.1 The structural approach

According to Abric's (1993) theory of the central nucleus, a social representation is structurally composed of a central nucleus (or central core) and a peripheral system. The central nucleus is made of one (or several) elements of the representation, and is characterized by having the generative function of ascribing meaning and organizing the elements of the representation (Guimelli, 1993). The central nucleus is directly linked and determined by historical and social conditions, being strongly marked by the groups system of norms. It is consensual and collectively shared by a social group. It is stable, coherent and resistant to change. It gives the representation a sense of continuity and consistency. It is in a certain way independent from the present social context (Abric, 1993). This central core structures the meaning of the whole representation, including the peripheral elements. It is a necessary condition for the representation's role as a meaning making tool. From a behavioral standpoint, the central nucleus plays a central role in the organization of values, attitudes and actions.

While the central core is normative, the peripheral system is functional, grounding the representation on reality. "It is the peripheral elements which can withstand the variations between individuals, between subgroups, and over time" (Flament, 1994, p.7). The peripheral system's role is turning the central core norms and prescriptions into concrete positions or courses of action, answering to concrete daily challenges. To do so the peripheral system is sensitive and determined by context, showing flexibility and accepting contradictions. Given this characteristics, the peripheral system serves a regulatory function in the adaptation of central core norms to new situations. It functions as a buffer, absorbing new information and events that challenge the core prescriptions of the representation, serving as a protection mechanism. This flexibility also allows for individual differences and creativity, integrating personal experiences and history in individualized social representations, but keeping them organized around the central core shared by the social group. From the interplay of this dual structure, central core and peripheral system, emerges the social representation apparently incongruent character, at once stable and fluid, consensual but marked by inter-individual differences.

3. Study 1: The Social Representation of Robot

3.1 Objectives

Study 1 aims to determine the social representation of robot in a sample of Portuguese people, and explore how the concept of social robot fits the current representation of robot.

3.2 M3.3 ethod

3.2.1 Participants

The convenience sample is composed of 212 participants (128 women and 76 men). Data was collected in the University of the Algarve, Gambelas campus, and at an adult education center in the district of Faro. Table 5.1 shows the socio-demographic characteristics of the participants.

Table 5.1

Socio-demographic characteristics of the participants in study 1

Study 1			N=212
Age		**Occupation**	
M	34.01	Student	108
SD	12.58	Management, sales & public service	26
Min-Max	19-69	Education & Health	9
Not reported	16	Engineering	-
Gender		Construction	8
Female	128	Tourism	26
Male	76	Unemployed	26
Not reported	8	Other	5
Years of School		Not reported	4
Up to 9	67		
Up to 12	23		
University Degree	116		
Not reported	6		

3.2.2 Material and procedure

The method used to collect data was free evocation with participants receiving the following instructions: Please write the ideas (names, adjectives...) that pop up into your mind when you listen to the word robot. Use a line for each idea. No limit number of ideas was given. These instructions were accompanied by an explanation of the voluntary character of the participation, of the confidentiality of the data and the explicit statement that they could stop to respond whenever they wanted if they felt uncomfortable with the task.

3.3 Results

3.3.1 Coding

All data was transcribed to a spreadsheet in order to be prepared for lexicographical analysis. Since some responses were given in the form of a sentence, they were replaced by a word that summarized the idea. If the sentence encompassed several ideas, several words would be used in order to represent each of the ideas.

3.3.2 Lexicographical analyses of the social representation of robot

The lexicon for this study is composed of a total of 1666 words, with 582 different words. It was built following Vergès, Scano and Junique (2002) recommendations. On average, participants evoked 7.74 words (SD = 4.63). The number of evocations varied between 1 and 22.

Evocations were organized by frequency and evocation order, in a four quadrant diagram, which allows the identification of what ideas are central to the social representation and what ideas compose the periphery system (Wachelke, 2011).

In order to conduct a lexicographical analyses three values must be determined: mean frequency, minimum frequency and mean order. Mean frequency and minimum frequency are calculated through the analysis of the frequency distribution of the evocations (see Vergès et al., 2002). The frequency table allows the identification of three distribution zones:

- Many words and very low evocation frequency (e.g. 419 words are present only 1 time in the lexicon);
- Few words and low evocation frequency (e.g. 4 words are present 8 times in the lexicon);
- Few words and high evocation frequency (e.g. 1 word is present 26 times in the lexicon).

Minimum frequency was considered 6, which represents the point where word frequency changes from many words and very low evocation to few words and low evocation. Mean frequency was considered 13, which represents the point where word frequency changes from few words and low evocation to few words and high evocation frequency.

To determine the mean order, the arithmetic mean of the frequency of the words with a frequency superior to the minimum frequency was calculated, determining the mean order to be 5.4. The data was analyzed using the software EVOC 2000 (Vergès et al., 2002). Table 5.2 shows the words frequency distribution and table 5.3 shows the four quadrant diagram representing frequency and order of evocation.

Table 5.2
Evocation frequency distribution

Frequency	Nº of words	Cumulative evocations		Cumulative inversed	
1	419	419	25.2 %	1666	100.0 %
2	56	531	31.9 %	1247	74.8 %
3	29	618	37.1 %	1135	68.1 %
4	15	678	40.7 %	1048	62.9 %
5	14	748	44.9 %	988	59.3 %
6	**4**	**772**	**46.3 %**	**918**	**55.1 %**
7	2	786	47.2 %	894	53.7 %
8	4	818	49.1 %	880	52.8 %
9	4	854	51.3 %	848	50.9 %
10	4	894	53.7 %	812	48.7 %
11	3	927	55.6 %	772	46.3 %
12	4	975	58.5 %	739	44.4 %
13	**2**	**1001**	**60.1 %**	**691**	**41.5 %**
14	1	1015	60.9 %	665	39.9 %
15	1	1030	61.8 %	651	39.1 %
16	1	1046	62.8 %	636	38.2 %
17	3	1097	65.8 %	620	37.2 %
18	1	1115	66.9 %	569	34.2 %
20	1	1135	68.1 %	551	33.1 %
21	2	1177	70.6 %	531	31.9 %
22	1	1199	72.0 %	489	29.4 %
24	1	1223	73.4 %	467	28.0 %
26	1	1249	75.0 %	443	26.6 %
30	2	1309	78.6 %	417	25.0 %
32	2	1373	82.4 %	357	21.4 %
36	1	1409	84.6 %	293	17.6 %
38	1	1447	86.9 %	257	15.4 %
45	1	1492	89.6 %	219	13.1 %
74	1	1566	94.0 %	174	10.4 %
100	1	1666	100.0 %	100	6.0 %

Notes: Minimum frequency and mean frequency in bold

Table 5.3

The four quadrant diagram representing frequency and order of evocation for the inductor word: Robot

Frequency ≥ 13 Mean Order <5.4	Frequency	Order	Frequency ≥ 13 Mean Order ≥5.4	Frequency	Order
Central nucleus			First periphery		
machine	100	1.9	movies	26	6.9
technology	74	3.9	science	22	6.4
future	45	4.9	unemployment	21	6.4
help	38	5.0	evolution	21	5.9
metal	36	4.0	computer	17	5.5
artificial intelligence	32	4.3	electronics	17	6.1
replaces men	32	5.0	innovation	16	6.8
industrial robot	30	4.8	without feelings	15	6.3
mechanical	30	3.6	programming	13	6.4
domestic robot	24	4.7	robocop	13	6.4
facilitates	20	4.1			
automatic	18	2.5			
puppet	17	3.0			
mechanization	14	3.7			
Frequency < 13 Mean Order <5.4	Frequency	Order	Frequency < 13 Mean Order ≥5.4	Frequency	Order
Contrast zone			Second periphery		
toy	12	4.4	robotics	12	5.5
iron	12	4.8	fiction	11	6.0
intelligent	12	3.0	invention	11	6.8
fast	11	4.6	electrical	10	5.5
artificial	10	3.0	entertainment	9	6.2
grey	10	5.4	i robot	9	7.4
useful	10	4.0	i.t.	9	6.1
development	9	5.3	improvement	8	8.4
autonomous	8	5.0	humanoid	8	7.6
tin can	7	4.9	japan	8	8.0
intelligent creation	6	3.8	space	7	5.9
starwars	6	4.0	domination	6	13.2
			parts	6	7.5

3.3.2.1 Analysis of the central nucleus

According to Vergès, Tyszka and Vergès (1994), the elements of the central nucleus display two features: consensuality and easiness of recall. That is, if people are asked what their ideas about robots are, the ideas pertaining to the central nucleus would be those with a recollection rate above the average of the ideas recalled (consensus) and a recollection order below the average recollection order of the ideas recalled (evocation readiness).

In the four quadrant diagram the ideas more likely to pertain to the central nucleus are represented in the superior left quadrant (see Table 5.3). In this quadrant, *machine* is the idea with the highest frequency (100) and lowest rank order (1.9). That is, when participants are asked about the word robot, the idea of *machine* is not only the most evoked, but is also the one invoked first more frequently. The idea of *machine* is accompanied by the ideas of *metal*, *mechanical*, *mechanization*, *automatic*, *artificial intelligence* and *technology*. Still in the first quadrant are ideas like, *domestic robot*, *industrial robot*, *help, facilitates* and *replaces men*. While the first set of ideas revolves around how the robot operates, the second set revolves around the functions of the robot. There is also a reference to a time scale, placing robots in the *future*. Finally the idea of *puppet* is also part of the first quadrant. Interestingly, the word robot seems to evoke at the same time the idea of an industrial technological machine and a fancy toy for kids.

In brief, it could be said that the word robot evokes an idea of a technological machine, endowed with an artificial intelligence, which will help and facilitate work, replacing men both in industrial and domestic tasks in the future. It is to be noted that this idea of replacement of men is not associated with any negative emotions or adjectives but seems to be associated to the idea of replacing humans in tedious and dangerous tasks.

3.3.2.2 Analysis of the first periphery.

The upper right quadrant of the diagram is called the first periphery (Wachelke, 2011). The words presented here, although having a frequency above the mean frequency, are ranked below the mean order. Even though these elements are peripheral in the representation, they keep a close connection to the central nucleus, and function as a buffer to external threats (Abric, 1993). That is, they serve a regulatory function, adapting central core norms not only to daily but also new situations, absorbing new information and events even when they contradict the consensual nucleus elements.

In the present research, the ideas identified as belonging to the first periphery are a development of the ideas present in the central nucleus. The technological view of the robot continues in ideas like *science, computers, electronics* and *programming*. The idea of *innovation* and *evolution*, complement the idea of future identified in the nucleus, presenting robots as an improvement that will happen further ahead in time. In spite of this, the robot is nevertheless seen as being related to present technologies, like the computer. It is not clear how the idea of *unemployment* is related to the idea of *replacement of men* identified in the nucleus, since this was equated with replacement of men in unpleasant tasks. Besides detailing the idea of the robot machine, the first periphery introduces a different kind of robot, *Robocop*. This is an indication of the strong impact of popular culture in the construction of social representations, as the idea of robot is also associated with *movies*. Curiously, the physical appearance of the robot portrayed in movies like Robocop, a humanoid figure, is the opposite of what is portrayed in the central nucleus, an industrial or domestic machine. Finally, the idea of *without feelings* is also found in the first periphery, making more salient the differences between the "cold" machine and the "warm" human. This last idea is interesting as it contrasts with the concept proposed by social robots, robots that have and recognize emotions.

By definition the first periphery plays an important role both in maintaining the nucleus stability and at the same time accommodating new and unfamiliar objects. Given the consensual idea of robots as technological machines, with intelligence but without emotions, it can be said that the idea of robots with emotions, i.e., social robots, challenges some of the main tenets of the representation. Although there are some positive ideas about the robot as a helper in domestic and industrial tasks, the presence of the idea of unemployment in the first periphery should caution about some possible anxiety towards the introduction of robots. Although the idea of replacing men in unpleasant tasks, seems at face value, desirable, on the long run, the growing emphasis on automation may increase the salience of the idea of unemployment.

3.3.2.3 Analysis of the contrast zone.

The lower left quadrant of the diagram is called the contrast zone (Wachelke, 2011). The words present in this quadrant have an order of evocation above the mean order of evocation, but their evocation frequency is lower than the mean frequency of evocation. The contrast zone sometimes reveals complementary ideas or the presence of a subgroup with a different social representation (Wachelke, 2011). In this research, the contrast area is composed of ideas that complement the central nucleus, with references to components of the robot (*iron*, *tin*, *grey*, and *artificial*), to its capacities (*intelligent*, *fast*, and *autonomous*) and to its social impact (*development*, *useful*). The ideas of *toy* and *starwars* are also present in the contrast zone, underlining the ideas already present in the nucleus and in the first periphery of the robot as a fancy toy for children and as something belonging to science fiction movies. This absence of alternative ideas reinforces the consensual character of the ideas present in the nucleus.

3.3.2.4 Analysis of the second periphery.

The lower right of the diagram is composed of words with a frequency and an evocation order bellow the mean evocation and mean order. These are the more peripheral elements of the representation and they constitute the second periphery (Wachelke, 2011). The ideas already presented in the other quadrants are repeated. There are references to robot components (*parts*, *electrical*), use (*space*), technology (*robotics*, *IT*), social impact (*progress*, *invention*, *diversion*) and culture (*Japan*, *fiction*, *I robot*). Albeit this theme repetition, two new ideas are present in the second periphery, *humanoid* and *domination*. The idea of *humanoid* is probably associated with the images portrayed by the earlier mentioned movies and it is not clear how these ideas will affect either the central nucleus of the representation and the interaction with real robots in daily practices. The idea of *domination* is also probably linked to movie characters like those portrayed in movies like Terminator (or more recently The Matrix), that explore the concept of robots (or computers) taking control of the world. Although very peripheral, these ideas are still a part of the representation and can play a role in the construction of what is to be expected from social robots.

3.3.2.5 Synthesis of the representation.

Analysis of the four quadrant diagram shows a homogeneous representation of robot, a technological and electronic machine, that represents a progress over older machines. Automated, intelligent and emotionless, it will be used in industrial and domestic tasks, replacing men in tedious and dangerous works. Moving towards the periphery of the representation, these ideas are developed into more concrete aspects related to daily life, just like it is proposed by the structural model of social representations (Abric, 1993; Wachelk & Camargo, 2007). Besides the mechanical representation found in the central nucleus, another type of robot emerges in the peripheral system, a composite of robots presented in science fiction movies. It is not clear how these ideas influence the core representation, or will influence the future acceptance of robots. There is not a clear association between these movie robots and any specific task or favorable (or unfavorable) attitude, but it is reasonable to think that these representations will influence the expectations of robot's roles. Interestingly these robots, Robocop, C-3PO, represented in movies with humanoid form, stand in the opposite pole of the design continuum relative to the core social representation of robot: a machine.

Although the idea of replacement of men present in the central nucleus is portrayed in a benevolent way, the presence of the idea of unemployment in the first periphery suggests a possible future anxiety towards robots, as they may be perceived as a threat to job security.

3.3.3 Similitude analysis of the social representation of robot.

The similitude analysis is a technique to study the relations and the organization of the elements of a social representation, by displaying them in a graphical representation called the maximum tree[32] (Degenne & Vergès, 1973). In this representation the vertices are occupied by the words pertaining to the representation. These vertices are connected by edges that indicate the degree of connection between these words. This allows seeing which ideas have more connections, how strong they are and if words connect in such a way as to give rise to new ideas. This type of analysis gives a more dynamic view of the elements of the social representation.

[32] l'arbre maximum

For the purpose of this study the ideas pertaining to the central nucleus and the first periphery where organized into 24 categories and then analyzed with the software SIMI 2000 (Junique, Barbry, Scano, Zeliger & Vergès, 2002). Figure 5.1 shows the results. The ticker the line, the stronger the relation between the ideas (see Vergès, 2001).

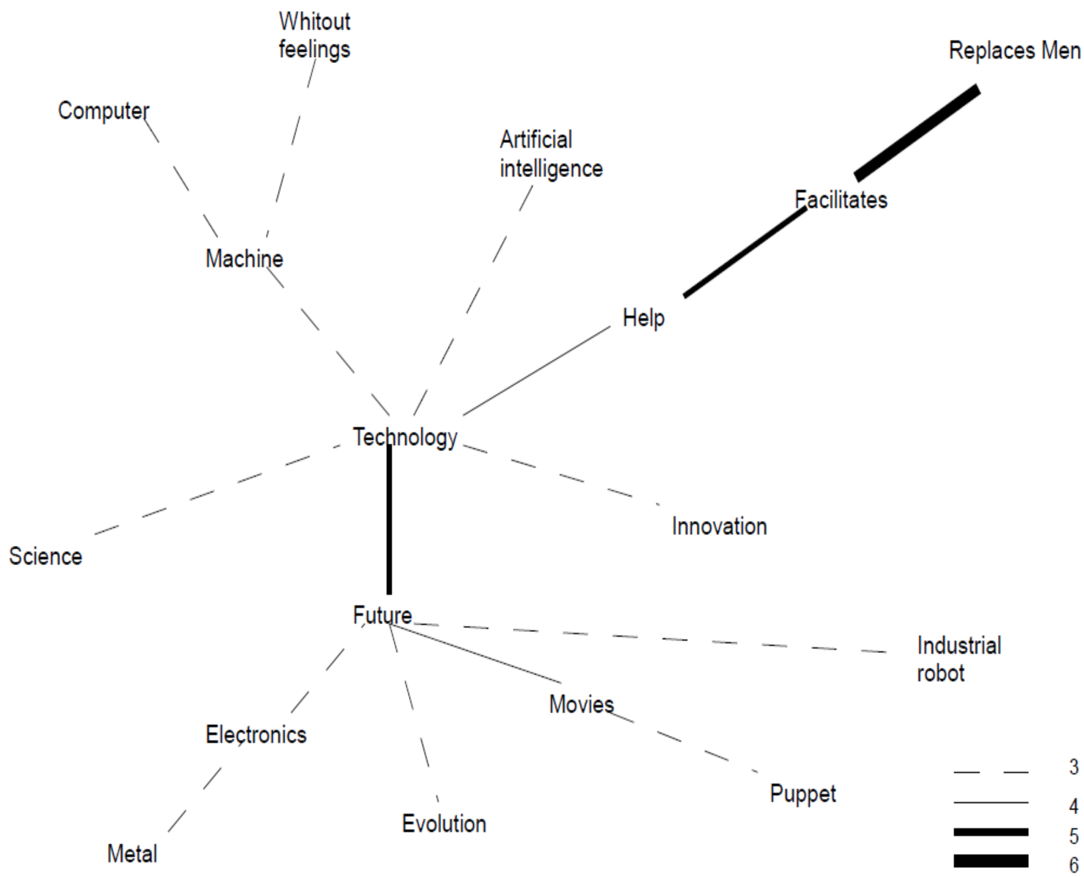

Figure 5.1. Tree with the elements of the social representation of robot.

The representation of robot is organized around the nodes of *technology* and *future*. The idea of technology is connected to *science*, *innovation*, *artificial intelligence*, *machine* and *help*. The idea of *machine* is connected to that of *computer* and *emotionless*. The idea of *help* is connected to *facilitate* and *replaces men*. Like in the analysis of the quadrants, the social representation of robot portrays it as a technological machine, intelligent but emotionless, similar to a computer, which can help humans. The second organizational node of the tree is the idea of *future*. This idea is connected to *evolution*, *electronics*, *industrial* and *movies*. Once again, although given concrete uses (e.g., industrial, electronics or movies) the robot is projected as something belonging to the future. In short, robots are seen as the technological machine of the future.

3.3.3.1 Comparison by socio-demographic characteristics.

One of the characteristics of social representations is their ability to form a coherent whole, while allowing for the formation of more individual and contextual representations. In order to better understand these dynamics, the sample was split by gender, age (two groups formed using the median, 32 years), and years of school (two groups, up to 12 years of schooling and university degree or frequency). The categories built for analysis used the words present in the central nucleus and the first periphery.

3.3.3.1.1 Gender.

Figures 5.2 and 5.3 show the organization of the representation for female and male participants. The social representation of robot in female participants (n = 128) is organized around the idea of *technology* (see Figure 5.2). This idea is connected to *science*, *innovation* and *future*. This is very similar to what was found for the total sample. Again the idea of *help* shows up, but in this case, the future robot is envisioned as a *domestic robot*.

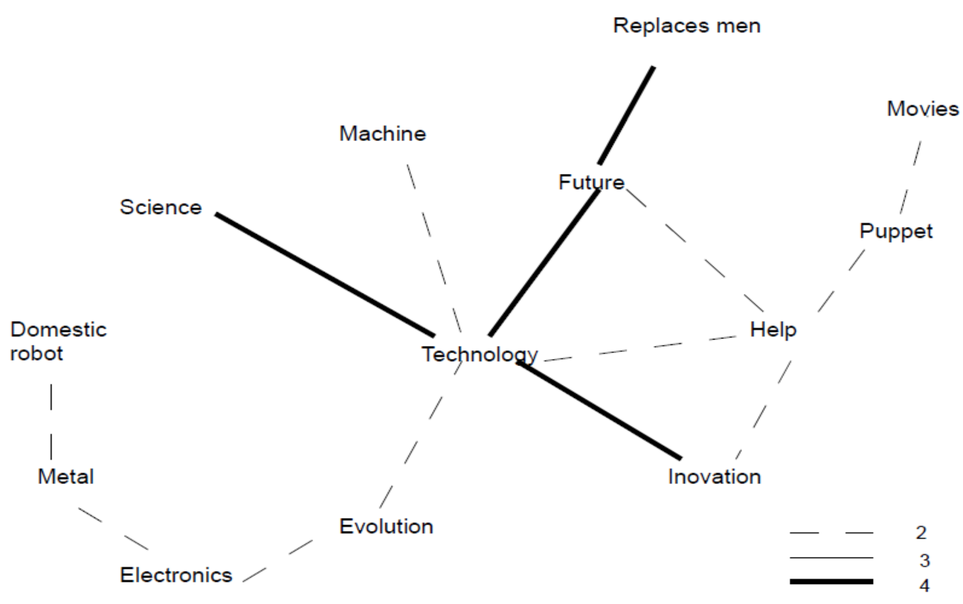

Figure 5.2. Elements of the social representation of robot by female participants.

The male participant (n = 76) social representation is organized around two nodes, *artificial intelligence* and *help* (see Figure 5.3). The idea of *artificial intelligence* is connected to *programming*, *industrial*, *technology*, *mechanical* and *future*. The idea of *help* is connected to *machine* and *replaces men*. Once again the idea of a technological machine that will replace men in the future is present. Interestingly what connects the ideas of *technology* and *help* is *unemployment*.

Unlike the feminine representation, the model of robot in the male representation is the *industrial robot*. This suggests that gender may play a role in the attribution of what is seen as an appropriate task for robots.

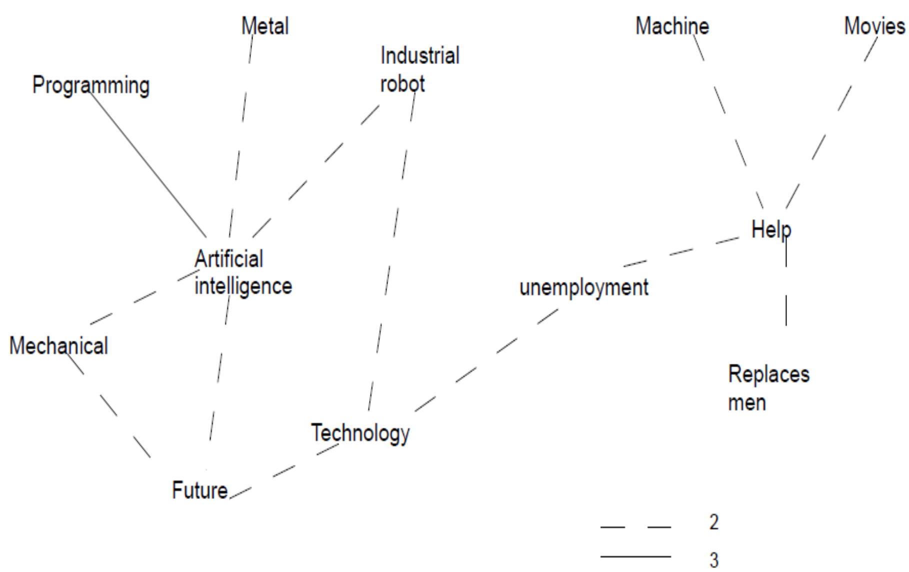

Figure 5.3. Elements of the social representation of robot by male participants.

3.3.3.1.2 Comparison by age.

For the comparison by age, the group was split into two groups, below 32 years (n = 98) and above 32 years of age (n = 98). The social representation of robot, for the group aged bellow 32 years, is organized around the idea of *technology* (see Figure 5.4). Once again this idea is connected to the idea of an *artificial intelligence*, which helps and replaces men in the future.

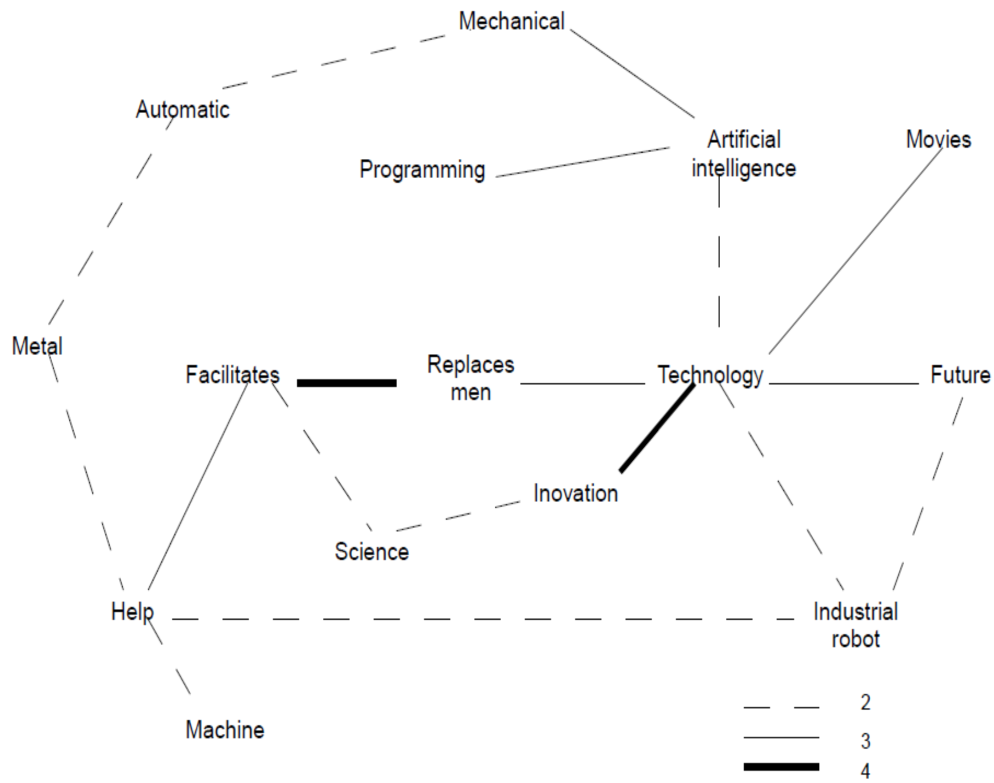

Figure 5.4. Elements of the social representation of robot by participants bellow 32 years of age.

For the group aged above 32 years, although the representation of the robot is still that of a *technology* that *helps*, this help is connected to *unemployment* (see Figure 5.5). Albeit the idea of something (a machine) that replaces men in dangerous and tedious work is well received, it also produces some ambiguity as this might imply a rise in unemployment. This ambiguity is more salient in the older participants, as they are already part of the job market. Another characteristic of this subgroup is that robots portrayed in movies or toys are clearly considered apart from those of real life.

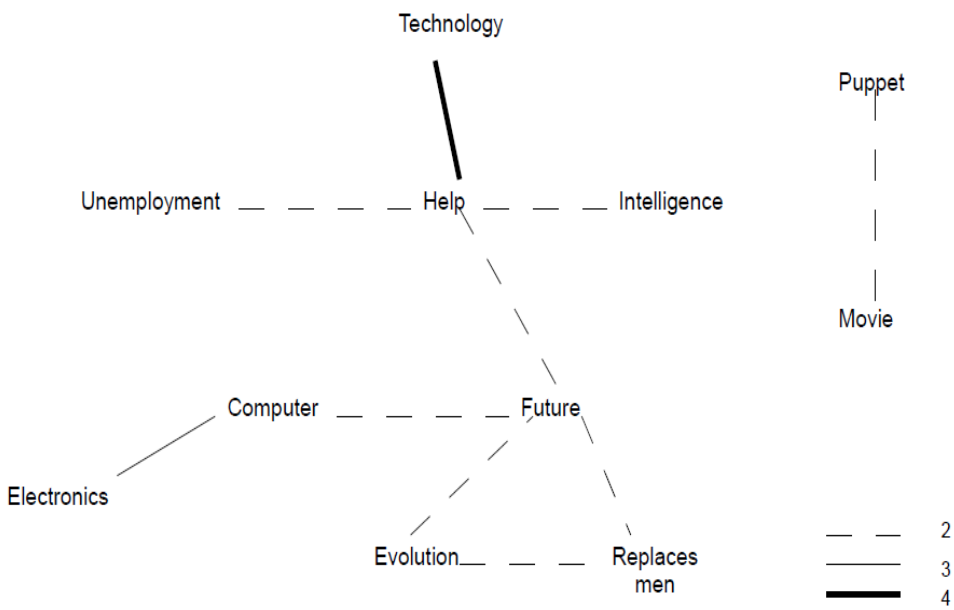

Figure 5.5. Elements of the social representation of robot by participants above 32 years of age.

3.3.3.1.3 Comparison by years of schooling

For the comparison by years of schooling, the group was split into two groups, up to 12 years of schooling (n = 90) and university degree (n = 116). For the first group, the social representation is organized around *help* and *technology*, following a similar structure to the one observed for the total sample (see Figure 5.6). Once more the idea of a technology that in the future will help and replace men in industrial tasks is present. The subgroup, university degree, does not present a clear node, or set of nodes, that organize the representation (see Figure 5.7). The representation for this group is more complex, integrating abstract and concrete ideas. This means that this subgroup has more ideas available to think about the effects robots will have in lives. Nevertheless, the conception of the technological machine, intelligent but emotionless, that will help and replace men in the future, performing automatically industrial tasks is present. For both groups there is a second kind of robots, those presented in films and toys.

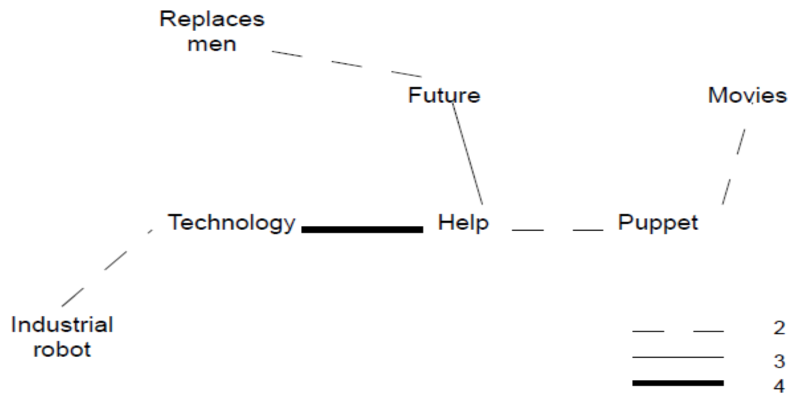

Figure 5.6. Elements of the social representation of robot by participants up to 12 years of schooling.

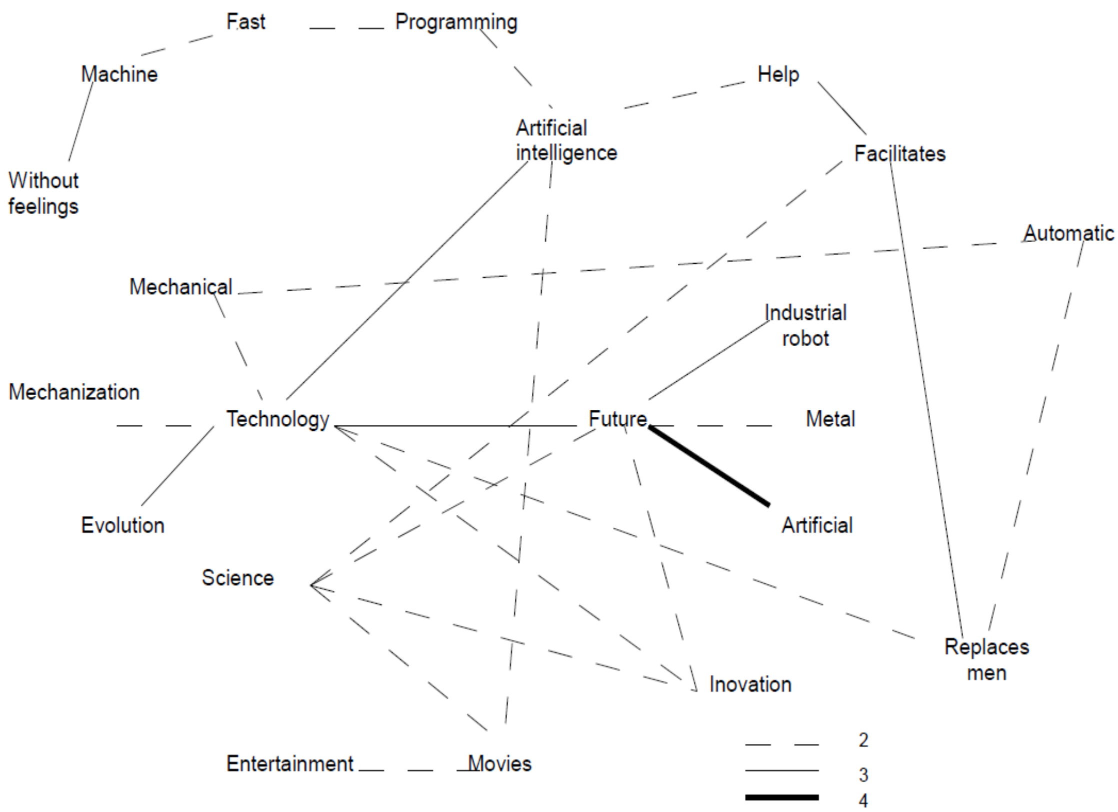

Figure 5.7. Elements of the social representation of robot by participants with university degree.

3.3.3.2 Synthesis of the similitude analysis.

The analysis of the social representation of robot for the various subgroups underlines the homogeneity of the representation. In general regardless of gender, age and schooling years, the social representation presents the robot as a technological machine, automatic and intelligent; an innovation brought by science, that in the future will replace men in industrial and domestic tasks. Besides these real robots, there are also those in movies or toys. The idea of entertainment robots is also present in the representation. Nevertheless some differences where identified. The idea of industrial robots is more prominent within male's representation, while the domestic robots is more prominent within the female's representation. The idea of unemployment is more prominent within male's social representation and in the subgroup of those above 32 years of age. And more years of schooling seem to produce a more complex social representation of robots.

3.4 Discussion

To sum up study 1, three points can be made. First, given the role of social representations as organizers of knowledge, their study uncovers not only the tendency towards robots, but also what robots are, where they are and why they are there. Participants in this study portray the robot as a high-tech machine, automated and fast in its performance (what), deployed on industrial or domestic settings (where), performing hard, dangerous, tedious and mundane tasks, helping, assisting and replacing men (why). Given this, it can be said that there is a fairly positive social representation of robots, as they are equated with technological progress and the pursuit of a "better life".

Second, on the other hand, this representation contrasts with the idea of social robot, a robot that recognizes and expresses emotions, uses natural speech and engages in social interactions, thus revealing the gap between lay people's expectations and current trends in robotics research. While people expect high-tech tools, the industry is preparing high-tech partners. The acceptance of social robots may depend on the efforts to narrow this gap.

Finally, the idea of replacement of men was identified as part of the central nucleus, in connection with the ideas of help and assistance. This can be interpreted as a tacit acceptance of robots as a technology that will improve the human condition by replacing men in a series of “dirty jobs”. On the other hand, in the peripheral system, this idea is connected to that of unemployment. So if at a general level, the idea of replacement by robots is seen as a positive thing, at an individual level it may be seen as a threat to job security.

These results are in line with previous research. Argot, Goodman & Schkade (1983), interviewed the workers of a plant during the installation of a robotic unit. When prompted with the open question “How would you describe a robot to a friend?” the major answers were: mechanical man, pre-programmed machine, something that loads machines, increases productivity or reduces manual work. See table 5.4 for a comparison between the results of Argot et al. (1983) and the identified central nucleus of the social representation of robot.

Table 5.4

Comparison of past representation of robot and current social representation of robot

Argote, Goodman & Schkade (1983)	Current central nucleus of the social representation
Mechanical man	Machine
Hydraulic arm	Technology
Computer	Future
Pre-programmed machine	Help
T.V. image	Metal
Moves material	Artificial intelligence
Loads machine	Replaces men
Better productivity	Industrial robot
Reduces manual work	Mechanical
Works continuously	Domestic robot
	Facilitates
	Automatic
	Puppet
	Mechanization

More recently, the results of the special eurobarometer 382, titled “Public Attitudes Towards Robots” (TNS Opinion & Social, 2012), a report that describes EU residents general attitude towards scientific discoveries, technology and robotics, presented a similar panorama. Participants were shown a picture of an industrial robot (an automated programmable arm filling boxes) and a picture of a humanized home helping robot (a service robot similar to the one used in the mechanical robot condition in experiments 7 and 8). They were then asked to rate how much, each of the pictures fitted their image of a robot. Around 80% of the participants stated that the image of the industrial robot fitted well with the image they had of robots, while 66% of the participants stated that the image of the humanized home helping robot fitted well with the image they had of robots. This suggests that the image of the industrial robot, automated, programmable, mechanical arm is still very pervasive amongst the lay person. In the case of Portugal the gap was smaller with 64% of the participants stating that the industrial robot fitted well their image of robot and 55% stating that the humanized home helping robot fitted well their image of robot. An analysis by country suggests that familiarity with robots may have an effect on the representation of robot, with the largest prevalence of the image of the industrial robot showing in more industrialized countries like Sweden (95% vs.63%), Germany33 (87% vs. 56%), Finland (93% vs. 65%) or Denmark (94% vs. 66%). The eurobarometer study also found differences for gender and age.

In short, the current social representation of robot is anchored in the idea of an automatic, technological, advanced machine that will help and facilitate some tasks (industrial and domestic). If this representation accommodates well contemporary industrial or agricultural robots, it is at odds with the paradigm driving social robotics research, and thus the organizational challenges posed by the introduction of social robots (see Mutlu & Forlizzi, 2008 for an example of the organizational challenges posed by the use of a robotic solution). This result underlines the need to study what factors may facilitate or hinder future work with social robots.

[33] It should be noted that Germany has the third largest number of robots per worker employed in industry.

Chapter 6: Scales Validation

1. Overview

The development of reliable and standardized measures is fundamental for the improvement of research in human-robot interaction. The following section is dedicated to the study of the psychometric qualities of the negative attitudes towards robots scale (NARS) and the belief in human nature uniqueness scale (BHNU). Studies 2, 3, 4 and 5 will test the structure and the validitie of the Portuguese version of the NARS (P-NARS). Study 6 will test the structure and validity of the BHNU scale.

2. Validation of the Portuguese Version of the Negative Attitude Towards Robots Scale[34]

2.1 Introduction

The NARS (Nomura et al., 2004, July; 2006; Nomura, Kanda, Suzuki, & Kato, 2004) was elaborated to assess psychological reactions evoked in humans by human-like and non-human-like robots. Specifically, the NARS gauges the extent to which people feel unwilling to interact with a robot. The NARS is a 14 item scale (see Table 6.1), composed of three subscales: the negative attitudes towards interacting with robots (NARS-Interaction), towards the social influence of robots (NARS-Social Influence) and towards emotions in interaction with robots (NARS-Emotion).

[34] Note: This section is an adaptation of the following paper: Piçarra, N. Giger, J.-C., P, Pochwatko, G. & Gonçalves, G (under review). Validation of the Portuguese Version of the Negative Attitudes Towards Robots Scale.

Table 6.1

Items of the Negative Attitudes towards Robots Scale in English and Portuguese

1		(SI)	I would feel uneasy if robots really had emotions.
			A ideia dos robôs terem emoções é desagradável.
2		(SI)	Something bad might happen if robots developed into living beings.
			Se os robôs se transformassem em seres vivos poderia ser mau.
3	(R)	(E)	I would feel relaxed talking with robots.
			Sentir-me-ia confortável a falar com robôs.
4		(I)	I would feel uneasy if I was given a job where I had to use robots.
			Seria desagradável trabalhar num local onde tivesse que usar robôs.
5	(R)	(E)	If robots had emotions, I would be able to make friends with them.
			Se os robôs tivessem emoções, poderíamos ser amigos.
6	(R)	(E)	I feel comforted being with robots that have emotions.
			Sinto-me bem na presença de robôs com emoções.
7		(I)	The word “robot” means nothing to me.
			A palavra “robô” não me diz nada.
8		(I)	I would feel nervous operating a robot in front of other people.
			Ficaria nervoso a operar um robô perante outras pessoas.
9		(I)	I would hate the idea that robots or artificial intelligences were making judgments about things.
			Detestaria ver decisões serem tomadas por robôs ou inteligências artificias.
10		(I)	I would feel very nervous just standing in front of a robot.
			Ficaria muito nervoso perante um Robô.
11		(SI)	I feel that if I depend on robots too much, something bad might happen.
			Receio que algo de mau possa acontecer, se eu depender demasiado dos robôs.
12		(I)	I would feel paranoid talking with a robot.
			Sentir-me-ia “paranóico” a falar com um robô.
13		(SI)	I am concerned that robots would be a bad influence on children.
			Receio que os Robôs sejam uma má influência para as crianças.
14		(SI)	I feel that in the future society will be dominated by robots.
			Penso que no futuro a sociedade será dominada por robôs.

Note. Items in English come from Nomura et al. (2004); (R) = reversed item in the Japanese version; Japanese original structure: (I) = negative attitudes towards interaction with robots (NARS-Interaction); (SI) = negative attitudes towards social influence of robots (NARS-social influence); (E) = negative attitudes towards emotions in interaction with robots (NARS-Emotion).

The NARS was translated into various different languages (see Tsui, Desai, Yanco, Cramer & Kemper, 2011, for a review). However, these translations were purposely made for the the studies and few provide the NARS' structural and psychometric properties. For example, Bartneck Nomura, Kanda, Suzuki and Kato (2005, April; 2005, July) uses participants from different nationalities but does not report any psychometric information for the NARS and its subscales. Bartneck, Suzuki, Kanda and Nomura (2007) used Dutch, Chinese, German, Mexican and English versions of the NARS and reported the Cronbach's α for each of the NARS' subscales for the total sample (α = .79, .65, .60 for respectively, NARS-Interaction, -Social Influence and -Emotion) but not by nationality/country. Cramer, Kemper et al. (2009) and Syrdal et al. (2009, April) reported the Cronbach α for the full scale (α = .82, .80 respectively) but not for the each of the three subscales. Finally, Syrdal et al. (2009) used an English version of the NARS and provided a more throughout analysis by conducting a principal component analysis with a sample of students and staff of a British university. They showed that their English version displayed a factorial structure that differed from the original Japanese version, and they had to remove 3 items (namely items 7, 8, 14), leading them to conclude that the NARS may be sensitive to cultural differences.

In short, despite its generalized use, aside from the studies conducted by Nomura and colleagues with Japanese participants (Nomura et al., 2004; Nomura, Kanda, & Suzuki, 2006; Nomura, Kanda, Suzuki, & Kato, 2004; Nomura, Suzuki, Kanda & Kato, 2006, July) little is known about the NARS' structural properties for non-Japanese participants, with the exception of a small study (N = 28) conducted by Syrdal et al. (2009) with an English sample. This leads to the conclusion that there is a need for reliable and standardized measures usable in human robot interaction research.

2.2 Aims and Overview

The set of studies presented in this section aims at adapting the NARS in Portuguese (PNARS), checking its structure in Portuguese samples and testing its nomological and predictive validities. Studies 2 and 3 check the structure of the PNARS using respectively a principal component analysis (PCA) and a confirmatory factorial analysis (CFA). Study 4 tests the PNARS nomological validity (i.e., the extent to which the PNARS correlates with other distinct but related constructs) studying how it correlates with the attitudes towards technology. Finally, study 5 tests whether the PNARS can predict behavioral intention (and its affective and cognitive components) to work with a social robot.

2.3 Study 2: Analysis of the structure of the PNARS

Study 2 aims to replicate the original structure of the NARS using a PCA.

2.3.1 Participants and procedure

Participants of a convenience sample (N = 300; see Table 6.2 for the characteristics of the sample) were approached at campus, at an adult education center and at their work places in various cities of the Algarve. They were informed through verbal and written instructions about the anonymity and confidentiality of the data and the possibility to stop answering at any time if they felt uncomfortable with the task.

2.3.2 Material.

The English version of the NARS presented by Nomura et al. (2004) was adapted to Portuguese (see Table 6.1) using the back translation method (Brislin, 1976). Items were translated into Portuguese and back translated into English in order to get a sense of the quality of the translation. Participants responded to the 14 items of the Portuguese Negative Attitude towards Robots Scale (PNARS) on a 7-point scale (1 = I strongly disagree; 7 = I strongly agree). Two versions of the scale were produced, with items randomly assigned to them, to control for order effect.

Table 6.2

Socio-demographic characteristics of the participants in the four studies

	Study 2 N = 300	Study 3 N = 536	Study 4 N = 107	Study 5 N = 59
Age				
M	29.60	30.12	28.14	22.41
SD	11.36	11.56	8.93	4.83
Min-Max	18-71	18-71	18-54	18-40
Gender				
Female	190	316	59	33
Male	109	218	48	26
Not reported	1	2	-	-
Years of School				
Less than 9	15	64	-	-
Between 9 to 12	77	167	27	-
University	208	299	79	59
Not reported	--	6	1	-
Occupation				
Student	132	183	48	49
Management, sales & public service	70	88	19	1
Restaurant & Hotel	13	35	21	-
Construction	6	14	1	-
Engineering	3	-	-	-
Education & Health	51	61	11	1
Unemployed	4	40	-	1
Retired	3	-	-	-
Others	9	96	4	7
Not reported	9	19	3	-

Note. All participants are Portuguese native speakers.

2.3.3 Results

2.3.3.1 Preliminary analyses

Normality, skewness, kurtosis, outliers and missing values were analyzed. No outliers were identified. No variable had more than 3% of missing values. All were missing at random and were replaced by the mean. No significant order effect was observed ($p > .05$).

2.3.3.2 Results of the PCA

A PCA with three factors and varimax rotation was conducted to replicate the original Japanese's factor structure. In the original Japanese version, all the items are phrased negatively (except for items 3, 5, 6) which makes reading of the results difficult. Consequently, scores were reversed for all the 11 negatively phrased items so that higher scores indicate a more positive attitude towards robots and lower scores indicate a more negative attitude towards robots (this coding system is used throughout the four studies). The Kaiser-Meyer-Olkin measure of sampling adequacy reached the minimum value required (KMO = .84) and the Bartlet test of sphericity was significant (X^2 (df = 91) = 974.25, $p < .001$). The three factors extracted accounted for 49.43% of the explained variance. Factor 1 was composed of items 1, 2, 9, 11, factor 2 of items 4, 7, 8, 10, 12, 13, and factor 3 of items 3, 5, 6, 14. Factors 1, 2 and 3 accounted for, respectively, 18.64%, 17.60% and 13.20 % of the explained variance (see table 6.3).

A close analysis of the three factors revealed that: 1) the distribution of the items on the factors did not replicate the original Japanese structure; 2) the items in each factor did not group into coherent themes; 3) several items presented high loadings in more than one factor; 4) factor 3 showed a very low internal reliability (Cronbach α = .43); 5) items 7 and 14 had very low communalitie loadings (respectively .17 and .28); and 6) the screeplot suggested a potential two factor structure (see figure 6.1). Consequently, items 7 and 14 were removed and a PCA with two factors and varimax rotation was conducted with the remaining 12 items.

The two factors accounted for 46.12 % of the explained variance (see Table 6.3). The first factor included items referring to robots as having emotions (items 6, 5, 1), as capable of making judgments (item 9), as potential living beings (item 2) and to feel relaxed in the company of robots (item 3). Because this factor grouped all the items in which robots are presented as having human qualities, it was labeled Negative Attitudes Towards Robots with Human Traits (NARHT). The second factor included items referring to attitudes towards interacting with robots and was labeled Negative Attitudes towards Interactions with Robots (NATIR). PNARS, NARHT and NATIR displayed good internal reliabilities (all Cronbach α > .73; see Table 6.4). To conclude, the three factor solution described by Nomura et al. (2004, July) for the Japanese population was not replicated, however a coherent two factor solution with 12 items emerged. Indeed, both NARHT and NATIR showed a coherent theoretical content and displayed good internal reliabilities.

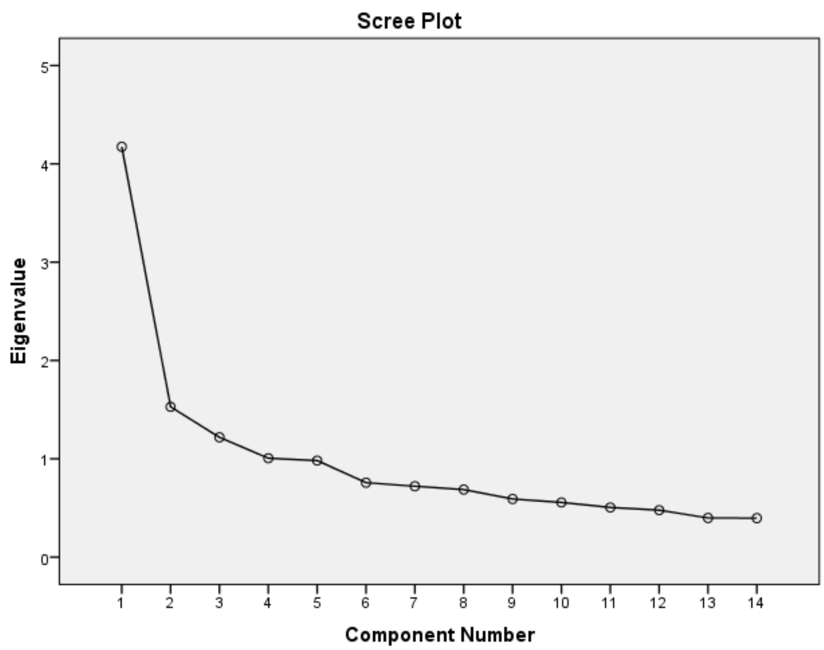

Figure 6.1. Scree plot for the PCA of the PNARS scale.

Table 6.3

Factorial Structure of the Portuguese Version of the NARS (PNARS)

Items	Japanese loading factors		Portuguese loading factors	
			NARHT	NATIR
Item 6	(E)	I feel comforted being with robots that have emotions.	**.73**	.05
Item 5	(E)	If robots had emotions, I would be able to make friends with them.	**.72**	.00
Item 1	(SI)	I would feel uneasy if robots really had emotions.	**.68**	.32
Item 2	(SI)	Something bad might happen if robots developed into living beings.	**.60**	.38
Item 3	(E)	I would feel relaxed talking with robots.	**.57**	.10
Item 9	(I)	I would hate the idea that robots or artificial intelligences were making judgments about things.	**.40**	.22
Item 10	(I)	I would feel very nervous just standing in front of a robot.	.01	**.76**
Item 8	(I)	I would feel nervous operating a robot in front of other people.	-.07	**.71**
Item 13	(SI)	I am concerned that robots would be a bad influence on children.	.34	**.65**
Item 11	(SI)	I feel that if I depend on robots too much, something bad might happen.	.31	**.60**
Item 12	(I)	I would feel paranoid talking with a robot.	.38	**.53**
Item 4	(I)	I would feel uneasy if I was given a job where I had to use robots.	.24	**.52**
Eigenvalues			4.10	1.43
Explained variance in %			23.39	22.73
Cronbach α			.73	.75

Note. Items 1,2, 4,7,8,9,10,11,12,13 and 14 are reversed so that higher scores means more positive attitudes towards robots; Loading factor for each item in the Japanese version: (I) = negative attitudes towards interaction with robots (NARS-interaction); (SI) = negative attitudes towards social influence of robots (NARS-social influence); (E) = negative attitudes towards emotions in interaction with robots (NARS-Emotion). NARHT= negative attitudes towards robots with human traits; NATIR = negative attitudes towards interaction with robots.

Table 6.4

Psychometric properties of the scales used in Study 2, 3, 4 and 5

	M	*SD*	N	Potential range	Actual range	Cronbach α	Skewness	Kurtosis
Study 1								
PNARS(R)	3.77	1.00	300	1-7	1-7	.82	.21	-.12
NARHT(R)	3.19	1.16	300	1-7	1-6	.73	.11	-.43
NATIR(R)	4.36	1.13	300	1-7	2-6	.75	.18	-.37
Study 2								
PNARS(R)	3.84	1.03	536	1-7	1-7	.80	.08	.17
NARHT(R)	3.33	1.20	536	1-7	1-7	.73	-.08	-.26
NATIR(R)	4.35	1.19	536	1-7	1-7	.76	-.03	-.15
Study 3								
PNARS(R)	3.76	0.96	107	1-7	1-7	.80	.01	-.45
NARHT(R)	3.13	1.18	107	1-7	1-6	.75	-.05	-.66
NATIR(R)	4.39	1.08	107	1-7	2-7	.73	.17	-.24
AT	4.89	0.71	107	1-7	3-6	.81	-.22	-.59
TC	5.12	0.85	107	1-7	2-7	.61	-.27	.59
TD	4.80	0.87	107	1-7	3-7	.72	-.01	.19
Study 4								
PNARS(R)	4.02	1.26	59	1-7	2-7	.89	-.18	-.96
NARHT(R)	3.43	1.33	59	1-7	1-7	.81	.18	-.83
NATIR(R)	4.62	1.41	59	1-7	1-7	.85	-.42	-.68
ATW	4.01	1.48	59	1-7	1-7	.94	.15	-.51
PBC	4.02	1.53	59	1-7	1-7	.89	-.22	-1.00
BI	2.88	1.54	59	1-7	1-6	.90	.60	-.49
AGEN	4.09	1.41	59	1-7	1-7	.88	-.35	-.61

Note. PNARS = Portuguese negative attitudes towards robots scale; NARHT= negative attitudes towards robots with human traits; NATIR = negative attitudes towards interactions with robots; (R) indicates that PNARS, NARHT and NATIR were reversed so that higher score indicate more positive attitudes towards robots; AT = attitudes toward technology; TC = technology consequences; TD = technology difficulty (higher scores indicates less perceived difficulty); ATW = attitude towards working with the Actroid DER1; PBC = perceived behavioral control in operating the Actroid DER1; BI = behavioral intention to work with the Actroid DER1 in the future; AGEN = agency.

2.4. Study 3: Confirmatory study of the structure of the PNARS

Study 3 tests the validity of the structure of the PNARS obtained in study 2 by using a CFA.

2.4.1 Participants, procedure and material.

Participants of a convenience sample (N = 536; see Table 5 for the characteristics of the sample) were approached at campus, at an adult education center and at their work places in various cities of the Algarve. They were informed through verbal and written instructions about the anonymity and confidentiality of the data and the possibility to stop answering at any time if they felt uncomfortable with the task. PNARS was measured like in study 2 (see Table 6.4 for statistical characteristics).

2.4.2 Results.

2.4.2.1. Preliminary analyses

Normality, skewness, kurtosis, outliers and missing values were analyzed. No variable had more than 3% of missing values and all were missing at random. These values were replaced by the mean. Analysis of the Mahalanobis distances suggests no multivariate outliers. Scores were reversed for all the negatively phrased items so that higher scores indicate a more positive attitude towards robots and lower scores indicate a more negative attitude towards robots.

2.4.2.2 Results of the CFA

A CFA was used to test the two factor model with 12 items obtained in study 2. This model not only displayed a good internal reliability, but also a sound theoretical organization of the items. The X^2 / degrees of freedom ratio, the root mean square error approximation (RMSEA), the standardized root mean square residual (SRMR), the comparative fit index (CFI), the nonnormed fit index (TLI) and the adjusted goodness of fit index (AGFI) values were used to evaluate the model.

Results of the CFA showed that only the SRMR presented a reasonably good fit value (see Table 6.5). Examination of the modification indices revealed a relationship between the error variances of the 3rd and 6th items (respectively, “I would feel relaxed talking with robots" and "I feel comforted being with robots that have emotions") and of the 8th and 10th items (respectively, "I would feel nervous operating a robot in front of other people", "I would feel very nervous just standing in front of a robot"). Adding error covariance between the meaningfully close items in the same factor is recommended (Byrne, 2010). Model 1 was consequently respecified following two steps: error covariance between items 3 and 6 was added (Model 1-A) and then error covariance between items 8 and 10 was added (Model 1-B). Model 1-B showed to fit better the data. Indeed, all of the indices fell in the interval of a reasonable good fit (see Table 6.5) showing that Model 1-B has an acceptable structure (see Figure 6.2). The PNARS, NARHT and NATIR displayed good internal reliability (respectively Cronbach α = .80, .73, .76). The NARHT and NATIR are moderately and positively correlated (r = .50) indicating that they are independent distinct factors and confirming internal discriminant validity. Both the NARHT and NATIR are highly correlated with the PNARS (respectively, r = .87 and .86) confirming the internal concurrent validity.

Table 6.5

Model Fit for the Model in Study 3

Model	$\chi 2$ (df)	$\chi 2$ /df	SRMR	AGFI	CFI	TLI	RMSEA	IC 90%	PCLOSE
1	289.86 (53)	5.47	.071	.87	.85	.81	.091	.08 - .10	.000
1 A	211.27 (52)	4.06	.063	.90	.90	.87	.076	.06 - .09	.000
1 B	166.67 (51)	3.27	.057	.92	.93	.90	.065	.05 - .08	.012

Note. Model 1 = two factor solution with 12 items; Model 1-A = respecified two factor solution with 12 items and error covariance between items 3 and 6; Model 1-B = respecified two factor solution with 12 items and error covariance between items 3 and 6, and 8 and 10.

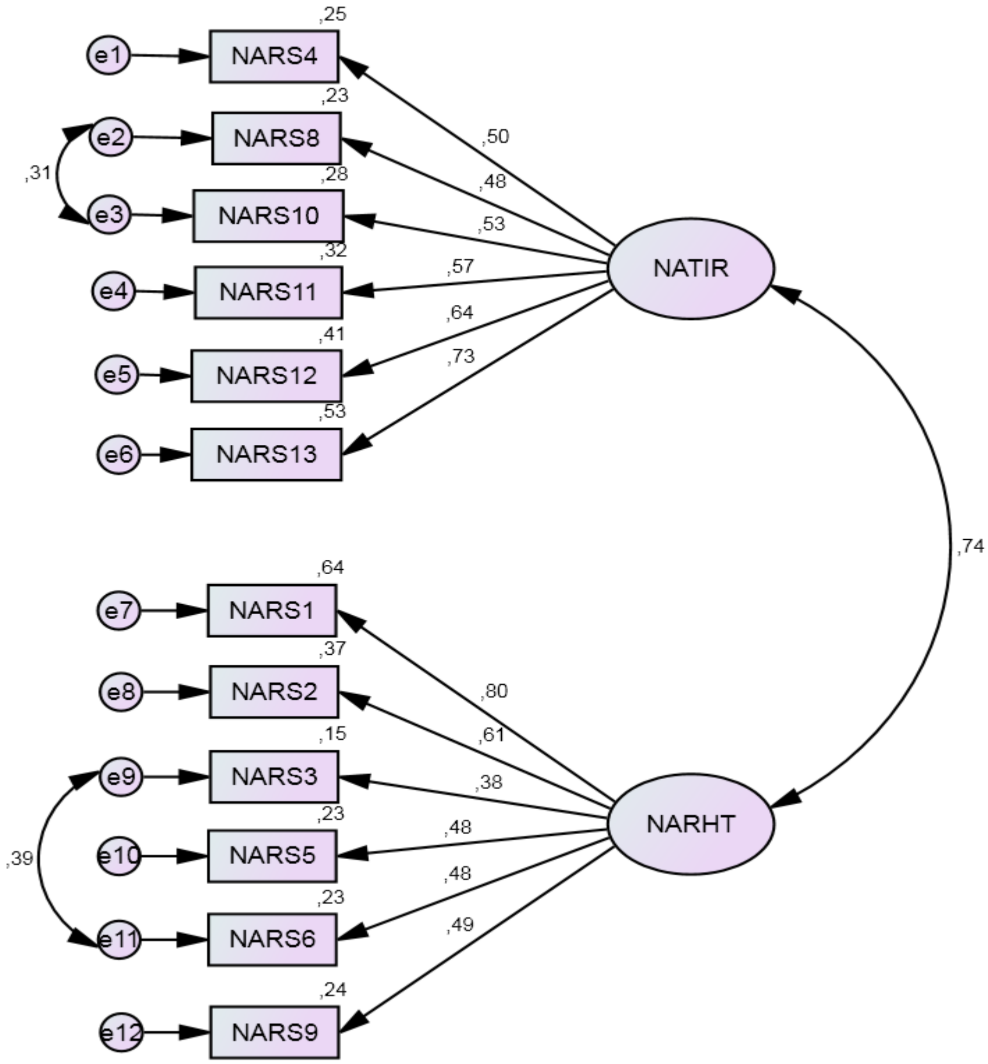

Figure 6.2. Structure of the final Portuguese Negative Attitudes Scale (PNARS; Model 1-B)

2.5 Study 4: Nomological validity of the PNARS

External nomological validity is the extent to which a scale correlates in theoretically predicted ways with other distinct but related constructs (Neale & Liebert, 1986). Since robots are technological devices, a correlation between the PNARS' factors and attitudes toward technology allows testing the PNARS' external nomological validity. Study 4 tests the association between the PNARS and attitudes towards technology.

2.5.1 Participants and procedure

Participants of a convenience sample (N = 107; see Table 6.2 for the characteristics of the sample) were approached at campus, at an adult education center and at their work places in various cities of the Algarve. They were informed through verbal and written instructions about the anonymity and confidentiality of the data and the possibility to stop answering at any time if they felt uncomfortable with the task.

2.5.2 Material.

The PNARS was measured like in studies 2 and 3 (see Table 6.4 for statistical characteristics). Scores were reversed to facilitate the reading of the results so that higher scores indicate a more positive attitude towards robots. The NARHT(R) and NATIR(R) will refer to reversed scores of the NARHT and NATIR. Participants responded to items of the attitudes towards technology (AT), consequences of technology (TC) and difficulty of technology (TD) subscales of the Pupils Attitude Towards Technology scale (PATT; Bame, Dugger, de Vries & McBee, 1993; Boser, Palmer & Daugherty, 1998) on a 7 point scale (1 = I completely disagree; 7= I completely agree). Items were reversed and averaged so that higher scores on AT and TC reflect a more positive attitude toward technology and its consequences, while higher scores on TD indicate that participants do not see technology as something difficult and hard to master (see Table 6.4 for statistical characteristics).

2.5.3 Results.

2.5.3.1 Preliminary analyses.

Normality, skewness, kurtosis, outliers and missing values were analyzed. No outliers were identified and no variable had more than 2% of missing values and all were missing at random. These values were replaced by the mean.

2.5.3.2 Nomological validity of the PNARS

Correlations support the nomologial validity of the PNARS (see Table 6.6). The PNARS(R) is positively correlated with attitudes toward technology subscale (r = .26) and consequences of technology subscale (r = .38). Participants with positive attitudes towards robots with human traits (NARHT) are also those who think that technology has more positive consequences (*r* = .24). Participants with positive attitudes towards interacting with robots (NATIR) are also those who have more positive attitudes towards technology (*r* = .33) and towards the consequences of technology (*r* = .41), and less perceived difficulties associated with technology (*r* = .22).

Table 6.6

Correlations between the variables used in Study 4

	PNARS(R)	NARHT(R)	NATIR(R)	AT	TC	TD
PNARS(R)	-	$.86^{**}$	$.83^{**}$	$.26^{**}$	$.38^{**}$	.19
NARHT(R)		-	$.44^{**}$	.11	$.24^{*}$	.10
NATIR(R)			-	$.33^{**}$	$.41^{**}$	$.22^{*}$
AT				-	$.58^{**}$	.04
TC					-	.10
TD						-

Note. Two-tailed correlation; * $p < .05$; ** $p < .01$; PNARS(R) = Portuguese negative attitudes towards robots scale (reversed); NARHT = negative attitudes toward robots with human traits; NATIR = negative attitudes toward interactions with robots; (R) indicates that PNARS, NARHT and NATIR were reversed so that higher scores indicate more positive attitudes towards robots; AT = attitudes toward technology; TC = technology consequences; TD = technology difficulty (higher scores indicate less perceived difficulty).

2.6 Study 5: Predictive validity of the PNARS

Behavioral intention (BI) was shown to be the proximal psychological determinant of effective/overt behavior (Fishbein & Ajzen, 1975). Studies in technology acceptance have shown that BI to use a technology is the best predictor of its effective use (Venkatesh & Davis, 2000). According to the theory of planned behavior (Ajzen, 1991), the BI is influenced by three affective and cognitive factors: 1) the attitude towards the behavior (one’s positive or negative feeling about performing the specific behavior in question); 2) the subjective norm (one’s perception that important others will approve or not the behavior); 3) the perceived behavioral control (i.e., the perceived ease or difficulty of performing the behavior, perception of internal and external constraints on behavior and self-efficacy). Moreover, the influence on BI of all factors external to the model, like socio-demographical characteristics or general attitudes towards a class of objects (e.g., PNARS), are assumed to be mediated by the attitude towards the behavior, the subjective norm and the perceived behavioral control (Ajzen, 1991). Study 5 aims to investigate whether the NARHT and the NATIR predict the BI to work with a robot that displays humanlike features and its affective and cognitive antecedents. To simulate a human-robot interaction (HRI), participants were exposed to a video displaying a human-like social robot presenting itself. The use of indirect methods, like video, in HRI's studies is quite common (e.g., see Tsui et al., 2011; Cramer, Goddijn, Wielinga & Evers, 2010; Cramer, Kemper, Amin, Evers, & Wielinga, 2009) and has received some empirical validation (Woods, Walters, Koay, & Dautenhahn, 2006).

2.6.1 Participants and procedure

Fifty nine participants were recruited on the faculty campus (see Table 5 for the characteristics of the convenience sample). Once in the laboratory, they received verbal and written instructions about the anonymity, the confidentiality of the data and the possibility to stop and quit the study at any time, if they felt uncomfortable with the task. After reading the instructions, participants completed the PNARS. Then, they were asked to see a video presenting a humanlike social robot called Actroid DER1, and were instructed as follows: "In the near future it will be common to interact with robots. This will happen in public spaces (factories, offices, museums) and in our houses. We are going to show you a video with one of those social robots. Your task is to imagine yourself working with this robot in the future and forming an opinion about it". Once the video finished, participants were asked to indicate their attitude, perceived behavioral control and BI to work with the Actroid DER1. Because perceived social and cognitive skills are crucial factors that make robots be perceived as social agents, the perceived level of agency of the Actroid was assessed as control. Finally, participants were asked whether they already knew this type of robot and debriefed.

2.6.2 Material.

The PNARS was measured like in studies 2, 3, and 4. Items were reversed and aggregated (all Cronbach $\alpha > .70$, see Table 6.4). NARHT(R) and NATIR(R) were calculated so that higher scores indicate more positive attitudes towards robots.

The BI was measured by 3 items on a 7 point scale (1 = I completely disagree; 7 = I completely agree) like “I’m willing to try hard to work with this robot in the future”. Items were aggregated (Cronbach α = .90) so that higher scores indicate stronger BI. Attitude toward working with the Actroid (ATW) was measured by a 7 point semantic differential scale composed of 10 items (e.g., “I think that working with this robot in the future will be: (1) useless / (7) useful; (1) foolish / (7) wise etc). Items were aggregated (Cronbach α = .94) so that higher scores indicate more favorable ATW. The perceived behavioral control (PBC) in working with the Actroid was measured by 7 items on a 7 point scale (1 = I completely disagree; 7 = I completely agree) like “It would be easy to work with this robot” or “I will not be able to communicate with this robot”. Items were aggregated (Cronbach α = .89) so that higher scores indicate a higher PBC. Although the subjective norm was measured, the analysis will be focused only on the effects of PNARS on ATW and PBC.

Agency was measured with the agency scale of Fiske, Cuddy, Glick and Xu (2002). Participants had to evaluate on a 7 point scale (1 = I completely disagree; 7 = I completely agree) whether they perceived the Actroid as confident, competitive, capable, efficient, skillful, competent, and independent. Items were aggregated (Cronbach α = .88) so that higher scores indicate higher perceived agency.

2.6.2.1 The video and the social robot

Figure 6.3. Actroid DER, the android social robot shown in the video used in the study.

The video lasted 1 minute and 50 seconds, and displayed the Actroid DER (see figure 6.3), a full body humanlike female social robot with a corporate look (i.e., make-up, black blazer, crème trousers, white shirt, and collar). It was edited from the original Japanese advertising video (see http://www.kokoro-dreams.co.jp/english/rt_rent/actroid.html). The original Japanese voice was dubbed by a Portuguese female voice who narrated the following: "Hello, my name is Actroid and I'm a social robot. A social robot is a robot created to interact with people in a natural fashion. In order to do that, my creators included in my design human characteristics like eyes, mouth, language and the capacity to understand and perform social behaviors. In the future I will be performing such jobs as a hotel receptionists, personal trainer or office clerk. Some even say that in the future I will be responsible for caring for the elders. Goodbye and see you in the future." During its speech, the Actroid displayed nonverbal behaviors (e.g. arm movements, blinks), was shown in different angles (e.g., ¾) and looking straightforward at the participant. The video was projected on a 1.50 m wide by 1.20 m tall on a screen with the participant standing approximately 2 meters away, giving the impression of a face-to-face interaction.The Actroid DER was though especially adequate because, the video showed a full body realistic humanlike social robot displaying verbal and non-verbal communication and a professional look that fitted the tasks suggested in the video.

2.6.3 Results

2.6.3.1 Preliminary analyses.

Normality, skewness, kurtosis, outliers and missing values were analyzed. No outliers were identified and no variable had more than 2% of missing values and all were missing at random. These values were replaced by the mean. Analyses showed participants who had already seen such type of robot (n = 10) did not differ significantly on main dependent variables from the other participants. No gender differences were observed. A one sample t-test showed that the mean of agency (M = 4.09; SD = 1.41) was significantly higher than the middle point of the scale (e.g., 3.5) indicating that the Actroid was perceived as a social agent, t (58) = 3.19, p = .002.

2.6.3.2 Correlational analyses

Bivariate correlations showed that the PNARS(R), NARHT(R) and NATIR(R) were all significantly and positively correlated with the ATW, PBC and BI (see Table 7.6). All Pearson *r* were close or above .50, indicating large effects.

Table 6.7

Correlations between the variables used in Study 5

	PNARS(R)	NARHT(R)	NATIR(R)	ATW	PBC	BI
PNARS(R)	-	.91**	.92**	.63**	.80**	.54**
NARHT(R)		-	.69**	.67**	80**	.53**
NATIR(R)			-	.48**	68**	.47**
ATW				-	.79**	.72**
PBC					-	.70**
BI						-

Notes. Two-tailed correlation; * *p* <.05; ** *p* <.001. PNARS = Portuguese negative attitudes towards robots scale; NARHT = negative attitudes toward robots with human traits; NATIR = negative attitudes toward interactions with robots; (R) indicates that PNARS, NARHT, and NATIR were reversed so that higher scores indicate more positive attitudes towards robots; ATW = attitude towards working with the Actroid DER; PBC = perceived behavioral control in working with the Actroid DER; BI = behavioral intention to work with the Actroid DER.

2.6.3.3 Regression analyses

Preliminary analyses showed no effects for gender and familiarity with the robot and these variables were not included in the regression models.

2.6.3.3.1 Direct effect of PNARS' sub-factors on ATW and PBC

Hierarchical regression analyses were conducted to test whether NARHT(R) and NATIR(R) were significant predictors of the ATW and PBC (see Table 6.8). Age was entered at Step 1 as a control. At step 2, results showed that NARHT(R) significantly predicted ATW (β = .64) and PBC (β = .69) while NATIR(R) only predicted significantly PBC (β = .32).

2.6.3.3.2 Direct and indirect effects of PNARS' sub-factors on BI

In order to test the direct and indirect effect of NARHT(R) and NATIR(R) on BI, multiple hierarchical regression analyses were performed (see Table 6.9).

In model 1, the BI to work with the Actroid was regressed on age, NARHT(R), NATIR(R) and ATW. At step 1, age was entered as a control and turned out to predict significantly the BI (β = - 0.12; $p < .05$). At step 2, age (β = -0.14; $p < .05$) and NARHT(R) (β = 0.35; $p < .05$) predicted significantly the BI. At step 3, age (β = 0.09; $p < .001$) and ATW (β = 0.44; $p < .001$) were the only significant predictors. The fact that NARHT(R) stopped being a significant predictor of BI when ATW is entered in the equation indicates that ATW could be a potential mediator of the effect of NARHT(R) on BI. The Preacher and Hayes (2008) bootstrapping technique for mediations was used to estimate the indirect effect of NARHT(R) on BI through ATW. Results, based on 5000 bootstrapped samples, showed that NARHT(R) did have a significant indirect effect on BI through ATW (effect = .44; standard error = .11; 95% Bias Corrected and Accelerated Confidence Intervals Lower = .28; Upper = .74).

In model 2, the BI to work with the Actroid was regressed on age, NARHT(R), NATIR(R) and PBC. At step 1, age was entered as a control and turned out to predict significantly BI (β = - 0.12; $p < .05$). At step 2, age (β = -0.14; $p < .05$) and NARHT(R) (β = 0.35; $p < .05$) predicted significantly the BI. At step 3, age (β = - 0.11; $p < .001$) and BPC (β = 0.51; $p < .05$) were the only significant predictors. The fact that NARHT(R) stopped being a significant predictor of BI when the PBC is entered in the equation indicates that the PBC could be a potential mediator of the effect of NARHT(R) on BI. The Preacher and Hayes (2008) bootstrapping technique for mediations with 5000 bootstrapped samples was used to estimate the indirect effect of NARHT(R) on BI through PBC. Results showed that the NARHT(R) had a significant indirect effect on BI through PBC (effect = .59; standard error = .15; 95% Bias Corrected and Accelerated Confidence Intervals Lower = .31; Upper = .93).

To recap, the ATW and PBC are significant predictors of the BI as proposed by the theory of planned behavior. Moreover, participants with a more positive attitude towards robots displaying human traits, i.e., higher score on NARHT(R), are also those who have a more positive attitude towards working with, a higher PBC in working with and a stronger BI to work with the Actroid. Participants who have more positive attitudes towards interacting with robots, i.e., higher score on NATIR(R), are also those who report a higher PBC in working with the Actroid. Finally, NARHT(R) influences BI through ATW and PBC. These results support the predictive validity of the PNARS.

Table 6.8

NARHT and NATIR as Predictors of the Attitude towards Working with and the Perceived Behavioral Control in Working with the Actroid DER

	B	Std. Error	Beta	*t*
Dependent variable: ATW				
Step 1				
Age	-0.08	0.03	-0.29	-2.29*
R^2 = 0.08; *F*(1,57) = 5.28*				
Step 2				
Age	-0.10	0.02	-0.34	-3.71**
NARHT(R)	0.64	0.13	0.57	4.65**
NATIR(R)	0.16	0.13	0.15	1.23 *ns*
R^2 = 0.56; R^2_{adj} = .54; *F*(3,55) = 23.56***				
Dependent variable: PBC				
Step 1				
Age	-0.03	0.04	-0.10	-0.77 *ns*
R^2 = 0.01; *F*(1,57) = 0.59 *ns*				
Step 2				
Age	-0.05	0.02	-0.17	-2.33*
NARHT(R)	0.69	0.11	0.59	5.81***
NATIR(R)	0.32	0.11	0.30	2.87**
R^2 = 0.69; R^2_{adj} = .68; *F*(3,55) = 42.66 ***				

Note. * $p < .05$; ** $p < .01$; *** $p < .001$; NARHT = negative attitudes toward robots with human traits; NATIR = negative attitudes toward interactions with robots (reversed); (R) indicates that NARHT and NATIR were reversed so that higher scores indicate more positive attitudes towards robots; ATW = attitude towards working with the Actroid DER; PBC = perceived behavioral control in working with the Actroid DER.

Table 6.9

Hierarchical Regression Analyses for Variables Predicting Intention to Work with the Actroid DER

	B	SE	Beta	*t*
Model 1				
Step 1				
Age	-0.12	0.03	-0.39	-3.26**
$R^2 = 0.15$; $F(1,57) = 10.64$**				
Step 2				
Age	-0.14	0.03	-0.44	-4.10***
NARHT(R)	0.35	0.16	0.31	2.13*
NATIR(R)	0.22	0.16	0.20	1.38
$R^2 = 0.38$; $R^2_{adj} = 0.35$; $F(3,55) = 11.49$**				
Step 3				
Age	-0.09	0.03	-0.29	-2.62*
NARHT(R)	0.07	0.18	0.06	0.39
NATIR(R)	0.15	0.15	0.14	0.98
ATW	0.44	0.15	0.43	2.87**
$R^2 = 0.46$; $R^2_{adj} = 0.42$; $F(4,54) = 11.49$**				
Model 2				
Step 1				
Age	-0.12	0.03	-0.39	-3.26**
$R^2 = 0.15$; $F(1,57) = 10.64$**				
Step 2				
Age	-0.14	0.03	-0.44	-4.10***
NARHT(R)	0.35	0.16	0.31	2.13*
NATIR(R)	0.22	0.16	0.20	1.38
$R^2 = 0.38$; $R^2_{adj} = 0.35$; $F(3,55) = 11.49$**				
Step 3				
Age	-0.11	0.03	-0.35	-3.30**
NARHT(R)	0.00	0.20	0.00	0.01
NATIR(R)	0.05	0.16	0.05	0.33
PBC	0.51	0.17	0.52	2.88**
$R^2 = 0.46$; $R^2_{adj} = 0.42$; $F(4,54) = 11.49$**				

Notes. * $p < .05$; ** $p < .01$; *** $p < .001$; NARHT = negative attitudes toward robots with human traits ; NATIR = negative attitudes toward interactions with robots ; (R) indicates that NARHT and NATIR were reversed so that higher scores indicate more positive attitudes towards robots ATW = attitude towards working with the Actroid *DER*; PBC = perceived behavioral control in working with the Actroid *DER*.

2.7 General Discussion

The purpose of the present research was to adapt the Negative Attitude towards Robot Scale (NARS; Nomura et al., 2004) to Portuguese (PNARS) and examine its psychometric properties. This is in line with the concern expressed by several authors regarding the heterogeneity of measurements and methodologies in HRI and how it impairs communication and application of results across research groups and projects (e.g. Dautenhahn, 2007; Steinfeld et al., 2006; Syrdal et al., 2009, April). Thus, the development and validation of common standardized tools for HRI is a central endeavor.

2.7.1 Psychometrics of PNARS

A confirmatory factor analysis (study 3) showed that the final two factor solution with 12 items identified in study 2 displayed reasonable good fit indices, indicating that the PNARS reproduced adequately the observed data. The PNARS also showed a consistent internal reliability across the 4 studies with Cronbach α ranging from .80 to .89 for the PNARS, .73 to .81 for NARHT, .73 to .85 for NATIR. Finally, correlations between NARHT and NATIR are positively and moderately correlated across studies (from r = .44 to .69) indicating that each factor can be viewed as a distinct factor, and correlations between the PNARS and its two factors are positive and significantly high (from r = .83 to .92) supporting internal concurrent validity.

2.7.2 Structure of the PNARS

The PNARS showed differences with the original Japanese NARS in terms of number of items and factors.

2.7.2.1 Number of factors

The original Japanese version of the NARS (Nomura et al., 2004, July) is a three factor scale composed of the negative attitudes towards: 1) situations of interaction with robots; 2) social influence of robots; 3) emotions in interaction with robots. Unlike the original version, the PNARS is organized around two factors. The first factor, the negative attitudes toward robots with human traits (NARHT), captures the responses to robots that display human traits, like emotions, language and agency. The second factor, the negative attitudes toward interactions with robots (NATIR), encompasses the reactions to interactions with robots. Several factors can explain why the factorial structures of the PNARS and the NARS differ.

2.7.2.1.1 Familiarity with the idea of robots.

Japanese may be more used to the idea of robots displaying human features through popular culture (e.g., Astro Boy, Ghost in the shell) than western people (Bartneck, 2005, July). Moreover, intercultural studies showed that, although Japanese do not like more robots than Americans (Bartneck et al., 2007), they are more concerned with the impact of robots on society than Chinese and Dutch (Bartneck et al., 2005, April) or German (Bartneck et al., 2005, July). To explain such differences, it has been suggested that Japanese, due to a higher exposition to robots, could be more aware of robots' assets and flaws than western people (Bartneck et al., 2005, April). In other words, Japanese may have a more complex cognitive representation of robots than Western people. The results of the Special Eurobarometer 382, titled public attitudes towards robots, requested by the European Commission (TNS Opinion & Social, 2012) provide some empirical support to this statement. According to it, 87% of the EU residents report to never have personally used a robot and that the main representation of robot they have is an instrument-like machine rather than a human-like machine. In the particular case of Portugal, when participants were shown a picture of two different robots (i.e., machine-like vs. human-like), 65% said that the machine-like robot corresponded well to the idea that they had of robots, against 55% for the human-like robots. Moreover, only 9% of the Portuguese participants said to have contact with robots at home or at work. Finally, when asked to predict when it will become commonplace for robots to do house work in Europe, 9% of the Portuguese participants answered in 5 years' time, 18% in 10 years' time, 14% in 20 years' time, 21% in more than 20 years' time, 6% said never, and 24% did not know. Only 8% said robots were already commonplace.

Results of study 1, the social representation of robot, also support the argument of familiarity. Indeed, the social representation of robot elicited by the participants portrayed an image of a technological machine that will help in industrial and domestic tasks somewhere in the future. That is, although participants were generally aware of the concept of robot and the technological prowess it represents, there is not a thoughtful reflection on the impact that the robotic "helping hand" will have on society. Given this, it makes sense that the social influence of robots does not show as an independent factor.

In short, Portuguese may have a more abstract representation of robots than Japanese, and perceive interactions with robots, as well as their social impact, as very distant future events, which may result in a different set of expectations. This could, thus explain why the "social influence of robots" of the Japanese version of the NARS does not emerge as an independent factor in PNARS.

2.7.2.1.2 Demographic features of the samples

The NARS was mainly tested with small samples (except Nomura et al., 2006, July; N = 400) that were composed of students (e.g., Nomura et al., 2004, 2006; Nomura et al. 2008; Bartneck et al., 2005, April). Inversely, the PNARS was validated not only with students, but also with active people, with a larger age range, level of education and professional categories than previous studies. Such difference in demographic features could explain why the Japanese and Portuguese structures differ. Results of the European survey about robotics (TNS Opinion & Social, 2012) support such an assumption, showing that the representation of robots differ according to demographic variables such age, gender and profession.

2.7.2.2 Number of items

PNARS is composed of 12 items instead of 14. Items 7 and 14 were removed from the Portuguese adaptation due to very low communalities. Syrdal et al. (2009, April) also reported to have removed items (7, 8 and 14) from their English adaptation of the NARS. Results of the European survey about robotics (TNS Opinion & Social, 2012) showed that Portuguese do have a picture of robots in mind (mainly as industrial machines) and they perceive interactions with robots and their social impact as very distant future events. Results of study 1, the social representation of robot, shows a similar picture. Although participants had no difficulty eliciting ideas when prompted with the stimulus word robot, the concept was associated with an unspecific future. This could explain why items 7 ("The word "robot" means nothing to me") and 14 ("I feel that in the future society will be dominated by robots") loaded low in the PCA and had to be ruled out from the final scale.

In short, cultural and demographical characteristics could explain why the structures of NARS and PNARS differ, and future studies testing the validity of the NARS' and PNARS' constructs are recommended.

2.7.2.3 Validities

2.7.2.3.1 Nomological validity

Study 4 showed that the PNARS, NATIR and NARHT were associated differently to the subscales of the attitude towards technology scale (Bame et al., 1993). These results provided evidences for the nomological validity of the PNARS. Interestingly, whereas NATIR(R) is associated significantly with more favorable attitudes towards technology and consequences and perceived ease of technology, NARHT(R) is only associated with consequences. In other words, participants with positive attitudes towards robots with human traits are also those who think that technology has positive consequences. The high correlations between NARHT(R) and NATIR(R) and ATW found in study 5 support the nomological net of the PNARS, since the general attitude towards robots is significantly correlated with the attitude towards working with the depicted social robot.

2.7.2.3.2 Predictive validity.

Results of study 5 support the predictive validity of the PNARS. Indeed, the PNARS, NARHT and NATIR turned out to be correlated with and to be significant predictors of the BI to work with a humanlike robot, and of its affective and cognitive determinants.

The fact that NARHTR and NATIR (*i.e*. general attitudes towards robots), are significant predictors of the attitude towards and the perceived behavioral control in working with a social robot is congruent with assumptions of the theory of planed behavior (Ajzen, 1991). According to this theory, background factors, like gender or general attitudes towards an object, are assumed to influence the set of beliefs on which attitude towards the behavior and the perceived behavioral control are derived, and have an indirect influence on BI through them (Ajzen, 1991). The attitude towards performing a behavior is based on behavioral beliefs, that is, the beliefs about the consequences of the behavior and their evaluations (*e.g*., if consequences are positive or negative). The PBC is derived from the control beliefs, that is, the beliefs about the presence or absence of individual and/or contextual factors that make performance of a behavior easier or more difficult. The NARHT and NATIR, as a general attitude towards robots, could influence the behavioral and control beliefs. For example, people who already have a positive evaluation of robots that display human traits could see more favorable consequences in working with a humanoid social robot. Observed results are congruent with such an explanation: (1) NARHT is a significant predictor of ATW and PBC, and (2) ATW and PBC mediates the influence of NARHT on BI.

Interestingly, both NATIR and NATRH are significant predictors of PBC. Both scales deal with anticipated emotions (e.g., anxiety, comfort) when thinking about interacting with a robot, and could explain why both are significant predictors of the PBC. Results also showed that NATRH(R) (β = .63) is a stronger predictor of the PBC than NATIR(R) (β = .25). This could be due to the fact that the NARHT specifically focuses on interacting with robot that displayed emotions. Displaying, recognizing and sharing emotions facilitate understanding others intentions and actions and consequently allows the regulation of social interactions. Consequently, participants with positive attitude towards robots displaying emotions could consider that interacting with a social robot like the Actroid would be easy.

2.7.3 Conclusions

The present research was aimed at adapting the NARS (Nomura et al., 2004, 2006) into Portuguese (PNARS). Results showed that the PNARS is organized around two factors: (1) the negative attitudes toward robots with human traits (NARHT) that captures the responses to robots that display human traits, like emotions, language and agency; (2) the negative attitudes toward interactions with robots (NATIR) that encompasses the reactions to interactions with robots. The PNARS displayed good psychometric qualities in terms of internal reliability, nomological validity and predictive validity. To our best knowledge, the present research is the first systematic validation of the NARS (*i.e*., PCA, CFA, nomological and predictive validity) in a language other than Japanese. Moreover, the PNARS is a significant predictor of the intention to work with a social robot and of its affective and cognitive components, indicating that PNARS is useful to identify psychological facilitators or inhibitors of contact with social robots and to study HRI.

3. Validation of the Belief in Human Nature Uniqueness Scale

3.1 Study 6. Measuring the Belief in Human Nature Uniqueness

3.1.1 Introduction

What does it mean to be human? John Locke, four centuries ago asserted that being human implied: 1) a capacity for reason or rationality; 2) mental states like beliefs, intentions, desires, and emotions; 3) language; 4) social relationships; and 5) moral accountability (Friedenberg, 2010). Some of these features have been shown to be also dimensions on which out-groups are discriminated (e.g. Haslam, Bain, Douge, Lee & Bastian, 2005; Leyens et al., 2001) and are associated with lay conceptions of human nature (Haslam, 1998). Interestingly, these same features have been presented as the key to the development of social robots (Breazeal, 2003).

The belief in human nature uniqueness scale (BHNU) was created in order to assess the extent to which people deny what are seen as uniquely human features to social robots.

3.1.2 Objectives

Study 6 aims to explore the structure and reliability of the scale. For that purpose a PCA was conducted. The relation between BHNU, religiousness, interest in science fiction and PNARS was studied with a bivariate correlation in order to test the scales convergent and discriminant validities.

3.1.3 Scale construction

In order to develop the BHNU scale, literature on the themes of essentialism, dehumanization and social robotics was reviewed. This review provided an overview of the features generally associated with human nature and essence and what features engineers are trying to build into social robots. Based on this review a set of statements was produced, which underwent discussion with colleague researchers. A set of 6 statements was agreed and are tested in this study.

3.1.4 Participants and procedure.

Data was collected online using a Google Docs survey form. Prior to answering the questionnaire participants were informed about the voluntary character of participation and the confidentiality of the data collected. Table 6.10 presents the socio-demographic characteristics of the participants.

Table 6.10

Socio-demographic characteristics of the participants in study 6

Study 6			N=187
Age		**Occupation**	
M	26.14	Student	113
SD	7.97	Management, sales & public service	22
Min-Max	18-56	Construction	1
Gender		Education & Health	15
Female	142	Unemployed	7
Male	43	Others	16
Years of School			
Until 12	55		
University Degree	123		

3.1.5 Material

Several measures were used in this study. Table 6.11 shows a summary.

Table 6.11

Scales used in study 6

	Measures
BHNU	Belief in human nature uniqueness
REL	Religiousness
SciFi	Interest in science fiction
PNARS(R)	Negative attitudes towards robots (Portuguese version)
NARHT(R)	Negative attitudes towards robots with human traits
NATIR(R)	Negative attitudes towards interactions with robots

Belief in human nature uniqueness (BHNU). This 6-item scale was developed for the study in order to assess the extent to which people deny uniquely human features to social robots. Participants rated on a 7-point scale (1 = totally disagree to 7 = totally agree) the following items: “Even if ultra-sophisticated… (1) a robot will never be considered as human being; (2) a robot will never feel the same emotions as a human being, (3) a robot will never use language in the same way as a human being; (4) a robot will always be a mechanical imitation of the human being; (5) a robot will never have consciousness; (6) a robot will never have morality.” Higher values indicate a stronger conviction in the uniqueness of the human nature.

Religiousness (REL). Level of religiousness intends to capture people’s religious belief and the extent of its influence in their lives. It was measured by four items. Participants were asked to answer on a 7-point scale, to the four following statements: “How would you describe your belief” from (1) non believer to (7) strong belief; “To what extent do you consider yourself religious?” from (1) not at all religious to (7) very religious; “In my life I follow my religion's teachings thoroughly” from (1) not at all to (7) very much; “In my opinion, the teachings and rules of my religion should have a big influence on the model of the society in my country/in the world” from (1) completely disagree to (7) completely agree. Higher scores indicate a higher level of religiousness and spirituality.

Interest in Science-Fiction (SciFi). Interest in Science-Fiction Culture was measured by two items. Participants were asked to report their liking for science films and books on a 7-point scale ranging from (1) I really dislike it to (7) I really like it. Higher scores indicate more interest in science fiction culture.

Attitudes towards social robots. Attitudes towards social robots was measured using the PNARS. The PNARS was measured like in the previous studies. PNARS(R), NARHT(R) and NATIR(R) were calculated so that higher scores indicate more positive attitudes towards robots.

3.1.6 Results

3.1.6.1Preliminary analysis

The data was analyzed for normality, skewness, kurtosys, outliers and missing values. Although the results of Kolmogorov-Smirnov index suggests some variables may have nonnormal distributions, skewness and kurtosis values are all below the threshold recommended by Curran, West & Finch (1996), 2 and 7 respectively. The analyses of box and whisker plot didn't show evidence of outliers in the sample. All variables, except the ones of the religiosity measure, have less than 2% missing values. Three of the religiosity variables are below 5% and one has 6% missing values. Little's missing at random (MCAR) test confirms that values are missing at random. Missing values were replaced using the expectation maximization (EM) method.

3.1.6.2 Descriptive statistics

Table 6.12 shows the descriptive statistics for the scales used in study 6. All the scales show good reliability results ($\alpha > .70$).

Table 6.12

Descriptive Statistics of the Scales used in Study 6

	N	Min-Max	Cronbach alpha	Mean	SD	Skewness	Kurtosis
BHNU	187	2-7	.84	5.38**	1.30	-0.74	-0.00
PNARS(R)	187	1-7	.86	4.23**	1.11	-0.24	-0.35
NARHT(R)	187	1-7	.75	3.63	1.24	-0.13	-0.36
NATIR(R)	187	2-7	.78	4.82**	1.17	-0.35	-0.20
REL	187	1-7	.93	3.13*	1.73	0.44	-0.93
Sci-Fi	187	1-7	.85	4.47**	1.65	-0.40	-0.63

Note. Means differ from the middle point of the scale (i.e., 3.5) at * $p < .05$; ** $p < .001$. BHNU = Beliefs in human nature uniqueness; PNARS= negative attitudes towards robots scale; NARHT= negative attitudes towards robots with human traits; NATIR= negative attitudes towards interactions with robots; ® indicates that PNARS, NARHT and NATIR were reversed so that higher scores indicate more positive attitudes towards robots. BHNU= belief in human nature uniqueness; REL= level of religiousness; Sci-Fi= interested in Science-Fiction.

The results of the comparison of the scales means to the medium point of the scale are shown in table 6.12. There is a generally positive attitude towards robots, with PNARS and NATIR rating significantly above the medium point of the scale. In spite of this, there is a strong belief that robots will not have qualities uniquely human, with BHNU rating significantly higher than the medium of the scale. There is also a general interest in science fiction. As for the level of religiousness, participants rated themselves significantly below the medium point of the scale.

3.1.6.3 Structure of the BHNU scale.

A PCA was conducted in order to study the latent structure of the BHNU scale. The Kaiser-Meyer-Olkin measure of sampling adequacy reached the minimum value required (KMO = .791) and the Bartlet test of sphericity was significant (X^2 (df = 15) = 542.08, $p < .001$), indicating that the data is suitable for factorial analysis.

The analysis produced a one component solution (Eigenvalue = 3.47) that accounts for 58% of the explained variance. All the variables presented loadings above .60. Analysis of the scree-plot confirmed the adequacy of the one component solution (see figure 6.4).

Figure 6.4. Scree plot for the PCA of the BHNU scale

3.1.6.4 Correlational analysis

Table 6.13 displays the correlation between BHNU, P-NARS(R), NARHT(R), NATIR(R), level of religiousness and interest in science fiction. BHNU is negatively correlated to NARHT(R) (r = -.49) and NATIR(R) (r = -.33). BHNU is negatively correlated with Sci-Fi (r = -.24), and positively correlated with REL (r = .17). NARHT(R) and NATIR(R) are positively correlated with Sci-Fi (r = .26 and r = .33 respectively), and negatively correlated with REL (r = -.20 and r = -.28 respectively). Sci-Fi and REL are not correlated.

Table 6.13

Correlations Between the variables used in Study 6

	P-NARS	NARHT	NATIR	REL	Sci-Fi	BHNU
P-NARS(R)	-					
NARHT(R)	.92***	-				
NATIR(R)	.91***	.69***	-			
REL	-.26***	-.20**	-.28***	-		
Sci-Fi	.32***	.26***	.33***	-.11	-	
BHNU	-.45***	-.49***	-.33***	.17*	-.24**	-

Note. All correlations are 2-tailed. * p < .05 ; ** p < .001.BHNU = Beliefs in human nature uniqueness; PNARS= negative attitudes towards robots; NARHT= negative attitudes towards robots with human traits; NATIR= negative attitudes towards interactions with robots; REL= level of religiousness; Sci-Fi= interested in Science-Fiction.

In short, participants with a stronger belief in the uniqueness of the human nature and a higher level of religiousness will have a more negative attitude towards social robots, that is, robots with emotions, language and life like features. On the other hand, those who reported more interest in science fiction also reported a more positive attitude towards social robots while presenting a lower belief in human nature uniqueness.

3.1.7 Discussion

Study 6 aimed to test the reliability and validity of BHNU, a measure of the extent that people believe in a unique human nature, and that the traits that comprise that nature will not be reproduced by social robots.

3.1.7.1 Structure and reliability

A PCA was conducted in order to study the latent structure of the scale items. Results indicate that the scale is unifactorial, accounting for 58% of the explained variance. A Cronbach alpha value of .84 indicates a good internal reliability for the scale.

3.1.7.2 Convergent and discriminant validities

By gauging the extent to which people deny what are seen as uniquely human features to social robots, one obtains a measure of their favorableness (or unfavorableness) towards endowing robots with human traits. That is, a measure similar to the attitude towards robots. As such it is reasonable to expect BHNU to be related to PNARS. Results of the correlational study support this, showing that the two variables are significantly correlated (r = -.45), with a stronger belief in human nature uniqueness being associated with a less favorable attitude towards robots, thus, supporting BHNU convergent validity with PNARS. It should be noted that although correlated with both NARHT and NATIR, BHNU shares more variance with the first (r = -.49 and r = -.33 respectively). This shows that BHNU has a stronger relation with attitudes toward robots with human traits, than with attitudes towards robots in general, thus providing further support for convergent validity.

Some research results suggest that a person's religiousness is associated with her expectations about robots (e.g. Metzler & Lewis, 2008). Since a religious belief includes a prescription of what it means to be human, it is expectable to see a relation between the measure of religiousness and BHNU. Although results of the correlational study show a significant correlation between the two measures (r = .17), the percentage of shared variance shared is small (3%). Like the BHNU, the measure of religiousness is also related with PNARS and its factors. However while BHNU has a stronger correlation with NARHT, religiousness has a stronger correlation with NATIR. That is, BHNU has a stronger relation with attitudes towards robots with human traits and religiousness a stronger relation with attitudes towards interactions with robots in general. This suggests that, although sharing some variance, BHNU and REL are measuring different constructs, thus confirming discriminant validity, and showing that the belief in human nature uniqueness is not necessarily rooted in religious norms.

Interest in science fiction is associated to a lower level of belief in human nature uniqueness (r = -.24). This may result from the extended exposure that science fiction lovers have to the theme of robots and technology. Like with religiousness, interest in science fiction shows a stronger relation to NATIR than to NARHT. Interest in science fiction shows no significant relation to religiousness.

PNARS and its subscales, NARHT and NATIR showed good internal reliability with Cronbach alpha's of .86; .75 and .78 respectively, further confirming the results obtained in the validation studies.

Chapter 7: Predicting the intention to work with a social robot and its determinants.

1. Overview

In the following sections the socio-cognitive models, presented earlier, are used to predict the intention to work with a social robot in the near future. Study 7 uses a hierarchical multiple regression analysis with the TRA and the TPB to investigate the intention to work with a social robot in the near future and its determinants. These models contend that all external factors are mediated by the model. As such, the effects of the following external factors on attitude towards working with a social robot and perceived behavioral control are studied: 1) social robot appearance, 2) perceived warmth and competence, 3) perceived anthropomorphism, and 4) attitudes towards robots with human traits and attitudes towards interactions with robots.

Study 8 uses a path analysis with the MGB to investigate the intention to work with a social robot in the near future and its determinants. The effects of the following external factors on attitude towards working with a social robot, perceived behavioral control and anticipated emotions are studied: 1) robot appearance, 2) belief in human nature uniqueness, 3), perceived warmth and competence and 4) attitudes towards robots with human traits and attitudes towards interactions with robots.

Study 9 uses a hierarchical multiple regression analysis with the TRA TPB and MGB to investigate the intention to work with a social robot in the near future and its determinants. A path analysis is used to study further the mediating effects of desire like postulated by the MGB.

2. Study 7: Exploring the TRA and TPB to predict the intention to work with a social robot and the effect of some external factors

2.1 Objectives

This study was conducted in order to understand people's intention to work with a social robot in the near future. Two theoretical models were tested, the theory of reasoned action (TRA) and the theory of planned behavior (TPB), both arguing that behavioral intention is the most proximal measure of actual behavior. Behavioral intention is conceptualized as either the product of attitude towards the behavior and subjective norms (TRA), or the product of attitude towards the behavior, subjective norms and perceived behavioral control (TPB). All the other factors, socio-demographic, personal and contextual characteristics have their effects mediated by these variables. The second part of study 7 will analyze the effects of social robot appearance (mechanical vs. android), perceived warmth, perceived competence, anthropomorphism, attitudes towards robots with human traits and attitudes towards interactions with robots, on the attitude towards working with a social robot and perceived behavioral control.

Study 7 will explore the following hypotheses:

H1: Intention to work with a social robot is a function of attitude towards working with a social robot and subjective norm (i.e. the theory of reasoned action). A more positive attitude and subjective norm towards working with a social robot will lead to a stronger intention to work with a social robot.

H2: Intention to work with a social robot is a function of attitude towards working with a social robot, perceived behavioral control and subjective norm (i.e. the theory of planned behavior). A more positive attitude, higher perceived behavioral control and a more favorable subjective norm towards working with a social robot will lead to a stronger intention to work with a social robot

H5: The general attitude towards robots (PNARS) will affect the attitude towards working with a social robot and the perceived behavioral control. The more favorable the general attitude towards robots, the more favorable the attitude towards working with a social robot and the stronger the perceived behavioral control.

H6: The level of warmth and competence attributed to the social robot will affect the attitude towards working with a social robot and the perceived behavioral control. The higher the level of warmth and competence attributed to the social robot, the more favorable the attitude towards working with a social robot and the stronger the perceived behavioral control.

H7: The level of anthropomorphism attributed to the social robot will affect the attitude towards working with a social robot and the perceived behavioral control. The higher the level of anthropomorphism attributed to the social robot, the more favorable the attitude towards working with a social robt and the stronger the perceived behavioral control.

H8: The appearance of the social robot (mechanical vs. android) will affect the attitude towards working with it and the perceived behavioral control. The more humanlike the social robot, the more positive the attitude towards working with a social robot and the higher the level of perceived behavioral control.

2.2 Method

2.2.1 Participants and procedure

The sample for this study is composed of 60 participants (33 males and 27 females) and was collected in the University of the Algarve, Gambelas campus, among students from several study fields. Table 7.1 shows the socio-demographic characteristics of the participants.

Table 7.1

Socio-demographic characteristics of the participants of study 7

Study 5			N= 60
Age		**Occupation**	
M	23.95	Student	46
SD	7.33	Researcher	3
Min-Max	18-56	Management, sales & public service	4
Gender		Education & Health	3
Female	33	Unemployed	2
Male	27	Others	2
Years of School:		**Area of study**	
University degree	56	Science & technology	10
Master	3	Social sciences, culture and humanities	48
PhD	1	Not reported	2

Participants were invited to participate in an experiment about socio-psychological variables mediating the use of new technologies. After being informed about the conditions of participation and confidentiality of the data collected, participants were asked to complete the first questionnaire. This first questionnaire included the PNARS scale. After completing the questionnaire the participants were instructed about the video and the second questionnaire. Participants were randomly assigned to one of two video conditions presenting either a mechanical robot (video of Snackbot) or an android robot (video of Actroid DER) (see figure 7.1). Participants were evenly distributed by the two conditions, 30 watched the mechanic robot, and 30 watched the android robot. Sixteen women watched Actroid DER and 17 watched Snackbot, while 14 men watched Actroid DER and 13 watched Snackbot.

The video is 1 minute and 50 seconds long and was projected on the wall facing the subjects using a ceiling video projector. This allowed for a close to real life size view of the robots (see figure 7.1).

Figure 7.1. Experimental setting. Participant watching the video presenting the android social robot, Actroid DER.

Before viewing the videos, participants received the following instructions: "In the future it will be common to interact with robots. This will happen in public spaces (factories, offices, museums) and in our houses. We are going to show you a video with one of those social robots. Your task is to imagine yourself working with this robot in the near future and forming an opinion about it". During the video a female voice narrated the following: "Hello, my name is Snackbot (or Actroid) and I'm a social robot. A social robot is a robot created to interact with people in a natural fashion. In order to do that, my creators included in my design human characteristics like eyes, mouth, language and the capacity to understand and perform social behaviors. In the future I will be performing such jobs as a hotel receptionists, personal trainer or office clerk. Some even say that in the future I will be responsible for caring for the elders. Goodbye and see you in the future." After watching the video the participants were instructed to complete the second questionnaire. The second questionnaire included the following measures: attitude, subjective norms, perceived behavioral control, desire, intention, warmth/competence, psychological anthropomorphism, animacy and likeability.

At the end of the experiment the participants received more information about the research project and were asked for feedback about the experiment and the theme of social robots. Participants took approximately 45 minutes to complete the experiment.

All participants received a participation certificate and all participants entered a lottery in which a 50€ prize was awarded.

2.2.2 Material

In order to control for order effects, the items were randomly assigned to the questionnaire. Two versions of the questionnaire were used. Table 7.2 shows a summary of the measures used in this study.

Table 7.2

Scales used in study 7

	Measures
PNARS	Negative attitudes towards robots
NARHT	Negative attitudes towards robots with human traits
NATIR	Negative attitudes towards interactions with robots
ATW	Attitude towards working with a social robot
SN	Subjective norms
PBC	Perceived behavioral control
BI	Intention to work with a social robot in the near future
COMP	Competence
WARM	Warmth
ANT	Anthropomorphism
ANI	Animacy
LIKE	Likeability

Measures of Behavioral Intention and its antecedents:

Behavioral Intention (BI). Measures the effort a person is willing to invest in order to work with the social robot presented in the video in the future (e.g. I'm willing to try hard to work with this robot in the future: disagree/agree) and was based on Perugini and Conner (2000). Items are measured on a 7-point Likert type scale (1 = minimum to 7 = maximum). Higher scores indicate a stronger intention to work with the social robot presented in the video.

Attitude towards working with a social robot (ATW). Measures a person's attitude towards working with the social robot presented in the video (e.g. working with this robot will be useless/ useful) and was based on Perugini and Conner (2000). Items are measured on a 7-point Likert type scale (1 = minimum to 7 = maximum). Higher scores indicate a more positive attitude towards working with the social robot presented in the video.

Subjective norms (SN). Measures the person's beliefs about significant others attitude towards him working with the social robot presented in the video in the future (e.g. people close to me, would approve/ disapprove that I work with robots in the future) and was based on Perugini and Conner (2000). Items are measured on a 7-point Likert type scale (1 = minimum to 7 = maximum). Higher scores indicate more favorable subjective norms towards working with the social robot presented in the video.

Perceived behavioral control (PBC). Measures the extent that a person sees himself as capable of operating the social robot presented in the video (e.g. It would be easy to work with this robot: disagree/agree) and was based on Perugini and Conner (2000). Items are measured on a 7-point Likert type scale (1 = minimum to 7 = maximum). Higher scores indicate a higher level of perceived behavioral control in operating the social robot presented in the video.

Socio-cognitive factors:

Negative attitudes towards robots. The Portuguese negative attitudes towards robots scale (PNARS) was measured like in previous studies. (R) indicates that PNARS, NARHT, and NATIR items were reversed so that higher scores indicate a more positive attitude towards robots and lower scores indicate a more negative attitude towards robots.

Warmth and competence (WARM and COM). Fiske, Cuddy, Glick and Xu. (2002) suggest that social perception should be measured through the dimensions of competence and warmth. The dimension of competence was measured by the following items: competent, capable, intelligent, efficient, skillful, and confident). The dimension of warmth was measured by the following items: warm, good natured, sincere, friendly, well-intentioned, and trustworthy. Participants were asked to rate the robot on the video in a Likert type scale from 1 (Not) to 7 (Very). Higher scores indicate attribution of a higher level of competency/ warmth.

Antropormorphism (ANT). Measures the attribution of human psychological states to the social robot presented in the video. The scale comprises six anthropomorphic traits (thoughtful, considerate, sympathetic, creative, devious, and jealous) and was based on Epley, Waytz, Akalis, and Cacioppo (2008). Participants were asked to rate the robot on the video in a Likert type scale from 1(not at all) to 7 (very). Higher scores reflect a higher level of anthropomorphic trait attribution.

Social Robot Appearance:

The manipulation of the level of human-likeness of the robot (mechanical vs. android) was done with the use of two different robots in the video presented to the participants (Snakbot and Actroid DER; see figure 7.2). Snackbot is an assistive social robot developed at Carnegie Mellon University. The wheels set on its base allow the robot to move autonomously. The robot is about 142 cm high, with a round shaped head that served as housing for the visual and verbal hardware. A led display was used to simulate the mouth. The robot is able to produce simple verbal interactions. Although its arms are not fully functional, they carry a tray that allows Snackbot to transport objects from one place to another. A series of sensors allow it to travel without bumping into objects (see Lee et al., 2009 for a detailed discription). Actroid, was already described in study 5.

Figure 7.2. The mechanical social robot, Snackbot (left) and the android social robot, Actroid DER (right)

Control variables:

Two measures of appearance were used, animacy (e.g. inert/ interactive) and likeability (e.g. awful/ nice). All two measures are comprised of 5 items each. These measures are adapted from the godspeed scale, developed by Bartneck, Kulic, Croft and Zoghbi (2009). Animacy (ANI) is defined as the quality of "being alive". Likeability (LIK) is the positive impression about the robot. All the items were measured on a 7-point Likert type scale (1 = minimum to 7 = maximum). Higher scores reflect a higher level of the attribute.

2.3 Results

2.3.1 Preliminary analyses

The data was analyzed for normality, skewness and kurtosis. Although the results of the Kolmogorov-Smirnov test of normality suggests that some of the variables may have a nonnormal distribution, the skewness and kurtosis values are all below the threshold recommended by Schumaker & Lomax (2002), for univariate skewness ($-1 < sk < 1$) and kurtosis ($-1.5 < ks < 1.5$)[35]. All of the variables had less than 2% of missing values. A non-significant Little´s MCAR test indicates that these values are missing at random. Values were replaced using the EM (expectation maximization) method. No extreme outliers were detected.

[35] Curran, West & Finch (1996), propose a less stringent limit of 2 and 7 for univariate skewness and kurtosis, respectively.

2.3.1.1 Manipulation checking

A first analysis of the data was conducted in order to control for the effects of gender. For that purpose a series of multiple analyses of variance (MANOVA) were conducted using the measures of behavioral intention (ATW, SN, PBC and BI), attitudes (NARHT and NATIR) and social perception (COM, WARM and ANT) as outcome variables. No differences were found between genders for the measures of behavioral intention (V = 0.06, F (4, 55) = 0.83, p = .512), for attitudes (V = 0.02, F (2, 57) = 0.68, p = .510), or the measures of social perception (V = 0.07, F (3, 56) = 1.52, p = .220) or

This study assumes that the effects of robot type are due to the external appearance of the social robots presented in the videos, mechanical versus android. The measures of likability (LIK), and animacy (ANI) are used in order to control for other factors. Results of the MANOVA show that both robots were perceived as having a similar degree of animacy and likeability (V = 0.07, F (2, 57) = 2.01, p = .143).

Effects of participant's area of study and professional occupation are beyond the scope of this research.

2.3.2 Descriptive statistics

Table 7.3 shows the descriptive statistics for the scales used in the study. All scales show good reliability results (all $\alpha > .70$).

In order to seize a general impression of participant's characteristics and participant's evaluation of the robots shown in the video, a one sample t-test was conducted, comparing the variables means to the medium point of the scales (i.e., 3.5; see table 7.3 for results of the t-test).

Table 7.3

Psychometric properties of the scales used in study 7

	M	SD	N	Potential Range	Actual Range	Cronbach alpha	Skewness	Kurtosis
PNARS(R)	4.20***	1.08	60	1-7	1-7	.85	-0.11	-0.31
NARHT(R)	3.62	1.14	60	1-7	1-7	.70	0.20	-0.44
NATIR(R)	4.79***	1.28	60	1-7	1-7	.84	-0.35	-0.17
ATW	4.21***	1.28	60	1-7	1-7	.93	-0.06	-0.45
SN	3.98*	1.43	60	1-7	1-7	.86	-0.29	-0.31
PBC	4.22***	1.37	60	1-7	1-7	.87	-0.44	-0.58
BI	2.91**	1.39	60	1-7	1-6	.79	0.46	-0.58
COM	4.23***	1.25	60	1-7	1-7	.85	-0.33	0.28
WARM	4.07**	1.44	60	1-7	1-7	.87	-0.42	-0.65
ANT	4.61***	1.04	60	1-7	3-7	.70	0.22	-0.43
ANI	3.60	1.23	60	1-7	1-6	.79	0.36	-0.27
LIK	4.49***	1.23	60	1-7	2-7	.83	0.19	-0.46

Note. Means differ from the middle point of the scale (*i.e.*, 3.5) at *p < .05, **p < .01, ***p < .001. PNARS= Portuguese negative attitudes towards robots; NARHT= negative attitudes towards robots with human traits; NATIR= negative attitudes towards interactions with robots; (R) indicates that PNARS, NARHT and NATIR were reversed so that higher score indicate more positive attitudes towards robots ATW= attitude towards working with the presented social robot; SN= subjective norm; PBC= perceived behavioral control; BI= behavioral intention; COMP= competence; WARM= warmth; ANT= psychological anthropomorphism; ANI= animacy; LIK= likability.

There is a general good impression (LIK, M= 4.49) of the robots presented in the videos. There is a positive attitude towards working with the social robots presented (ATW, M= 4.21), and they are perceived as warm (WARM, M= 4.07), competent (COM, M= 4.23) and high in human psychological traits (ANT, M= 4.61) leading participants to think it will be easy to work with them (PBC, M= 4.22). The idea of working with robots seems to be socially acceptable (NS, M= 3.98). These results are in line with the general positive attitude towards robots (PNARS, M= 4.20).

In spite of the general good impression and positive attitude toward working with robots, the mean of the intention to work with these social robots (VOL, M= 2.91) is significantly below the medium point of the scale. This suggests that although in general people are favorable to the idea of social robots and working with them, at a personal level they may not be particularly interested in doing so.

The variables NARHT and ANI did not differ significantly from the medium point of the scale.

2.3.3 Understanding the intention to work with a social robot in the near future using the TRA and the TPB

2.3.3.1 Correlations between the components of TRA and TPB

In order to obtain an overview of the strength and direction of the relations between the variables of the TRA and TPB a two-tailed Pearson correlation was conducted (see table 7.4).

Table 7.4

Correlations for the measures of TRA and TPB

	ATW	PBC	SN	BI
ATW	-			
PBC	.76*	-		
SN	.66*	.52*	-	
BI	.69*	.59*	.49*	-

Note. * all correlations are significant at $p < .001$. ATW= attitude towards working with the social robot; PBC = perceived behavioral control; SN = subjective norms; BI= behavioral intention.

All the variables show correlation values close to, or above .50, indicating strong positive and significant correlations. Attitude towards working with a social robot (ATW) is significantly correlated with PBC (r = .76), SN (r = .66) and BI (r = .69), with shared variances[36] ranging from 43% (SN) to 58% (PBC). PBC shares 27% of variance with SN (r = .52) and 35% with BI (r = .59). SN shares 24% of variance with BI (r = .49).

As it would be expected from the theoretical models and previous research, attitude towards working with a social robot, perceived behavior control and subjective norms are strongly correlated with intention to work with a social robot in the future, with all the variables varying in a positive direction. In sum, people with a more positive attitude towards working with a social robot, who see themselves as competent in doing

[36] Pallant (2005) points out that since significance levels of correlations are strongly affected by sample size, the coefficient of determination should also be used.

so, and who think they will have social support for that goal, present a stronger intention to work with a social robot in the future.

2.3.3.2 Testing the TRA and TPB

The theory of reasoned action contends that behavioral intention is the product of attitude and subjective norms (see figure 2.1, theoretical part). The theory of planned behavior contends that behavioral intention is the product of attitude, perceived behavioral control and subjective norms (see figure 2.3, theoretical part).

2.3.3.2.1 Preliminary analyses

Analysis of residuals using Leverage values (all values < 0.2) and Cook's distances (all values < 1) suggest no outliers. The assumptions for normality, linearity, homoscedasticity and independence of residuals are attained. VIF (all values < 5), and tolerance values (all values > .2) suggest no multicollinearity issues (Marôco, 2010a; Field, 2009; Pallant, 2005).

2.3.3.2.2 Regression analyses

In order to compare the two models and understand the role of these variables in determining the intention to work with a social robot in the near future, a hierarchical multiple regression analysis was conducted. Variables entered in the first block were ATW and SN (*i.e.* the determinants of intention according to the TRA). Variables entered in the second block were ATW, SN and PBC (*i.e.* the determinants of intention according to the TPB). Method of entry for variables within each block was forced entry.

Table 7.5

Predicting intention to work with a social robot using the TRA and the TPB

	BI				
	B	SE B	*β*	*t*	Sig.
TRA:					
Constant	-0.30	0.47		-0.63	.528
ATW	0.71	0.14	.66	5.17	.000
SN	0.05	0.12	.05	0.43	.669
TPB:					
Constant	-0.40	0.48		-0.84	.405
ATW	0.60	0.18	.55	3.29	.002
SN	0.05	0.12	.05	0.40	.692
PBC	0.14	0.15	.14	0.94	.351
TRA:	R= .69 R^2 = .48	R^2_{adj} = .46	F (2, 57) = 26.36, p = .000		
TPB:	R= .70 R^2 = .49	R^2_{adj} = .46	F (3, 56) = 17.83, p = .000		
Diference between models: *F*(1, 56) = 0.88, p = .351					

Note. ATW= attitude towards working with the presented social robot; SN = subjective norms; PBC= perceived behavioral control; BI= behavioral intention.

The results of the regression analysis (see table 7.5) indicate that the TRA explains 46% of the variance of intention to work with social robots (R^2_{adj} = .46, *F* (2, 57) = 26.36. p = .000). Analysis of the Beta values indicates that ATW (*β*= .66) is a significant positive predictor of the intention to work with a social robot in the future. That is, the more positive the attitude towards working with a social robot, the stronger the intention to work with a social robot in the future. On the other hand, no statistically significant effects where found for SN. This apparent lack of effect for SN is still in line with the model predictions, since it is contended that the two variables may have different weights, thus contributing differently to behavioral intention.

These results partly confirm hypotheses, 1: Intention to work with a social robot is a function of attitude towards working with a social robot and subjective norms (*i.e.* the theory of reasoned action).

The results of the regression analysis (see table 21) indicate that the theory of planned behavior explains 46% of the variance of intention to work with a social robot (R^2_{adj} = .46, *F* (3, 56) = 17.83. p = .000). Analysis of the Beta values indicates that ATW (*β*= .55) is a significant positive predictor of the intention to work with a social robot in the future. That is, the more positive the attitude towards working with a social robot, the stronger the intention to work with a social robot in the future. No statistically significant effects where found for PBC and SN. These results partly confirm hypotheses 2, that the intention to work with a social robot is a function of attitude, perceived behavioral control and subjective norms (*i.e.* theory of planned behavior).

Both models explain the same amount of variance (46%). This is explained by the fact that only ATW has a significant effect on BI. As discussed in the theoretical part, the weight of the variables in the prediction of intention is not fixed, so it is not totally unexpected a situation where the contribution of SN and PBC is negligible. These aspect nevertheless, underlines the importance of measuring all the variables in the model prior to delineating a strategy to increase (or decrease) the intention to perform a behavior. In this case, an intervention drawn towards the change of normative beliefs or control beliefs may be ineffective in changing intention to work with a social robot.

2.3.3.2.3 Discussion

The TRA accounted for 46% of the variance of BI. Adding PBC, like it is proposed by the TPB did not increase the predictive power of the model. Both models contend that the contribution from each of the determinants of behavioral intention is not fixed, as such is not surprising the finding of no statistically significant effects for SN and PBC. This suggests that in some contexts assessing attitude towards working with a social robot may be enough to predict intention to work with a social robot. The lack of effect for subjective norm may result from the limited presence of social robots. This may limit a person’s understanding of what significant other think about the subject. The lack of effect for PBC may have the same cause. Given the limited chances to interact with a real robot, people may find difficult to evaluate their proficiency at doing so and what factors can constrain an effective interaction.

Since only ATW was found to have significant effects, hypotheses 1 and hypotheses 2 are considered partly confirmed.

2.3.4 Predictors of attitudes towards working with a social robot and perceived behavior control

According to the TRA and TPB, behavioral intention is conceptualized as either the product of attitude towards the behavior and subjective norms (TRA), or the product of attitude towards the behavior, subjective norms and perceived behavioral control (TPB). All the other factors, socio-demographic, personal and contextual, have their effects mediated by these variables. As such, this section will explore the effect of the appearance of the social robot (mechanical vs. android), and socio-cognitive factors external to the model (perceived warmth, perceived competence, anthropomorphism, negative attitudes towards robots with human traits and negative attitudes towards interactions with robots) on ATW and PBC.

2.3.4.1 Effects of social robot appearance on ATW and PBC

As mentioned in the theoretical underpinnings, HRI research has focused its attention on questions such as: should a robot have limbs (Syrdal, Dautenhahn, Woods, Walters & Koay, 2007), what should be the face shape and size (Tamagawa, Watson, Kuo, MacDonald & Broadbent, 2011; DiSalvo, Gemperle, Forlizzi & Kiesler, 2002), that is, what are the effects of robot design in human-robot interaction. In order to assess the effects the social robot appearance (mechanical vs. android) a MANOVA was conducted using ATW and PBC as outcome variables.

Although results of Box's test indicate that the assumption of homogeneity of variance-covariance matrices is met, results of the Levene's test indicate that the assumption of equality of variances is not met for PBC. Analysis of residuals using Leverage values (all values < 0.2) and Cook's distances (all values < 1) suggest no outliers.

Analysis of Pillai's trace indicates no statistically significant effects for type of robot ($V = 0.00$, $F\ (2, 57) = 0.11$, $p = .894$). Analysis of the univariate tests confirmed these results. Since the assumption of equality of variances was not met for PBC, results for this variable were further studied with Welch's test, thus confirming that there are no effects for type of robot (see figure 7.3).

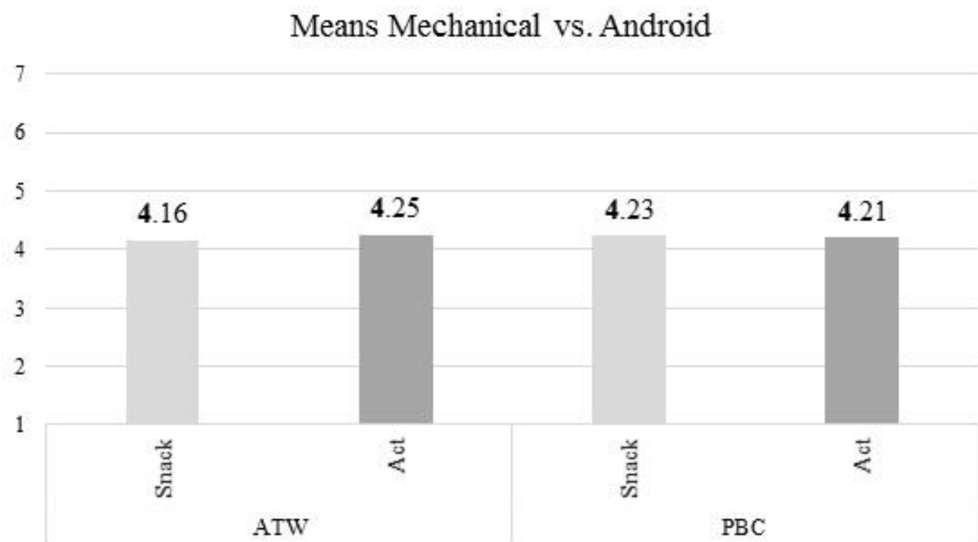

Figure 7.3. Effects of the social robot appearance on ATW and PBC

The results of the MANOVA do not support hypotheses 8: the appearance of the social robot (mechanical vs. android) will affect the attitude towards working with it and the perceived behavioral control. These results suggest that type of robot does not affect ATW or PBC.

2.3.4.2 Effects of socio-cognitive factors on ATW and PBC

Given the current trend towards affording robots with social abilities, it is vital to understand the factors at play when social agents interact. According to the stereotype content model, social perception is based on two fundamental judgments, the evaluation of the dimensions of warmth and competence. That is, how friendly is the other social agent, and how capable is he of performing his intents. The results of this evaluation will determine a set of behavioral and emotional responses towards the other social agent. Anthropomorphism is the attribution of human mental states to non-human animals and inanimate objects. The attribution of mental states (e.g. feelings, goals, desires) to other social agents has been pointed by research, as fundamental to social perception, since it entails not only the base for empathy, but also for moral worth and accountability. An attitude was earlier defined as a positive (or negative) stance towards a social object, which is composed of a set of beliefs about the said object. Thus, the degree of negative attitudes towards robots is expected to create a predisposition towards working and interacting with social robots.

This next section aims to determine the effects of perceived warmth (WARM), perceived competence (COM), anthropomorphism (ANT), negative attitudes towards robots with human traits (NARHT) and negative attitudes towards interactions with robots (NATIR) on the determinants of behavioral intention, namely ATW and PBC.

2.3.4.3 Correlations between the socio-cognitive factors and ATW and PBC

In order to obtain an overview of the strength and direction of the relations between the variables studied in this section a two-tailed Pearson correlation was conducted (see table 7.6).

Table 7.6

Correlations of the socio-cognitive measures and ATW and PBC

	WARM	COM	ANT	NARHT	NATIR	ATW	PBC
WARM	-						
COM	.76***	-					
ANT	.87***	.72***	-				
NARHT (R)	.41**	.37**	.39**	-			
NATIR (R)	.23	.22	.22	.60***	-		
ATW	.64***	.60***	.65***	.60***	.44***	-	
PBC	.51***	.45***	.51***	.71***	.54***	.76***	-

Note. * $p < .05$; ** $p < .01$; *** $p < .001$. WARM = warmth; COM = competence; ANT= psychological anthropomorphism; NARHT= negative attitudes towards robots with human traits; NATIR= negative attitudes towards interactions with robots; (R) indicates that NARHT and NATIR were reversed so that higher score indicate more positive attitudes towards robots; ATW= attitude towards working with the presented social robot; PBC= perceived behavioral control in working with the presented social robot.

The socio-cognitive variables are all significantly correlated with ATW and PBC. WARM is positively correlated with ATW (r = .64) and PBC (r = .51), sharing 41% and 26% variance respectively. COM is positively correlated with ATW (r = .60) and PBC (r = .45), sharing 36% and 20% variance respectively. ANT is positively correlated with ATW (r = .65), and PBC (r = .51), sharing 42% and 26% variance respectively.

Both components of the negative attitudes towards robots scale, are significantly correlated with ATW and PBC. NARHT is positively correlated with ATW (r = .60) and PBC (r = .71), sharing 36% and 50% variance respectively. NATIR is positively correlated with ATW (r = .44) and PBC (r = .54), sharing 19% and 29% variance respectively.

WARM (r = .41), COM (r = .37) and ANT (r = .39) are significantly correlated to NARHT (17%, 14% and 15% shared variance respectively). There is no statistically significant correlation between WARM (r = .23), COM (r = .22) and ANT (r = .22) and NATIR.

In short, there seems to be a medium to strong positive correlation between socio-cognitive factors and ATW and PBC. Those who perceive the social robot as warmer, more competent and endowed with a higher level of human psychological traits have a more positive attitude towards working with a social robot (ATW) and have a stronger sense of control (PBC). Previous attitudes towards robots show similar effects, presenting medium to strong positive correlations with ATW and PBC. Those participants who present a more positive attitude towards robots with human traits (NARHT) and interactions with robots (NATIR), have a more positive attitude towards working with a social robot (ATW) and have a stronger sense of control (PBC).

2.3.4.4 Regression analysis for the effects of the socio-cognitive variables ATW and PBC

In order to study the contribution of the socio-cognitive factors to ATW and PBC, a multiple regression analysis was conducted. Variables where entered following a hierarchical method. Variables in the first block were WARM and COM. Variables in the second block were NARHT and NATIR. Method of entry for variables within each block was forced entry. Analysis of residuals using Leverage values (all values < 0.2) and Cook's distances (all values < 1) suggest no outliers. The assumptions for normality, linearity, homoscedasticity and independence of residuals are attained. VIF (all values < 5), and tolerance values (all values > .2) suggest no multicollinearity issues (Marôco, 2010a; Field, 2009; Pallant, 2005).

The high correlation between WARM and ANT warrant some caution, as it may produce collinearity effects. A closer analysis of the scales showed that both the items for both warmth and for psychological anthropomorphism refer to social support and connection, showing considerable overlap. Given this, these two measures will be treated as equivalent. That is, higher levels of warmth can be considered to also mean the attribution of social support anthropomorphic traits to the robots presented in the video (*i.e.* anthropomorphisation). As such, only the measure of warmth will be used for the remaining research.

The results of the regression analysis for attitude towards working with a social robot (see table 7.7) indicates that warmth and competence (Model 1) explains 42% of the variance (R^2_{adj} = .42, *F* (2, 57) = 22.04. *p* = .000).

Table 7.7

Predictors of attitude towards working with a social robot

	B	SE B	β	*t*	Sig.
Model 1:					
Constant	1.48	0.45		3.29	.002
WARM	0.38	0.14	.43	2.81	.007
COM	0.27	0.16	.27	1.75	.085
Model 2:					
Constant	0.25	0.53		0.48	.635
WARM	0.28	0.12	.32	2.28	.026
COM	0.21	0.14	.21	1.53	.133
NARHT (R)	0.36	0.13	.32	2.72	.009
NATIR (R)	0.12	0.11	.12	1.12	.269
Model 1:	R= .66 R^2 = .44	R^2_{adj} = .42	*F* (2, 57) = 22.04, *p* = .000		
Model 2:	R= .76 R^2 = .57	R^2_{adj} = .54	*F* (4, 55) = 18.60, *p* = .000		
Diference between models: *F* (2, 55) = 8.99, *p* = .000					

Note. ATW= attitude towards working with the presented social robot; WARM = warmth; COM = competence; NARHT = negative attitudes towards robots with human traits; NATIR= negative attitudes towards interactions with robots. (R) indicates that NARHT and NATIR were reversed so that higher score indicate more positive attitudes towards robots

Analysis of the Beta values indicates that WARM (β= .43) is a significant positive predictor of the attitude towards working with a social robot (ATW). That is, the more a person judges a social robot as warm (good natured, sincere, friendly, well-intentioned), the more positive the attitude towards working with it in the future. This result is also indicative that the more people attribute anthropomorphic psychological traits to the robot the more positive the attitude towards working with it. These results partially confirm hypotheses 6 and confirm hypotheses 7 for ATW. Higher levels of warmth lead to an increase on the level of intention to work with a social robot. Unlike it was hypothesized, the level of competence attributed to the social robot does not affect the attitude towards working with it.

Analysis of Model 2 results show that the introduction of NARHT and NATIR increases the percentage of explained variance to 54%, which is a significant increase relatively to Model 1 (F (2, 55) = 8.99, p = .000). Analysis of the Beta values indicates that NARHT and WARM have a statistically significant effect (β= .32 for both variables). Unlike it was hypothesized, NATIR does not affect the attitude towards working with a social robot. These results partially confirm hypotheses 5 for ATW.

The results of the regression analysis for perceived behavioral control (see table 7.8) indicates that warmth and competence (Model 1) explains 25% of the variance (R^2_{adj} = .25, F (2, 57) = 10.63. p = .000).

Table 7.8

Predictors of perceived behavioral control

	B	SE B	β	t	Sig.
Model 1:					
Constant	1.99	0.55		3.63	.001
WARM	0.38	0.17	.40	2.27	.027
COM	0.16	0.19	.15	0.86	.392
Model 2:					
Constant	0.01	0.55		0.02	.981
WARM	0.21	0.13	.22	1.64	.107
COM	0.06	0.15	.06	0.44	.662
NARHT	0.60	0.14	.49	4.24	.000
NATIR	0.19	0.12	.18	1.64	.106
Model 1:	R= .52	R^2 = .27	R^2_{adj} = .25	F (2, 57) = 10.63, p = .000	
Model 2:	R= .77	R^2 = .59	R^2_{adj} = .56	F (4, 55) = 19.75, p = .000	
Diference between models: F (2, 55) = 21.30, p = .000					

Notes: ATW= attitude towards working with the presented social robot; WARM = warmth; COM = competence; NARHT= negative attitudes towards robots with human traits; NATIR= negative attitudes towards interactions with robots.

Analysis of the Beta values indicates that WARM (β= .40) is a significant positive predictor of perceived behavioral control (PBC). That is, the more a person judges a social robot as warm (good natured, sincere, friendly, well-intentioned), the higher the perceived behavioral control. This result is also indicative that the more people attribute anthropomorphic psychological traits to the robot the higher the perceived behavioral control. These results partially confirm hypotheses 6 and confirm hypotheses 7 for PBC. Higher levels of warmth lead to an increase on perceived behavioral control. Unlike it was hypothesized, the level of competence attributed to the social robot does not affect the attitude towards working with it.

Analysis of Model 2 results show that the introduction of NARHT and NATIR increases the percentage of explained variance to 56%, which is a significant increase relatively to Model 1 (F (2, 55) = 21.30, p = .000). Analysis of the Beta values indicates that NARHT is the only variable with a statistically significant effect (β= .49). These results partially confirm hypotheses 5 for PBC.

2.4 General discussion

Both the TRA and the TPB explain the same percentage of the observed variation of the intention to work with a social robot, 46%. Nevertheless the TRA does so with fewer variables. In both cases the statistically significant contributor to the model is ATW. Neither SN, nor PBC showed statistically significant effects on intention to work with a social robot in the near future. It should be noted that both models start by arguing that, although behavioral intention is the product of attitudes towards the object and subjective norms (attitudes towards the object perceived behavioral control and subjective norms in the case of TPB), these variables may contribute with different weights, given different contexts. Thus, the fact that no statistically significant effects were identified for SN and PBC, does not mean that this variables are not relevant for the study of intention to work with a social robot in the near future, or that these variables will not prove to be the main predictors of intention in a different context.

According to the TRA and TPB, the effects of personal, social and contextual factors will always be mediated by ATW, PBC and SN. Results of the multiple regression analyses showed that NARHT and WARM are significant predictors of ATW (β= .32 for both variables), while NARHT is a significant predictor of PBC (β= .49). In short, social perception and attitudes towards robots with human traits seem to play a significant role as predictor of ATW, while attitudes towards robots with human traits seems to play significant role as predictor of PBC.

The MANOVA used to study the effects of the appearance of the social robot on ATW and PBC did not identify any significant effects.

In brief, it can be said that both TAR and TPB are useful models to understand intention to work with social robots in the future, as both models account not only for personal tendencies, but also for the social impact that social robots will have in the person's social web. The fact that SN and PBC do not present statistically significant effects in the particular context of this study should not be interpreted has a limitation of the models but as an appeal for further research.

Both the TRA and TPB argue that all the other variables always have their effects mediated by the variables of the model. This contention was tested in the second part of the study. NARHT and WARM showed significant effects on ATW, while NARHT showed significant effects on PBC. Study 5 had already identified effects for NARHT, on ATW and PBC. This results underline the importance of studying the effects of socio-cognitive factors on the determinants of intention.

3 Study 8: Exploring the MGB in the prediction of the intention to work with a social robot and its determinants and the influence of some external factors

3.1 Objectives

This study further explores the factors underlying behavioral intention by looking at the model of goal directed behavior (MGB). According to some authors (e.g. Leone et al., 1999), factors like attitude although incorporating a tendency to act, do not provide a motivation to do so. In order to provide this motivational element Perugini and Conners (2000) propose the concept of desire. "Desires represent the motivational state of mind wherein appraisals and reasons to act are transformed into a motivation to do so" (Perugini & Conner, 2000, p. 706). Given this, attitude towards the object, subjective norms and perceived behavioral control will have their effects on behavioral intention mediated by desire. Besides desire, the MGB also introduces an affective component, anticipated emotions. Like the other variables, anticipated emotions will also have their effect on behavioral intention mediated by desire.

Like in study 7, the appearance of the social robot and socio-cognitive factors are studied as predictors of the determinants of intention. For this study social robot appearance comprises three kinds of robots: mechanical (Snackboot), humanoid (Asimo) and android (Actroid DER). The socio-cognitive factors studied are belief in human nature uniqueness, perceived warmth, perceived competence, negative attitudes towards robots with human traits and negative attitudes towards interaction with robots. This variables will be used as predictors of attitude towards working with a social robot, perceived behavioral control, positive anticipated emotions and negative anticipated emotions.

Study 8 will explore the following hypotheses:

H3: Intention to work with a social robot in the near future is a function of desire. Desire is determined by attitude towards working a social robot, anticipated emotions, perceived behavioral control and subjective norms. The effect of these variables on intention is mediated by desire (i.e. the model of goal directed behavior). An increase in desire will lead to a stronger intention to work with social robots. An increase in attitude towards working with a social robot, positive anticipated emotions, subjective norm and perceived behavioral control will lead to a stronger desire to work with social robots. An increase in negative anticipated emotions will lead to a decrease in desire

H4. The level of belief in human nature uniqueness will affect the attitude towards working with a social robot, perceived behavioral control and anticipated emotions. The stronger the belief in human nature uniqueness, the less favorable the attitude towards working with a social robot, the lower the level of positive anticipated emotions, the higher the level of negative anticipated emotions and the weaker the perceived behavioral control.

H5. The general attitude towards social robots will affect the attitude towards working with a social robot, perceived behavioral control and anticipated emotions. The more favorable the general attitude towards social robots, the more favorable the attitude towards working with a social robot, the stronger the perceived behavioral control, the higher the level of positive anticipated emotions, and the lower the level of negative anticipated emotions.

H6. The level of warmth and competence attributed to the social robot will affect the attitude towards working with a social robot, perceived behavioral control and anticipated emotions. The higher the level of warmth and competence attributed to the social robot, the more favorable the attitude towards working with a social robot, the stronger the perceived behavioral control, the higher the level of positive anticipated emotions and the lower the level of negative anticipated emotions.

H8. The appearance of the social robot will affect the attitude towards working with a social robot, perceived behavioral control and anticipated emotions. The more humanlike the social robot, the more positive the attitude towards working with a social robot, the higher the level of perceived behavioral control, the higher the level of positive the anticipated emotions, and the lower the level of negative anticipated emotions

3.2 Method

3.2.1 Participants and procedure

Data for this study was drawn from two sources, a laboratory experiment conducted at the University of the Algarve, Gambelas campus, and an online experiment hosted on a web site created for the research (www.automatosocial.pt)[37]. Table 8.9 shows the socio-demographic characteristics of the participants.

[37] This web site is no longer online.

Table 7.9
Socio-demographic characteristics of the participants in study 8

	Lab sample	N= 92	Online sample	N= 65	Total	N=157
Age						
M		21.86		30.91		25.61
SD		4.80		10.40		8.82
Min-Max		18-45		18-66		18-66
Gender						
Female		53		44		97
Male		39		21		60
Years of School						
Up to 12 years		3		10		13
University degree		80		35		115
Master and PhD		9		20		29
Area of study						
Science & technology		25		24		49
Social sciences, Culture and humanities		67		43		108
Occupation						
Student		83		22		105
Management, sales & public service		1		13		14
Education & Health		1		11		12
Engineering		-		4		4
Tourism		-		2		2
Unemployed		2		4		6
Other		3		5		8
Not reported		2		4		6

3.2.2 Procedure for the laboratory experiment

Participants were approached at the university and invited to participate in an experiment about socio-psychological variables mediating the use of new technologies. After being informed about the conditions of participation and confidentiality of the data collected, participants were invited to complete the first questionnaire. This first questionnaire includes the P-NARS and the belief in human nature uniqueness scale (BHNU).

Figure 7.4. Experimental setting. Participant watching the video presenting the humanoid social robot, Asimo

After completing the questionnaire the participants were instructed about the video and the second questionnaire. Participants were randomly assigned to one of three conditions, mechanic robot (video of Snackbot), humanoid robot (video of Asimo) or android robot (video of Actroid DER). Participants were evenly distributed by the three conditions, 30 watched the mechanic robot, 31 watched the humanoid robot, and 31 watched the android robot. Seventeen women watched Snackbot, 17 watched Asimo and 19 watched Actroid, while 13 men watched Snackbot, 14 watched Asimo and 12 watched Actroid.

The video is 1 minute and 50 seconds long and was projected on the wall facing the subjects using a ceiling projector, allowing a close to real life size view of the robots. Before viewing the videos, participants received the following instructions: “In the future it will be common to interact with robots. This will happen in public spaces (factories, offices, museums) and in our houses. We are going to show you a video with one of those social robots. Your task is to imagine yourself working with this robot in the future and forming an opinion about it”. During the video a female voice narrated the following: “Hello, my name is Snackbot (or Actroid, or Asimo) and I’m a social robot. A social robot is a robot created to interact with people in a natural fashion. In order to do that, my creators included in my design human characteristics like eyes, mouth, language and the capacity to understand and perform social behaviors. In the future I will be performing such jobs as a hotel receptionists, personal trainer or office clerk. Some even say that in the future I will be responsible for caring for the elders. Goodbye and see you in the future.” After watching the video the participants were instructed to complete the second questionnaire. The second questionnaire includes the following measures: attitude, subjective norms, perceived behavioral control, positive anticipated emotions, negative anticipated emotions, desire, intention, warmth/competence, anthropomorphic form, animacy and likeability.

At the end of the experiment the participants received more information about the research project and were asked for feedback about the experiment and the theme of social robots. Each individual experiment took around 60 minutes. Of the total participants, 44 reported having already seen this robot or a similar one. All participants received a participation certificate and all participants entered a lottery in which a 50€ prize was awarded. Some participants also participated in exchange of course credits.

3.2.3 Procedure for the online experiment

Participants were invited by e-mail and via social networks to participate in an experiment about socio-psychological variables mediating the use of new technologies. The experiment followed the same steps as the laboratory experiment and used the same videos. Participants were informed about the conditions of participation and confidentiality of the data, complete the first questionnaire, received instructions about the second task, watched the video with the social robot and completed the second questionnaire. At the end of the experiment an e-mail address was available for those interested in knowing more details about the research. Participants were evenly distributed by the three conditions, 22 watched the mechanic robot, 22 watched the humanoid robot, and 21 watched the android robot. Thirteen women watched Snackbot, 12 watched Asimo and 19 watched Actroid, while 9 men watched Snackbot, 10 watched Asimo and 2 watched Actroid.

3.3 Material

In order to control for order effects, the items were randomly assigned to the questionnaire. Two versions of the questionnaire were used. Table 8.10 shows a summary of the measures used in this study.

Table 7.10

Scales used in study 8

	Measures
BHNU	Belief in human nature uniqueness
PNARS	Negative attitudes towards robots
NARHT	Negative attitudes towards robots with human traits
NATIR	Negative attitudes towards interactions with robots
ATW	Attitude towards working with social robots
PAE	Positive anticipated emotions
NAE	Negative anticipated emotions
SN	Subjective norm
PBC	Perceived behavioral control
DES	Desire to work with social robots
BI	Behavioral intention
COMP	Competence
WARM	Warmth[38]
ANI	Animacy
LIKE	Likeability

Measures of Behavioral Intention and its antecedents:

Behavioral Intention (BI). Behavioral intention was measured like in previous studies. Higher scores indicate a stronger intention to work with the social robot presented in the video.

Desire (DES). Measures the extent that a person desires to work with a social robot in the future (e.g. My desire to work with this robot in the future can be describe as:

[38] In study 7 was noted a high correlation between the measures of warmth and psychological anthropomorphism (*r* = .87) which could lead to collinearity problems. It was also noted a considerable overlap of the items of these two measures. Given this, it was decided that WARM would be used as a measure of both concepts.

no desire/ very strong desire) and was based on Perugini and Conner (2000). Items are measured on a 7-point Likert type scale (1 = minimum to 7 = maximum). Higher scores indicate more desire to work with a social robot.

Attitude towards working with a social robot (ATW). Attitude towards working with a social robot was measured like in previous studies. Higher scores indicate a more positive attitude towards working with the social robot presented in the video.

Subjective norms (SN). Subjective norms was measured like in previous studies. Higher scores indicate more favorable subjective norms towards working with the social robot presented in the video.

Perceived behavioral control (PBC). Perceived behavioral control was measured like in previous studies. Higher scores indicate more favorable subjective norms towards working with the social robot presented in the video.

Positive and negative anticipated emotions (PAE; NAE). Measures to what extent a person anticipates that working with a social robot will elicit positive or negative emotions, and was based on Perugini and Conner (2000). It is composed of two sets of items. One set, comprising 7 items, with statements related to positive anticipated emotions (e.g. “If I work with this robot I will feel … proud”). Another set, comprising 10 items, with statements related to negative anticipated emotions (e.g. “If I work with this robot I will feel … sad”). Items are measured on a 7-point Likert type scale (1 = not at all to 7 = very much). Higher scores indicate more positive anticipated emotions and more negative anticipated emotions respectively.

Socio-cognitive factors:

Belief in human nature uniqueness (BHNU). Belief in human nature uniqueness (BHNU) was measured like in previous studies. Higher scores indicate a stronger belief in a unique human nature that sets it apart from robots.

Negative attitudes towards robots. The Portuguese negative attitudes towards robots scale (PNARS) was measured like in previous studies. (R) indicates that PNARS, NARHT, and NATIR items were reversed so that higher scores indicate a more positive attitude towards robots and lower scores indicate a more negative attitude towards robots.

Warmth and competence (WARM and COM). Warmth and competence were measured like in previous studies. Higher scores indicate attribution of a higher level of competency/ warmth.

Type of robot (Appearance of the robot):

The manipulation of the level of human-likeness of the robot (mechanical vs. humanoid vs. android) was done with the use of three different robots in the video presented to the participants, Snakbot, Asimo and Actroid DER (see figure 8.5). Asimo is a humanoid bipedal social robot developed by Honda Corporation (http://asimo.honda.com/).With a height of 130 cm, Asimo can move autonomously and use its hands to pick up and use objects. Snackbot, was described in study 7. Actroid, was described in study 5.

Figure 7.5. The mechanical social robot, Snackbot (left), the humanoid social robot, Asimo (center), and the android social robot, Actroid DER (right)

Control variable:

Animacy (ANI) and likeability (LIK) were measured like in previous studies. All the items were measured on a 7-point Likert type scale (1 = minimum to 7 = maximum), with higher scores reflecting a higher level of perceived animacy and a higher level of likability.

3.4 Results

3.4.1 Preliminary analyses

Both the lab and the online samples were analyzed for normality, skewness, and kurtosys. Results of the Kolmogorov-Smirnov index for the laboratory sample (N= 92) suggest that some of the variables may have a nonnormal distribution, however the skewness and kurtosis values are all below the threshold recommended by Schumaker & Lomax (2002), for univariate skewness ($-1 < sk < 1$) and kurtosis ($-1.5 < ks < 1.5$)[39]. All of the variables had less than 5% missing values, which is at the threshold suggested by Kline (2011). A non-significant Little´s MCAR test indicates that these values are missing at random. Values were replaced using the EM (expectation maximization) method.

Although the results of the Kolmogorov-Smirnov index for the online sample (N= 65) suggest that some of the variables may have a nonnormal distribution, skewness and kurtosis values are all below the threshold recommended by Schumaker & Lomax (2002). The sample had no missing values.

Preliminary analysis of the data showed no statistically significant differences between the means of the variables used in the laboratory experiment and the means of the variables used in the online experiment. Given this, the data of the two experiments was merged into a new sample with 157 participants. The new sample was analyzed for normality, skewness, and kurtosys confirming that the values for univariate skewness and kurtosis are within the values recommended (Schumaker & Lomax, 2002).

3.4.2 Manipulation checking

A first analysis of the data was conducted in order to control for the effects of gender. For that purpose a MANOVA was conducted. Outcome variables were grouped in the following way: measures of the model of goal directed behavior, measures of attitude towards robots and measures of social perception.

No gender effects were found for the measures of the model of goal directed behavior (ATW, PAE, NAE, PBC, SN, DES and BI). Pillai’s trace indicates no statistically significant effects ($V = 0.35$, $F(7, 147) = 0.77$, $p = .614$). This result was confirmed by the univariate tests.

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[39] Curran, West & Finch (1996), propose a less stringent limit of 2 and 7 for univariate skewness and kurtosis, respectively.

Analysis of the multivariate tests for attitude towards robots (NARHT and NATIR) using Pillai's trace indicates a statistically significant effects for gender (V = 0.55, F (2, 154) = 444, p = .013, partial η2= .05). Analysis of the univariate tests show differences for both NARHT (F (1, 155) = 5.07, p = .026, partial η2 = .03), and NATIR (F(1, 155) = 8.71 p = .004 partial η2 = .05), with males showing a significantly higher mean for NARHT and NATIR. Analysis of the partial eta squared values indicates that these are small effects (partial η2 ≤ 0.05; Marôco, 2010a).

Analysis of the multivariate tests for social perception (WARM, COM and BHNU) using Pillai's trace indicates a statistically significant effect for gender (V = 0.09, F (3, 153) = 4.95, p = .003, partial η2= .09). Analysis of the univariate tests show differences for BHNU (F (1, 155) = 14.58, p = .000, partial η2 = .09), with females showing a significantly higher mean for BHNU. Analysis of the partial eta squared values indicates that these is a medium effect (0.05 ≤ partial η2 ≤ 0.25; Marôco, 2010a).

In short, male participants have a more positive attitude towards robots, while females have a stronger belief in human nature uniqueness.

Study 8 uses three different robots on the assumption that they are representative of a continuum, from mechanical to humanoid to android. In order to control for other effects than robot appearance, the following measures are used: likability (LIK) and animacy (ANI). Analysis of the multivariate test indicate no significant effects (V = 0.05, F (4, 308 = 2.13, p = .077). In short, the robots presented in the videos are perceived as equally lively and likable.

Effects of participant's area of study and professional occupation are beyond the scope of this research.

3.5 Descriptive statistics

Table 8.11 shows the descriptive statistics for the scales used in this study. All scales show good reliability results (α > .70).

Table 7.11

Psychometric properties of the scales used in study 8

	M	SD	N	Range	Actual Range	Cronbach alpha	Skewness	Kurtosis
PNARS	4.21***	1.04	157	1-7	1-7	.85	-.22	-.27
NARHT	3.68	1.17	157	1-7	1-7	.76	-.01	-.21
NATIR	4.75***	1.13	157	1-7	2-7	.76	-.38	.04
BHNU	5.45***	1.31	157	1-7	1-7	.85	-.88	.47
ATW	4.20***	1.46	157	1-7	1-7	.96	-.36	-.28
PAE	3.49	1.40	157	1-7	1-7	.93	-.08	-.53
NAE	2.62***	1.36	157	1-7	1-6	.93	.69	-.35
SN	3.70	1.37	157	1-7	1-7	.82	-.10	-.16
PBC	4.41***	1.39	157	1-7	1-7	.90	-.65	-.22
DES	3.16**	1.57	157	1-7	1-7	.94	.15	-.93
BI	3.27	1.50	157	1-7	1-7	.83	.20	-.55
COM	4.25***	1.13	157	1-7	1-7	.82	-.50	.46
WARM	3.74*	1.27	157	1-7	1-6	.88	-.33	-.49
LIK	4.24***	1.33	157	1-7	1-7	.86	-.33	-.26
ANI	3.69*	1.12	157	1-7	1-7	.77	-.05	-.21

Note. Means differ from the middle point of the scale (i.e., 3.5) at *p < .05, **p < .01, ***p < .001. PNARS= Portuguese negative attitudes towards robots scale; NARHT= negative attitudes towards robots with human traits; NATIR= negative attitudes towards interactions with robots; (R) indicates that PNARS, NARHT and NATIR were reversed so that higher score indicate more positive attitudes towards robots; BHNU= belief in human nature uniqueness; ATW= attitude towards working with robots; PAE= positive anticipated emotions; NAE= negative anticipated emotions; SN= subjective norm; PBC= behavioral perceived control; DES= desire; BI= intention; COM= competence; WARM= warmth; ANI= animacy; LIK= likability.

In order to obtain an overview of the results, a one sample *t*-test was conducted, comparing the variables means to the medium point of the scales (3.5). Table 28 shows the results of the *t*-test.

There is a general good impression (LIK, M= 4.24) and positive attitude towards the social robots presented in the videos (PNARS, M= 4.21). Participants have a positive attitude towards interacting (NATIR, M= 4.75) and working (ATW, M= 4.20) with social robots, anticipating a low level of negative emotions (NAE, M= 2.62). The robots are characterized as competent (COM, M= 4.25), warm (WARM, M= 3.74) and lively (ANI, M= 3.69). Participants see themselves as capable of working with the presented social robots (PBC, M= 4.41). In spite of this general positive attitude and the attribution of warmth, there is a strong belief that robots will never acquire traits that are uniquely human, like consciousness or moral (BHNU, M= 5.45).

Albeit this general favorable attitude towards working with robots, participant's desire to do so is below the medium point of the scale (DES, M=3.16). That is, participants don't seem very eager themselves to work with this kind of technology.

The variables NARHT (M= 3.68), PAE (M= 3.49), SN (M= 3.70) and BI (M= 3.27), do not differ significantly from the medium point of the scale.

3.6 Understanding the intention to work with a social robot in the near future using the model of goal directed behavior

The model of goal directed behavior (MGB) contends that the classical socio-cognitive models, like the TPB, although accounting for people's evaluations of a behavior (positive, negative or undecided), fall short in providing a mechanism that transforms that evaluation into action. In order to overcome that limitation the MGB integrates two new sets of variables: desire and anticipated emotions. Desire represents a person's intent to perform a given behavior, which is perceived as instrumental to achieve a valued goal (e.g. "I value exercising because it will allow me to lose weight and look more attractive"). That is, desire is proposed as the "mechanism" that transforms attitudes, social norms and self-efficacy into an intention to act. Anticipated emotions are the emotions that a person expects to feel when their goal is achieved[40]. According to Bagozzi et al., (1998) the process of goal setting would entail a set of anticipatory emotions that would have a motivational potential in goal striving.

This section starts with the study of behavioral intention as it is conceptualized by the model of goal directed behavior. A second analysis aims to study the effects of robot appearance (mechanical, humanoid and android), belief in human nature uniqueness,

[40] Baumgartner et al., (2008) distinguish anticipatory and anticipated emotions. The first kind refers to emotions felt in the present when thinking about a behavior (e.g. I feel anxious about going to the gym).The second kind refers to what a person expects to feel as the result of performing a behavior (e.g. Losing weight will make me feel proud of myself). The authors argue that both anticipatory and anticipated emotions elicit behavior, although research results suggest that anticipated emotions may have a stronger motivational effect.

perceived warmth, perceived competence, and attitudes towards robots on the components of the MGB, namely ATW, PBC, PAE and NAE.

3.6.1 Correlations for the measures of the MGB

In order to obtain an overview of the strength and direction of the relations between the variables studied in this section a two-tailed Pearson correlation was conducted (see table 8.12).

Table 7.12

Correlations for the measures of the model of goal directed behavior

	ATW	PAE	NAE	PBC	SN	DES	VOL
ATW	-						
PAE	.73	-					
NAE	-.45	-.36	-				
PBC	.63	.64	-.65	-			
SN	.40	.50	-.32	.48	-		
DES	.67	.77	-.51	.71	.57	-	
VOL	.55	.70	-.34	.60	.45	.77	-

Note. N= 155. All correlations significant at $p < .001$. ATW= attitude towards working with a social robot; PAE= positive anticipated emotions; NAE= negative anticipated emotions; SN= subjective norm; PBC= behavioral perceived control; DES= desire; BI= intention.

Pattern of correlations support the theoretical relationships between the variables as assumed by the MGB. DES (r = .77) is positively correlated with VOL (sharing 59% of variance). ATW (r = .67, PAE (r = .77), PBC (r = .71), and SN (r = .57) are positively correlated with DES (sharing from 32% to 59% of variance), while NAE (r = -.51) is negatively correlated with DES (26% shared variance).

ATW is positively correlated with PAE (r = .73; 53% shared variance), PBC (r = .63; 40% shared variance) and SN (r = .40; 16% shared variance). NAE is negatively correlated with ATW (r = -.45; 20% shared variance), PAE (r = -.36; 13% shared variance), PBC (r = -.65; 42% shared variance) and SN (r = -.32; 10% shared variance). PBC (r = .48) is positively correlated with SN, sharing 23% variance.

In short, people who anticipate more positive emotions (and less negative emotions), see themselves as more competent to work with a social robot and think that working with it is socially acceptable will have a stronger desire and intention to work with social robots in the future.

3.6.2 Predicting the intention to work with a social robot with the MGB: a path analysis

Expanding on the TPB and TSR, Perugini & Bagozzi (2001) defended that desire mediates[41] the effects of attitude, perceived behavioral control and subjective norms, on intention. The authors introduced also another set of motivational variables, anticipated emotions (see Bagozzi et al., 1998 for the role of emotions on goal directed behavior).

In order to test the assumptions of the MGB a path analysis was conducted, since this statistical technique allows the study of mediation, accounting for both direct and indirect effects (see figure 8.6 for model).

3.6.2.1 Preliminary analyses

The assumption of multivariate normality and the existence of multivariate outliers were assessed through Mardia’s normalized estimate of multivariate kurtosis and the Mahalanobis distances, respectively. Analysis of the variables for the Model of Goal Directed Behavior identified a Mardia´s estimate value of 6.41, which is suggestive of non-normality. Further analysis identified two multivariate outliers that were extracted from the sample. Reanalysis of the variables indicate that the assumption of multivariate normality is attained (Mardia’s normalized estimate of multivariate kurtosis = 3.13). The following path analysis using the MGB variables is computed with a 155 participant sample.

3.6.2.2 The path analysis

The results of the path analysis indicate that the model explains 60% of the variance (see figure 7.6). All paths are statistically significant except for the direct effects of ATW on DES (β= .08, p = .228) and BPC on VOL (β= .12, p = .112). PAE (β= .45, p < .001), NAE (β= -.12, p < .043), SN (β= .17, p < .001) and PBC (β= .22, p = .002) have

[41] See Baron & Kenny (1986), for a full explanation of mediation effects.

statistically significant direct effects on DES and statistically significant indirect effects[42] on VOL (PAE: β= .31, p < .001; NAE: β= -.08, p = .030; SN: β= .11, p < .001; PBC: β= .15, p = .006), thus confirming the mediating role of DES. DES has a statistically significant direct effect on VOL (β= .69, p < .001). Results from the path analysis partly confirm hypotheses 3 (the MGB predicts intention to work with a social robot in the near future), since not all the variables showed statistically significant effects.

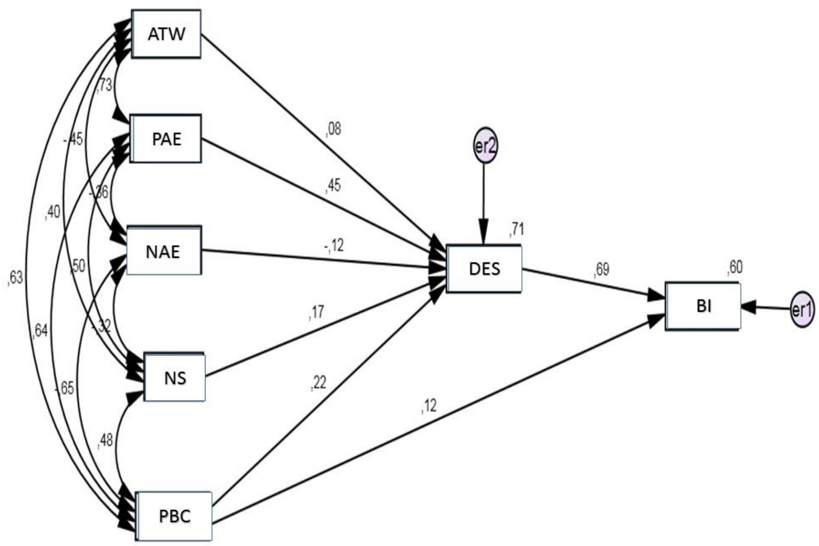

Figure 7.6. Path analysis for MGB

Note. Chi-square = 13.54; Degrees of freedom = 4; Probability level = .009
CMIN/DF = 3.38; GFI= .98; AGFI= .84; NFI= .98; CFI= .99
RMSEA= .12; LO 90= .06; HI 90= .20; PCLOSE= .039; CAIC= 158.58

Contrary to the model's prediction, no statistically significant effects were found for ATW. Likewise no direct effect was found for PBC. Once again it should be noted that in different contexts and with different behaviors the weight of the contribution of each variable is expected to vary. As such the lack of statistically significant effects for a variable of the model, does not invalidate the model per se, but may indicate the specificity of the behavior studied.

[42] Statistical significance of indirect effects was assessed using bootstrap resampling as suggested by Marôco (2010b) using Monte Carlo parametric bootstrap, 2000 samples, percentile confidence intervals at 90%, bias-corrected confidence intervals at 90%).

Analysis of the modification indices suggest that the model can be improved with the addition of a direct path from PAE to BI (see figure 7.7 for model). In order to test the respecified model another path analysis was conducted.

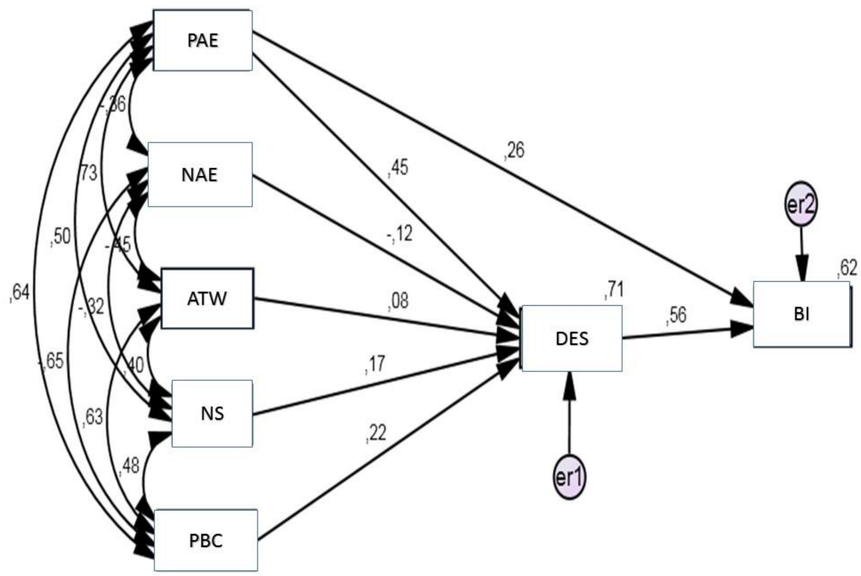

Figure 7.7. Path analysis for the MGB with direct path for PAE

Notes: Chi-square = 5.26; Degrees of freedom = 4; Probability level = .262
CMIN/DF = 1.31; GFI= .99; AGFI= .93; NFI= .99; CFI= 1.00
RMSEA= .04; LO 90= .00; HI 90= .14; PCLOSE= .44; CAIC= 150.30

The results of the path analysis indicate that the model explains 62% of the variance (see figure 7.7). All paths are statistically significant except for the direct effects of ATW on DES (β= .08, p = .228). PAE (β= .45, p < .001), NAE (β= -.12, p = .043), SN (β= .17, p = .001) and BPC (β= .22, p = .002) have statistically significant direct effects on DES and statistically significant indirect effects[43] on BI (PAE: β= .25, p = .001; NAE: β= -.07, p = .032; SN: β= .09, p = .001; PBC: β= .12, p = .003), thus confirming the mediating role of DES. DES (β= .56, p < .001) and PAE (β= .26, p < .001) have a statistically significant direct effect on BI.

In short, desire mediates the effects of positive and negative anticipated emotions, subjective norms and perceived behavioral control, has predicted by the model. That is,

[43] Statistical significance of indirect effects was assessed using bootstrap resampling as suggested by Marôco (2010b) using Monte Carlo parametric bootstrap, 2000 samples, percentile confidence intervals at 90%, bias-corrected confidence intervals at 90%).

those who anticipate more positive emotions (and less negative emotions), expect more social support and perceive themselves as more capable of working with social robots will have a stronger desire and hence, a stronger intention to work with a social robot in the near future. Contrary to the model's prediction, no statistically significant effects were found for ATW. On the other hand, analysis of the modification indices suggested respecification of the model with a direct from PAE to BI. The respecified model showed better fit indexes, identifying direct and indirect effects of PAE in BI.

3.7 Predictors of attitudes towards working with a social robot, perceived behavior control and anticipated emotions

Like the TRA and TPB, the MGB also contends that all the variables external to the model, will have their effects mediated by the variables of the model. In line with this, the next section will study the effects of social robot appearance, beliefs in human nature uniqueness, perceived warmth, perceived competence, negative attitudes towards robots with human traits and negative attitudes towards interactions with robots as precursors of ATW, PBC, PAE and NAE.

3.7.1 Effects of social robot appearance on ATW, PBC, PAE and NAE

This section studies the effects of social robot appearance (mechanical, humanoid and android). For that purpose a MANOVA was conducted using the following outcome variables: ATW, PAE, NAE and PBC (see figure 7.8).

Although results of Box's test indicate that the assumption of homogeneity of variance-covariance is met, results of the Levene's test indicate that the assumption of equality of variances is not met for PAE, NAE and PBC.

Analysis of the multivariate test using Pillai's trace indicates a statistically significant effect for social robot appearance ($V = 0.13$, $F(8, 304) = 2.63$, $p = .008$; partial $\eta^2 = .06$). Analysis of the between-subjects effects table shows that type of robot affects ATW ($F(2, 154) = 5.07$, $p = .007$, partial $\eta^2 = .06$), PAE ($F(2, 154) = 5.09$, $p = .007$, partial $\eta^2 = .06$) and PBC ($F(2, 154) = 8.02$, $p = .000$, partial $\eta^2 = .09$).

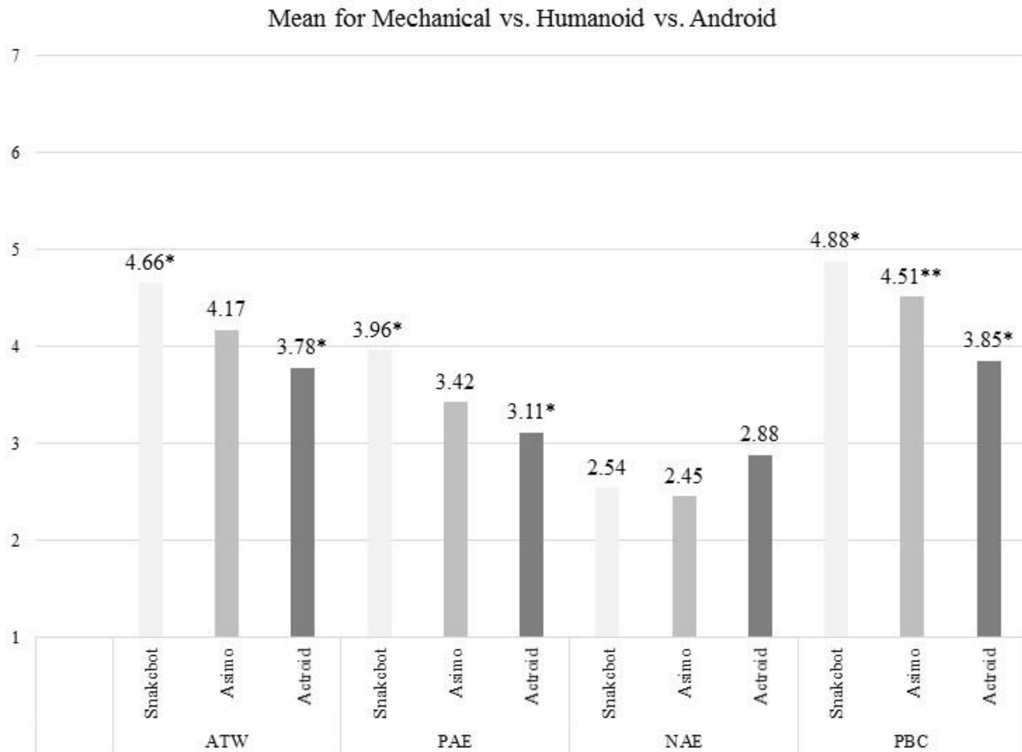

Figure 7.8. Effects of the social robot appearance on ATW, PAE, NAE and PBC

Note. *= difference between mean for Snackbot and Actroid statistically significant; **= difference between mean for Asimo and Actroid statistically significant ATW= attitude towards working with robots; PAE= positive anticipated emotions; NAE= negative anticipated emotions; PBC= behavioral perceived control; Snackbot= mechanical robot; Asimo= Humanoid robot; Actroid= Android robot.

Given that Levene's test suggests that the assumption of equality of variances is not met for PAE, NAE and PBC, Tukey's HSD and Games-Howell's post hoc tests were conducted (Field, 2009), confirming the previous results.

For ATW and PAE the statistically significant differences are between the two ends of the continuum, mechanical vs android robot. That is, Snackbot is rated significantly higher than Actroid on ATW and PAE. Although Snackbot is rated higher than Asimo in these variables, the difference is not statistically significant.

For PBC there is a statistically significant difference between the means of Snackbot vs. Actroid and Asimo vs. Actroid. That is, both Snackbot and Asimo are rated significantly higher on PBC than Actroid. Although Snackbot's rating is higher than Asimo's, the difference between the two is not statistically significant.

No effects were found for NAE.

In short, as robot type goes from mechanical to humanoid to android participant's attitude towards working with a social robot, positive anticipated emotions and perceived behavioral control ratings decrease. These results do not support hypotheses 8, which stated that a more humanlike the robot would result in a more positive attitude towards working with a social robot, more positive anticipated emotions and higher perceived behavioral control. The decrease in negative anticipated emotion was not supported.

3.7.2 **Effects of *socio-cognitive factors on ATW, PBC, PAE and NAE***

Research has associated both essentialism and social perception with the production of differentiated behavioral and affective responses towards ingroup and outgroup (e.g. Yzerbyt, Dumont,Wigboldus and Gordijn, 2003; Fiske & Glick, 2007). Attitudes have also been associated with behavioral and affective responses (e.g. Ajzen & Fishbein, 1977; Glasman & Albarracín, 2006). In line with this, the next section will study the role of beliefs in human nature uniqueness, perceived warmth, perceived competence, negative attitudes towards robots with human traits and negative attitudes towards interactions with robots as predictors of ATW, PBC, PAE and NAE.

3.7.2.1 Correlations between the socio-cognitive factors and ATW, PBC, PAE and NAE

In order to obtain an overview of the strength and direction of the relations between the variables studied in this section a two-tailed Pearson correlation was conducted (see table 7.13).

Table 7.13

Correlations of the socio-cognitive variables and ATW PAE, NAE and PBC

	BHNU	WARM	COM	NARHT	NATIR	ATW	PBC	PAE	NAE
BHNU	-								
WARM	-.31***	-							
COM	-.15	.63***	-						
NARHT(R)	-.55***	.50***	.31***	-					
NATIR(R)	-.43***	.25**	.12	.65***	-				
ATW	-.26**	.43***	.53***	.39***	.35***	-			
PBC	-.38***	.49***	.41***	.60***	.65***	.60***	-		
PAE	-.31***	.55***	.56***	.40***	.37***	.70***	.61***	-	
NAE	.32***	-.35***	-.20*	-.48***	-.51***	-.45***	-.60***	-.38***	-

Note. * p < .05; **p < .01; *** p < .001. BHNU= belief in human nature uniqueness; WARM = warmth; COM = competence; NARHT= negative attitudes towards robots with human traits; NATIR= negative attitudes towards interactions with robots;(R) indicates that NARHT and NATIR were reversed so that higher score indicate more positive attitudes towards robots; ATW= attitude towards working with the presented social robot; PBC= perceived behavioral control; PAE= positive anticipated emotions; NAE= negative anticipated emotions.

BHNU is negatively correlated with ATW (r = -.26), PBC (r = -.38) and PAE (r = .31), sharing 6%, 14% and 9% variance respectively. BHNU is positively correlated with NAE (r = .32), sharing 10% variance respectively.

Perceived warmth and competence measures are all significantly correlated with ATW, PBC, PAE and NAE. WARM is positively correlated with ATW (r = .43), PBC (r = .49) and PAE (r = .55), sharing 18%, 24% and 30% variance respectively. COM is positively correlated with ATW (r = .53), PBC (r = .41) and PAE (r = .56), sharing 28%, 17% and 31% variance respectively. Both WARM (r = -.35) and COM (r = -.20) are negatively correlated with NAE (12% and 4% shared variance, respectively).

The two components of the negative attitudes towards robots scale, NARHT and NATIR, are significantly correlated with ATW, PBC, PAE and NAE. NARHT is positively correlated with ATW (r = .39), PBC (r = .60) and PAE (r = .40), sharing 15%, 36% and 16% variance respectively. NATIR is positively correlated with ATW (r = .35), PBC (r = .65) and PAE (r = .37), sharing 12%, 42% and 14% variance respectively. Both NARHT (r = -.48) and NATIR (r = -.51) are negatively correlated with NAE (23% and 26% shared variance, respectively).

BHNU is negatively correlated with WARM (*r* = -.31), NARHT (*r* = -.55) and NATIR (*r* = -.43), sharing 9%, 30% and 18% variance respectively. WARM is positively correlated with NARHT (*r* = .50) and NATIR (*r* = .25), sharing 25% and 6% variance respectively. COM is positively correlated with NARHT (*r* = .31), sharing 9% variance. ATW is positively correlated with PBC (*r* = .60) and PAE (*r* = .70), sharing 36% and 49% variance respectively. ATW (*r* = -.45), PBC (*r* = -.60) and PAE (*r* = -.38) are negatively correlated with NAE, sharing 20%, 36% and 14% variance respectively.

In short, participants with a stronger belief in human nature uniqueness will have a less positive attitude towards working with a social robot, less positive anticipated emotions and a less perceived behavior control. On the other hand, they will experience stronger negative anticipated emotions. Those who perceived the presented robot as warm and competent, have a more positive attitude towards working with it, have a stronger sense of control and anticipate more positive emotions. Previous attitudes towards robots with human traits and towards interactions with robots show similar effects. Those participants who present a more positive attitude towards robots with human traits and interactions with robots, have a more positive attitude towards working with a social robot, have a stronger sense of control and anticipate more positive emotions. The attribution of higher levels of warmth and competence and more positive attitudes towards robots with human traits and interactions with robots reduces the level of anticipated negative emotions.

3.7.2.2 *Regression analysis for the effects of the socio-cognitive variables on ATW, PBC, PAE and NAE*

In order to study the effects of BHNU, WARM, COM, NARHT and NATIR on ATW, PBC, PAE and NAE, a series of multiple regression analysis was conducted.

The first regression analyses studies the predictors of ATW (table 7.14). Variables where entered following a hierarchical method. Variables in the first block were BUNH, WARM and COM. Variables in the second block were NARHT and NATIR. Method of entry for variables within each block was forced entry. Analysis of residuals using Leverage values (all values < 0.2) and Cook’s distances (all values < 1) suggest no outliers. The assumptions for normality, linearity, homoscedasticity and independence of residuals are attained. VIF (all values < 5), and tolerance values (all values > .2) suggest no multicollinearity issues (Marôco, 2010a; Field, 2009; Pallant, 2005).

Table 7.14

Predictors of ATW

	B	SE B	β	*t*	Sig.
Model 1:					
Constant	2.31	0.63		3.65	.000
BHNU	-0.18	0.08	-.16	-2.30	.023
WARM	0.10	0.10	.09	1.01	.314
COM	0.58	0.11	.45	5.23	.000
Model 2:					
Constant	0.12	0.86		0.14	.886
BHNU	-0.05	0.09	-.05	-0.61	.545
WARM	,040	0.10	.03	0.38	.702
COM	0.59	0.11	.46	5.51	.000
NARHT(R)	0.07	0.13	.05	0.53	.600
NATIR(R)	0.30	0.11	.24	2.76	.007
Model 1:	R= .57 R^2 = .32	R^2_a = .31	*F* (3, 153) = 24.09, *p* = .000		
Model 2:	R= .61 R^2 = .38	R^2_a = .36	*F* (5, 151) = 18.24, *p* = .000		
Diference between models: *F* (2, 151) = 6.76, *p* = .002					

Note. BHNU= belief in human nature uniqueness; WARM= warmth; COM= competence; ATW= attitude towards working with the presented social robot; NARHT= negative attitudes towards robots with human traits; NATIR= negative attitudes towards interactions with robots; (R) indicates that NARHT and NATIR were reversed so that higher score indicate more positive attitudes towards robots.

The results of the regression analysis for ATW (table 7.14) indicates that BHNU WARM and COM (Model 1) explain 31% of the variance (R^2_{adj} = .31, *F* (3, 153) = 24.09. *p* = .000).

Analysis of the Beta values indicates that BHNU (β= -.16) and COM (β= .45) are significant predictors of the attitude towards working with the social robot presented in the video (ATW). Nevertheless, these variables have different effects. The higher the level of BHNU, the lower will be the level of ATW. On the other hand the higher the level of COM the higher the level of ATW.

Analysis of Model 2 results show that the introduction of NARHT and NATIR increases the percentage of explained variance to 36% (R^2_{adj} = .36, F (5, 151) = 18.24. p = .000), which is a significant increase relatively to Model 1 (F(2, 151) = 6.76, p = .002). Analysis of the beta values indicates that NATIR and COM have a statistically significant effect (β= .46 and β= .24 respectively). Unlike it was hypothesized, the level of WARM and the level of NARHT, does not affect the attitude towards working with a social robot. In short, the more a person judges a robot as competent and the more positive the attitude towards interactions with robots, the more positive the attitude towards working with the robot presented in the video.

In spite of increasing the percentage of explained variance, the introduction of NARHT and NATIR, reduce the effect of BHNU to non-significant. Given these results, hypothesis 4, 5 and 6 for ATW are considered only partly confirmed.

The second regression analyses studies the predictors of PBC (table 7.15). Variables where entered following a hierarchical method. Variables in the first block were BUNH, WARM and COM. Variables in the second block were NARHT and NATIR. Method of entry for variables within each block was forced entry. Analysis of residuals using Leverage values (all values < 0.2) and Cook's distances (all values < 1) suggest no outliers. The assumptions for normality, linearity, homoscedasticity and independence of residuals are attained. VIF (all values < 5), and tolerance values (all values > .2) suggest no multicollinearity issues (Marôco, 2010a; Field, 2009; Pallant, 2005).

Table 7.15

Predictors of the perceived behavioral control

	B	SE B	β	*t*	Sig.
Model 1:					
Constant	3.78	0.60		6.27	.000
BHNU	-0.28	0.07	-.26	-3.79	.000
WARM	0.32	0.10	.30	3.30	.001
COM	0.22	0.11	.18	2.11	.036
Model 2:					
Constant	-0.58	0.68		-.85	.397
BHNU	-0.03	0.07	-.03	-.43	.666
WARM	0.20	0.08	.18	2.37	.019
COM	0.24	0.09	.20	2.86	.005
NARHT(R)	0.12	0.10	.10	1.21	.227
NATIR(R)	0.61	0.09	.50	7.00	.000
Model 1:	R= .57 R^2 = .32	R^2_{adj} = .31		*F* (3, 153) = 24.23, *p* = .000	
Model 2:	R= .75 R^2 = .57	R^2_{adj} = .55		*F* (5, 151) = 39.54, *p* = .000	
Diference between models: F (2, 151) = 42.70, p = .000					

Note. NARHT= negative attitudes towards robots with human traits; NATIR= negative attitudes towards interactions with robots; (R) indicates that NARHT and NATIR were reversed so that higher score indicate more positive attitudes towards robots; BHNU= belief in human nature uniqueness; WARM = warmth; COM = competence; ATW= attitude towards working with the presented social robot.

The results of the regression analysis for PBC (see table 7.15) indicates that belief in human nature uniqueness and social perception (Model 1) explain 31% of the variance (R^2_{adj} = .31, *F* (3, 153) = 24.23. *p* = .000).

Analysis of the Beta values indicates that BHNU (β= -.26) WARM (β= .30) and COM (β= .18) are significant predictors of PBC. BHNU is a negative predictor of PBC, that is, the higher the level of BHNU the lower will be the level of PBC. On the other hand, WARM and COM are positive predictors of PBC, That is, the higher its level the higher the level PBC.

Analysis of Model 2 results show that the introduction of NARHT and NATIR increases the percentage of explained variance to 55% (R^2_{adj} = .55, F (5, 151) = 39.54. p =

.000), which is a significant increase relatively to Model 1 ($F(2, 151) = 42.70$, $p = .000$). Analysis of the Beta values indicates that WARM, COM and NATIR have a statistically significant effect (β= .18; β= .20 and β= .50 respectively). Unlike it was hypothesized, the level of NARHT, does not affect the perceived behavioral control. In short, the more a person judges a robot as warm and competent and the more positive the attitude towards interactions with robots, the stronger the perceived behavioral control.

In spite of increasing the percentage of explained variance, the introduction of NARHT and NATIR, once more reduce the effect of BHNU to non-significant. Given these results, hypothesis 4, and 5 for ATW are considered only partly confirmed. Hypothesis 6 is supported by the results.

The third regression analyses studies the predictors of PAE (table 7.16). Variables where entered following a hierarchical method. Variables in the first block were BUNH, WARM and COM. Variables in the second block were NARHT and NATIR. Method of entry for variables within each block was forced entry. Analysis of residuals using Leverage values (all values < 0.2) and Cook's distances (all values < 1) suggest no outliers. The assumptions for normality, linearity, homoscedasticity and independence of residuals are attained. VIF (all values < 5), and tolerance values (all values > .2) suggest no multicollinearity issues (Marôco, 2010a; Field, 2009; Pallant, 2005).

Table 7.16

Predictors of the positive anticipated emotions

	B	SE B	β	*t*	Sig.
Model 1:					
Constant	1.48	0.57		2.61	.010
ESS	-0.19	0.07	-.18	-2.70	.008
WARM	0.28	0.09	.25	3.01	.003
COM	0.47	0.10	.38	4.70	.000
Model 2:					
Constant	-0.20	0.77		-0.26	.792
ESS	-0.11	0.08	-.10	-1.44	.153
WARM	0.26	0.09	.23	2.75	.007
COM	0.48	0.10	.39	5.00	.000
NARHT(R)	-.009	0.11	-.07	-0.77	.445
NATIR(R)	0.33	0.10	.27	3.36	.001
Model 1:	R= .64 R^2 = .41	R^2_{adj} = .40		*F* (3, 153) = 35.03, *p* = .000	
Model 2:	R= .67 R^2 = .45	R^2_{adj} = .44		*F* (5, 151) = 25.10, *p* = .000	
Diference between models: *F* (2, 151) = 6.47, *p* = .002					

Note. NARHT= negative attitudes towards robots with human traits; NATIR= negative attitudes towards interactions with robots; (R) indicates that NARHT and NATIR were reversed so that higher score indicate more positive attitudes towards robots;WARM = warmth; COM = competence; ATW= attitude towards working with the presented social robot.

The results of the regression analysis for PAE (see table 7.16) indicates that belief in human nature uniqueness and social perception (Model 1) explain 40% of the variance (R^2_{adj} = .40, *F* (3, 153) = 35.03. *p* = .000).

Analysis of the Beta values indicates that BHNU (β= -.18) WARM (β= .25) and COM (β= .38) are significant predictors of positive anticipated emotions (PAE). BHNU is a negative predictor of PAE, that is, the higher the level of BHNU the lower will be the level of PAE. On the other hand, WARM and COM are positive predictors of PAE, that is, the higher its level the higher the level PAE.

Analysis of Model 2 results show that the introduction of NARHT and NATIR increases the percentage of explained variance to 44% (R^2_{adj} = .44, *F* (5, 151) = 25.10. *p* = .000), which is a significant increase relatively to Model 1 (*F* (2, 151) = 6.47, *p* = .002). Analysis of the Beta values indicates that WARM, COM and NATIR have a statistically significant effect (β= .24; β= .39 and β= .27 respectively). Unlike it was hypothesized, the level of NARHT, does not affect the perceived behavioral control. In short, the more a person judges a robot as warm and competent and the more positive the attitude towards interactions with robots, the higher the level of positive anticipated emotions.

In spite of increasing the percentage of explained variance, the introduction of NARHT and NATIR, once more reduce the effect of BHNU to non-significant. Given these results, hypothesis 4, and 5 for PAE are considered only partly confirmed. Hypothesis 6 is supported by the results.

The fourth regression analyses studies the predictors of NAE (table 7.17). Variables where entered following a hierarchical method. Variables in the first block were BUNH, WARM and COM. Variables in the second block were NARHT and NATIR. Method of entry for variables within each block was forced entry. Analysis of residuals using Leverage values (all values < 0.2) and Cook's distances (all values < 1) suggest no outliers. The assumptions for normality, linearity, homoscedasticity and independence of residuals are attained. VIF (all values < 5), and tolerance values (all values > .2) suggest no multicollinearity issues (Marôco, 2010a; Field, 2009; Pallant, 2005).

Table 7.17

Predictors of the NAE

	B	SE B	β	*t*	Sig.
Model 1:					
Constant	2.38	0.65		3.64	.000
ESS	0.24	0.08	.23	3.00	.003
WARM	-0.32	0.11	-.30	-2.99	.003
COM	0.03	0.11	.02	0.24	.812
Model 2:					
Constant	5.792	0.84		6.93	.000
ESS	0.04	0.08	.03	0.44	.662
WARM	-0.21	0.10	-.19	-2.03	.044
COM	0.01	0.10	.01	0.13	.893
NARHT	-0.15	0.12	-.13	-1.20	.233
NATIR	-0.44	0.11	-.37	-4.13	.000
Model 1:	R= .42 R^2 = .17	R^2_{adj} = .16		F (3, 153) = 10.75, p = .000	
Model 2:	R= .57 R^2 = .33	R^2_{adj} = .30		F (5, 151) = 14.62, p = .000	
Diference between models: F (2, 151) = 17.04, p = .000					

Note. BHNU= belief in human nature uniqueness; NARHT= negative attitudes towards robots with human traits; NATIR= negative attitudes towards interactions with robots; (R) indicates that NARHT and NATIR were reversed so that higher score indicate more positive attitudes towards robots; WARM = warmth; COM = competence; ATW= attitude towards working with the presented social robot.

The results of the regression analysis for NAE (table 7.17) indicates that belief in human nature uniqueness and social perception (Model 1) explain 16% of the variance (R^2_{adj} = .16, F (3, 153) = 10.75. p = .000).

Analysis of the Beta values indicates that BHNU (β= .23) and WARM (β= -.30) are significant predictors of negative anticipated emotions (NAE). BHNU is a positive predictor of NAE, that is, the higher the level of BHNU the higher will be the level of NAE. On the other hand, WARM is a negative predictors of NAE, that is, the higher its level the lower the level NAE.

Analysis of Model 2 results show that the introduction of NARHT and NATIR increases the percentage of explained variance to 30% (R^2_{adj} = .30, F (5, 151) = 14.62. p = .000), which is a significant increase relatively to Model 1 (F (2, 151) = 17.04, p = .000). Analysis of the Beta values indicates that WARM and NATIR have a statistically significant effect (β= -.19 and β= -.37 respectively). Unlike it was hypothesized, the level of COM and NARHT, does not affect the negative anticipated emotions. In short, the more a person judges a robot as warm and the more positive the attitude towards interactions with robots, the lower the level of negative anticipated emotions.

In spite of increasing the percentage of explained variance, the introduction of NARHT and NATIR, once more reduce the effect of BHNU to non-significant. Given these results, hypothesis 4, 5 and 6 for PAE are considered only partly confirmed.

3.8 General discussion

This study was set to test that the model of goal directed behavior provides a framework to understand intention to work with a social robot in the future. The effects of social robot appearance and socio-cognitive factors was also tested.

The MGB extends the models previously studied, the TRA and the TPB. As hypothesized, the MGB not only predicts behavioral intention, but also accounts for a larger amount of explained variance (60%) than the TRA and TPB (both explaining 46% of variance). Although all the variables are significantly correlated at $< .001$, the path analysis shows no significant direct effects for ATW on DES. Also, PBC has no statistically significant direct effect on VOL. PAE, NAE, SN and PBC have statistically significant direct effects on DES and statistically significant indirect effects on VOL thus confirming the mediating role of DES. These results partly confirm hypotheses 3.

The results of the multivariate analysis of variance conducted to study the effects of the social robot appearance on intention suggest that ATW, PAE, PBC means decrease as robot type goes from mechanical (Snackbot) to android (Actroid). Although statistically significant these are medium effects (Marôco, 2010a) with partial η^2 values ranging from .06 to .09. No effects were found for NAE. It should be noted that the significant differences for the variables ATW and PAE are between the opposite types of robot (mechanical vs. android), that is, between Snackbot and Actroid. Although Asimo has a higher means then Actroid, the difference is not statistically significant. The significant differences for PBC are between the android and other two types of robot (Humanoid and Mechanical), that is, the means of Snackbot and Asimo are significantly higher than the mean of Actroid. Although Snackbot's mean for PBC is higher than the mean of Asimo, the difference is not statistically significant. These results suggest that type of robot affects socio-psychological factors, although in different proportions.

The study of the predictors of ATW showed that BHNU and COM (Model 1) presented statistically significant but opposite effects on ATW. That is, participants with a stronger belief in human nature uniqueness have a less positive attitude towards working with a social robot. On the other hand, participants that scored the social robot as more competent have a more positive attitude towards working with it. It should, nevertheless, be noted that COM has a stronger effect than BHNU (β= .45 and β= -.16 respectively). Adding NATIR and NARHT (Model 2) increased the percentage of explained variance, but reduced the effect of BHNU, which is no longer a statistically significant predictor of ATW. Although NATIR presents a statistically significant effect (β= .24), COM is still the stronger predictor of ATW (β= .46).

In short, although the belief in human nature uniqueness has a negative effect on the attitude towards working with the social robot, this effect is outweighed by the effects of a positive attitude towards interacting with robots and the attribution of competence to the social robot.

The study of the predictors of PBC showed that BHNU, WARM and COM (Model 1) have statistically significant effects. Once again BHNU presented a negative effect, an increase of BHNU leads to a decrease in the sense of perceived behavioral control. WARM and COM have a positive effect, their increase leads to an increase in the sense of perceived behavioral control. WARM has the largest effect (β= .30). Adding NATIR and NARHT (Model 2) increased the percentage of explained variance, but reduced the effect of BHNU, which is no longer a statistically significant predictor of PBC. WARM, COM and NATIR are statistically significant predictors of PBC, with NATIR presenting the stronger effect (β= .50).

In short, like for ATW, the effects of BUNH in PBC are outweighed by the effects of COM and NATIR. Besides COM and NATIR, the sense of perceived behavioral control is also positively affected by the perception of the robot as warm (endowed with social supportive traits). That is, not only the perception of the robot as competent, but also has warm will lead to a sense of control in working with the social robot.

The study of the predictors of PAE showed that BHNU, WARM and COM (Model 1) have statistically significant effects. Like with ATW and PBC, BHNU presented a negative effect, leading to a decrease in positive anticipated emotions. WARM and COM have a positive effect, their increase leads to an increase in positive anticipated emotions. COM has the largest effect (β= .38). The addition of NATIR and NARHT (Model 2) increased the percentage of explained variance, but reduced the effect of BHNU, which is no longer a statistically significant. WARM, COM and NATIR are statistically significant predictors of PAE, with COM being the stronger predictor (β= .39).

In short, a stronger belief in human nature uniqueness leads to less positive anticipated emotions. This effect is counterweighted by WARM, COM and NATIR, that is, a more positive attitude towards interactions with robots and the perception of the social robot as competent and warm will lead to more positive anticipated emotions.

The study of the predictors of NAE showed that BHNU and WARM (Model 1) have statistically significant, but opposite effects on NAE. Increasing BHNU leads to an increase in negative anticipated emotions, while an increase of COM leads to a decrease in negative anticipated emotions. Adding NATIR and NARHT (Model 2) increased the percentage of explained variance, but once again reduced the effect of BHNU, which is no longer statistically significant. NATIR and WARM are statistically significant negative predictors of NAE, with NATIR showing the strongest effect (β= -.37).

In short, a stronger belief in human nature uniqueness leads to more negative anticipated emotions. This effect is counterweighted by NATIR and WARM, that is, a more positive attitude towards interactions with robots and the perception of the social robot as warm (endowed with social supportive traits) will lead to more negative anticipated emotions.

4. Study 9: The intention to work with a social robot and its determinants: A test of three socio-cognitive models

4.1 Objectives

Study 9 aims to compare the three behavioral models previously studied, the TRA, the TPB and the MGB. For that purpose the data of the samples from study 4 and 5 are integrated into a new 217 participant sample.

Study 9 will also explore the following hypotheses:

H1: Intention to work with a social robot is a function of attitude towards working with a social robot and subjective norm (i.e. the theory of reasoned action). A more positive attitude and subjective norm towards working with a social robot will lead to a stronger intention to work with a social robot.

H2: Intention to work with a social robot is a function of attitude towards working with a social robot, perceived behavioral control and subjective norm (i.e. the theory of planned behavior). A more positive attitude, higher perceived behavioral control and a more favorable subjective norm towards working with a social robot will lead to a stronger intention to work with a social robot

H3: Intention to work with a social robot in the near future is a function of desire. Desire is determined by attitude towards working a social robot, anticipated emotions, perceived behavioral control and subjective norms. The effect of these variables on intention is mediated by desire (i.e. the model of goal directed behavior). An increase in desire will lead to a stronger intention to work with social robots. An increase in attitude towards working with a social robot, positive anticipated emotions, subjective norm and perceived behavioral control will lead to a stronger desire to work with social robots. An increase in negative anticipated emotions will lead to a decrease in desire

4.2 Method

4.2.1 Participants and procedure

The sample for this study is an aggregation of the samples from study 7 and 8. For socio-demographic characteristics see table 7.18. Experiment design was reported in pages studies 7 and 8. The sample comprises 130 female and 87 male participants, with a mean age of 25.15 (SD 8.45), ranging from 18 to 66 years old.

Table 7.18

Socio-demographic characteristics of the participants in study 9

	N= 217
Age	
M	25.15
SD	8.45
Min-Max	18 – 66
Gender	
Female	130
Male	87
Years of School	
12 years	13
University degree	171
Master and PhD	33
Area of study	
Science & technology	59
Social sciences, culture and humanities	156
Not reported	2
Occupation	
Student	151
Researcher	3
Management, sales & public service	18
Education & Health	15
Engineering	4
Tourism	2
Unemployed	8
Other	10
Not reported	6

Notes: Snackbot= 82; Asimo= 52; Actroid= 83.

4.3 Material

In order to control for order effects, the items were randomly assigned to the questionnaire. Two versions of the questionnaire were used. Table 7.19 shows a summary of the measures used in this study.

Table 7.19

Scales used in study 9

	Measures
ATW	Attitude towards working with robots
PAE	Positive anticipated emotions
NAE	Negative anticipated emotions
SN	Subjective norm
PBC	Perceived behavioral control
DES	Desire
BI	Intention

Measures of Behavioral Intention and its antecedents:

Behavioral Intention (BI). Behavioral intention was measured like in previous studies. Higher scores indicate a stronger intention to work with the social robot presented in the video

Desire (DES). Desire was measured like in previous studies. Higher scores indicate more desire to work with a social robot.

Attitude towards working with a social robot (ATW). Attitude towards working with a social robot was measured like in previous studies. Higher scores indicate a more positive attitude towards working with the social robot presented in the video.

Subjective norms (SN). Subjective norms was measured like in previous studies. Higher scores indicate more favorable subjective norms towards working with the social robot presented in the video.

Perceived behavioral control (PBC). Perceived behavioral control was measured like in previous studies. Higher scores indicate more favorable subjective norms towards working with the social robot presented in the video.

Positive and negative anticipated emotions (PAE; NAE). Positive anticipated emotions and negative anticipated emotions were measured like in previous studies. Higher scores indicate more positive anticipated emotions and more negative anticipated emotions, respectively.

Control variables:

Animacy (ANI) and likeability (LIK) were measured like in previous studies. Higher scores reflect a higher level of the attribute.

4.4 Results

4.4.1 Preliminary analyses

Preliminary analysis of the data showed no statistically significant differences between the means of the variables used in study 7 and 8.

The data was analyzed for normality, skewness and kurtosys. Although the results of the Kolmogorov-Smirnov index suggests that some of the variables may have a nonnormal distribution, the skewness and kurtosis values are all below the threshold recommended by Schumaker & Lomax (2002), for univariate skewness ($-1 < sk < 1$) and kurtosis ($-1.5 < ks < 1.5$). There were no missing values. No extreme outliers were detected.

4.4.2 **Manipulation checking**

A first analysis of the data was conducted in order to control for the effects of gender. For that purpose a MANOVA was conducted on the measures of MGB. No differences were found that could be attributed to gender ($V = 0.02$, F (7, 209) = 0.75, p = .629).

This study assumes that the effects of robot type are due to the external appearance of the social robots presented in the videos, mechanical versus humanoid versus android. The measures of likability (LIK), and animacy (ANI) are used in order to control for other factors. Results of the MANOVA show that the social robots were perceived as having a similar degree of animacy and likeability ($V = 0.02$, F (4, 428) = 0.85, p = .496).

Effects of participant’s area of study and professional occupation are beyond the scope of this research.

4.5 Descriptive statistics

Table 7.20 shows the descriptive statistics for the scales used in the study. All scales show good reliability results ($\alpha > .70$).

In order to obtain an overview of the results, a one sample t-test was conducted, comparing the variables means to the medium point of the scales (3.5). Table 7.20 shows the results of the t-test.

Table 7.20

Descriptive statistics of the scales used in study 9

	M	SD	N	Range	Actual Range	Cronbach alpha	Skewness	Kurtosis
ATW	4.20***	1.41	217	1-7	1-7	.95	-0.30	-0.29
PAE	3.50	1.34	217	1-7	1-7	.92	-0.08	-0.46
NAE	2.66***	1.31	217	1-7	1-6	.92	0.58	-0.49
SN	3.78**	1.39	217	1-7	1-7	.83	-0.15	-0.25
PBC	4.36***	1.38	217	1-7	1-7	.89	-0.58	-0.35
DES	3.18**	1.61	217	1-7	1-7	.94	0.21	-0.91
BI	3.17**	1.48	217	1-7	1-7	.82	0.28	-0.58
LIK	4.31***	1.30	217	1-7	1-7	.85	-0.22	-0.23
ANI	3.66*	1.15	217	1-7	1-7	.77	0.08	-0.27

Notes: Medium point of scale= 3.5; * $p < .05$ level; **$p < .01$; ***$p < .001$. ATW= attitude towards working with the social robot; PAE= positive anticipated emotions; NAE= negative anticipated emotions; SN= subjective norm; PBC= perceived behavioral control; DES= desire; BI= behavioral intention: LIK= likability; ANI= animacy.

There is a general good impression (LIK, M= 4.31) and a positive attitude towards working with the social robot presented (ATW, M= 4.20), and participants think it will be easy to do it (PBC, M= 4.36). The idea of working with robots seems to be socially acceptable (NS, M= 3.78), with participants anticipating a low level of negative emotions (NAE, M= 2.66). Participants also perceive the social robot as lively (ANI, M= 3.66).

In spite of this general positive attitude towards working with a social robot, the means of DES (3.18) and BI (3.17) are significantly below the medium point of the scale. This suggests that although in general people are favorable to the idea of social robots and working with them, at a personal level they may not be particularly interested in doing so.

PAE did not differ significantly from the medium point of the scale.

4.6 Understanding the intention to work with a social robot in the near future

In the previous sections the TRA, TPB and MGB were used to study the intention to work with a social robot in the near future. All three models proved useful in the prediction of behavioral intention, with variables behaving according to the theoretical predictions. This next section compares the three behavioral models studied in the previous chapters.

4.6.1 Correlations between the determinants of intention and intention

In order to obtain an overview of the strength and direction of the relations between the variables studied in this section a two-tailed Pearson correlation was conducted (see table 7.21).

Table 7.21

Correlations for the measures of the MGB

	ATW	PAE	NAE	PBC	SN	DES	BI
ATW	-						
PAE	.73	-					
NAE	-.49	-.43	-				
PBC	.64	.63	-.59	-			
SN	.44	.49	-.35	.47	-		
DES	.69	.77	-.55	.69	.59	-	
BI	.58	.67	-.41	.58	.44	.76	-

Notes: All $p < .001$.

The pattern of correlations support the effects hypothesized by the three models studied. As predicted by the TRA, ATW (r = .58) and SN(r = .44) are positively correlated with BI (sharing 34% and 19% of variance respectively). PBC (r = .58) is correlated with BI (sharing 34% of variance) as hypothesized by the TPB. Like it is hypothesized by the MGB DES (r = .76) is positively correlated with VOL (sharing from 58% of variance). ATW (r = .69), PAE (r = .77), PBC (r = .69), and SN (r = .59) are positively correlated with DES (sharing from 35% to 59% of variance). NAE (r = -.55) is negatively correlated with DES (30% shared variance).

ATW is positively correlated with PAE (r = .73; 53% shared variance), PBC (r = .64; 41% shared variance) and SN (r = .44; 19% shared variance). NAE is negatively correlated with ATW (r = -.49; 24% shared variance), PAE (r = -.43; 18% shared variance), PBC (r = -.59; 35% shared variance) and SN (r = -.35; 12% shared variance). PBC (r = .47) is positively correlated with SN, sharing 22% variance.

In short, people with a stronger desire to work with social robots in the future will also show a stronger intention to do so. They see themselves as competent to work with a social robot, anticipate more positive emotions and think that working with it is socially acceptable.

4.6.2 Comparing the three socio-cognitive models

In order to compare the predictive power of the three models studied a hierarchical regression analysis was conducted. This allows to observe if the introduction of new variables increases significantly the predictive power of the model (Field, 2009; Pallant, 2005). It will also allow to test for the mediating effects of DES in the MGB (Maroco, 2010a) Variables entered in the first block were ATW and SN, i.e. the determinants of intention according to the TRA (see table 7.22). Variables entered in the second block were ATW, SN and PBC, i.e. the determinants of intention according to the TPB. Variables entered in the third block were ATW, SN, PBC, PAE, NAE and DES, i.e. the determinants of intention according to the MGB. Method of entry for variables within each block was forced entry.

Analysis of residuals using Leverage values (all values < 0.2) and Cook's distances (all values < 1) suggest no outliers. The assumptions for normality, linearity, homoscedasticity and independence of residuals are attained. VIF (all values < 5), and tolerance values (all values > .2) suggest no multicollinearity issues (Marôco, 2010a; Field, 2009; Pallant, 2005).

Table 7.22. Three behavioral models in comparison

	BI				
	B	SE B	β	*t*	Sig.
Model 1:					
Constant	.14	0.28		0.50	.615
ATW	.50	0.06	.48	7.94	.000
SN	.24	0.06	.23	3.81	.000
Model 2:					
Constant	-.28	0.28		-0.98	.327
ATW	.33	0.07	.31	4.55	.000
SN	.16	0.06	.15	2.57	.011
PBC	.33	0.07	.31	4.45	.000
Model 3:					
Constant	.23	0.42		0.56	.577
ATW	.02	0.07	.02	0.28	.783
SN	-.03	0.06	-.03	-0.57	.567
PBC	.10	0.07	.10	1.44	.152
PAE	.20	0.08	.18	2.39	.018
NAE	.05	0.06	.04	0.76	.445
DES	.53	0.08	.58	6.94	.000
Model 1:	R= .61 R^2 = .38	R^2_{adj} = .37		*F* (2, 214) = 64.77. *p* = .000	
Model 2:	R= .66 R^2 = .43	R^2_{adj} = .42		*F* (3, 213) = 53.57. *p* = .000	
Model 3:	R= .77 R^2 = .59	R^2_{adj} = .58		*F* (6, 210) = 51.40, p = .000	
Diference between model 1 and 2:				*F* (1, 213) = 19.80, p = .000	
Diference between model 2 and 3:				*F* (3, 210) = 28.49, p = .000	

Notes: Medium point of scale= 3.5; * p < .05 level; **p < .01; ***p < .001. ATW= attitude towards working with the social robot; PAE= positive anticipated emotions; NAE= negative anticipated emotions; SN= subjective norm; PBC= perceived behavioral control; DES= desire; BI= behavioral intention.

The results of the regression analysis for model 1 (see table 39) indicates that the TAR explains 37% of the variance (R^2_a = .37, *F* (3, 214) = 64.77. *p* = .000). Analysis of the Beta values indicates that ATW (β= .48) and SN (β= .23) are significant predictors of the intention to work with the social robot presented in the video (BI).

The results of the regression analysis for model 2 (table 39) indicates that the TPB explains 42% of the variance (R^2_{adj} = .42, *F* (3, 213) = 53.57. *p* = .000). Analysis of the Beta values indicates that ATW (β= .31), PBC (β= .31) and SN (β= .15) are significant predictors of the intention to work with the social robot presented in the video (BI).

In short, the TPB explains a significantly larger percentage of variance, then the TRA (*F* (1, 213) = 19.80, *p* < .0001).

The results of the regression analysis for model 3 (table 39) indicates that the MGB explains 58% of the variance (R^2_{adj} = .58, F (6, 210) = 51.40, p < .0001). This indicates a significant increase in the percentage of explained variance relative to the TPB (F (3, 210) = 28.49, p = .000). Analysis of the Beta values indicates that DES (β= .58), and PAE (β= .18) are significant predictors of the intention to work with the social robot presented in the video (BI). The introduction of DES reduced the effects of ATW, PBC and SN which is expectable since the model hypothesizes that this variables have their effect mediated by it.

4.6.3 Revisiting the MGB

Unlike the two previous models (TRA and TPB), the MGB proposes that the model's variables (ATW, PAE, NAE, SN and PBC) affect behavioral intention not directly but through desire (DES). In order to test this assumption the model will be studied through a path analysis.

Analysis of residuals using Leverage values (all values < 0.2) and Cook's distances (all values < 1) suggest no outliers. The assumptions for normality, linearity, homoscedasticity and independence of residuals are attained. VIF (all values < 5), and tolerance values (all values > .2) suggest no multicollinearity issues (Marôco, 2010a; Field, 2009; Pallant, 2005). The assumption of multivariate normality and the existence of multivariate outliers were assessed through Mardia's normalized estimate of multivariate kurtosis and the Mahalanobis distances, respectively. Analysis of the variables for the Model of Goal Directed Behavior identified a Mardia´s estimate value of 7.78 which is suggestive of multivariate non-normality (Byrne, 2010). Further analysis identified 4 potential multivariate outliers that were extracted from the sample. Reanalysis of the variables indicate that the assumption of multivariate normality is attained (Mardia's normalized estimate of multivariate kurtosis = 3.86). All the following analysis using the MGB variables are computed with 213 participants.

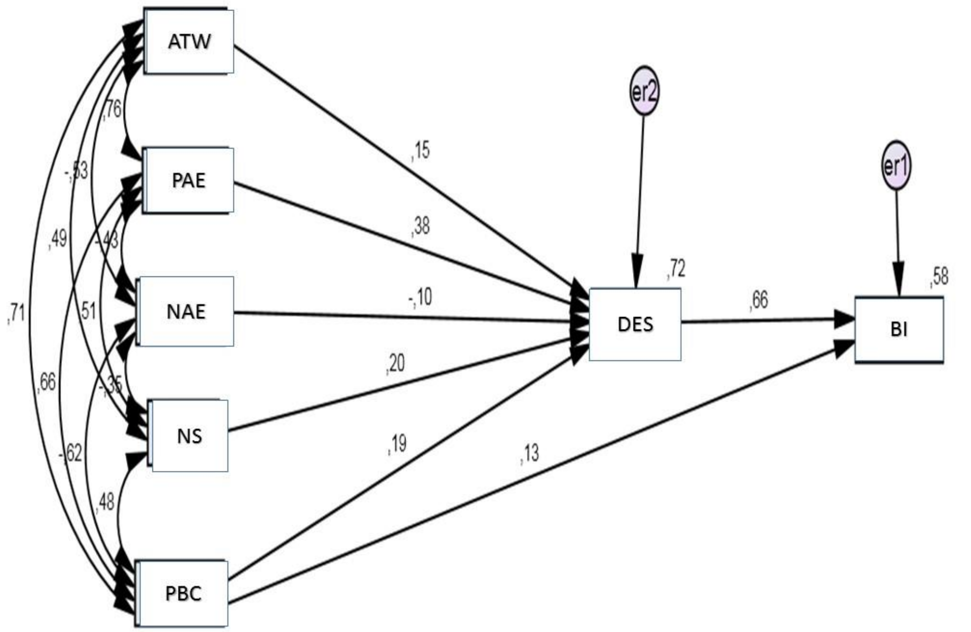

Figure 7.9. Path analysis for MGB

Notes: Chi-square = 8.00; Degrees of freedom = 4; Probability level = .092
CMIN/DF = 2.00; GFI= .99; AGFI= .93; NFI= .99; CFI= 1.00
RMSEA= .07; LO 90= .00; HI 90= .14; PCLOSE= .26; CAIC= 160.67

The result of the path analysis indicates that the model explains 58% of the variance (see Figure 7.9). All paths are statistically significant. Analysis of the standardized direct effects indicates that ATW (β= .15, p = .018), PAE (β= .38, p < .001), NAE (β= -.10, p = .031), SN (β= .20, p < .001) and PBC (β= .19, p = .001) account for 72% of the variance of DES. DES (β= .66, p < .001) and PBC (β = .13, p = .040) have a significant positive direct effect on the intention to work with social robots in the future (BI). Statistical significance of indirect effects was assessed using bootstrap resampling as suggested by Marôco (2010b; Monte Carlo parametric bootstrap, 2000 samples, percentile confidence intervals at 90%, bias-corrected confidence intervals at 90%). ATW (β = .10, p = .014), PAE (β = .25, p = .001), NAE (β = -.07, p = .025), SN (β = .13, p = .001) and PBC (β = .13, p = .002) have a significant indirect effect on VOL, thus confirming the mediating role of desire in the model.

In short, as hypothesized in the model, desire mediates the effects of attitude, anticipated emotions, subjective norms and perceived behavioral control on the intention to work with social robots in the future. That is, a more positive attitude, more positive anticipated emotions (and less anticipated negative emotions), a higher sense of control and perceived social acceptability of working with robots will increase the desire to do so. This in turn strengthens the intention to work with social robots. It should be noted nevertheless, that the sense of perceived behavioral control also contributes directly to behavioral intention.

In study 8, a slightly different formulation of the MGB was proposed, based on the analysis of the modification indices which suggested a direct effect for PAE in BI. In this study the modification indices for the MGB model are once again suggestive of a direct effect for PAE in BI. As such, another analysis was carried out in order to test further this effect (see figure 7.10 for model).

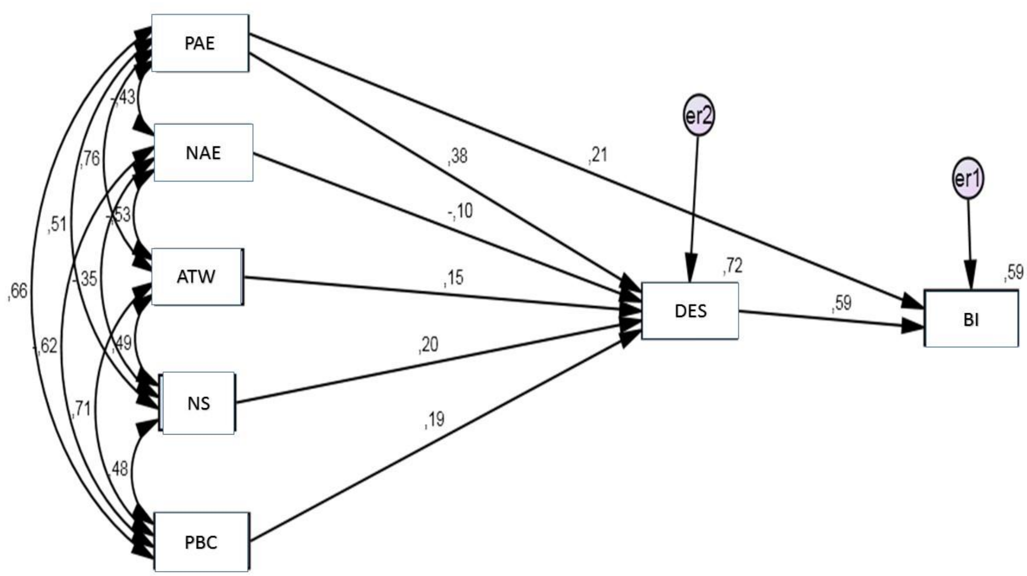

Figure 7.10. Path analysis for MGB

Notes: Chi-square = 2.99; Degrees of freedom = 4; Probability level = .56
CMIN/DF =.75; GFI= 1.00; AGFI= .97; NFI= 1.00; CFI= 1.00
RMSEA= .00; LO 90= .00; HI 90= .09; PCLOSE= .76; CAIC= 155.66

The result of the path analysis indicates that the model explains 59% of the variance (see Figure 7.10). All paths are statistically significant. Analysis of the standardized direct effects indicates that ATW (β= .15, p = .018), PAE (β= .38, p < .001), NAE (β= -.10, p = .031), SN (β= .20, p < .001) and PBC (β= .19, p = .001) account for 72% of the variance of DES. DES (β= .59, p < .001) and PAE (β = .21, p = .002) have a significant positive direct effect on the intention to work with social robots in the future (BI). Statistical significance of indirect effects was assessed using bootstrap resampling as suggested by Marôco (2010b; Monte Carlo parametric bootstrap, 2000 samples, percentile confidence intervals at 90%, bias-corrected confidence intervals at 90%). ATW (β = .09, p = .014), PAE (β = .23, p = .001), NAE (β = -.06, p = .024), SN (β = .12, p = .001) and PBC (β = .11, p = .002) have a significant indirect effect on BI, thus confirming the mediating role of desire in the model.

In short, the relations hypothesized by the model are confirmed. The effects (β values) of ATW, PAE, NAE, SN and PBC are the same as in the previous model. The direct effects of PBC on BI are now non-significant and thus were omitted from the model. Like in study 5 a statistically significant direct effect was identified for PAE on BI.

4.7 General discussion

The results of the comparison of the three models follow the results of published research in this area (e.g. Perugini, & Bagozzi, 2004a; Richetin et al., 2008). The TPB, with the inclusion of PBC, accounts for more variance than the TRA. It also accounts for behaviors over which the person does not have complete volitional control. The introduction of desire as a mediating variable and the inclusion of anticipated emotions as predictors make the MGB a model with more explaining power than the TRA and the TPB, both empirically and theoretically. By making explicit the difference between the affective component of attitudes and emotions (positive and negative anticipated emotions) the MGB contributes to a clearer understanding of the latter's role in eliciting behavioral intention. It is also noteworthy that, the MGB model predicting a direct effect of PAE on BI seemed to fit better the data than the original model. This result warrants the need to further research the role of emotions in eliciting desire and behavioral intention.

Part 3: discussion and general conclusions

Chapter 8: General conclusion

1. Aims and objectives

As mentioned in the introduction, robots, given their ability to perform tasks in a manner comparable to humans, are operating profound changes in the work place and in organizational settings[44]. The exponential progresses of engineering and computation are allowing robots to apply for an increasing number of job categories. Some of these professions were until recently thought to be exclusively human (see Manjo, 2011). In order to face the challenges brought by automation, the study of the human factors that can facilitate or hinder the use and collaboration with social robots becomes an imperative enterprise. As Borenstein (2011) points out: "Anticipating what the public wants is not a simple thing. They might more willingly tolerate one type of automation (bank telling services) than others (food service) for reasons that are not always obvious. Yet these kinds of behaviors can tangibly impact the dynamics of the workforce." Vámos (2014) lays it even more bluntly: "Our age of information changes all human working conditions known in the entire history of the human race. These processes influence our concepts of traditional human roles." In this context, it is worth noting that the general public's swiftness in associating robots with "automated machines" (see Chapter 5, study 1 for the social representation of robot), is a significant sign of how unprepared society, in general, is for the next chapter on automation and artificial intelligence: social robots and social interfaces.

It was within this framework that the present research question, what are the determinants of the intention to work with a social robot in the near future, developed. In order to answer it, three socio-cognitive models were studied: the TRA, the TPB and the MGB[45]. According to these models intention to work with a social robot in the near future is determined by attitudes towards working with a robot, subjective norms (TRA) and perceived behavioral control (TPB). Besides these three variables, the MGB also includes anticipated emotions (positive and negative), contending that the effect of these

[44] See Pagallo (2011) for a discussion of the legal implications of robotics and automation.

[45] As noted before, the TSR is seen as a transitional steep from the TPB to the MGB, as such it was not studied on its own.

five variables on intention is mediated by desire. The three models were tested and compared to determine which accounted for the largest percentage of explained variance.

Variables like socio-demographic status, attitudes, values or personality traits are external to the model and have their effects mediated by it. Revision of research results in robotics and social perception/ social cognition, suggested that variables like the social robot appearance (more or less humanoid), and socio-cognitive factors like belief in human nature uniqueness, perceived warmth, perceived competence, anthropomorphism and attitudes towards robots, play a role in human-robot interactions. Hence, the role of this variables as determinants of attitude towards working with a social robot, perceived behavioral control and anticipated emotions, was also studied. The next section presents a summary of the research results.

2. Summary of results

This section presents a summary of the research results, discussing them in relation to the hypotheses presented in chapter 4. Table 8.1 presents a summary of the results.

Table 8.1

Summary of the main results of studies 1 to 9.

Study	Results
1	Social representation of robot: • Four quadrant diagram. Central nucleus main idea is that of a technology (machine) that will help in the future by replacing men in industry and domestic task. The peripheral system develops on the themes of technology, and introduces movies, unemployment and the idea of an emotionless machine. • Similitude analysis. The representation is organized around the nodes technology and future. Female representation is also organized around the idea of technology, while the male representation is organized around the nodes of artificial intelligence and help. Comparison by age shows that the representation of participants under 32 years is organized around the node of technology, while that of participants over 32 years is organized around the node of help and future. Participants with up to 12 years of school organize their representation around the node of help, while those with university frequency organize their representation around multiple nodes, technology, artificial intelligence, future and replacement of men.
2	Principal component analysis of the negative attitudes towards robots scale: • PCA yielded a two factor solution, negative attitudes towards robots with human traits (NARHT) and negative attitudes towards interactions with robots (NATIR).
3	Confirmatory factor analyses: • CFA showed that the two factor solution identified in the PCA has reasonably good fit indexes.
4	External nomological validity: • P-NARS two factors are correlated with attitude towards technology, technology consequences and technology difficulty scales, which supports the contention of nomological validity.
5	Predictive validity: • Regression analysis showed that: NARHT is a predictor of ATW and PBC; NATIR is a predictor of PBC. • Regression analysis using Preacher and Hayes (2008) bootstrapping technique for mediations showed indirect effects for NARHT on BI through ATW and PBC.

6	Belief in human nature uniqueness scale: • PCA showed BHNU to be unifactorial. Cronbach alpha= .84 • BHNU is negatively correlated to NARHT, NATIR and Sci-Fi. • BHNU is positively correlated to Religion. • Religion is negatively correlated to NARHT and NATIR.
7	Intention to work with a social robot in the near future (Mechanical vs Android): • TRA explains 46% variance. ATW is a predictor of BI. • TPB explains 46% variance. ATW is a predictor of BI. • Type of robot has no effect on ATW and PBC • NARHT and WARM are significant predictors of ATW. • NARHT is a significant predictor of PBC.
8	Intention to work with a social robot in the near future (Mechanical vs Humanoid vs Android): • Path analysis shows that the MGB accounts for 60% of the variance • PAE, NAE, SN and PBC have significant direct effects on DES. • PAE, NAE, SN and PBC have significant indirect effects on BI through DES • ATW has no direct or indirect effects. PBC has no direct effect on BI • Alternative MGB accounts for 62% of the variance • PAE, NAE, SN and PBC have significant direct effects on DES. • PAE, NAE, SN and PBC have significant indirect effects on BI through DES • PAE has a direct effect on BI • ATW has no direct or indirect effects. • Type of robot has an effect on ATW, PAE and PBC. Moving from mechanical to android robot decreases the values of these variables • COM and NATIR are significant predictors of ATW. • NATIR, COM and WARM are significant predictors of PBC. • COM, NATIR and WARM are significant predictors of PAE. • NATIR and WARM are significant negative predictors of NAE.

9	Intention to work with a social robot in the near future • TRA explains 37% variance. ATW and SN are significant predictors of BI. • TPB explains 42% variance. ATW, PBC and SN are significant predictors of BI. • Path analysis shows that the MGB accounts for 58% of the variance • ATW, PAE, NAE, SN and PBC have significant direct effects on DES. • ATW, PAE, NAE, SN and PBC have significant indirect effects on BI through DES • PBC has a significant direct effect on BI • Alternative MGB accounts for 59% of the variance • ATW, PAE, NAE, SN and PBC have significant direct effects on DES. • ATW, PAE, NAE, SN and PBC have significant indirect effects on BI through DES • PAE has a direct effect on BI

2.1 The Social Representation of Robot

Results of study 1 – the social representation of robot, show that, despite the outstanding engineering success in the implementation of robotic systems and automation solutions, participant's idea of what is a robot is not very different from that identified by Argote et al. (1983) more than thirty years ago. It is also noteworthy the fact that while Argote et al.'s study was conducted with workers of an industrial plant installing its first industrial robot, the current study was conducted with a diverse set of participants, including students, workers from different professional areas and a wide age range.

Results of study 1 are also is in line with the results of the special eurobarometer 382 (TNS Opinion & Social, 2012), were the majority of the Portuguese participants (64%) reported that the image of an industrial robot fitted well their image of what a robot is. Albeit some regional differences results for European countries follow a similar pattern, with around 80% of Europeans asserting that the industrial robot shown fits well with their idea of robot. Interestingly, the participants that made a bigger distinction between the two robots, with a clear preference for the image of the industrial robot, all belonged to industrialized countries like Sweden (95% vs.63%), Germany (87% vs. 56%), Finland (93% vs. 65%) or Denmark (94% vs. 66%). That is, even in countries with an already high presence of robots, like Germany (the third largest number of robots per worker employed in industry) the industrial robot, automated, programmable, mechanical arm is still pervasive.

Other aspects worth noting are: 1) the slightly different focus of the female and male representation of social robot, the first focusing on domestic robots and the second on industrial robots, which suggests that gender stereotypes may play a role in the type of tasks people think robots will be valuable for; 2) comparison by age group suggests that older participants might have a less benevolent perception of robots, with the idea of help associated with unemployment; and 3) comparison by years of schooling, shows a much more complex and interdependent set of ideas for those with more school years (University degree).

Social representations are a system of values, ideas and practices, allowing the person to navigate and master her world, while communicating with the other members of the community. Through anchoring and objectifying, they are a sense making system (Bergman, 1998). Attitudes on the other hand, do not create new objects, they are an evaluative (good vs. bad; pleasant vs. unpleasant; likable vs. dislikable) stance towards an object (Ajzen, 2001) and do not have to be shared by group members. But this is not to say that social representations do not intertwine with attitudes. Given their object constructing role, they can have an informational character. Since beliefs are based on the probabilistic information a person has about the properties of an object, the social representation is bound to, even if indirectly, orientate the attitude. But the opposite is also possible. An attitude towards an object, by creating a certain behavioral disposition, will orient perception and categorization, and in the way, anchoring and objectifying and the social representation (Bergman, 1998). People think of robots as machines (the social representation) and will have a certain intention to act toward robots given what they know about its properties (behavioral beliefs). What they think significant others consider to be the appropriate action to take toward robots (normative beliefs). What they think are the challenges of operating this new technology (control beliefs). And, how they think they will feel operating this new machine (anticipated emotions). All this process is bound to feedback into what people think that a robot is (social representation).

The background presented by the results of the study on the social representation of robot, showing a wide gap between the contemporary representation of robot by the lay person, and the exponential growth rate of automation and robotic technology, underlines the need to study people's expectations and willingness to accept social robots in their work routines. Thus, the relevance of a question such as: what are the determinants of the intention to work with a social robot in a near future?

2.2 Predicting the intention to work with a social robot in the near future: Models and variables

2.2.1 The socio-cognitive models

This research was set to test the usefulness of three socio-cognitive models, The TRA, the TPB and the MGB in the prediction of the intention to work with a social robot in the near future. All three models have received ample support from empirical research. The TRA, the TPB and the MGB were tested and their predictive capabilities compared. Although all three models proved themselves useful, in the prediction of behavioral intention, the percentage of variance explained varied.

In study 7, both the TRA and TPB were found to predict intention to work with a social robot in the near future. The two models predicted the same amount of variance (46%). Attitude towards working with a social robot was the only variable with a statistically significant effect. No effects were found for subjective norms or perceived behavioral control.

A possible explanation for the lack of effect of subjective norms may be the context in which the question was asked. Participants were requested to imagine themselves working with the social robot in the near future, that is, the behavior towards the robot was set in a professional context, while the questions regarding subjective norm, although concerned working with the social robot, were directed at significant ones. Significant ones are generally taken to be close friends and family. This may have lead participants to consider that, although they take into account significant other's position, it is not very relevant for future job interaction with a machine, no matter how sophisticated it is. As Bagozzi (1992), points out, normative beliefs are conditioned by social context, a person can be an independent agent, part of a group or part of a formal organization. If a person ponders what a significant one (e.g. father or uncle) thinks she should do regarding her boyfriend, when regarding if she should work with a social robot, her department manager and coworkers, will become the significant others.

The lack of effect of perceived behavioral control may be explained by the limited experience with real social robots. Participants may base their intention to work with social robots solely on attitude since they lack the real experience of operating a robot and thus cannot make a judgment on how they would perform.

Study 8 found that the MGB predicts 60% of the variance of intention to work with a social robot in the near future. Positive anticipated emotions, negative anticipated emotions, subjective norms and perceived behavioral control were found to have their effect on intention mediated by desire. Unlike proposed by the model, no direct effects were found for perceived behavior control on intention. Contrary to the results of study 7 no significant, direct or indirect, effects were found for attitude towards working with social robots.

Also noteworthy is the identification of a direct effect of positive anticipated emotions on intention. This alternative MGB model, although explaining approximately the same amount of variance (62%), resulted in a model with better fit indexes. All the other paths remained as in the first model. A similar effect for PAE was found by Kim et al., (2012). Their study, about the role of tourist's gender on the intention to travel overseas, besides the postulated direct effects of desire and perceived behavioral control, identified direct significant effects of positive anticipated emotions on intention. Two possible explanations for the direct effects of PAE on BI are advanced. The first is methodological: the measure of desire is not reliable and thus does not capture all mediating effects. In the present research PAE was found to have a direct effect on desire, and an indirect effect on intention, through desire, thus confirming mediation, which questions this first explanation. The second explanation, is functional. Research on emotions has underlined their role in setting forward the intention to act, be it through the valence (negative, positive) it affords the stimuli, be it through motivational drive, suggesting that each emotional category can be distinguished by different appraisal patterns and action readiness modes (Frijda, Kuipers and Schure, 1989). Drawing from this both Bagozzi, Baumgartner and Pieters, (1998) emotional goal system model and Bagozzi and Lee (1999) goal setting and goal striving model of acceptance of innovation, propose that emotional appraisal plays a major role in volitional processes. Anticipated emotions would provide a drive to act, while comparison with actually felt emotions would provide feedback on the process of striving towards the achievement of the goal and thus, play an important role in self-regulation. The concept of social robot and the idea of working with social robots are rather recent. With very few examples of real life situations from where to draw inferences, it is reasonable to suppose that emotional appraisal will play a salient role in the acceptance and intention to work with a social robot.

In study 9, intention to work with a social robot in the near future is investigated using the three models, the TRA, TPB and MGB and a larger sample. A hierarchical regression was conducted in order to compare the predictive power of the three models, with results showing a significant increase in the percentage of explained variance from the TRA (37%) to the TPB (42%) to the MGB (58%).

In study 9 all the effects postulated by the models were observed. Like proposed by the TRA, ATW and SN are predictors of intention. Like proposed by the TPB, ATW, PBC and SN are predictors of intention. And like proposed by the MGB, desire and PBC are predictors of intention, with desire mediating the effects of ATW, PAE, NAE, SN and PBC on intention.

The alternative MGB model, identified in study 8 was tested, confirming the previously identified direct effects of PAE on intention. Although these alternative MGB model produced better fit indexes than the MGB, it predicts approximately the same amount of variance (MGB R^2= 58; alternative MGB R^2= 59).

In short, although all the three models performed according to their postulates, they accounted for different amounts of explained variance. That is, the MGB has more explaining power than the TPB, while the TPB has more explaining power then the TRA.

One important note about behavioral intention. In spite of the growing interest in the use of social robots, its presence in real settings is still small, thus reducing the chances of conducting research using actual behavior as outcome. The concept of behavioral intention has received systematic empirical support as the proximal predictor of actual behavior and thus, can be informative of the effort people will be willing to go through in order to work with social robots in the near future. The TRA, TPB and MGB provide not only measures of behavioral intention, but also of its determinants, thus providing a sound theoretical and practical framework to study human-robot interactions.

2.2.2 Determinants of Behavioral Intention

Analysis of the individual contribution of each variable shows that in the context of the 3 studies, DES, ATW and PBC are the best predictors of BI. PAE in the context of the 3 studies is the best predictor of DES. It is noteworthy to mention that ATW and PBC have a more significant effect when used in the TRA or TPB. When used in the MGB the weight of their contribution lowers. Since these two variables have a significantly higher contribution when used in models that posit a direct effect on intention, the mediating role of desire may be questioned. This however is not supported by the results. Direct paths from ATW and PBC to intention were tested in the preliminary analysis of the MGB and provided non-significant effects. PAE, on the other hand, has a significant effect on DES and on BI (both directly and indirectly). This is suggestive of the importance of emotional appraisal in eliciting desire and intention. This is in line with the argument of Bagozzi et al., (1998, see also Bagozzi & Lee, 1999), and that emotional appraisal, in the form of anticipated emotions, plays a major role in the formation of behavioral intentions and goals. The effects identified for PAE underline the importance of further studying the relation between anticipated emotions, desire and behavioral intention.

The contribution of SN stays relatively stable independently of the model used. As the number of social robots deployed increases it is reasonable to expect an increased awareness of the robots social repercussions and thus normative beliefs may become more salient.

Other researchers (e.g. Leone et al, 2005) have found that negative emotions have a higher impact on behavioral intentions, than positive emotions. This research however, found that NAE, although showing a statistically significant effect, has a reduced weight compared to PAE. One possible explanation for this may be the limited availability of experiences with real social robots. Hence people may be building their expectations based on their satisfactory interactions with current technology, like computers or smartphones.

Although this is the first attempt (to the researcher's knowledge) to apply the aforementioned socio-cognitive models to the question of the intention to work with a social robot in the near future, similar variables have already been used in research studying the factors that affect people's use of robots. For example, Heerink, Kröse, Evers and Wielinga (2009, September)[46], found that intention to use an assistive social robot predicts actual use and that the attitude toward using the social robot has a significant effect on intention. BenMessaoud, Kharrazi & MacDorman (2011)[47] studied use and acceptance of surgery-robots. They found that variables like perceived usefulness, facilitating conditions, attitudes towards using technology and subjective norm were facilitating factors, while perceived usefulness, perceived ease of use, complexity and perceived behavioral control were barriers to adoption. Graaf & Allouch (2013) found significant effects for user attitude and perceived behavioral control on the intention to use a social robot. They also found perceived behavioral control to have significant effect in the perception of ease of use of the social robot.

In short, the effects identified in this research for attitude towards working with social robots, perceived behavioral control, subjective norms and intention are in line with previous research results in the area of human robot interaction.

If on the one hand, there seems to be a general positive attitude both towards robots and towards working with a social robot. On the other hand, there is a considerably low desire and intention to work with a social robot in the future. Since variables like ATW and PBC are already above the medium point of the scale, while NAE are bellow, the challenge of increasing desire and intention may only be engaged via PAE. Although this variable was identified as an important contributor to desire and intention, its mean is similar to the medium point of the scale, which turns increasing PAE also challenging. In sum, even though the models are significant predictors of intention, an analysis of the means of the variables used suggests that the deployment of social robots will have to face some challenges, being the first leading people to move

[46] This study is based on the theoretical framework provided by TAM and its extended version the UTAUT. It should be noted however that the TAM is itself based on the TRA and its principles (see Davis, Bagozzi & Warshaw, 1989; Venkatesh & Davis, 2000 and Venkatesh, Morris, Davis & Davis, 2003).

[47] This study is on the theoretical framework provided by the UTAUT (see Venkatesh, Morris, Davis & Davis, 2003).

from a relatively positive position towards the use of social robots, into one in which they desire to use social robots and are willing to exert an effort to do so.

2.3 Factors External to the Socio-Cognitive Models

All the three models studied in this research posit that all the external variables will have their effect on intention and overt behavior mediated by the variables of the model[48]. Based on this postulate, it was posited that the appearance of the social robot, the belief in human nature uniqueness, perceived warmth, perceived competence, attitudes towards robots with human traits and attitudes towards interactions with robots would have a direct effect on ATW, PBC, PAE and NAE.

2.3.1 The belief in human nature uniqueness

There is a growing consensus on the importance of essentialism in social cognition and intergroup behavior. Research findings support its role in the attribution of a human essence to others in contexts such as group identity and stereotypes (e.g. Yzerbyt, Rocher & Schadron, 1997), inter-group conflict (Yzerbyt, Dumont, Wigboldus & Gordijn, 2003), and moral accountability (Zagefka, Pehrson, Mole & Chan, 2010).

The effects of essentialism are not circumscribed to human social interactions. Results from Gong's (2008) research suggest that racial prejudice transfers to interactions with virtual agents. In his study, participants were asked to order by preference fifteen white, black and robot virtual characters. Both explicit and implicit prejudice predicted preference for white versus black virtual agents. Among participants who reported little interest in robots, explicit racial prejudice predicted preference for the robotic virtual agent over the black virtual agent. Eyssel and Kuchenbrandt (2012) studied the effects of ingroup bias in the context of human robot interaction, showing that participants when rating a robot in terms of mind attribution, warmth, psychological closeness, contact intentions, and design showed a preference for the robot in the ingroup condition.

[48] Although all explaining models are in principle open to the addition of new variables, it is always desirable to strive for some parsimony. Ajzen (2011) argues vehemently that if a variable is to be added to the model, it should respect the following principles: 1) conform to the principle of compatibility; 2) be a possible causal factor of intention and behavior; 3) be independent of the existing predictors; 4) usable in a wide range of behaviors; and 5) consistently improve prediction of intentions and behavior.

The belief in human nature uniqueness scale draws from the ingroup bias and the differential attribution of secondary emotions (i.e. emotions that are thought to be distinctive of the human species), in order to gauge to what extent people assign for themselves these distinctive human traits, while denying them to social robots.

2.3.1.1 The BHNU Scale

The results of study 6, show that a stronger belief in human nature uniqueness is associated with a less favorable attitude towards robots. Interestingly, although correlated with both PNARS components, BHNU shares more variance with NARHT (24%) than with NATIR (11%). Results from study 6 also suggest BHNU is related to, but different from religiousness, since the two variables relate differently to PNARS. The BHNU is strongly related to attitudes towards robots with human traits, while REL shows a stronger relation to attitudes towards interactions with robots. This suggests that a belief in human nature uniqueness is not rooted in strict religious norms, thus allowing the use of BHNU irrespective of the religious cultural background of the participants.

Participants with a stronger interest in science fiction had an associated lower level of belief in human nature uniqueness. The familiarity and interest with cutting edge themes related to technology, space exploration and the existence of other intelligent species in the universe may explain this less human-centric perspective.

Study 8 investigated the effects of BHNU on ATW, PBC, PAE and NAE. BHNU is negatively correlated with ATW, PBC and PAE, and positively correlated with NAE. Regression analysis (Model 1) showed BHNU to be a statistically significant negative predictor of ATW, PBC and PAE and a positive predictor of NAE. It should be noted however that the inclusion of PNARS factors in the regression model (model 2), reduced the effects of BHNU to non-significant. Given the correlations identified in study 6 and study 8, between BHNU and the PNARS factors it is sensible to infer that the considerable percentage of variance shared by these variables is responsible for this effect. Further research to study the relation between PNARS and BHNU is recommended.

Three aspects about the effects of the BHNU deserve further scrutiny. First, BHNU has a significant effect on negative anticipated emotions. Negative emotions have been shown to affect behavioral intentions (Leone, Perugini & Bagozzi, 2005), thus a factor that increases negative anticipated emotions can hinder interactions with social robots and so deserves more attention. Second, by reducing PBC, BHNU can have a negative effect on people's willingness to attempt to work with social robots. Research on human computer interaction (HCI) as shown that self-efficacy is related to people's decision to use computers (Hill, Smith & Mann, 1987). Third, in both study 6 and study 8, BHNU was the variable with the highest mean (above 5 in a scale of 7). This is suggestive of the strength of this belief. Since BHNH was found to be more strongly correlated to NARHT, than to NATIR, it is reasonable to expect BHNU to play a relevant role in the acceptance of social robots with more human traits.

2.3.2 Attitudes towards robots

The NARS, was developed by Nomura et al., (2004, July) to assess the psychological factors that could prevent people from interacting with robots. Studies 2 through 5 tested the psychometric qualities of the Portuguese version of the NARS (PNARS). The Portuguese version is comprises two factors, negative attitudes towards robots with human traits and negative attitudes towards interactions with robots. It was posited that NARHT and NATIR would have a direct effect on ATW, PBC, PAE and NAE.

Results of study 5 show that NARHT is a statistically significant predictor of ATW and PBC, while NATIR is a statistically significant predictor of PBC. Results of study 5 are also consistent with the assumption that external variables have their effect on intention mediated by the determinants of behavior, showing that NARHT and NATIR have a statistically significant indirect effect on BI through ATW and PBC.

Results of study 7 show that although NARHT and NATIR are significantly correlated to ATW and PBC, only NARHT is a statistically significant predictor of ATW and PBC. Results of study 8 showed that both NARHT and NATIR are significantly correlated with ATW, PBC, PAE and NAE, but only NATIR is a significant predictor.

Although the results suggest that PNARS has an effect on ATW, PBC, PAE and NAE, they follow an irregular trend. NARHT is a significant predictor of all four variables on studies 5 and 7, and has no significant effects on study 8. On the other hand, NATIR is a statistically significant predictor of all four variables on study 8, but has no significant effects on study 7, and predicts only PBC on study 5. Given this, it is difficult to assert with some reliability what are the variables predicted by NARHT and NATIR. In all three studies PNARS was measured in equal circumstances, prior to viewing the video. However, when conduction the hierarchical regression analysis, different sets of variables were used. WARM, COM, NARHT and NATIR in study 7, and BHNU, WARM, COM, NARHT and NATIR in study 8. It was already mentioned that the analysis of the correlation tables for study 6 and study 8, showed that both PNARS factors were correlated with BHNU. Thus it is reasonable to expect some interaction effects between these two variables. Interestingly, NARHT showed a stronger correlation with BHNU, than NATIR. From a theoretical point of view, NARHT and BHNU are related concepts. Negative attitudes towards robots with human traits can be seen as a subset of beliefs about what attributes a person thinks a robot should not have. It is then suggested that further research on general attitudes towards robots should investigate the role of BHNU as an antecedent of PNARS.

Research on attitude-behavior consistency (e.g, Ajzen & Fishbein, 1977) has shown that general attitudes towards an object (e.g. towards Blacks, sports, BMW) demonstrate little predictive power towards a specific behavior (e.g., sitting near a black person, playing tennis, buying a BMW). This could explain the mixed results obtained by the researchers trying to predict actual behavior towards robots using NARS. The NARS is a general attitude measure towards robots with human traits (emotions, intentions, language) that does not make any assumptions about the appearance of the robot, the set of tasks, and context, and thus is not be a robust predictor of a specific behaviors. Nevertheless, has shown in studies 5, 7 and 8 general attitudes towards robots (NARHT and NATIR) have direct effects on the determinants of intention, ATW, PBC, PAE and NAE. These results, support the contention that, given its definition as a favorable or unfavorable tendency towards an object, and since that evaluative stance is based on the beliefs about the object, attitudes are an important factor underlying the determinants of behavioral intention.

2.3.3 Perceived warmth and perceived competence

Research on social perception, not only has confirmed the importance of this dichotomy, but has also linked it to characteristic subsets of affective and behavioral responses to other social agents. Some research results are suggestive of the role of social perception in human robot interaction. Research on virtual agent's believability found it to be correlated with the level of perceived warmth and competence (Demeure, Niewiadomski & Pelachaud, 2011).

Hinds, Roberts and Jones (2004), results showed that participants: relied more on the human partner then on the robot partners, reported lower levels of responsibility when working with the human-like robot, and relied more on the peer robot, than on the subordinate or supervisor robot. The robot presented as supervisor, received less credit for the work done and was more likely to be blamed for mistakes, than the peer and the subordinate robot. Although the study does not use explicit measures of competence, the effect of the robot's perceived status are in line with what would be expected from the framework of the stereotype content model.

Study 7 investigated the effects of warmth and competence on ATW and PBC. Results show that WARM is a significant predictor of ATW (both in model 1 and model 2), while COM has no significant effects on ATW or PBC (both in model 1 and model 2). WARM is also a significant predictor of PBC (model 1). The introduction of NARHT and NATIR in the regression model (model 2), reduces the effect of WARM to non-significant.

Study 8 investigated the effects of warmth and competence on ATW, PAE, NAE and PBC. COM was identified as a significant predictor of ATW (both in model 1 and model 2). WARM and COM were identified as significant predictors of PBC and PAE (both in model 1 and model 2). WARM was identified as a significant predictor of ATW (both in model 1 and model 2). These results suggest that WARM and COM may have different weights in determining ATW, PBC, PAE and NAE.

In short, results suggest that WARM has a stronger effect on PBC and PAE. The perception of warmth was earlier defined as the perception of the other social agent's intentions (good or bad) and was associated with traits like trustworthiness, sincerity, kindness or friendliness (*i.e.* traits associated with social support). As such, the perception of the social robot as warm, will transmit a sense of cooperation and support that may not only increase perceived behavioral control, but also increase the positive anticipated emotions elicited by the perspective of future cooperation. Since PAE were identified as the major determinant of desire to work with a social robot, these effects of WARM on PAE may have a significant role on the future willingness to work with a social robot. Likewise, the effects of perceived warmth on PBC, that is, the perception of the social robot as a cooperative partner will lead to a stronger sense of control and self-efficacy regarding the operation and the interaction with the social robot, also playing a role on the future willingness to work with it.

Results of the regression analysis suggest that the major effects of COM are on ATW and PAE. COM was earlier defined as the perception of the other social agent's capability of performing his intentions (competent vs. incompetent) and was associated with traits like efficacy, skill, creativity or intelligence. As such, the perception of the social robot as competent will transmit a sense of efficacy, contributing this way to a more favorable evaluation regarding working with it, that is, a more favorable attitude towards working with a social robot. This perception of a competent social robot, will also contribute to an increase in PAE, as the sense of being able to accomplish work diligently, with a competent partner will result in an anticipated sense of a successful effort.

Interestingly, although COM has an effect on both PBC and PAE, this effect is stronger on PAE. Since PBC is associated with the perceived capacity to perform a given action, this result is somewhat unexpected. The perception of the social robot as competent, should be one of the main factors contributing to PBC. However this can be explained by the hypothetical character of the task proposed. Given the limited contact that participants have with real social robots, it may be easier for them to imagine how they will fell cooperating with a social robot (*i.e.* PAE), than to imagine the concrete challenges posed by a real interaction (*i.e.* PBC).

One final note, should be made about the effects of WARM and COM. While the effects of WARM decreased from study 7 to study 8, the effects of COM went from non-significant to main contributor. Study 8 also included the measure of BHNU, and like it was already mentioned this variable may have unaccounted effects on NARHT. WARM deals with the attribution of social supportive traits, like sincerity and kindness, which can be seen as uniquely human. Thus it is not to exclude an interaction between BHNU and WARM. Given the role of WARM as antecedent of PAE and PBC and the role of BHNU as an antecedent of NAE, the relation of WARM and BHNU is one that deserves attention from future research.

2.3.4 Anthropomorphism

In Part 1 anthropomorphism was defined as "…imbuing the imagined or real behavior of nonhuman agents with humanlike characteristics, motivations, intentions, and emotions…" (Epley, Waytz & Cacioppo, 2007, p. 864). Research results suggest that individual differences in the way people anthropomorphize play a significant role in creating an empathic connection and for the judgments of responsibility and culpability of non-human objects (Waytz, Cacioppo & Epley, 2010). In the area of robotics, anthropomorphism is frequently confused with the attempt to use humanoid forms in robot design, what was earlier termed anthropomorphic form (Disalvo & Gemperle, 2003). Anthropomorphism on the other hand is independent of form. People attribute human psychological traits, to other living animals, or inanimate objects irrespective of their form. Anthropomorphism is a case of inductive inference, i.e. using available information about the human behavior, to explain the behavior of non-human agents.

Study 7 aimed to investigate the effects of anthropomorphism on ATW and PBC. However, as it was pointed out, the measure used for anthropomorphism (ANT), given its overreliance on social supportive anthropomorphic traits revealed a significant overlap with the measure of warmth, which also presented items relating to social supportive traits. For that reason it was decided that only the measure of warmth would be used. Thus, the effects describe in the above section for warmth are applicable verbatim to anthropomorphism. Nevertheless these results may be of limited use given the somewhat reductive operationalization of ANT. It is then recommended further work on the development of a measure that offers a better formalization of the concept in order to produce a more reliable analysis.

2.3.5 *The social robot appearance*

A considerable effort has been put in the study of the design of social robots in order to produce engaging robotic agents. Nevertheless this research as focused mainly on the manipulation of the robot appearance (e.g. head size and shape or the presence of limbs) in order to simulate some degree of humanness and to induce the perception of the robots capabilities. However this line of research offers little reflection on the socio-cognitive mechanisms underlying the person's perception of the social robot. In order to explore this knowledge gap, this research investigated robot appearance to gauge its effect on the following determinants of BI: ATW, PBC, PAE and NAE.

Study 7 tested the effects of two social robots, Snackbot, with a mechanical appearance, and Actroid DER, with an android appearance. A MANOVA was used to compare the effects of social robot appearance on ATW and PBC, with no significant differences being identified. Study 8 furthers the research by using three distinct appearances, Snackbot, with a mechanical appearance, Asimo, with a humanoid appearance and Actroid DER, with an android appearance. Effect of social robot appearance was also tested with a MANOVA. Dependent variables where: ATW, PBC, PAE and NAE. Social robot appearance was found to have a significant effect on ATW, PBC and PAE. That is, as the social robot gets more humanized, the levels of ATW, PBC, and PBC decrease. Participants, who saw the Snackbot presented a more positive attitude towards working with it, anticipate more positive emotions and believe they will be more competent in operating it, than those who saw the Actroid. It should also be noted that, while the means of these variables (ATW, PBC, PAE) for Snackbot are always significantly above the medium point of the scale (3.5), for the Actroid the values for ATW and PBC are close to the medium point, and for PAE is below the medium point (this is also true for ASIMO). These results have significant practical implications. They clearly suggest that the appearance of the robot has a significant effect on factors that determine the desire and intention to work with a social robot. Given this, the future deployment of social robots in professional settings should take into account that appearance may hinder, or facilitate this task.

Two possible explanations for the preference for Snackbot are advanced. The first draws on Masahiro Mori's uncanny valley effect. In the early 70's of the XX century, Mori advanced the idea that as a robot resembles more a human in appearance, its likeability increases, until a point where the similarity between robot and human induces feelings of eeriness and dread. Research on the causes underlying the uncanny valley effect, has been inconclusive with results suggesting a complex link between human appearance and eeriness (MacDorman, 2005; Seyama & Nagayama, 2007; MacDorman, Green, Ho & Koch, 2008; Saygin, Chaminade, Ishiguro, Driver & Frith, 2012). This apparent discomfort with humanoid realistic robots has lead authors to question if robots really need to look like humans (Duffy, 2006; Duffy & Joue, 2005). Recent research has framed the uncanny valley effect in evolutionary (Steckenfinger & Ghazanfar, 2009) and developmental terms (Lewkowicz & Ghazanfar, 2012) suggesting that this response may not be specific to the presentation of a realistic humanoid robot.

At first glance, the uncanny valley effect seems a reasonable explanation for the fact that Snackbot generate a more positive ATW, a higher sense of PBC and more PAE, than Actroid. But a closer look shows some fragility in this argument. According to Mori, has a robot looks more human, its likability grows, until a point where similarity produces an abrupt fall in likability, because although looking almost human, its lack of realness, becomes to apparent and eerie. As such, it would be more reasonable to expect likability to increase from Snackbot to Asimo and only decrease for Actroid, but what the results show is a constant decrease from Snackbot, to Asimo, to Actroid. As a side note, it should be remarked that a quick look at the graph showing the results of the MANOVA for NAE may suggest the uncanny valley effect. However, in spite of the absolute values showing that as we move from Snackbo to Asimo there is a decrease in negative anticipated emotions, and that moving from Asimo to Actroid leads to an increase in negative anticipated emotions, there is no statistically significant difference between these means, and thus, this apparent uncanny effect may be completely illusory.

The second explanation draws from a different line of research, believability of virtual agents. Researching on what factors contribute the most to the believability of a virtual agent, Demeure, Niewiadomski and Pelachaud's (2011) found that the first factor that was taken into account was emotional appropriateness and plausibility, and only secondarily, embodiment (physical features and animation). These results provide some interesting clues to explain why Snackbot received higher ratings than Actroid. Judgments of appropriateness and plausibility of emotional response are in part based on the perceiver's expectations about the agent and the context. Snackbot, given its simpler look will not create expectations of great emotional complexity and thus be seen as more congruent in its behaviors, than Actroid. Actroid on the other hand, given its attempt to simulate a human, will create expectations of emotional complexity, and thus, will be judged more harshly with every little deviance from "naturality" being noticed, hence reducing the sense of emotional appropriateness and plausibility. Although research on the effects of robot appearance has already been conducted, the effect of appearance on believability and emotional appropriateness is still lacking and should be pursued.

3. Practical Implications of the Results

3.1. Some clues for intervention

Social robots were defined as physically embodied agents endowed with a social interface in order to elicit social responses from humans. Contrasting with this, the social representation of robot identified in study 1 showed that people consider robots as technological machines. It may be equipped with high tech instruments, but it does not display emotions. The first challenge to be overcome for a successful employment of social robots is this wide gap between the current state of the art in robotics and the layperson's perception of what is a robot. Although there is an idea of robot and of some of its applications, it is the idea of a technology set far into the future. Given this state of affairs, before gearing an intervention towards the determinants of intention identified by the socio-cognitive models, it is necessary to bring the social representation of robot into par with the current state of social robots. This would mean providing the general public with information about social robots. Since the beliefs underlying the determinants of behavioral intention are themselves based on information about the object (*i.e.* a probabilistic reasoning about the properties of the object, in this case the social robot), the introduction of new information about social robots could also be used to set forward a change in beliefs about it.

According to the results of studies 7, 8 and 9 the best predictors of intention, if the TRA or the TPB are used, are ATW and PBC. If the MGB is used, the best predictor is DES. In order to increase the intention to work with a social robot the intervention should be targeted at one of these variables. However, in the case of the participants in this research, there is already a positive ATW, with the mean of this variable significantly higher than the medium point of this scale. Also, participants seem to perceive themselves as capable of working with social robots, with the mean of PBC also above the medium point of the scale. This means that, in this case, an intervention specifically geared at changing behavioral and control beliefs, even if effective, may not increase significantly the intention to work with a social robot. Besides, it is important to note that in spite of the already positive ATW and high PBC, BI presents a mean significantly lower than the medium point of the scale. This means that, in order to produce a meaningful change in BI, an intervention geared towards ATW and PBC would have to very significantly increase the level of favorableness towards working with a social robot and the sense of being able to work with it.

The MGB offers alternative paths of intervention. The other variable identified as a strong predictor of BI was DES. The means of desire through the three studies are below the medium point of the scale. This could explain the low BI. Studies 8 and 9 identified PAE as the best predictor of DES. Thus an intervention strategy targeting PAE would, in principle lead to an increased desire to work with a social robot. PAE are pre-factual appraisals, that is, the person imagines how she will feel performing successfully the intended behavior. Emotional appraisals are not directly affected by information. However information targeted at beliefs may indirectly affect PAE. Attitudes are by definition evaluative judgments (e.g. god vs. bad). A person holding a set of beliefs towards working with a social robot that associate this behavior with a set of positive consequences (e.g. being more efficient, being promoted, being admired by coworkers), besides having a positive attitude, will also anticipate that working with a social robot will make him feel joyful. Thus beliefs that associate social robots to more positive outcomes may indirectly increase PAE and thus, desire to work with a social robot.

In short, intervention must always start with a diagnosis of the current representation and beliefs about social robots in particular and robots in general, as these will provide the information necessary for the decision of what model and theoretical framework should be used to support the intervention. In the case of the participants of this research, the framework provided by the TRA and TPB offers two variables that in spite of having already relatively high means, produce a feeble behavioral intention. A change to the framework provided by the MGB, showed another possible path of intervention, through DES and PAE that could result in more significant changes in intention to work with social robots.

4. The role of variables external to the models

This research advanced that socio-cognitive factors like BHNU, NARHT, NATIR, WARM, COM and ANT could have an effect on the determinants of behavior. Results suggest that NARHT and WARM are positive predictors of ATW. NATH, NATIR and WARM are positive predictors of PBC. And NATIR, WARM and COM are positive predictors of PAE. That is, in order to promote a more positive attitude towards working with a social robot, one could promote a more positive attitude towards robots with human traits or devise a strategy that increased the perception of the robot as warm. To increase the sense of being able to use a social robot (PBC), one could promote a more positive attitude towards interactions with robots and robots with human traits. Likewise increasing the perception of the robots warmth would also increase PBC. Promoting a positive attitude towards interactions with robots, and increasing the perception of the robots warmth and competence will increase the level of PAE.

Research results also showed that NARTIR and WARM are negative predictors of NAE, while BHNU is a negative predictor of ATW, PAE and PBC. That is, in order to decrease the level of NAE, one could promote a more positive attitude towards interactions with robots and increase the perception of the robots warmth. A strategy aimed at decreasing the strength of BHNU would lead to more positive ATW, a stronger PBC, and an increase in PAE. However, since BHNU is rooted in beliefs about what it means to be human, it is probably not very amenable to change.

5. Avenues for Future Research

Although the results of this research answered some questions related to the intention to work with a social robot, they also pointed to the need for further studies. This section offers a brief summary of ideas deserving further investigation.

Live experiments

Although behavioral intention has received empirical support has a reliable predictor of actual behavior, given the novelty of social robots, extrapolating from the behavioral intention to actual use of social robots may be risky. It is then recommended the replication of these studies using real social robots in real interaction settings.

Exploring the role of desire

Desire was defined as the motivational element of the MGB, transforming reasons to act into an intention to act. Given the low means presented by the measure of desire in the curse of studies 8 and 9 further research is recommended. First in order to understand if the low mean is the result of an unreliable measure that does not account completely for the variable. Second to further understand how determinants interact to form a desire, clarifying the relation between beliefs (behavioral, control and normative) and anticipated emotions. And third, to clarify the process leading from desire to intention. For example Perugini & Bagozzi (2004a) distinguish goal desire and behavioral desire. They also recall aspects like desire feasibility that play a role in the decision to act.

Exploring the role of anticipated emotions

Results from study 8 and 9 showed PAE to be the main determinant of desire. This result warrants further research in order to clarify how anticipated emotions and desire interact. Study 8 and 9 also showed that PAE can have a direct effect on intention. Further research is recommended in order to understand under in what conditions this effect occurs and if it also applies to actual behavior. Finally, the appraisal conditions that underlie PAE and NAE should also be clarified.

Expanding the concept of subjective norm

In the context of this research subjective norm and significant others were defined in relation to the individual. However as Bagozzi (1992) argues, normative experiences are conditioned by social context, and thus a person can be an independent agent, part of a group or part of a formal organization. Future interactions with social robots will take place in formal organizational settings. Given this, future research should account for subjective norms defined in relation to work partners, supervisors and employers.

Clarifying the role of BHNU

Results of studies 6 and 8 suggest that BHNU may be related to PNARS, WARM and COM in ways not accounted by this research. The concept of belief in human nature uniqueness draws from research on social cognition and intergroup bias, where the notion of a human essence has been found to be related to the attribution of responsibility and empathy towards ingroup and outgroup members. Given the apparent core role played by the attribution of human unique traits in social interactions, the concept of BHNU should be regarded with further attention.

Operationalization of Anthropomorphism

The research presented in the theoretical underpinnings support the contention of the role of anthropomorphism in social interactions. However given the significant overlap between the measures of WARM and ANT, identified on study 7, it was not possible to assess in a reliable manner the effects of ANT. Nevertheless if WARM is considered as a proxy of ANT, some ideas can be drawn from the results of studies 7 and 8, which suggest that WARM/ ANT plays a role in PBC and PAE. It is then recommended further work on the development of a measure that offers a better formalization of the concept in order to produce a more reliable analysis.

Social robot appearance

Although research on the effects of robot appearance has already been conducted, research on the effect of appearance on the determinants of behavioral intention is still incipient. Results from study 8 suggest that the discussion on how humanoid a robot should look is not closed, and that further research is necessary and should be pursued.

Limitations of this study

The main limitation of this research is not using real robots in a live setting. However, given the still limited presence of social robots, other methodologies had to be considered, thus the focus, not on overt behavior (i.e. actually working with a social robot) but on behavioral intention, (i.e. the intention to work with a social robot in the near future). Although some objections may be raised to this option, Ajzen (1985) himself, pointed out that: “although complete applications of the theory require assessment of all variables from beliefs to overt behavior, many questions can be answered by investigating a more limited set of relationships. (…) In other cases, the intention-behavior relation is of little immediate concern; instead, the theory’s ability to predict and explain intentions is at issue. In these instances, it is unnecessary to secure a measure of the actual behavior.”

Also, given the research results presented in the theoretical underpinnings, there is ample empirical support to the contention that behavioral intention is the most proximal predictor of behavior. Therefore, this focus was considered compatible with the objective of studying the intention to work with a social robot in the near future. Furthermore, by focusing on intention, and not on actual behavior allows the use of these models in contexts were social robots are being deployed for the first time.

This however, does not mean that research in live settings with real robots is not necessary and should not be pursued. In fact there are compelling arguments for the need of direct experience with robots, since research results suggest that direct and indirect experience may have consequences on both attitude-behavior consistency and on attitude proprieties. Information learned by direct experience stems from a direct contact with the attitude object through sampling, trial, inspection (for a product) or face-to-face interaction (with group members). Regan and Fazio (1977) suggested that in comparison to indirect experience, direct experience produces attitudes which are "more clearly, confidently, and stably maintained". Fazio and Zanna (1981) also speculated that direct experience may provide more information about the object and this information may be more available in memory. Having more information at hand, one could then feel more confident in one’s attitude.

Attitudes formed on the basis of prior direct experience have been shown to be more predictive of the subsequent behavior and held as more certain. Regan & Fazio (1977) in a field study have shown that attitudes of students living in temporary housing predicted better the signing of a petition than attitudes of students who knew about the housing shortage but did not experience it (study 1). Furthermore, in a laboratory study they asked participants to solve puzzles (direct experience) or they told participants how to solve them (indirect experience). Then, participants were given the opportunity to play with the puzzles. Results showed that participants with a direct experience displayed a greater attitude-behavior correlation ($r = .53$) than participants with indirect experience ($r = .21$). These results have been replicated by Fazio and Zanna (1981, study 1).

In the studies conducted for this research, participants had an indirect experience with social robots (*i.e.* through video). Since direct experience vs. indirect experience seems to have an effect on attitude formation and strength it is also reasonable to posit that it will have an effect on the other determinants of behavioral intention, and thus in actual behavior. For these reason, replicating this research in an experimental setting that allows a direct experience with social robots would help clarify some of the effects observed herein.

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