LISBON SCHOOL OF ECONOMICS & MANAGEMENT
UNIVERSIDADE DE LISBOA

MASTER

MANAGEMENT INFORMATION SYSTEMS

2018/2019

MASTER'S FINAL WORK

DISSERTATION

SOCIALLY ASSISTIVE ROBOTS ADOPTION

MARIA CAROLINA MATOS ROLO DE ALMEIDA GOMINHO

OCTOBER - 2019

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ORIENTATION:

PROFESSOR DOUTOR ANTÓNIO PALMA DOS REIS

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List of Acronyms

10VAF – 10-point visual analogue format

AVE – Average Variance Extracted

CFI – Comparative Fit Index

CMB – Common Method Bias

CR – Composite Reliability

EU – European Union

FP7 – 7th Framework Programme

GDPR - General Data Protection Regulation

GFI – Goodness of Fit Index

HRI – Human-Robot Interaction

ICT - Information and Communication Technology

INE – Instituto Nacional de Estatística

MSV – Maximum Shared Variance

OCDE - Organization for Economic Co-operation and Development

RFID – Radio Frequency Identification

RMSEA – Root Mean Square of Error Approximation

SAR – Socially Assistive Robots

SEM – Structural Equation Modeling

UN – United Nations

UTAUT – Unified Theory of Acceptance and Use of Technology

VIF – Variance Inflation Factor

Abstract

With the world population ageing rapidly comes an increase in the number of people requiring care from others. However, the phenomenon also brings the consequence of a decrease in the number of people capable of providing such care. Societies are then increasingly left with a gap which must be bridged for the elderly to be afforded to age with the dignity and the care which they deserve. One way to close said gap can be found in the field of assistive technologies. Socially Assistive Robots (SAR) are one such, relatively recent, assistive technology that offers support to humans through social interaction. The aim of the current study is to investigate how the elderly Portuguese population would respond to this kind of technology, more specifically, what their propension for adoption would be. In other to meet this objective, three aspects had to be looked into and assessed: what factors influence the adoption of Socially Assistive Robots, which of the robots' functionalities people find to be of most use and what are the main concerns permeating the adoption process. Thus, firstly a review of literature gathering the necessary information from previously conducted studies was put together. Secondly, a quantitative study based on the application of questionnaires to the Portuguese population aged 65 and over was conducted. In order to study the robot acceptance factors, an adaptation of the second version of Unified Theory of Acceptance and Use of Technology was created and deployed. The study results showed the importance of finding solutions that are cost efficient and considered fun to use and indicated that the people inquired seem to prefer solutions with functionalities related to guaranteeing their safety. While not being as encompassing as initially desired, the present dissertation serves to complement the knowledge base being currently built around this topic, illuminating and informing the work of individuals focused on designing Socially Assistive Robots.

Keywords: socially assistive robots, SAR, robots, assistive technologies, population ageing, elderly care

Resumo

Com o rápido envelhecimento da população mundial, verifica-se um aumento do número de pessoas que requerem cuidados da parte de outrem. Contudo, o fenómeno mencionado tem, também, a consequência de uma redução do número de pessoas disponíveis para prestar tais cuidados. Como tal, as sociedades são cada vez mais forçadas a lidar com esta discrepância que deve ser colmatada de modo a permitir aos idosos envelhecer com a dignidade e os cuidados que estes merecem. Uma forma de colmatar tal discrepância pode ser encontrada no campo das tecnologias de apoio. *Socially Assistive Robots* (SAR) são um tipo, relativamente recente, de tecnologia de apoio capaz de apoiar os humanos através da interação social. O objetivo do presente estudo é investigar o modo como a população idosa portuguesa reagiria a este tipo de tecnologia, mais especificamente, qual seria a sua propensão para adoção. De modo a ir de encontro a este objetivo, três aspetos tiveram de ser investigados e avaliados: quais os fatores que influenciam a adoção de *Socially Assistive Robots,* quais das funcionalidades dos robots são tidas como sendo mais úteis e quais as principais preocupações que se afigurariam num processo de adoção. Para esse fim, primeiro foi conduzida uma revisão da literatura onde foi recolhida informação relativa a estas questões disponível em outros estudos. De seguida, um estudo quantitativo baseado na aplicação de questionários à população portuguesa com 65 ou mais anos foi levado a cabo. De modo a estudar os fatores que influenciam a adoção dos robots, uma adaptação da segunda versão do modelo *Unified Theory of Acceptance and Use of Technology* foi criada e operacionalizada. Os resultados do estudo demonstraram a importância de encontrar soluções eficientes ao nível dos custos e consideradas divertidas de utilizar e indicaram que as pessoas inquiridas parecem preferir soluções com funcionalidades destinadas a garantir a sua segurança. A presente dissertação, embora não tão abrangente como inicialmente desejado, serve para complementar a base de conhecimento a ser constituída em torno deste tópico, iluminando e informando o trabalho daqueles que desenvolvem *Socially Assistive Robots.*

Palavras-chave: *socially assistive robots*, SAR, robots, tecnologias de apoio, envelhecimento da população, cuidados a idosos

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1. Introduction

1.1. Research Problem

The world population is aging rapidly. According to a study published by the United Nations (UN, 2017), in 2017 the number of people aged over 60 was 962 million. By 2050, that number is expected to reach 2.1 billion, roughly 16% of the world's population. The ageing process is more advanced in Europe and North America, but other areas of the globe are growing old as well. The UN attributes such a worldwide phenomenon to a decrease in fertility accompanied by an improvement in survival.

The scenario in Portugal follows this trend. According to Instituto Nacional de Estatística (INE, 2017), between 2015 and 2080 the number of elderly people (people aged 65 or over) will have gone from 2.1 million to 2.8 million. Simultaneously, a decrease in population aged under 15 is expected to occur, decreasing to 0.9 million by 2080. The two trends combined will cause the ageing index to more than double – there will be 317 people aged 65 or older per every 100 people aged under 15. The active population (population aged between 15 and 64) in Portugal was 6.7 million in 2015. By 2080 that number is expected to have decreased to 3.8 million. Due to the combination of an increasing older population with a decreasing active one, INE (2017) expects that by 2080 there will be 137 people of active age for every 100 elderly ones.

According to Botia et al. (2012), *aging society* is the term used to englobe all the consequences arising from the sharp increase in the population's average age. Such consequences include an increase in the number of people requiring care and support from others. As stated by Melo and Barreiros (2002), as someone ages, the deterioration of the nervous system makes processing information more of a challenge. Consequently, older people suffer from memory troubles and difficulty in learning, as well as in making decisions. At a motor level, movements that are quick or require processing of external information become difficult to perform. Because of a loss in perception when it comes to most senses, elderly people have trouble controlling their march, move slowly and are at an increased risk of falling. Additionally, an ageing society sees an increase in the occurrence of pathologies associated with age such as dementia. According to a report published jointly, in 2018, by the Organization for Economic Co-operation and Development (OCDE) and the European Union (EU), that year there were 9.1 million people aged over 60 living with dementia in the EU. In the next couple of decades, said number is expected to increase by 60% reaching 14.3 million people by 2040. Besides or, sometimes, due to dementia, other conditions like depression seem to be common in people of a certain age and must also be monitored (Shibata & Wada, 2010).

In summary, what seems to be taking place is an increase in the number of people requiring support and care from others accompanied by a decrease in the number of people capable of offering such care. This leaves societies to ponder what to do with their elderly and, more specifically, how to allow them to age with the care and dignity which they deserve.

The solution to such a problem might be coming in the form of technology, especially the assistive kind. Socially Assistive Robots (SAR) are a type of technology designed to support humans through social interaction. It is possible to define them as robots that "… create close and effective interactions with a human user for the purpose of giving assistance and achieving measurable progress in convalescence, rehabilitation, learning, etc." (Feil-Seifer & Matarić, 2005, p.465). We should note that the technology in question is still relatively recent and, as such, most of the studies developed are exploratory in nature. Still, the potential of the area is strong, with benefits being shown in the support of people suffering from impairments at a cognitive or mobility level. Therefore, it seems plausible to declare SAR as a technology positioned to accompany and mitigate some of the consequences of the demographic evolution. In the face of population ageing and consequent reduction of caretakers available, SAR offer extensive monitorization and encouragement allowing elderly people to live lives of quality and to live as independently as possible.

1.2. Objectives and Research Questions

By having an ageing society, Portugal will tend to have more and more citizens that could benefit from socially assistive robots' help. It is important to know, however, if those citizens would be open to such technology. Thus, the main objective of the present dissertation is to study the propension of elderly Portuguese people for the adoption of SAR. To that end, a comprehensive literature review focused on the ways in which SAR can be of use to the elderly, robot acceptance factors and adoption concerns was compiled.

Additionally, a quantitative study based on the application of questionnaires was conducted. These looked to determine what factors seem to impact SAR acceptance, which of these robots' skills are of more value and what are the main concerns permeating the adoption process.

Thus, the study looks to find answers to the following questions:

a) Which factors determine SAR acceptance by elderly people?
b) Which of the robots' skills are of more value to the elderly?
c) What are the main concerns troubling the elderly when it comes to adoption?

2. Review of Literature

2.1. Defining socially assistive robots

SAR "…has emerged as a promising and growing area of HRI that uses robotics for the provision and administration of motivation, encouragement, and rehabilitation for those suffering from cognitive, motor and social deficits." (Wade et al., 2011, p.218). According to Feil-Seifer and Matarić (2005), SAR exist in the intersection of two concepts: assistive robots and socially interactive robots. Assistive robots offer help or support mostly through physical contact with the user. Socially interactive robots have the sole purpose of establishing close and effective relationships with humans. SAR share with the first type of robot the goal of aiding humans and with the second type the focus on social interaction. These robots are considered good therapeutic tools as they can adapt to the user's needs and their behaviors tend to be more predictable and repetitive than that of humans' (Fosch-Villaronga & Albo-Canals, 2019). Additionally, the reduced or total absence of physical contact makes them safer and they can be used at home, at the hospital or in care facilities. So far, research done in the field of question seems to focus mostly on aiding individuals with reduced cognitive ability or mobility, victims of strokes in need of rehabilitation and children with Autism (Tapus et al., 2013). Ideally, SAR must be capable of recognizing and interpreting a user's emotional state, processing and expressing emotions through a variety of modalities (e.g. voice, movement, facial expressions), communicating and keeping perspective in order to express personality and empathy (Tapus et al., 2013). The robot should be easy to operate without placing a further burden on the caregiver and be able to adapt to the changing needs of its users. It must also allow for different modes of interaction such as speech (synthetic or prerecorded human voice), gestures or direct input (Feil-Seifer & Matarić, 2005). SAR can take on many different forms. Some, as is the case of PEPPER, are built with features that closely resemble those of humans – they are humanoid robots. Others, like the robot PEARL, are more basic in their design possessing more mechanical features. Additionally, there are robots like PARO that are built to be animal-like. SAR can be built from scratch or be adapted from already existing robotic toys. What is important is that they are built with the specific intent of aiding humans (Rabbitt et al., 2015). SAR can be seen as "… an interdisciplinary field that combines robotics, engineering, medicine, communication, and psychology and has a wide range of real and potential applications." (Rabbitt, et al., 2015, p.36). These applications, when it comes to the support of elderly people, can be varied and will be the focus of the next section of this review of literature.

2.2. Areas of support

2.2.1. Comprehensive solutions

Some researchers have tried to develop all-in-one solutions specifically designed to allow the elderly to age well at home, as people seem to prefer it since it allows them to keep their independence (Do et al., 2018). According to Schiffer et al. (2012), a nursing home should be the last case resource. Staying in a familiar space, such as one's own home, during as long as possible, is key to maintaining quality of life. While certain tasks become progressively difficult to accomplish, being capable of caring for oneself and being active in one's community are essential steps to maintaining independence and living with dignity.

Under the guise of EU FP7 (7^{th} Framework Programme), the European Union's Research and Innovation funding program for 2007-2013, HOBBIT was developed. At its inception, HOBBIT was designed to assist the elderly in their own homes mostly through fall prevention and emergency handling (Fischinger et al., 2016). Since 2011, two HOBBIT prototypes have been developed. The most recent version, HOBBIT PT2, includes functions like automatic fall detection - the robot identifies body/fall instability or the user lying on the floor and a predefined gesture or voice command can also be preset for the user to ask the robot for help in an emergency (Fischinger et al., 2016). HOBBIT PT2 has fall prevention measures such as clearing the floor from clutter, transporting small items as well as searching for objects as programmed by the user. In case of need (e.g. if the user falls) the robot can place emergency calls, communicate with family members and maintain a calming dialogue with its user. Additionally, the robot offers reminders to the user regarding appointments, medication or the need to eat or drink. Other robot capabilities are less serious and more geared towards keeping the user entertained – HOBBIT PT2 can play the radio, music, games or audiobooks and even has exercise (exercises are shown in the robot's screen which the user must then repeat) and video chat functionalities (Pripfl et al., 2016). When it comes to user acceptance of such a robot, HOBBIT PT2 was tested in the homes of seven elderly persons during three weeks per user. The test results were somewhat ambivalent – the users appreciated the robot and its functionalities very much (especially finding and picking up objects, offering reminders, emergency detection and fitness) but did not feel as if the robot had increased their independence or made them feel safer in their home. This might be because the people chosen to participate in the study were still relatively healthy and capable of carrying out by themselves most of the tasks the robot was meant to help them with. The test participants indicated that people with more severe mobility impairments, more isolated or fragile could have appreciated the robot's support much more. It is also important to note that the prototype tested was too basic and not robust enough causing some users to have a poor experience which might have reflected negatively on their opinions regarding the robot's potential and usefulness (Pripfl et al., 2016).

Another EU FP7 project, CompanionAble, has the goal of integrating a socially assistive robot (HECTOR) with a smart home environment with the purpose of allowing people with mild cognitive impairments to maintain an independent life (Schroeter et al., 2013). The robot must work in tandem with the smart home in order to access the network infrastructure, additional sensors, static interaction devices and remote-control capabilities such as to turn lights on/off and open/close curtains. Infrared presence sensors help monitor the user's whereabouts within the home. One of the system's functionalities includes keeping an agenda for the user in which things like events, appointments or lists are kept. When one of these events is close, the robot will find the user and remind him/her of it. Additionally, activities (e.g. reading a newspaper, eating or drinking) can be introduced in the agenda by caregivers with the robot, occasionally, suggesting one to the user. HECTOR can also help the user communicate through video chat with formal (e.g. doctors, nurses, therapists) or informal (e.g. family, friends) caregivers. In order to stimulate the user's cognitive abilities, a Cognitive Training application is included. It contains a variety of cognitive exercises that can be pre-approved by the user's doctor or therapists who have access to performance results. Another important skill of the robot is keeping track of the user's personal belongings. The robot has a basket and can recognize when a Radio Frequency Identification (RFID) tag is placed in it. By putting tags in personal items like wallets, keys, phones or glasses and placing the items in the basket, the robot can keep custody of them. Through presence sensors placed in the hallway the robot knows when the user is about to leave home; the robot approaches him/her and asks when he or she is planning to return. Based on this answer, it reminds the user of agenda events happening in the time the user is absent, suggests certain items the user might want to take and offers to turn off the lights or close the curtains. When the robot detects the user has returned home (through a front door sensor), it welcomes him/her, informs the user of any missed calls or events and invites the user to place his/her personal items in the robot's basket. The system was tested in smart home environments in Belgium and the Netherlands. In total, eleven people (5 couples and one single person) lived in the smart homes for two consecutive days. In all the couples, one person had been diagnosed with some form of dementia and the other was his/her caregiver. Overall, the robot was perceived as helpful not only to the elderly but to the caregivers whose burden would be slightly alleviated. Even though participants were initially frightful, after interacting with the robot, their reactions were quite positive. Eventually all users found the trials to be enjoyable. The patients found the robot entertaining, tended to attribute a personality to it, and suggested improvements so that it was even more adaptable to their needs. The robot's proactive attitude was extremely appreciated. While the trial did not involve a lot of participants and was of short duration, these results are encouraging as people seem open to a system of this kind.

2.2.2. Other applications

Above, examples of pretty comprehensive solutions to allow users to age well in their own homes have been presented. There are, additionally, other solutions that, while not as comprehensive, can also aid the elderly. For instance, Pino et al. (2015) reference how SAR can help users with everyday tasks such as online shopping, journey planning or by providing the weather forecast.

When it comes to more health-related capabilities, Pino et al. (2015) make mention of robots that can, through sensors and algorithms, monitor the user's physiological signs and behavioral patterns (e.g. sleeping patterns) alerting caregivers in case of relevant anomalies. Such is the case of the GiraffPlus system (Coradeschi et al., 2014) that, through a network of sensors, can not only monitor the user's health state but also keep up with where the user is in the house, if is sitting in a couch or lying in bed or, for instance, if is using electrical appliances. All the gathered information is processed and, if such is necessary, an alarm is sent off to the user and/or to the primary caregiver. The information gathered is stored in a database being accessible to the primary user and to caregivers through personalized interfaces. At the center of this system is a telepresence robot named GIRAFF. The robot is mostly used so that the user can receive “virtual visits” from caregivers. That way, not only can the user and the caregiver discuss the information gathered through the sensors but, as the robot is mobile and can be operated remotely by the caregiver, he or she can also assess the user’s health state and living conditions (Coradeschi et al., 2014). This is convenient to any person but can be particularly beneficial for those who struggle with leaving their homes.

Recognizing the importance of exercise in maintaining certain motor functions as well as avoiding a cognitive decline (Piezzo & Suzuki, 2017), both Lofti et al. (2018) and Fasola and Matarić (2013) built robots destined to help the elderly exercise. The robot takes on the role of a coach, demonstrating exercises, monitoring performance and offering encouragement. Test results were positive in both cases. Users considered exercising with a robot more fun than doing it alone and future compliance with the exercise program was shown to be higher when the robot is involved (Lofti et al., 2018). Piezzo and Suzuki (2017) as well as Montemerlo et al. (2002) showed the potential of SAR as walking aids for the elderly. Walking can be another form of physical exercise, useful in the maintenance of motor skills, accessible to all and facilitating of social interactions as it is performed outside (Piezzo & Suzuki, 2017). Additionally, when accompanied by a robot, the risk of falling is reduced. Socially assistive robots’ role in this context is to motivate the users to walk, accompany them, monitor their performance and help if necessary. Piezzo and Suzuki (2017) tested the humanoid robot PEPPER and found it capable of adapting its behavior to the user’s performance. The study at hand showed that while the participants (eight people aged between 73 and 92) may not have had complete trust in the robot they were not fearful either, walking closely to and even touching it.

One of the main areas of research in the field of SAR focuses on the support that these robots can offer to individuals suffering from dementia. For these patients, therapies based on playing with animals seem beneficial (Libin & Cohen-Mansfield, 2004). However, since there are situations in which the use of real animals might not be safe or possible, the usage of robotic ones has been tested with researchers finding very few differences between the two (Libin & Cohen-Mansfield, 2004; Banks et al., 2008). Perhaps the most famous and commonly used robotic animal is PARO. This robot, specifically designed for therapy use, resembles a baby harp seal. Both Abdi et al. (2017) and Marti et al. (2006) studied the effects of PARO on dementia patients finding a reduction in anxiety, stimulation of sociability, less agitation and depression levels and more positive emotions. Abdi et al. (2017) also found that the positive effects of SAR on dementia patients seem clearer when the interaction takes place in a group setting instead of in a one-on-one scenario. SAR can also be used in games designed to help patients with dementia practice their memory. The robot BANDIT was used in a music-based game in which the user had to guess the title of songs being played by the robot (Tapus et al., 2009). In the study (with a six-month duration) participated four people aged over 70 with a degree of cognitive impairment considered low or moderate. While the sample was too small to tell for sure, all patients were able to keep their attention on the game for a long period of time. All of them showed an improvement in their performance proportional to their cognitive skills.

PARO has been used not only in the therapy of patients with dementia but also in helping mitigate the symptoms of depression which seem to be somewhat common in elderly patients both as a consequence and outside of dementia. Shibata and Wada (2010), attest to said robot's capacity to improve patients' moods as well as help both patients and therapists overcome stress. Its effects on the symptoms of depression also seem promising. Robinson et al. (2013), tested PARO with residents of care homes and hospitals exhibiting symptoms of loneliness and depression. They found that individuals who interacted with the robot reported a decrease in their feelings of loneliness. The robot seemed to have a positive impact on the social environment becoming a topic of conversation for both patients and professionals. It was also found that the robot was capable of keeping the patients entertained which reduced some of the burden placed on the professionals. PARO, whilst more sophisticated, is not the only robotic animal that can help elders. Banks et al. (2008) showed how the commercially available robotic dog AIBO can reduce elderly people's feelings of loneliness. What we see then, is socially assistive robots' potential not only in mitigating the symptoms of a serious condition such as dementia but also as possible companions, being able to improve moods and decrease people's feelings of loneliness. While researchers have tested these robots mostly with nursing home residents, PARO and other animal-like robots could serve as companions for the elderly who live alone and, possibly, isolated.

2.3. User Acceptance

2.3.1. Acceptance Factors

According to the available literature, SAR acceptance varies according to a few different variables such as the robot's physical presence or embodiment – users have been found to consider embodied robots (as opposed to digital versions) as more satisfactory, present, helpful and useful (Matarić et al., 2007; Fasola & Matarić, 2013). The robot's voice (Matarić et al., 2009), the type of robot at hand (Pino et al., 2015; Vandemeulebroucke et al., 2017) and the robot's engagement (Matarić et al., 2007; McColl & Nejat, 2013) have also been shown to affect acceptance. Another factor considered relevant is the robot's personality (defined by proxemics, speed of movement, speech patterns, etc.) – users are more likely to accept robots with personalities close to theirs (Tapus & Matarić, 2008; Matarić et al., 2009). One step further, is the robot's ability to adapt its personality to that of its different users – when such is possible, user compliance and performance tend to be higher (Matarić et al., 2009; White et al., 2013). A few different authors (Orrel et al., 2008; Louie et al., 2014; Pino et al., 2015) found that the role played by those questioned (e.g. patients, caregivers, etc.) affects perceptions of the robot's usefulness, the needs it should meet, the most adequate type of robot and the tasks it should be capable of completing. Another factor determinant of acceptance and use seems to be the robot's capacity to adapt, through time, to the user's capabilities (Montemerlo et al., 2002; White et al., 2013; Louie et al., 2014). The available literature makes light of the way sociodemographic variables can affect the acceptance of SAR. These include the age of potential users. While older people tend to be more skeptical and closed off to technology, if its benefits are clearly laid out, they tend to be much more open and accepting (Ezer et al., 2009; Flandorfer, 2012). Additionally, elderly people seem more open than younger ones to accept robots as social entities (Nomura & Sasa, 2009). Gender has also been shown to be a relevant factor when it comes to acceptance (Heerink et al., 2006; Flandorfer, 2012). It seems that men are more open to technology in general as well as less afraid of becoming dependent on others. However, it must be said that men seem to be more experienced with technology, especially when considering the older generation. In fact, both technological literacy and education have a positive effect on the reception of technology in general and robots in particular (Flandorfer, 2012). The last sociodemographic variable of note is culture – if a robot is able to adapt to the characteristics of a certain culture (especially the preferred style of communication) it is more likely to be accepted by its users (Wang et al., 2010). Flandorfer (2012) points out that sociodemographic variables can interact between themselves not always being entirely correct to credit acceptance to just one (e.g. technological literacy can mitigate age).

2.3.2. Adoption Concerns

Despite their potential, the usage of socially assistive robots still raises some questions. Perhaps the main concern is that SAR will cause users to lose contact with other humans (Sharkey & Sharkey, 2012). However, it could be said that SAR can be of use to elderly people who live on their own, no longer have contact with their family or friends and may reside in fairly remote areas where medical care is not as readily available. Another concern of notice is the possibility that SAR replace human professionals, especially therapists (Pino et al., 2015). While this is a valid concern and it is true that robots are being designed to be increasingly autonomous, SAR are not meant to replace humans. They will still likely need some human input such as to program them to a specific user's needs. It also seems important to note that SAR can take on more repetitive work leaving professionals to deal with more demanding situations (Rabbitt et al., 2015). It appears that older adults are concerned with the possibility of becoming completely dependent on a robot (Heerink et al., 2006; Vandemeulebroucke et al., 2017). The literature shows that both elderly and younger people worry about the stigma associated with such a reality (Pino et al., 2015). They are afraid that this casts older people as not worthy of human attention having to be tended to by a machine – in a way, robots being used to unload the burden placed on caregivers (Sharkey & Sharkey, 2012). This also ties into the fear that elderly people interacting with robots that resemble toys may infantilize them (Vandemeulebroucke et al., 2017). On the topic of users depending on robots, one very common concern is that, especially with more realistic looking robots, users might become overtly attached going as far as considering the robot to be real (Sharkey & Sharkey, 2012; Rabbitt et al., 2015). As a consequence, they may expect more from the robot than it is capable of giving such as expecting the robot to reciprocate the care they bestow upon it. Sharkey and Sharkey (2012) argue that any situation in which a human considers a robot to be their companion involves some degree of dissimulation. They worry about how ethical such a unilateral relationship can be. Privacy concerns may also be raised (Vandemeulebroucke et al., 2017). After all, SAR do monitor the user and record some degree of information. Questions can be raised about how the data recorded is being stored and processed. Notwithstanding, users do have some control over the robot. They can authorize or decline access to certain information and send the robot away when not wanting to be monitored (Feil-Seifer et al., 2007; Battistuzzi et al., 2018). Additionally, regulations like the General Data Protection Regulation (GDPR), in place in the EU, must force further considerations about how data is being handled and protected (Fosch-Villaronga & Albo-Canals, 2019). A very commonly raised concern has to do with how elderly people may no longer possess the skills to use a robot. This has both to do with technological skills (Rabbitt et al., 2015) and cognitive capabilities (Flandorfer, 2012). When it comes to the former it is important to note there might be a generational effect at play – as the current younger generations grow older this will, most likely, not be a challenge posed to them. Recognizing this aspect though, developers are working towards creating SAR that will not be more difficult to operate than a smartphone (Rabbitt et al., 2015). Concerning the lack of cognitive capabilities, it is true that an individual with an advanced case of dementia might not be able to operate a robot. However, robots designed for use by this kind of patient, like PARO, tend to be quite simple and can be relatively easily set up by a caregiver. Other concerns also found in literature have to do with the robot's safety and cost (Rabbitt et al., 2015; Pino et al., 2015). When it comes to cost, it is indeed true that SAR can be expensive. While most of the mentioned robots are still in development stages, the few available in the market are expensive. As an example, an AIBO[1] costs around $2900, a PARO[2] robot retails for around £5000 and the telepresence robot GIRAFF[3] goes for around $12000. These are in line with cost estimates for robots looking to enter the market – the makers of HOBBIT PT2 have the goal of selling it for around €15000 (Pripfl et al., 2016). However, they are a one-time investment, may be shared by different users and as production increases the costs can be expected to lower (Shibata & Wada, 2010). In relation to safety, it should be noted that SAR do not require physical contact with the user to be operated. Finally, certain issues of legal nature might also have to be considered when it comes to using SAR. It is important to consider if the available laws cover the usage of SAR – not only

[1] https://direct.sony.com/aibo-ERS1000W/
[2] https://www.paroseal.co.uk/purchase
[3] https://telepresencerobots.com/robots/giraff-telepresence

the aforementioned issue of data privacy but also in relation to any possible damages they may cause (Alaiad & Zhou, 2014; Fosh-Villaronga & Albo-Canals, 2019).

2.3.3. Technology Acceptance Models

In order to assess user propension to adopt a certain technology, a few authors (e.g. Venkatesh et al., 2003; Heerink et al., 2010; Venkatesh et al., 2012) have developed technology acceptance models. Heerink et al. (2010) developed the Almere model with the purpose of predicting acceptance of socially assistive agents (robots or virtual/screen agents) by the elderly. The model has different constructs that seem to impact the elderly user's intention to accept and actually use socially assistive agents (Heerink et al., 2010): (1) Perceived Usefulness (the extent to which someone believes the system would be assistive), (2) Perceived Ease of Use (the extent to which someone believes using the system would be effortless), (3) Social Influence (the individual's perception that the people close to him/her believe he/she should or shouldn't use the system), (4) Facilitating Conditions (existing factors in the environment that facilitate the use of the system), (5) Intention to Use (the intention to use the system for a longer period of time), (6) Perceived Enjoyment (feelings of joy or pleasure derived from using the system), (7) Perceived Adaptiveness (the perceived capacity of the system to adapt to its user's needs), (8) Social Presence (feeling of sensing a social entity when interacting with the system), (9) Perceived Sociability (the system's perceived ability to perform behavior that is social), (10) Trust (believing the system will perform with integrity and reliability), (11) Attitude towards technology (the potential user's positive or negative feelings about the appliance of the technology) and (12) Anxiety (having anxious or emotional reactions evoked by the system). There are a few similarities between these constructs and some of the factors already identified in this review of literature as affecting adoption of SAR. When it comes to Social Influence, we have seen how often the elderly person and his/her caregivers have different views regarding the robots and how the caregivers often react positively to them as a form of unloading some of the burden that is placed upon them (Schroeter et al., 2013; Robinson et al., 2013; Rabbitt et al., 2015). Relating to Perceived Ease of Use, we have seen how some worry that the elderly no longer possess the technological or cognitive skills necessary to operate the robot (Flandorfer, 2012; Rabbitt et al., 2015). As shown before, the robot's ability to adapt to its user's needs is a key acceptance factor (Montemerlo et al., 2002; White et al., 2013; Louie et al., 2014) hence its presence in the model in the form of Perceived Adaptability. Finally, when it comes to the Social

Presence and Perceived Sociability constructs, literature has shown that users respond better to embodied robots (Matarić et al., 2007; Fasola & Matarić, 2013) and are affected by their engagement (Matarić et al., 2007; McColl & Nejat, 2013). The Almere model is based on the first version of the Unified Theory of Acceptance and Use of Technology (UTAUT), a model designed to predict technology use in an organizational context (Venkatesh et al., 2003). Succeeding the release of Almere came the second version of the UTAUT model which, going forward, will be referred to as UTAUT2. This version, as compared to the first one, targets the individual consumer instead of organizations. It has eight main constructs influencing Use Behavior (Venkatesh et al., 2012): Performance Expectancy[4], Effort Expectancy, Facilitating Conditions, Social Influence, Hedonic Motivation, Habit - the degree to which an individual is prone to perform behaviors automatically because of learning (Venkatesh et al., 2012 use the definition by Limayem et al., 2007) -, Price Value - consumers' tradeoff between the perceived benefits of applications and the monetary cost for using them (Venkatesh et al., 2012 use the definition by Dodds et al., 1991) - and Behavioral Intention. As it is possible to see, a lot of the constructs are similar to those of Almere: Performance and Effort Expectancy, already present in UTAUT, are Perceived Usefulness and Ease of Use, respectively, renamed by Heerink et al. (2010). Social Influence and Facilitating Conditions are also present in both models. The Perceived Enjoyment construct is very similar to Hedonic Motivation. The UTAUT2 model also has three moderating variables: Age, Gender and Experience. These moderate the impact of the main constructs on Behavioral Intention and Use Behavior. The inclusion of these factors is especially relevant as we have seen, previously, in this review of literature how sociodemographic variables such as age, gender and experience with technology affect the acceptance of SAR (Flandorfer, 2012).

3. Model and Hypotheses

3.1. Chosen model

At first, the Almere model seemed liked the perfect candidate to test the elderly Portuguese population's propension for SAR adoption. However, a few of the model's constructs (e.g. Social Presence, Perceived Sociability) would require the usage of real SAR to test. As most of these robots are still in prototype stage or extremely expensive, they are not easy to come by. Additionally, the Almere model has no moderating variables

[4] The definitions for the remaining constructs can be found on Table 1

which have been shown in literature to be quite important (Flandorfer, 2012). Thus, the choice fell on the UTAUT2 model (Venkatesh et al., 2012), a more recent, widely cited (according to ResearchGate, as of August 1st, 2019, it had been cited 2449 times) model that includes sociodemographic variables as moderators.

Despite being a rather complete model, it will still have to be adapted in order to fit the issue at hand. First, as usage of these robots is not yet prevalent, the definitions for the model's constructs had to focus on what the individual expected to take place when interacting with the robot.

Table 1 - Model Constructs

Construct	**Definition (UTAUT2- Venkatesh et al., 2012)**	**Definition (adapted by the author from Venkatesh et al., 2012)**
Performance Expectancy (PE)	"…the degree to which using a technology will provide benefits to consumers in performing certain activities…" (p.159)	Degree to which users believe that using a socially assistive robot will provide benefits in their daily lives
Effort Expectancy (EE)	"…the degree of ease associated with consumers' use of technology…" (p.159)	Degree of expected ease associated with using a socially assistive robot
Social Influence (SI)	"… the extent to which consumers perceive that important others (e.g., family and friends) believe they should use a particular technology… (p.159)	Extent to which an individual perceives that important others (e.g. family and friends) believe he or she should use a socially assistive robot
Facilitating Conditions (FC)	"…consumers' perceptions of the resources and support available to perform a behavior… (p.159)	Degree to which an individual believes that an infrastructure exists to support usage of a socially assistive robot
Hedonic Motivation (HM)	"…fun or pleasure derived from using a technology…" (p. 161)	Fun or pleasure expected to be derived from using a socially assistive robot
Behavioral Intention (BI)	"…behavioral intention to use a technology." (p. 161)	Behavioral Intention to use a socially assistive robot

Additional changes had to be made. At this point only a few robots, in limited quantities, are available in the market and most robot prices are only estimates. Therefore, robot prices were not mentioned in the questionnaire and the construct relating to price was dropped as an accurate representation of robot prices could not be given to respondents.

The Habit construct had to be removed as none of the people inquired have ever used a robot of this type. Use Behavior, in UTAUT2, is measured by the frequency with which the individual uses the technology. As such use does not yet exist, the construct was removed, and our dependent construct became Behavioral Intention. The moderating variable Experience has to do with the user's experience with the technology at hand. As such experience does not exist, the author decided to take that experience as the experience with technology in general. Flandorfer et al. (2012) points to how this sociodemographic variable influences SAR acceptance. The construct was thus renamed to Technological Literacy. Venkatesh et al. (2012) found that Experience, which we measure as Technological Literacy, does not seem to have a significant moderating effect on Facilitating Conditions' impact on Behavioural Intention. Therefore, in the adapted model, the moderating effect of Technological Literacy on Facilitating Conditions is not considered.

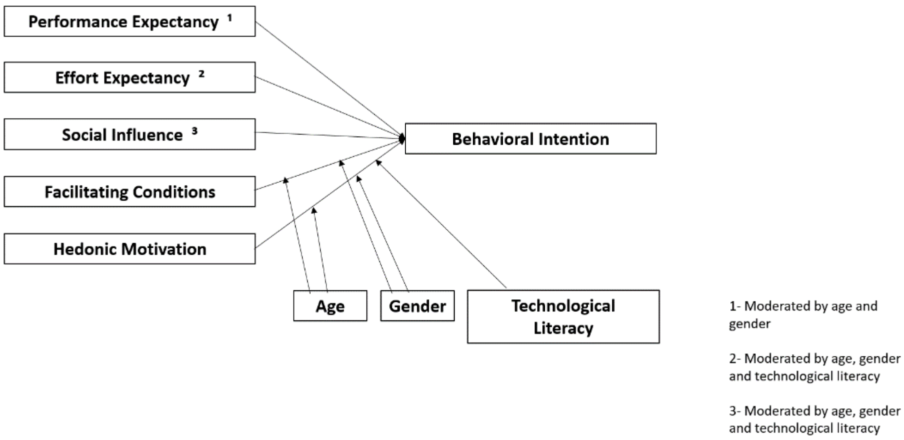

Figure 1 - Adapted UATUT2 model (adapted from Venkatesh et al., 2012)

3.2. Hypotheses

Cimperman et al. (2016) utilized a modified version of UTAUT2 to study the acceptance behavior of elderly users regarding home telehealth services. The authors found Performance and Effort Expectancy as well as Facilitating Conditions to have a positive effect on Behavioral Intention. Furthermore, Macedo (2017) used UTAUT2 to test the acceptance and use of Information and Communication Technology (ICT) by elderly adults. The author found that Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions, Hedonic Motivation and Habit all have a positive effect on elderly people's intention to use computers and the Internet. Based on these findings, the following hypotheses are put forward for testing:

H1: Behavioral Intention is positively influenced by Performance Expectancy

H2: Behavioral Intention is positively influenced by Effort Expectancy

H3: Behavioral Intention is positively influenced by Social Influence

H4: Behavioral Intention is positively influenced by Facilitating Conditions

H5: Behavioral Intention is positively influenced by Hedonic Motivation

The adapted model has three moderating variables. The UTAUT model (Venkatesh et al., 2003) already confirms three moderating effects that will be utilized in this study:

H6: The impact of Performance Expectancy on Behavioral Intention will be moderated by Age and Gender

H7: The impact of Effort Expectancy on Behavioral Intention will be moderated by Age, Gender and Technological Literacy

H8: The impact of Social Influence on Behavioral Intention will be moderated by Age, Gender and Technological Literacy

As mentioned above, Venkatesh et al. (2012) found that Experience (which we measure as Technological Literacy) does not have a significant moderating impact on Behavioral Intention – contrary to what was believed by Venkatesh et al. (2003). The authors also introduce the Hedonic Motivation variable and find it to be moderated by age, gender and experience. Thus, the following hypotheses are put forward:

H9: The impact of Facilitating Conditions on Behavioral Intention will be moderated by Age and Gender

H10: The impact of Hedonic Motivation on Behavioral Intention will be moderated by Age, Gender and Technological Literacy

Table 2 - Summary of Model Hypotheses

Main Constructs	
Hypotheses	Sources
H1: Behavioral Intention is positively influenced by Performance Expectancy	Cimperman et al. (2016) Macedo (2017)
H2: Behavioral Intention is positively influenced by Effort Expectancy	Cimperman et al. (2016) Macedo (2017)
H3: Behavioral Intention is positively influenced by Social Influence	Macedo (2017)

H4: Behavioral Intention is positively influenced by Facilitating Conditions	Cimperman et al. (2016) Macedo (2017))
H5: Behavioral Intention is positively influenced by Hedonic Motivation	Macedo (2017)
Moderating Variables	
Hypotheses	Sources
H6: The impact of Performance Expectancy on Behavioral Intention will be moderated by Age and Gender	Venkatesh et al. (2003)
H7: The impact of Effort Expectancy on Behavioral Intention will be moderated by Age, Gender and Technological Literacy	Venkatesh et al. (2003)
H8: The impact of Social Influence on Behavioral Intention will be moderated by Age, Gender and Technological Literacy	Venkatesh et al. (2003)
H9: The impact of Facilitating Conditions on Behavioral Intention will be moderated by Age and Gender	Venkatesh et al. (2012)
H10: The impact of Hedonic Motivation on Behavioral Intention will be moderated by Age, Gender and Technological Literacy	Venkatesh et al. (2012)

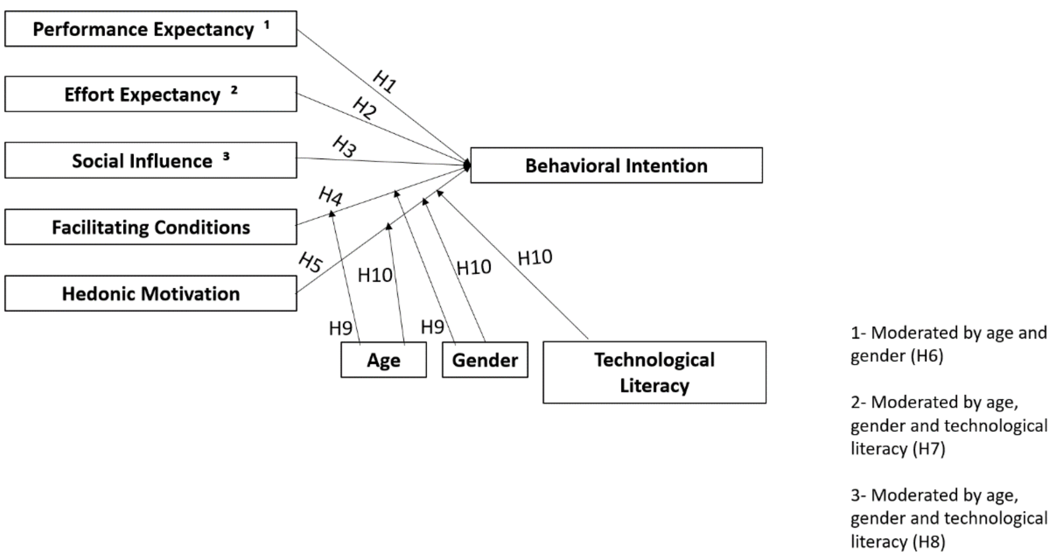

Figure 2 - Conceptual model

4. Methodological Approach

4.1. Gathering Data

In order to validate the model at hand, a quantitative approach is appropriate. Thus, questionnaires were chosen as the data collecting tool. As the present thesis focuses on the ways in which SAR can help the elderly, it was only right they were also the target population for the questionnaire. Thus, initially, only people aged 65 or older were targeted. However, applying questionnaires to individuals of such demographic is likely to be quite difficult and time consuming which could potentially have a negative effect on the amount of answers received. That way, and since these robots are still some years away from being widely available for use, it was decided to also include people in their fifties in the study as, due to the robots' very long time-to-market, they will more likely be potential users of SAR than some elderly people who are currently of quite advanced age. In summary, the questionnaires were applied to people aged 50 and up with priority being giving to respondents aged, at least, 65. People too debilitated to give their consent or to understand and complete the questionnaire were excluded from the study. The same questionnaire was made available both online (created using Google Forms) and on paper. The online version of the questionnaire was emailed to those potential respondents who had an e-mail address. The paper version was distributed to the rest. Keeping in line with the recommendations of Podsakoff et al. (2003) the questionnaire was made as simple and as easy to understand as possible. Also following the advice of Podsakoff et al. (2003), respondents' anonymity was guaranteed, and it was stressed that there were no wrong or right answers. An initial version of the questionnaire was completed by five people, within the target demographic, as to assess its adequacy. As a result, minor changes were made to the wording of some of the questions in order to make them clearer. These five test questionnaires were not included in the final reported results.

The elaborated questionnaire is divided into four different sections[5]. As the concept is rather recent and possibly totally new to most of the people taking the questionnaire, a cover page explaining the concept using both text and images was used.

Section I -The first section is designed to obtain data related to the model's moderating variables. The respondents age, gender and experience with technology are assessed. The last two questions pertaining to the technologies used by the respondent and the degree of interest in new technologies are adapted from Pino et al. (2015).

[5] For the applied questionnaire look to Appendix 2

Section II -The second section is meant to test which of the robots' skills are of more value to the potential user and which are the participants' main concerns regarding the use of such a robot. To that end, respondents were asked to rate a series of SAR capabilities and common concerns associated with their usage, gathered from literature, on five-point Likert scales. The choice to place this section before the one pertaining to the model is due to an attempt to give respondents a little bit more knowledge about the robots before thinking about how they would suit them personally.

Section III -The UTAUT2 model comes with an assortment of statements meant to test each of its constructs. For the purpose of this dissertation those had to be slightly modified. Also, as the Almere model has very similar constructs, some statements from there were also used and adapted. Finally, a few of the statements were created by the author based on the available literature. As both UTAUT2 and the Almere model were written in English, statements taken from these models were separately translated to Portuguese and back to English by the author and a colleague, with knowledge of both the English language and Information Systems, as to ensure consistency. Upon comparing both translations, very minimal changes to wording were made. Respondents were asked to rate each statement on a five-point Likert Scale anchored by "Strongly disagree" and "Totally agree". All the Likert scales used in this questionnaire resort to a five-point format. While UTAUT2 uses a seven-point scale, Almere, which targets the elderly, uses a five-point format. Additionally, Castle and Engberg (2004) found that, after the 10-point visual analogue rating format (10VAF), five-point Likert scales were the preferred instrument of people aged 65 and older.

As the questionnaire was meant for people aged 50 and up, in this section, those who were already 65 or over were asked to think of how the robot would be useful to them at the current moment. The others were asked to think of how the robot would be useful to them when they were 65 or more.

Table 3 - Model Statements

Dimension	Statement	Source
PE	I think the robot would be useful in my daily life	UTAUT2 (adapted)
PE	It would be convenient for me to have the robot	Almere
PE	I think the robot could help me with many things	Almere (adapted)

PE	I think the robot could help me be more independent	Schroeter et al., 2013 Fischinger et al., 2016 Georgiadis et al., 2016
PE	The robot would make me feel less alone	Banks et al., 2008 Robinson et al., 2013
PE	I think the robot could help improve my quality of life	Montemerlo et al., 2002 Feil-Seifer et al., 2007 Fischinger et al., 2016 Georgiadis et al., 2016
EE	Learning how to use the robot would be easy for me	UTAUT2 (adapted)
EE	I think I could use the robot without any help	Almere (adapted)
EE	I think I could use the robot if there was someone around to help me	Almere (adapted)
EE	I think I could use the robot if I had a good instruction manual	Almere (adapted)
SI	I think my family would like me using the robot	Almere (adapted)
SI	I think it would give a good impression if I should use the robot	Almere
FC	I would have the resources necessary to use the robot	UTAUT2 (adapted)
FC	I would have the knowledge necessary to use the robot	UTAUT2 (adapted)
FC	I could get help from others if I had difficulties using the robot	UTAUT2 (adapted)
HM	Using the robot would be fun	UTAUT2 (adapted)
HM	I believe the robot would be a good companion	Dautenhahn et al., 2005 Banks et al., 2008 Robinson et al., 2013
BI	I would only use the robot if human support was not available	Pino et al. (2015) Pripfl et al. (2016)

Because the Behavioral Intention dimension mostly has to do with the time frame in which the respondent would think to use the robot, a separation had to be made.

Table 4 - Behavioral Intention Statements (separated by age)

Dimension	Statement	Source
For those 65 and over		

BI	If the robot was available now, I would use it	Almere (adapted)
BI	I would use the robot in a near future (about 4 to 6 years)	European Commission (2018) UTAUT2 (adapted)
BI	I would use the robot in a distant future	UTAUT2 (adapted)
For those under 65		
BI	After 65, I would use the robot in a near future	UTAUT2 (adapted)
BI	After 65, I would use the robot in a distant future	UTAUT2 (adapted)

Section IV - The fourth and final section asks respondents to select from a series of ailments or difficulties they might live with such as memory problems, anxiety or fear of falling. This question was adapted from Pino et al. (2015). It was saved for last as according to Podsakoff et al. (2003), certain items might alter the respondents' mood which might carry on to the remaining of the questionnaire.

4.2. Data Analysis

In order to answer the first research question, structural equation modeling (SEM) was utilized. According to Hair et al. (2014), this statistical method enables the discovery and confirmation of relationships between multiple variables – the intended purpose of the deployment of UTAUT2. By allowing for the examination of these relationships in a way that reduces model error, SEM facilitates the elimination of variables characterized by weak measurement (Hair et al., 2014). There are two SEM based techniques for the researcher to choose from: covariance-based SEM and partial least squares-based SEM. The first method, based on a maximum likelihood procedure, is more appropriate for confirmatory factor analysis. Meanwhile, the second method has the goal of maximizing the explained variance of the model's endogenous constructs being more adequate for exploratory work (Hair et al., 2014). In the present dissertation, covariance-based SEM was utilized. When utilizing covariance-based SEM, error terms and factor loadings of each individual indicator are obtained, allowing for the elimination of items with large error terms and/or low loadings and, consequently, improving the quality of the latent model constructs. Due to the confirmatory factor analysis aspect of covariance-based SEM, all the model's latent constructs can covary mutually which then makes possible to assess convergent and discriminant validity for each construct. Additionally, the approach in question can be applied to models that include moderating effects which is essential since the created model has three moderating variables (Hair et al., 2014). The software chosen to perform the structural equation modeling based on covariance was an add-on for SPSS named AMOS. First, a measurement model (tests the relationships between the latent variables and its indicators) and then a structural model (tests the relationships between latent variables) were assessed. Secondly, the possible existence of moderation was tested.

For both the second and third research questions, Microsoft Excel was utilized.

5. Analysis of Results

5.1. Preliminary Data Analysis

As mentioned above, initially, it was planned to target the population aged 50 and over out of fear of not receiving enough responses from the elderly population alone. However, during the data collecting process (which took place during the month of July and the first week of August) it became apparent that it was, indeed, possible to obtain a valid number of responses from these individuals. Consequently, the author decided to only consider responses from people aged 65 and up as these constituted the demographic most likely to need a robot of this kind and, therefore, more capable of assessing its functionalities and utility. As such, while a total of 160 valid questionnaires were collected, only the 116 pertaining to respondents aged 65 and up were considered.

The obtained data was checked for any missing values and none were found. Also, the standard deviation for all the data pertaining to the model's latent constructs, robot functionalities and adoption preoccupations was calculated. One observation was found to have a standard deviation of zero which indicated that one person gave the same answer to all the items and could thus be considered to not have been totally engaged with the questionnaire. This observation was removed. Thus, the final sample is made up of 115 observations. As the age and number of technologies used variables were not measured on a Likert scale, they could have outliers. The test performed through SPSS found that no outliers existed for said variables. Covariance-based SEM requires data to be normally distributed (Hair et al., 2014). Skewness and kurtosis values were obtained for all data to be utilized in SEM. Both are measures of deviation from normality. According to the available literature, if skewness and kurtosis have values between -2 and 2 then the deviation from normality is not considered to be troubling (George & Mallery, 2016). All values fit within the -2/2 interval (Appendix 5) allowing us to proceed with utilizing AMOS.

The average age of respondents was 77 years old. 52 respondents (45.22%) were male while 63 (54.78%) were female. In average, the respondents' degree of experience with technology was found to be basic. The participants' interest in new technologies was, in average, a 3 on a five-point Likert scale – it can, thus, be considered moderate. Around 46% of people reported suffering from chronic conditions such as hypertension or diabetes, 39% of respondents said they either struggled with falling or lived in fear of falling and 35% reported suffering from memory troubles.

5.2. SAR acceptance factors – operationalizing the model (first research question)

For this portion of the data analysis process both SPSS Statistics (v25) and the SPSS add-on AMOS (v25) were used.

5.2.1. Measurement Model

The first step taken, was the construction of a measurement model using AMOS. The measurement model relates each latent variable with its items. Dr. James Gaskin's macro for Microsoft Excel was used to test the measurement model's adequacy. The test is based on the assessment of three aspects: reliability, convergent validity and discriminant validity. When it comes to reliability, the Composite Reliability (CR) index should be over 0.7. Regarding convergent validity, the Average Variance Extracted (AVE) index should be over 0.5. Finally, concerning discriminant validity, the AVE for each latent variable should be bigger than the Maximum Shared Variance (MSV) and the square root of the AVE for each variable should be higher than the absolute value of the correlations with the other factors. In the original measurement model, all latent variables have a CR value over 0.7 except for Behavioral Intention. When it comes to the AVE, all but Effort Expectancy and Behavioral Intention have values over 0.5. Only Hedonic Motivation has an AVE bigger than the MSV. Finally, when it comes to all variables but Hedonic Motivation, the square root of the AVE is less than the absolute value of the correlations with another factor. Thus, the initially constructed measurement model is not ideal and will have to be subjected to alterations in order to improve its adequacy.

Table 5 - Initial measurement model adequacy

	CR	AVE	MSV	MaxR(H)	BI	HM	PE	EE	SI	FC
BI	0,641	0,376	0,430	0,809	**0,613**					
HM	0,819	0,695	0,684	0,835	0,656	**0,833**				
PE	0,943	0,736	0,748	0,951	0,491	0,792	**0,858**			
EE	0,755	0,446	0,856	0,791	0,147	0,374	0,249	**0,668**		
SI	0,819	0,695	0,748	0,844	0,543	0,827	0,865	0,383	**0,834**	
FC	0,777	0,545	0,856	0,835	0,309	0,388	0,123	0,925	0,277	**0,738**

Zainudin (2012) recommends that in order to achieve unidimensionality in the measurement model, all items with factor loadings under 0.6 should be deleted. Thus, “EEusarajuda”, “BIajudahumana” and “FCajudaoutros” were removed from the model. This alteration, while fixing the problems with the CR returning a value under 0.7 and the AVE returning a value under 0.5, did not fix the remaining issues. Further alterations had to be made. As Performance Expectancy was the variable with the most indicators remaining (6), we experimented with removing a few of these – “PEajuda”, “PEconv” and “PEútil” were removed. The model’s adequacy was improved, however, was still not ideal. Also, the discriminant validity was showing that the Hedonic Motivation, Facilitating Conditions and Social Influence variables were all quite similar. Therefore, we tried eliminating one of them – Social Influence. These two alterations resolved almost all problems but concerns when it came to the model’s adequacy were still prevalent for the Facilitating Conditions and Effort Expectancy variables. Thus, we tried removing the Facilitating Conditions construct. With this final change, no more concerns were raised regarding the validity of the measurement model.

Having obtained a measurement model that was adequate, it was important to check for the existence of Common Method Bias (CMB). So, SPSS was used to conduct a Harman’s single factor test. Only 35.5% of the total variance is explained. As this value is under 50%, we can reject the existence of CMB. Next, before we move on to the structural model, the current model should be tested for linearity and multicollinearity. For that, first, the Data Imputation function of AMOS was utilized to create a new dataset in which the four latent variables were computed by the software based on their indicators. Then, using SPSS, linearity was tested for the three relationships that would be present in our structural model: PE-BI; EE-BI and HM-BI. Unfortunately, the relationship between Effort Expectancy and Behavioral Intention does not seem to be linear (Appendix 7). Thus, it was decided to try and reshape the measurement model without EE.

Effort Expectancy was removed from the measurement model, the two variables that had been previously eliminated (Social Influence and Facilitating Conditions) as well as the removed indicators for Performance Expectancy were put back in. The model was adjusted to the point where no validity concerns were raised. This included removing the Social Influence variable since discriminant validity again showed it to be too like Facilitating Conditions and Hedonic Motivation as well as utilizing the Modification Indices function of AMOS to establish covariance between “PEconv” and “PEútil”.

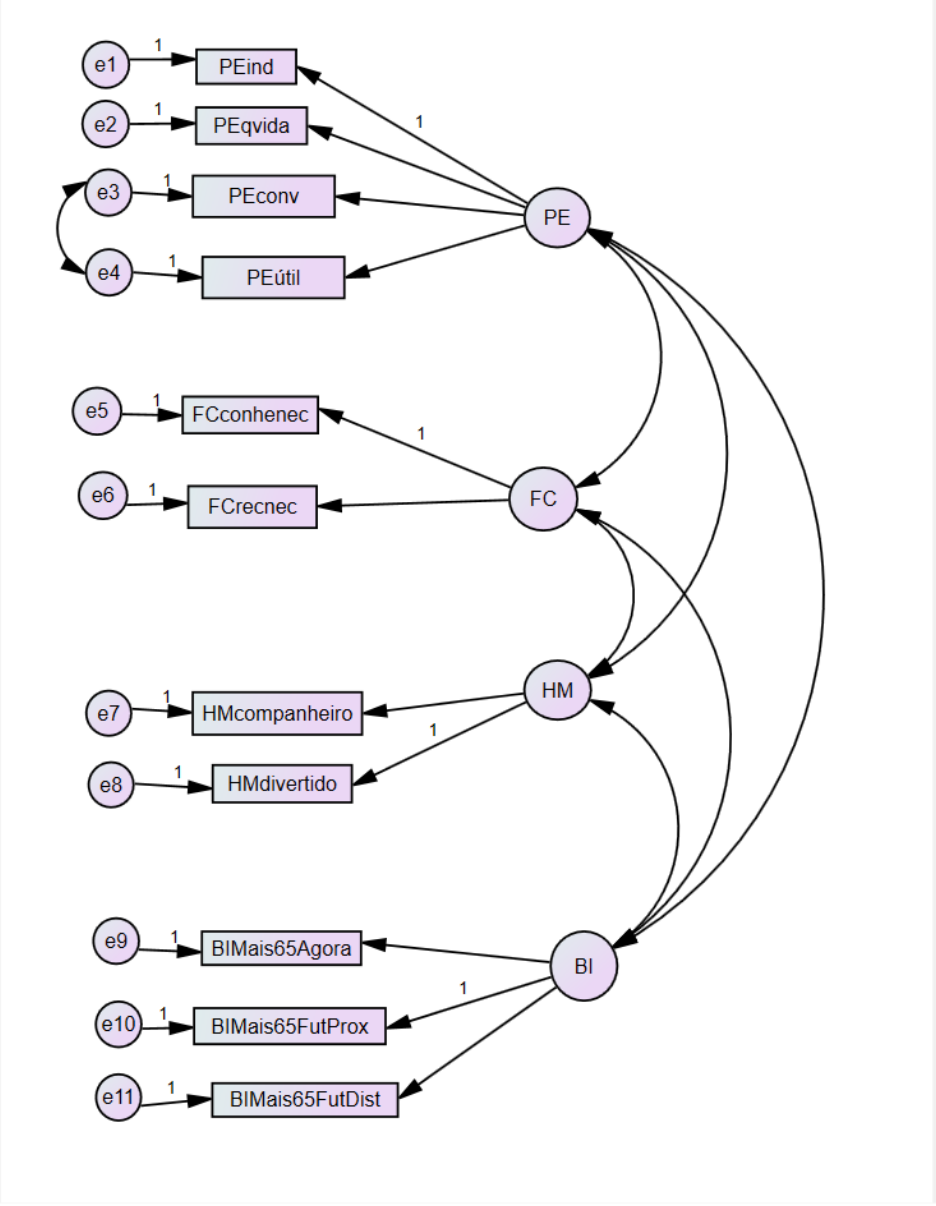

Figure 3 - Final measurement model

Table 6 – Final measurement model adequacy

	CR	AVE	MSV	MaxR(H)	BI	HM	PE	FC
BI	0,749	0,509	0,424	0,850	**0,714**			
HM	0,817	0,691	0,602	0,822	0,651	**0,831**		
PE	0,917	0,736	0,602	0,926	0,435	0,776	**0,858**	
FC	0,824	0,703	0,158	0,887	0,222	0,398	0,095	**0,839**

As it can be observed in Table 6, when it comes to reliability, all variables have a CR above 0.7. Another indicator that can also be utilized when it comes to reliability is the Cronbach Alpha. Like CR, the Cronbach Alpha values should also be above 0.7 (Henseler et al., 2009). Table 7 shows that this criterion is met.

Table 7 – Final measurement model reliability

	CR	**Cronbach Alpha**
BI	0.749	0.718
PE	0.917	0.928
FC	0.824	0.809
HM	0.817	0.816

Regarding convergent validity, the AVE for all variables is over 0.5. No concerns are raised when it comes to discriminant validity. There are two items in the model that have factor loadings of 0.59 – "BIMais65Agora" and "BIMais65FutDist". These are under the recommended 0.6 however, they are extremely close. Additionally, Zainudin (2012) indicates that the researcher might not remove items with loadings under 0.6 if the fitness indices for the measurement model have already been achieved. Table 8, concerning the values for the most commonly reported fitness indices (Zainudin, 2012) – Chi Square/Degrees of Freedom (Chisq/df), Root Mean Square of Error Approximation (RMSEA), Goodness of Fit Index (GFI) and Comparative Fit Index (CFI) - shows that the measurement model has the appropriate fit. Thus, the two items with somewhat low factor loadings were kept

Table 8 - Measurement model fitness indices

Indices	**Recommended Values (Zainudin, 2012)**	**Obtained Values**
Chisq/df	Chisq/df < 5.0	1.539
GFI	GFI > 0.90	0.923
CFI	CFI > 0.90	0.974

RMSEA	RMSEA < 0.08	0.069

Next it was important to test for Common Method Bias. Again, a Harman's single factor test was conducted. As the total variance explained is under 50% - it is 41,98% - it is possible to reject the presence of CMB. The following step was to test the final model for linearity and multicollinearity. When it comes to linearity, the PE-BI, FC-BI and HM-BI relationships were tested in SPSS through a curve estimation. All three relationships proved to be linear (Appendix 9). To test for multicollinearity, SPSS was used to run linear regressions with a collinearity diagnosis. This was done for the three independent variables – PE, FC and HM. Three regressions were created with each variable taking a turn as the dependent variable and the other two serving as the independent ones (Appendix 10). In the study for multicollinearity, the Variance Inflation Factor (VIF) should be under 5.0 as to not risk rendering redundant variables that are significant to the model (Akinwande et al., 2015). Fortunately, all three regressions returned VIF values under 5.0 which indicates that no relevant multicollinearity seems to be present. Thus, we can now move on to the structural model.

5.2.2. Structural Model

The structural model looks at the relationships between the latent variables. Following the construction of the measurement model, the following structural model was built in AMOS.

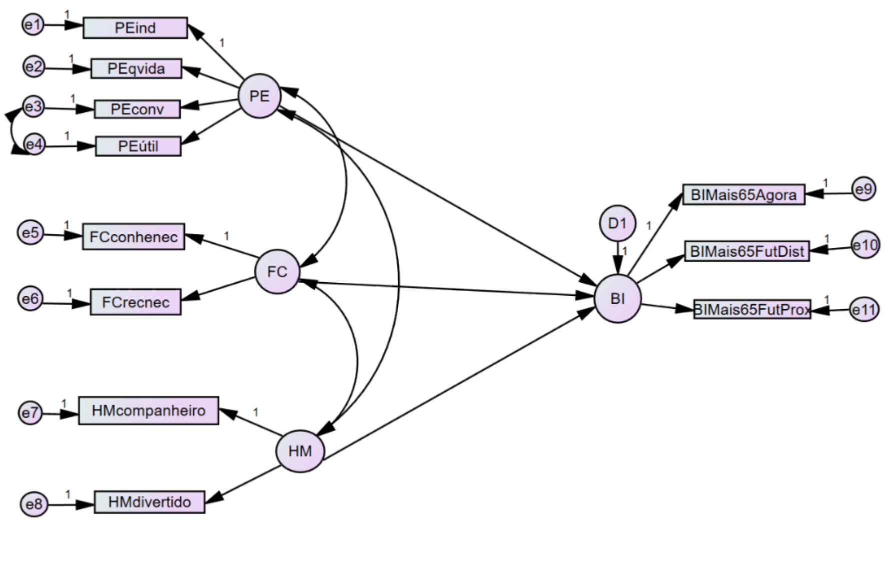

Figure 4 - Structural model

In order to test the adequacy of the structural model, we should again look to the fitness indices recommended by Zainudin (2012).

Table 9 – Structural model fitness indices

Index	Recommended Values (Zainudin, 2012)	Model Values
RMSEA	RMSEA < 0.08	0.069
GFI	GFI > 0.90	0.923
CFI	CFI > 0.90	0.974
Chisq/df	Chisq/df < 5.0	1.539

As it can be observed in the above table, all the indices have an adequate value. This allows us to say that the structural model has a good fit. Let us, then, look at the relationships between the latent variables.

Table 10 - Structural model regression weights

Relationship	Regression Weights	Standardized Regression Weights	P value
PE-BI	-0.162	-0.234	0.299
FC-BI	-0.086	-0.103	0.431
HM-BI	0.574	0.874	0.003*

*significant at the 0.01 significance level

Looking at table 10, it is possible to see that only Hedonic Motivation has a positive and significant relationship with Behavioral Intention. The negative values of the betas por PE and FC would indicate that these have a negative impact on BI. Such was not expected by the author and does not agree with literature. Thus, when it comes to hypotheses 1-5 it is only possible to confirm hypothesis 5.

5.2.3. Moderation

The independent variables in the adapted UTAUT2 model are all moderated by some combination of three variables: Age, Gender and Technological Literacy. In order to test for moderation, all three independent variables – Performance Expectancy, Facilitating Conditions and Hedonic Motivation – were standardized using SPSS. The three moderating variables were also standardized. When it came to Technological Literacy it had to be built based on the factor loadings for its three dimensions: number of technologies used, degree of experience with technology and degree of interest in new technologies. After obtaining the factor loadings, each item was multiplied by its corresponding loading and then all was divided by the number of loadings (Appendix 11). Having standardized both independent and moderating variables, each independent variable was multiplied by its moderating variables. The resulting moderated variables are “PEmoderada”, “FCmoderada” and “HMmoderada”. These were then included in the structural model.

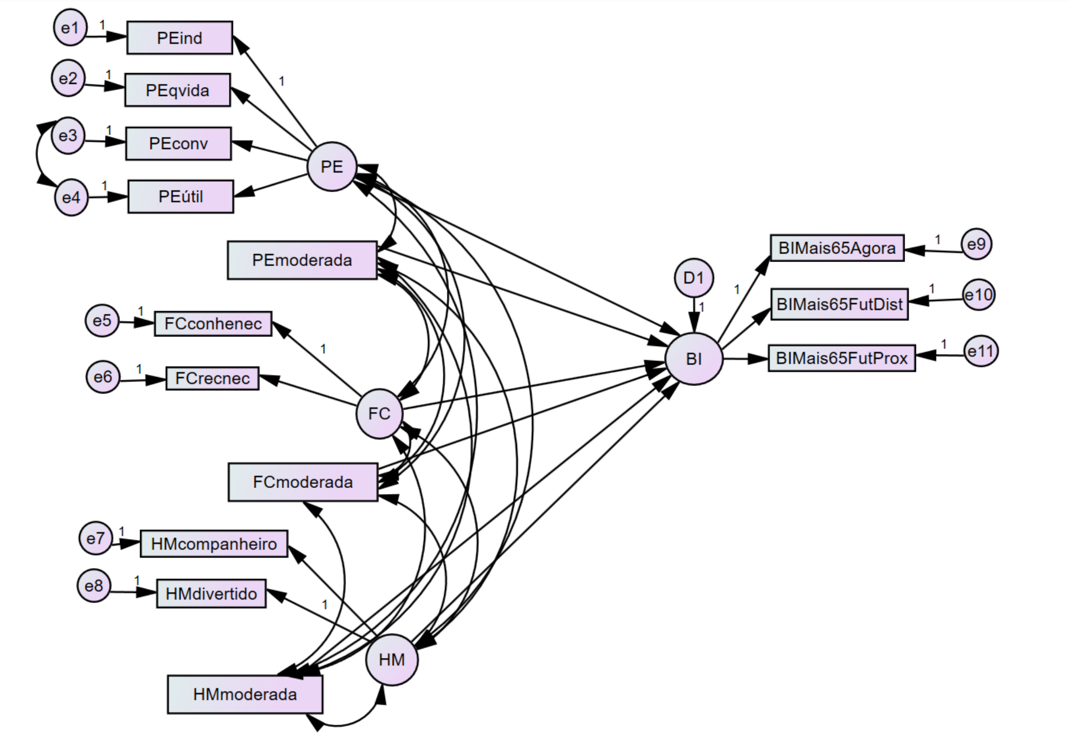

Figure 5 - Structural model with moderation

Table 11 shows that the model with moderation has an adequate fit.

Table 11 –Structural model with moderation fitness indices

Index	Recommended values (Zainudin, 2012)	Structural Model with moderation
Chisq/df	Chisq/df < 5.0	1.327
GFI	GFI > 0.90	0.920
CFI	CFI > 0.90	0.975

RMSEA	RMSEA < 0.08	0.054

When it comes to confirming the hypotheses regarding moderation, only "HMmoderada" seems to have a relationship with Behavioral Intention that is statistically significant.

Table 12 –Structural model with moderation regression weights

Relationship	Regression Weights	Standardized Regression Weights	P value
PEmoderada – BI	0.066	0.085	0.377
FCmoderada – BI	-0.014	-0.018	0.842
HMmoderada - BI	-0.145	-0.212	0.028*

*significant at the 0.05 level

Thus, it seems possible only to confirm hypothesis 10 – the impact of Hedonic Motivation on Behavioral Intention is moderated by Age, Gender and Technological Literacy.

5.3. Assessment of robot functionalities (second research question)

To determine what the respondents found to be the robots' most important functionalities, Microsoft Excel was used to obtain the sum of values attributed to each functionality by respondents. As individuals taking the questionnaire were asked to rate each functionality on a five-point Likert scale, the maximum possible score a functionality could receive was 575 (5*115). The top 3 most valued robot capabilities were: emergency detection and reporting (476), object monitoring and locating (474) and fall prevention (465). On the opposite end of the spectrum the top 3 least valued robot skills were company (346), support in everyday activities (366) and entertainment (388).

Table 13 - User assessment of robot capabilities

Robot Functionality	Attributed score (maximum = 575)
Emergency detection and reporting	476
Object monitoring and locating	474
Fall prevention	465

Memory aid	464
User activity monitoring	456
Health monitoring and alert issuing	444
Memory training aid	426
Communication aid	419
Exercise aid	404
Fetching objects for the user	395
Entertainment	388
Support in everyday activities	366
Company	346

5.4. Concerns pertaining to robot adoption (third research question)

As with capabilities, respondents were asked to rate a series of common concerns regarding robot adoption on a five-point Likert scale ranging from "Not at all concerning" to "Extremely concerning". The procedure utilized to calculate potential users' main concerns was the same as described above for functionalities. Again, with a maximum possible score of 575, the top 3 main concerns were costs (486), the risk of loss of human contact (425) and the risk of loss of human jobs (409).

Table 14 - Concerns pertaining to SAR adoption

User concerns	**Attributed score (maximum = 580)**
Costs	486
Risk of loss of human contact	425
Risk of loss of human jobs	409
Loss of autonomy/excessive dependency on the robot	385
Lack of cognitive skills necessary to use the robot	384
Lack of technological skills necessary to use the robot	382
Security risks	378
Privacy concerns	353
Unilaterality characteristic of a relationship w/ a robot	351
Risk of infantilizing the user	342

6. Conclusions, Contributions, Limitations and Future Work

6.1. Conclusions

Regarding the first research question, when considering non-moderating variables, only one hypothesis could be confirmed with certainty trough structural equation modeling – Hedonic Motivation has a positive impact on Behavioral Intention (H5). This means that an increase in the fun or pleasure expected to be derived from using SAR results in an increase in the intention to use the robot. One could extrapolate that the more fun the socially assistive robot is to use (or is expected to be to use), the more likely is a person to actually intend to use it. Moderating variables were a quite important part of this work as they are present in the UTAUT2 model and literature points to their importance when it comes to robot acceptance (Flandorfer, 2012). One hypothesis seems to be confirmed within this scope – Hedonic Motivation's impact on Behavioral Intention is moderated by Age, Gender and Technological Literacy.

When it comes to the SAR skills more valued by respondents, those were found to be emergency detecting and reporting, monitoring and locating objects and fall prevention. Except for object monitoring and locating, which may have been such a favorite due to the convenience it offers the user, it seems that people tend to lean into the robot functionalities that can help ensure their safety. As 46% of people reported suffering from chronic conditions such as hypertension or diabetes and 39% of respondents said they either struggled with falling or lived in fear of falling, perhaps this sway towards robot functionalities to do with safety is not so strange. 35% of people taking the questionnaire also reported living with memory problems and the robot functioning as a memory aid was the fourth most favorite functionality. One could argue that the favoring of the locating and monitoring objects function could not only be related to convenience but also could be favored as an aid for people with memory troubles. Overall, the chosen robot functionalities seem to be in agreeance with the difficulties and troubles the respondents reported suffering from. Interestingly enough, the company function received the lowest score. On one hand this could mean that the respondents have no need for additional company. However, together with the functions that did receive a high score, could indicate that people still see the robot more as a utilitarian machine and less as a social being.

Regarding the third and last research question, the main concerns permeating SAR adoption seem to be costs, risk of losing human contact and risk of losing human jobs. Costs were, by far, the most selected concern. This seems to show how important it is to find cost efficient solutions. Even though robot prices were not mentioned in the questionnaire it is easy to assume that such a technology would be quite expensive. So far, that still is the case. However, these robots are mostly still in development stages so it is difficult to assess what they will cost once they enter the market in larger numbers. Nevertheless, it's not too extreme to expect costs to reduce as such takes place and, perhaps in a more distant future, when these robots enter the market in mass they could be considered, if not totally affordable, a worthy investment. The other two main concerns indicated relate to a possible loss that SAR could bring to humans. These are, as seen in literature (Sharkey & Sharkey, 2012; Rabbitt et al., 2015), quite common concerns. Regardless, it may be important to restress that these robots are not designed to replace humans but to aid them in their work and to mitigate some situations in which human aid and contact might not exist or be readily available.

6.2. Contributions

As the field in question is still relatively recent, any research done in its domain serves to enrich the body of work and knowledge being actively built as the present dissertation is being written. Even though, in Portugal, prototypes for robots of this kind are being developed and tested with generally positive results (e.g. Oliveira et al., 2017; Avelino et al., 2018), offering some hints regarding the elderly population's feelings towards them, to the author's knowledge, there has been little research focusing solely on the feelings of the general elderly Portuguese population regarding this type of robots. This includes a deeper understanding of which functionalities they value the most, what their main concerns are and what factors seem to determine acceptance. The main contribute this research can offer is to further inform the design and conception process of future robots of this kind. For instance, it showed how a robot that the users perceive as fun increases its acceptance potential and how cost needs to be a big concern when designing the robots. The study also has, perhaps, the advantage of not being limited to one specific type of elderly person (e.g. dementia patients) which means the results can be used in future research without being limited to one focus. On the topic of future research, the present work also offers an adaptation of the UTAUT2 model and questionnaire, especially made with elderly people in mind, that while not perfect, do possess moderating variables and can be a starting point for someone else's research.

6.3. Limitations

One of the limitations of the present dissertation has to do with the target demographic. People in the targeted age range were found to be not that used to responding to questionnaires especially one that, due to its nature, included so many Likert scales. Even though the questionnaire was made as simple as possible, many respondents still required quite a bit of guidance in completing it which could be time consuming. Additionally, the focus on a technology, especially one so new, translated into people having some difficulty understanding what it entailed. Despite an explanation of the concept being provided alongside the questionnaire there were still a lot of questions and the author is not entirely certain that the respondents fully understood the concept which might have affected the way in which they responded.

Focusing the research on robots, especially on those that support humans, had the effect of garnering some impassionate responses from the participants. There were people who outright rejected such a technology while others were fully on board. It is the author's belief that some of the difficulties that came with analyzing the data and that, in the end, made it so that the model could not be fully validated are rooted in this limitation.

The instrument used to gather the people's opinions and the desire to make it as simple as possible for the target population, while necessary in order to validate the user acceptance model, made so that it was not possible to fully dive into the people's thoughts regarding the robots at hand. For example, it did not allow to explore why people found the companion functionality to be of so little interest.

The impossibility of having the people interact with real SAR can be a limitation as it could have altered the way in which they reacted to the technology at hand. It has been proven that once the elderly contact with a technology and can clearly understand its benefits they become much more open (Flandorfer, 2012; Ezer et al., 2009).

The sample size could have difficulted the data analysis. While 115 responses are a respectable number, models like UTAUT2 or Almere are usually tested with many more. For example, the UTAUT2 model had a final sample of 1512 consumers (Venkatesh et al., 2012). Consequently, the results presented in this study represent the opinions of a small amount of people which can influence its overall validity.

6.4. *Future Work*

Taking into consideration what has been written in this section, so far, we can thus leave some recommendations and suggestions for future work.

Firstly, would be good to try and have the elderly interact with real SAR, perhaps through a collaboration with one of the institutions that are currently developing them, in an attempt to have the obtained responses be as close to reality as possible. Also, such practice would make much easier for the elderly to understand the concept at hand.

When it comes to the data collecting instrument being used, it does indeed have to be kept as simple as possible when the target population are the elderly. However, it would perhaps be good to introduce some counter questions as a way to reduce some of the responses guided by emotional impulse. It would also be positive to try and increase the number of responses gathered even if such can be quite a time-consuming process. Additionally, it would be ideal to do a follow up with the respondents, in an interview format, allowing for some more clarity regarding the data collected through the quantitative approach.

As was mentioned in literature (Orrel et al., 2008; Louie et al., 2014; Pino et al., 2015) the role played by those questioned seems to affect their perceptions of SAR. It could be interesting to take this variable into consideration when looking into the research questions. That would mean investigating how, for instance, elderly people and their formal and informal caregivers vary in their opinions when it comes to acceptance factors, favorite functionalities and adoption concerns.

Regarding the actual data analysis process, further work should be done in order to investigate the hypotheses that were not confirmed but are in agreeance with the literature. This includes doing further testing when it comes to the moderating variables. Not only further testing should be done in order to try and confirm the remaining hypotheses relating to moderation, but it could also be good to consider the moderation effects. In order to do the latter, multigroup analysis could be performed. Also, new software such as LISREL or SmartPLS can be explored.

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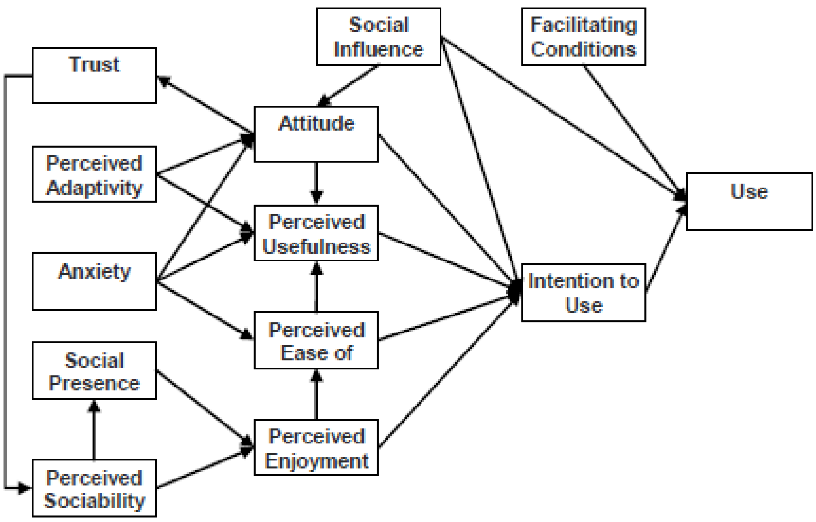
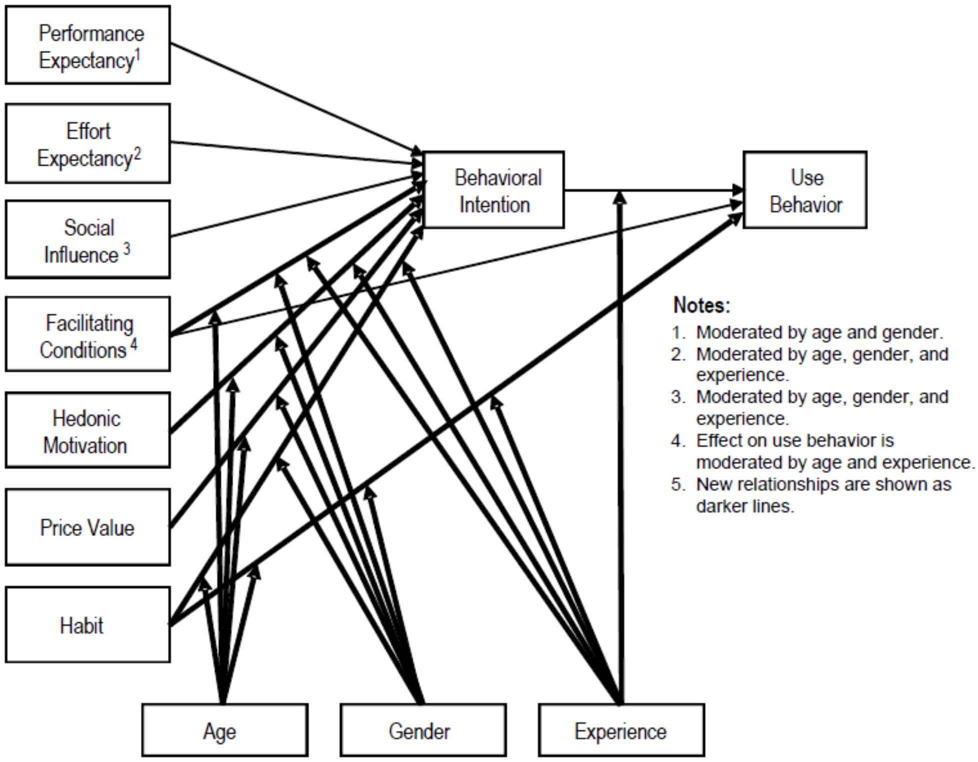
Appendixes

Appendix 1 – Technology Acceptance Models

- Almere Model (from Heerink, 2011)



- UTAUT2 test model (from Venkatesh et al., 2012)



Appendix 2 – Applied Questionnaire

A Propensão da População Portuguesa para a Adoção de Socially Assistive Robots/Robots de Apoio Social

O presente questionário realiza-se no âmbito de uma dissertação de Mestrado em Gestão de Sistemas de Informação no ISEG (Instituto Superior de Economia e Gestão). O seu objetivo é estudar a propensão da população portuguesa para a adoção de **Socially Assistive Robots/Robots de Apoio Social.**

Socially Assistive Robots/Robots de Apoio Social constituem um tipo de tecnologia, ainda em fase de desenvolvimento, destinada a apoiar os humanos através da interação social - o contacto físico com o utilizador é nulo ou reduzido.

Recorrendo a diversas funcionalidades, estes robots têm-se mostrado capazes de apoiar a população em envelhecimento, ajudando-a a manter uma vida de qualidade e independente durante o máximo de tempo possível. Algumas maneiras em que os robots podem prestar assistência incluem: deteção e comunicação de emergências, prevenção de quedas, ajuda na realização de exercício físico, auxílio à memória ou, simplesmente, companhia/socialização.

INSTRUÇÕES

1. Não existem respostas certas ou erradas. Selecione as opções que melhor se adequam ao seu caso específico.
2. O questionário é anónimo. Os dados recolhidos serão utilizados, exclusivamente, em contexto académico

Socialização com o robot PARO

Sessão de exercício orientada por robot

Robot deteta uma emergência

Robot PEAL guia utilizador até ao seu destino

Robot joga cartas com o utilizador

Imagens retiradas de (da esquerda para a direita):

Shibata, T. and Wada, K. 2010. Robot Therapy: A New Approach for Mental Healthcare of the Elderly – A Mini-Review. *Gerontology* 57(4), 378-386

Fasola, J. and Matarić, M. 2013. A Socially Assistive Robot Exercise Coach for the Elderly. *Journal of Human-Robot Interaction* 2(2), 3-32

Fischinger, D., Einramhof, P., Papoutsakis, K., Wohlkinger, W., Mayer, P., Panek, P., Hoffman, S., Koertner, T., Weiss, A., Argyros, A. and Vincze, M. 2016. Hobbit, a care robot supporting independent living at home: First prototype and lessons learned. *Robotics and Autonomous Systems* 75, 60-78

Montemerlo, M., Pineau, J., Roy, N., Thrun, S. and Verma, V. (2002) *Experiences with a Mobile Robotic Guide for the Elderly.* In Eighteenth national conference on Artificial intelligence. Edmonton, July 28th to August 1st, 2002. American Association for Artificial Intelligence Menlo Park, CA. 587-592

Louie, W., Li, J., Vaquero, T. and Nejat, G. (2014). *A Focus Group Study on the Design Considerations and Impressions of a Socially Assistive Robot for Long-Term Care.* In 23rd IEEE International Symposium on Robot and Human Interactive Communication. Edinburgh, August 25th to August 29th, 2014. IEEE. 237242

I

Género

☐ Masculino

☐ Feminino

Idade

_____ anos

Como classificaria a sua experiência com tecnologia?

☐ Nenhuma

☐ Básica

☐ Intermédia

☐ Avançada

De entre as seguintes tecnologias, assinale as que utiliza ou já utilizou frequentemente (pelo menos uma vez por semana)

	Rádio
	Televisão
	Leitor de CD/DVD
	Telemóvel – realização de chamadas
	Telemóvel – utilização da agenda e/ou internet
	Computador
	Tablet
	Internet
	E-mail
	Redes sociais
	Micro-ondas
	Máquina de lavar roupa/loiça
	Máquinas de exercício

De acordo com a escala apresentada classifique o seu grau de interesse por novas tecnologias

1 – Não interessado/a de todo

5 – Muito interessado/a

1	2	3	4	5

II

Por favor classifique, de acordo com a escala apresentada, as funcionalidades dos robots em questão

1 – Sem qualquer importância

5 – Extremamente importante

Funcionalidade	1	2	3	4	5
Deteção e comunicação de emergências (exemplo: quedas)					
Auxiliar de memória – relembrar o utilizador de consultas, da medicação, da necessidade de comer/beber ou de se exercitar					
Apoio no treino da memória através da realização de jogos					
Apoio na realização de exercício – indicação de movimentos a realizar e monitorização do desempenho					
Prevenção de quedas – guiar o utilizador até ao seu destino, desimpedir o seu caminho					
Monitorização e localização de objetos do utilizador (exemplo: chaves de casa, carteira, óculos, telemóvel)					
Ir buscar objetos na vez do utilizador					
Companhia					
Entretenimento – música, jogos, ajuda na leitura de jornais/revistas, apoio na utilização da televisão					
Apoio na comunicação – contacto com familiares/amigos/profissionais de saúde através de videochamada					
Apoio em atividades do quotidiano – ajuda a fazer compras online, previsão meteorológica, informar sobre eventos a decorrer na comunidade					

Em baixo pode encontrar uma lista daquelas que costumam ser indicadas como as principais preocupações suscitadas pela utilização de um robot. Por favor, classifique os itens de acordo com a escala providenciada

1 – Nada preocupante

5 – Extremamente preocupante

Fator	1	2	3	4	5
Risco de perda de contacto humano					
Risco de perda de empregos humanos					
Perda de autonomia/dependência excessiva do robot					
Unilateralidade/falta de reciprocidade característica da relação com um robot					
Risco de infantilização do utilizador					
Questões de privacidade resultantes da monitorização do utilizador					
Falta de competências tecnológicas adequadas para utilizar o robot					
Falta de competências cognitivas adequadas para utilizar o robot					

III

As seguintes questões prendem-se com a utilidade que um robot deste género poderá ter para si. Classifique as afirmações de acordo com a escala providenciada

1 – Discordo fortemente

5 – Concordo totalmente

<u>Tenha em atenção</u>

Caso ainda não se encontre na faixa etária à qual estes robots se destinam (65+) tente pensar em como estes poderão ser úteis para si nessa altura. Caso contrário, por favor pense em como estes robots poderiam ser úteis para si nesta altura.

Afirmação	1	2	3	4	5
Penso que o robot seria útil na minha vida diária					

Seria conveniente para mim ter o robot					
Penso que o robot me poderia ajudar com muitas coisas					
Penso que o robot me poderia ajudar a ser mais independente					
O robot iria fazer-me sentir menos sozinho/a					
Penso que o robot poderia melhorar a minha qualidade de vida					
Aprender a utilizar o robot seria fácil para mim					
Penso que conseguiria utilizar o robot sem qualquer ajuda					
Penso que conseguiria utilizar o robot se houvesse alguém disponível para me ajudar					
Penso que conseguiria utilizar o robot se eu tivesse um bom manual de instruções					
Penso que a minha família iria gostar que eu utilizasse o robot					
Penso que iria criar uma boa impressão se eu utilizasse o robot					
Eu teria os recursos necessários para utilizar o robot					
Eu teria o conhecimento necessário para utilizar o robot					
Eu poderia ter ajuda de outros se tivesse dificuldades ao usar o robot					
Utilizar o robot seria divertido					
Acredito que o robot seria um bom companheiro					
Eu só utilizaria o robot se apoio humano não se encontrasse disponível					

Caso se encontre na faixa etária 65+ classifique as afirmações abaixo apresentadas de acordo com a escala providenciada

1 – Discordo fortemente

5 – Concordo totalmente

Afirmação	1	2	3	4	5
Se o robot estivesse disponível agora eu iria utilizá-lo					
Eu utilizaria o robot num futuro próximo (cerca de 4 a 6 anos)					
Eu utilizaria o robot num futuro distante					

Caso ainda não se encontre na faixa etária de 65+ classifique as afirmações abaixo apresentadas de acordo com a escala providenciada

1 – Discordo fortemente

5 – Concordo totalmente

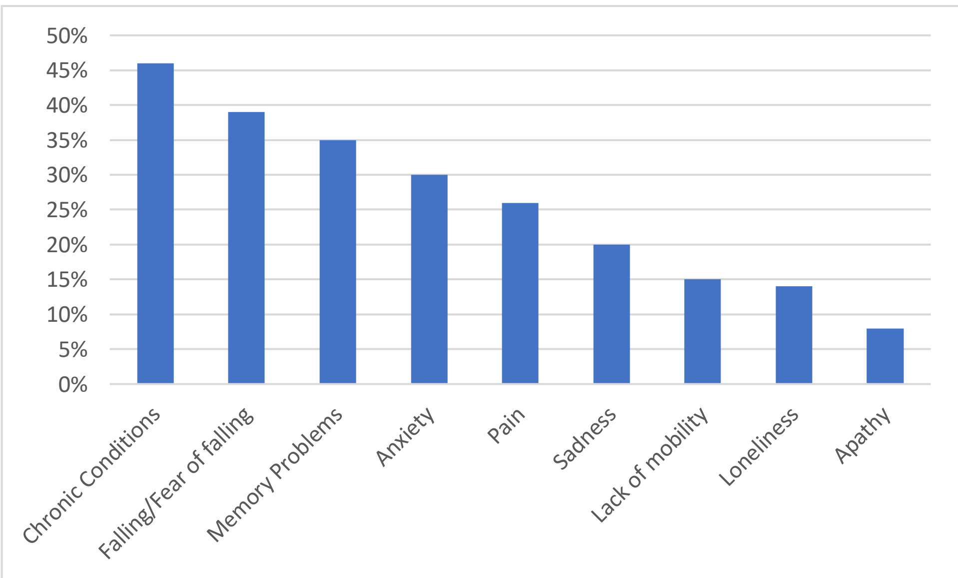
Afirmação	1	2	3	4	5
Após os 65 anos, eu utilizaria o robot num futuro próximo					
Após os 65 anos, eu utilizaria o robot num futuro distante					

IV

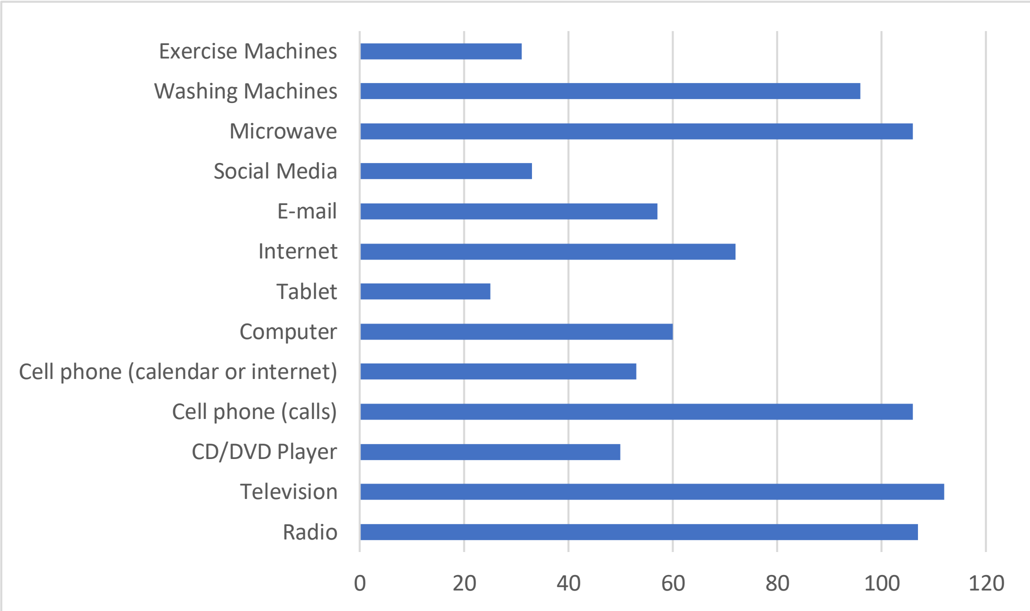
Por favor indique se vive com alguma/as das dificuldades abaixo listadas

	Problemas de memória
	Pouca mobilidade
	Quedas/medo de cair
	Tristeza; depressão
	Solidão; isolamento
	Dor
	Ansiedade
	Apatia
	Doenças crónicas (diabetes, hipertensão, etc..)

Appendix 3 – Day-to-day living difficulties of participants



Appendix 4 – Technologies utilized by participants



Appendix 5 – Skewness and Kurtosis

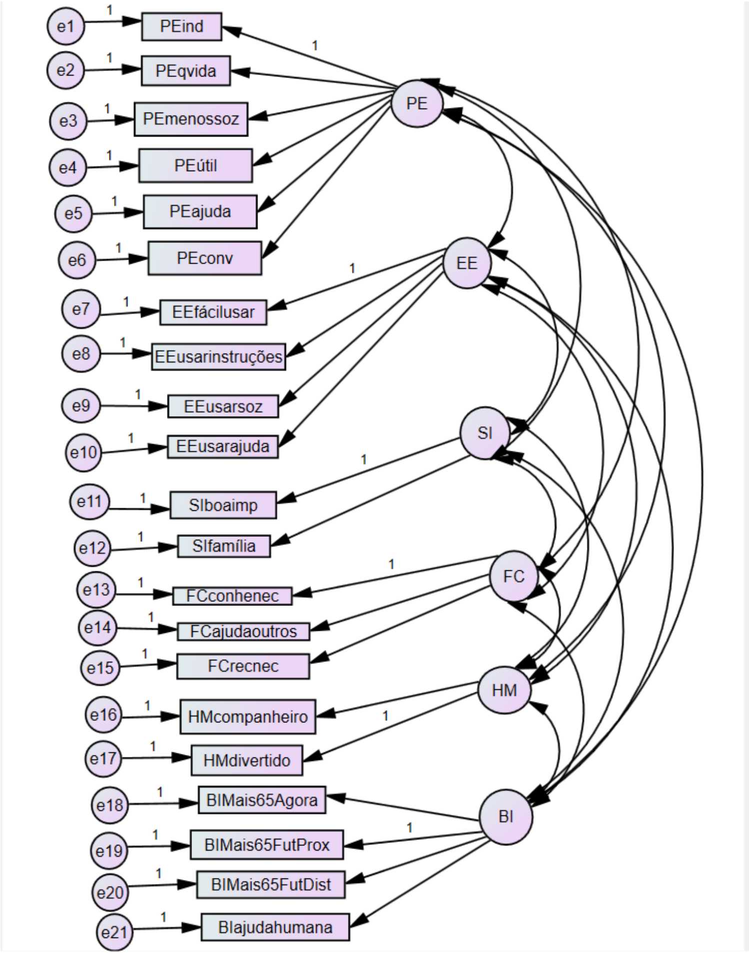
Estatísticas

		Blajudahumana	BIMais65Agora	BIMais65FutDist	BIMais65FutProx	EEfácilusar	EEusarajuda	EEusarinstruções	EEusarsoz
N	Válido	115	115	115	115	115	115	115	115
	Omisso	0	0	0	0	0	0	0	0
Assimetria		-0,753	0,525	-0,069	-0,089	-0,088	-0,349	0,204	0,592
Erro de assimetria		0,226	0,226	0,226	0,226	0,226	0,226	0,226	0,226
Curtose		-0,835	-0,925	-1,145	-0,947	-0,769	-0,226	-0,885	-0,870
Erro de Curtose		0,447	0,447	0,447	0,447	0,447	0,447	0,447	0,447

		FCrecnec	FCconhenec	Genero	HMcompanheiro	HMdivertido	Idade	InteresseTech	NivExpTech	NumTechUsadas
N	Válido	115	115	115	115	115	115	115	115	115
	Omisso	0	0	0	0	0	0	0	0	0
Assimetria		0,232	0,406	-0,195	0,397	0,076	0,145	-0,284	0,423	0,139
Erro de assimetria		0,226	0,226	0,226	0,226	0,226	0,226	0,226	0,226	0,226
Curtose		-0,677	-0,825	-1,997	-1,053	-1,050	-0,856	-0,504	-0,131	-0,947
Erro de Curtose		0,447	0,447	0,447	0,447	0,447	0,447	0,447	0,447	0,447

		PEajuda	PEconv	PEind	PEmenossoz	PEqvida	PEútil	SIboaimp	SIfamília
N	Válido	115	115	115	115	115	115	115	115
	Omisso	0	0	0	0	0	0	0	0
Assimetria		-0,163	0,063	-0,029	0,411	-0,067	-0,121	0,266	0,041
Erro de assimetria		0,226	0,226	0,226	0,226	0,226	0,226	0,226	0,226
Curtose		-0,932	-1,019	-1,154	-0,825	-1,014	-0,921	-0,815	-0,909
Erro de Curtose		0,447	0,447	0,447	0,447	0,447	0,447	0,447	0,447

Appendix 6 – Original Measurement Model



Appendix 7 – Test for linearity (original measurement model - Effort Expectancy)

Resumo do modelo e estimativas de parâmetro

Variável dependente: BI

Equação	Resumo do modelo					Estimativas de Parâmetro			
	R quadrado	Z	df1	df2	Sig.	Constante	b1	b2	b3
Linear	,012	1,345	1	113	,249	2,455	,154		
Logarítmico	,016	1,806	1	113	,182	2,564	,324		
Inverso	,018	2,070	1	113	,153	3,066	-,504		
Quadrático	,017	,945	2	112	,392	2,041	,599	-,104	
Cúbico	,021	,797	3	111	,498	1,178	2,137	-,888	,119
Composto	,011	1,204	1	113	,275	2,199	1,065		
Potência	,016	1,830	1	113	,179	2,288	,140		
S	,019	2,205	1	113	,140	1,049	-,224		
Crescimento	,011	1,204	1	113	,275	,788	,063		
Exponencial	,011	1,204	1	113	,275	2,199	,063		

Logística	,011	1,204	1	113	,275	,455	,939		

A variável independente é EE.

Appendix 8 – Harman's single factor test for final measurement model

Variância total explicada

Fator	Autovalores iniciais			Somas de extração de carregamentos ao quadrado		
	Total	% de variância	% cumulativa	Total	% de variância	% cumulativa
1	5,062	46,015	46,015	4,618	41,981	41,981
2	1,928	17,525	63,540			
3	1,172	10,656	74,196			
4	,673	6,122	80,319			
5	,635	5,773	86,092			
6	,377	3,428	89,520			
7	,329	2,992	92,512			
8	,292	2,651	95,162			
9	,246	2,241	97,403			
10	,181	1,643	99,046			
11	,105	,954	100,000			

Método de Extração: fatoração pelo Eixo Principal.

Appendix 9 – Test for Linearity (final measurement model)

Resumo do modelo e estimativas de parâmetro

Variável dependente: BI

Equação	Resumo do modelo					Estimativas de Parâmetro			
	R quadrado	Z	df1	df2	Sig.	Constante	b1	b2	b3
Linear	,064	7,715	1	113	,006	2,136	,311		
Logarítmico	,052	6,183	1	113	,014	2,456	,514		
Inverso	,039	4,630	1	113	,034	3,177	-,666		
Quadrático	,070	4,194	2	112	,018	2,509	-,097	,093	
Cúbico	,071	2,808	3	111	,043	2,847	-,688	,386	-,043
Composto	,054	6,429	1	113	,013	1,982	1,128		
Potência	,052	6,180	1	113	,014	2,219	,217		
S	,046	5,472	1	113	,021	1,116	-,305		
Crescimento	,054	6,429	1	113	,013	,684	,120		
Exponencial	,054	6,429	1	113	,013	1,982	,120		
Logística	,054	6,429	1	113	,013	,505	,886		

A variável independente é FC.

Resumo do modelo e estimativas de parâmetro

Variável dependente: BI

Equação	Resumo do modelo					Estimativas de Parâmetro			
	R quadrado	Z	df1	df2	Sig.	Constante	b1	b2	b3
Linear	,237	35,128	1	113	,000	1,480	,487		
Logarítmico	,214	30,715	1	113	,000	1,863	1,037		
Inverso	,168	22,876	1	113	,000	3,547	-1,645		
Quadrático	,238	17,503	2	112	,000	1,648	,337	,028	
Cúbico	,239	11,638	3	111	,000	2,069	-,297	,298	-,034
Composto	,215	30,946	1	113	,000	1,509	1,217		
Potência	,200	28,331	1	113	,000	1,749	,424		
S	,162	21,849	1	113	,000	1,252	-,682		
Crescimento	,215	30,946	1	113	,000	,411	,196		
Exponencial	,215	30,946	1	113	,000	1,509	,196		
Logística	,215	30,946	1	113	,000	,663	,822		

A variável independente é PE.

Resumo do modelo e estimativas de parâmetro

Variável dependente: BI

Equação	Resumo do modelo					Estimativas de Parâmetro			
	R quadrado	Z	df1	df2	Sig.	Constante	b1	b2	b3
Linear	,519	122,095	1	113	,000	,624	,773		
Logarítmico	,484	105,906	1	113	,000	,981	1,882		
Inverso	,417	80,988	1	113	,000	4,355	-3,781		
Quadrático	,523	61,366	2	112	,000	1,052	,430	,060	
Cúbico	,523	40,546	3	111	,000	1,024	,466	,047	,002
Composto	,460	96,435	1	113	,000	1,079	1,360		
Potência	,457	95,014	1	113	,000	1,216	,772		
S	,421	82,245	1	113	,000	1,602	-1,604		
Crescimento	,460	96,435	1	113	,000	,076	,307		
Exponencial	,460	96,435	1	113	,000	1,079	,307		
Logística	,460	96,435	1	113	,000	,927	,735		

A variável independente é HM.

Appendix 10 - Test for Multicollinearity (final measurement model)

Coeficientes[a]

Modelo		Coeficientes não padronizados B	Erro Erro	Coeficientes padronizados Beta	t	Sig.	Estatísticas de colinearidade Tolerância	VIF
1	(Constante)	1,108	,189		5,858	,000		
	PE	-,682	,108	-,837	-6,294	,000	,303	3,302
	HM	,987	,116	1,132	8,511	,000	,303	3,302

a. Variável Dependente: FC

Coeficientes[a]

Modelo		Coeficientes não padronizados B	Erro Erro	Coeficientes padronizados Beta	t	Sig.	Estatísticas de colinearidade Tolerância	VIF
1	(Constante)	,546	,154		3,548	,001		
	HM	1,039	,053	,970	19,565	,000	,812	1,231
	FC	-,383	,061	-,312	-6,294	,000	,812	1,231

a. Variável Dependente: PE

Coeficientes[a]

Modelo		Coeficientes não padronizados B	Erro Erro	Coeficientes padronizados Beta	t	Sig.	Estatísticas de colinearidade Tolerância	VIF
1	(Constante)	-,007	,137		-,050	,960		
	FC	,398	,047	,347	8,511	,000	,988	1,012
	PE	,744	,038	,797	19,565	,000	,988	1,012

a. Variável Dependente: HM

Appendix 11– Factor Loadings for Technological Literacy

Matriz dos fatores[a]	
	Fator
	1
NivExpTech	0,795
InteresseTech	0,724
NumTechUsadas	0,637

Método de Extração: máxima Verossimilhança.
a. 1 fatores extraídos. 4 iterações necessárias.

LitTec = (NivExpTech*0.795+InteresseTech*0.724+NumTechUsadas*0.637)/3