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Social Robots in the Home: What Factors Influence Attitudes Towards their Use in Assistive Care?

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Abstract

Advances in technology and science have led to the application of artificial intelligence in many different areas of life. In particular, they have led to the appearance of robots in the domestic sphere. One type of robot – namely, the social robot – has been endowed with a very human aesthetic and is designed to interact with humans, and it is increasingly being used to perform "human tasks". Social robots have also been introduced into the social services, providing companionship and assistive services for children, the infirm and the elderly. Such usage has rightly attracted the interest of the social sciences, fuelling the debate about the acceptance of social robots by their end-users. In this paper, regression analysis is applied to data from the Eurobarometer survey to investigate how socio-demographic features and self-confidence on technological development influence European citizens' attitudes towards robots in the social services. The results show that men, with a high level of education, living in a big city and with experience of robot use have more positive attitudes towards the concept of robots for assistive services. This study emphasizes the need to consider the relation between attitudes towards social robots and their use to avoid the generation of social inequalities.

Keywords: human robot, social robot, social assistance, elderly, Europe.

1. Introduction

The modern era has witnessed an exponential increase in the use of technologies in all aspects of daily life. Evidence of this "technological revolution" can be found in multiple dimensions. One of the perhaps most

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heavily influenced is the healthcare system, where the introduction of new technologies has revolutionized healthcare and professional practices, including the management of illnesses, and thus patient experiences (Faulkner, 2009). Another noteworthy example are the practices of the "*quantified-selfer*" – people who track many kinds of data about themselves, i.e. "life-logging", through the use of wearable technologies and mobile social media, with the scope of improving well-being and tracking physical, mental, and/or emotional parameters (Lupton, 2013). Advances have also resulted in "smart home" technology – used to equip a house in order to improve the safety of ageing people and even monitor their health (Etemad-Sajadi, Dos Santos, 2020).

A relevant change also concerns the development of robotic technologies for daily life activities. Improvements in robotic construction and processes of "technological diffusion" (Bijker, Hughes, Pinch, 1987; Dafoe, 2015) have led to the use of robots in areas outside the industrial (Čaić, Mahr, Oderkerken-Schröder, 2019; Mordechai, Mondada, 2018) and military sectors (Shaw, 2017; Moelker, Schenk, 2018) – areas where robots were used first. Nowadays, robots are increasingly being used in other many areas, for example, in the healthcare sector, in the form of "assistive devices" for instance (Bogue, 2011, Green, Hartley, Gillespie, 2016), the entertainment sector (e.g. toys) (Robinson, MacDonald, Broadbent, 2014), and even the domestic sphere (Fortunati, Esposito, Lugano, 2015; IFR, 2019; Taipale et al., 2015; Young et al., 2009) where they may be used to perform housework tasks in the context of healthcare services and social assistance for the elderly and even children (Broekens, Heerink, Rosendal, 2009; Smarr et al., 2014).

This transition of robots into the healthcare sphere has relevant implications, not only for welfare policies (Bodenhagen et al., 2019) and from the stance of legislation (Bertolini, Aiello, 2018; Leenes et al., 2017), but also from the ethical standpoint (Sparrow, 2019; Vincent et al., 2015) and with regard to human values (de Swarte, Boufous, Escalle, 2019) since it has meant that people must now interact with non-human beings or assist interactions between non-human beings.

The adaptation of robots for other non-industrial spheres, such as welfare and healthcare services, has prompted new scientific inquiries from the social science viewpoint, which do not regard technological perspectives (Broadbent, Stafford, MacDonald, 2009). One line of inquiry, which has generated much research interest, concerns people's attitudes towards robots (Gnambs, Appel 2019; Hudson, Orviska, Hunady, 2017; Naneva et al., 2020).

An understanding of the nature and dynamics of the relationships between people and social robots is relevant because it expands the debate about the roles that robots can play in replacing human workers (Dahlin, 2019), thus involving and engaging the interest of IT experts, IT education programmes

(Gnambs, Appel, 2019) and legislators. It will also help to advance our sociological understanding of social robots, which is still in its infancy (van Oost, Reed, 2011).

The paper begins with a review of the literature on social robots and the presentation of the study's research questions. The following section introduces the data and the methods adopted. The results section describes the outputs of the analysis and is followed by the concluding discussion, which compares the results with previous studies and underlines the implications that the attitudes towards social robots could produce.

2. Theoretical framework and research questions

For some years now, the World Bank Organization has sustained that one of the consequences of the Fourth Industrial Revolution (4IR), with its new and emerging technologies, is that the traditional boundaries between the physical, biological and digital worlds are no-longer so reliable. Instead, a whole new set of possibilities have become conceivable, opening the way to a multitude of new realities. The technological developments characterizing this new era so far, in addition to improving the efficiency of organizations, have allowed billions of people to connect to digital networks. Indeed, they are central to many developing fields such as the artificial intelligence, robotics, the Internet of Things, autonomous vehicles, nanotechnology, biotechnology, 3-D printing, and quantum computing (Bainbridge, Roco, 2016, Ford, 2015; Schwab, 2016).

Although, on the one hand, the 4IR has guaranteed very high levels of technological quality, having a positive effect on manufacturing production, it has also raised difficult questions concerning the broader impact of automation on the workforce as a whole and on life in general (OECD, 2019). These technological developments also support the diffusion of robots. Whereas in the past we witnessed a process of robotization of human activities, such as the modularization and replacement of biological entities or structures, through plastic surgery or cloning processes (Brynjolfsson, McAfee, 2014), nowadays we are witnessing a process of humanization of robots, a process of conscientization and sensitization of inorganic entities. Some examples of this can be seen in the activities of biotechnology, in genetic and biomedical engineering, and even in social robots.

No single definition of the robot exists in the literature (Mordechai, Mondada, 2018; Shaw, 2017). However, according to the Robot Institute of America (RIA) (1979), a robot can be defined as a "reprogrammable, multifunctional manipulator designed to move materials, parts, tools, or specialized devices through various programmed motions for the performance of a variety of tasks".[1] References to some forms of robots and automata – as noted by Fron and Korn (2019) – can even be found in ancient Greek literature, but it was the Czech novelist Karel Capek who first coined the word "robot" in 1921 and Isaac Asimov who went on to popularize the term through its use in his novels written in the 1940s (Vincent et al., 2015; Shaw, 2017).

Technological progress, by combining artificial intelligence with biological features (Winfield, 2012), has transformed robot shapes and functions, mimicking human forms, to generate robots increasingly able to interact and communicate with humans and other "autonomous physical agents" that abide by human social rules (Hegel et al., 2009), such that "socially intelligent robots" have become a part of human life (Katz, Halpern, Crocker, 2015; Zhao, 2006). These kinds of robots, which combine technical characteristics with social features, are the so-called social robots (Čaić, Mahr, Oderkerken-Schröder, 2019; Fortunati et al., 2018; van Oost, Reed, 2011). Social robots have social functions that permit them to interact according to the context as well as build social relations with humans. The literature offers different definitions of social robots. For example, Fong, Nourbakhsh, and Dautehahn (2003) introduced the concept of a "socially interactive robot", which means that "social interaction plays a key role in 'peer-to-peer' HRI (human-robot interactions), different from other robots that involve 'conventional' HRI, such as those used in teleoperation scenarios" (Dautenhahn, 2007, 684).

With the introduction of robots into the domestic sphere of life (Fortunati, 2013; Fortunati, Esposito, Lugano, 2015; Taipale et al., 2015) – an environment that is much less formalized than that of the industrial sector – social robots have started to carry out tasks such as providing companionship (van Oost, Reed, 2011) or assisting the elderly – work that is usually performed by women (Fortunati, Esposito, Lugano, 2015).

Many examples can be found in the literature of the application of social robots for the assistance of medical professionals, for example in the operating theatre (Chen, Jones, Moyle, 2018; Leite, Martinho, Paiva, 2013; Wang et al., 2019), whereas the application of social robots in the social services, for example to assist the elderly, has been explored much less from the sociological point of view, and thus is in need of further examination. Moreover, the empirical studies carried out in this area have mainly been conducted using qualitative methods, thus additional investigations employing quantitative approaches and large data bases (Hudson, Orviska, Hunady, 2017) would help us understand the use of social robots from different perspectives.

Studies conducted with survey data are mainly focussed on the European context, and this is most likely thanks to the availability of data from the

[1] https://www.robotics.org/

Eurobarometer surveys, which include questions related to this topic. Taipale et al. (2015) investigated the socio-demographic profile of European citizens already exposed to robots in social scenarios. They used data from the Eurobarometer 382 for their analysis, pertaining to the year 2012, with a sample size of 26,751 citizens. It emerged that "large cities seem to be the most favourable places for the introduction of robots into the health and care sectors. While in villages and smaller towns attitudes towards the care and health services seem to be still family and community oriented, in the large cities people are used to relying more on external or technological aid" (Taipale et al., 2015, 22). They also showed that while pensioners are favourable to robot use in the domestic sphere, they were concerned about receiving less human contact as a consequence, and although this result arose from the misinterpretation of the question, it reflects the fear that robots stand to substitute human beings.

The influence of demographic variables upon robot acceptance was also demonstrated by Loffredo and Tavakkoli (2016), who identified that gender and age influence attitudes towards robots in Europe.

Moreover, Hudson, Orviska, and Hunady (2017) investigated people's attitudes towards robots used for caring for the elderly. From their analysis, it emerged that elderly people are more hostile than the young towards the use of social robots, and that men are more supportive of their use than woman. Furthermore, those living in a village or small town showed less positive attitudes towards social robots than those living in larger towns or cities. These last two findings confirm the previous results of Taipale et al. (2015). However, a discordant result between the two papers regards Hudson, Orviska, and Hunady's (2017) finding that pensioners' views do not differ to those of younger citizens.

The study by Gnambs and Appel (2019), which analysed data related to the 28 EU countries focusing mainly on Austria and Germany, identified – in line with previous studies – that men, compared with woman, have more favourable attitudes towards social robots, and that these men are more likely to be highly educated rather than having a low education level. Regarding employment conditions, Gnambs and Appel (2019) distinguished between white-collar, blue-collar and non-employment, and they discovered that white collars are associated with slightly more positive attitudes towards robots than other employment categories. In contrast with Hudson, Orviska, and Hunady et al. (2017), the study found age to have a negligible impact upon the evaluation of robots.

A similar study, but which focussed on the American context, was carried out by Kadylak and Cotten (2020). It dealt with an internet-based survey (carried out from October to November 2017) involving 1,148 respondents aged 65 and older and analyzed the factors that predict the willingness of American senior citizens to use six distinct emerging technologies, including assistive robots (the other technologies examined were: autonomous vehicles, internet-connected home appliances, internet-connected cameras, smart homes and virtual reality). The results obtained by these scholars show that 24% of the senior citizens interviewed would be willing to use assistive robots. We can also interpret this finding as suggesting that older adults with physical limitations are more willing to use assistive robots. Other factors that positively influence attitudes towards social robot use are education level, as identified by Gnambs and Appel (2019), and limitations in key daily living activities (e.g. shopping or cooking), thus social robots may support the elderly in these daily activities (Lawton, Brody, 1969).

On the basis of the above-cited literature, this study aims to further our understanding of how socio-demographic dimensions affect attitudes towards the use of social robots for social care using the most recent Eurobarometer database. By considering additional socio-demographic features, such as family condition, household composition and social class, it expands upon the investigations obtained in the above-cited studies. Indeed, none of these variables have been addressed in the studies published to date.

In line with the previous literature, we can expect that men with a high level of education living in big cities will be those most favourable to the social robots. Moreover, I predict that being older will not correlate with a reluctant attitude towards social robots for social assistance; instead, being retired may in fact correlate with more positive attitudes. Furthermore, although no quantitative empirical evidence is available, to the best of my knowledge, on the relationships between family condition (single, married, etc.), household composition, social class and attitudes towards social robots, we can hypothesize that those in a stable relationship will have less positive attitudes towards social robots compared with those who are single or divorced, since the former may be more likely to envisage support from the family network only when they are old or infirm, whereas those without stable family relationships may have less expectations regarding to this regard and therefore be more open to external support. The presence of children in the house might also be expected to generate more positive attitudes towards robots, which might arise due to greater contact with robotic technology in the form of children's games. Finally, we can hypothesize that those considering themselves as belonging to a high social class would have more favourable opinions of social robots, since they might have more economic opportunities to implement new technologies in general, such as, for example, buying a social robot, compared with those from the lower classes.

Furthermore, in light of the literature showing that past experience of technology is able to influence the willingness of end-users to embrace future technologies (Katz, Halpern, Crocker, 2015), it will be interesting to understand whether this relationship extends to the acceptance of social robots. Therefore, this work also aimed to investigate the hypothesis that having previous experience of robots would positively influence attitudes towards the acceptance of social robots for assistive care in the home.

Another question investigated in this paper not considered in the abovementioned previous studies concerns the relationship between the use of information and communication technology (ICT) and perceptions about social robots. This issue was addressed, however, in a publication by Katz, Halpern, and Crocker (2015), who investigated robot perceptions in more than 700 undergraduate students attending communication courses at a large university in the north-east of the United States; the study reported there to be "no significant effect for individuals who reported higher levels of competence communicating with ICT, suggesting that just using ICT is not enough to change how individuals respond to or accept robots" (Katz, Halpern, Crocker, 2015, p. 30). Thus, the present study also investigates whether the time that European citizens spend using the internet influences their attitudes towards robots for social assistance. In accordance with the findings by Katz, Halpern, and Crocker (2015), the final hypothesis addressed is that people who frequently use the internet are not more likely to express more positive attitudes towards robots for assistive care than people without internet access or those who use it less frequently.

3. Data and methods

The data come from the Eurobarometer survey carried out in 2017 (Eurobarometer 87.1).[2] The interviews were conducted by means of face-to-face interviews at the respondents' homes in the mother tongue language of the participants. The Eurobarometer surveys involve approximately 1000 interviews per country (of the population aged 15 years or over). Interviewee sampling consists of the random selection of a sampling point after stratification for the distribution of the national and regional population. The 2017 survey is composed of 27,901 interviewee responses from across the 28 EU member states. At the start of the interviews, respondents were introduced to the concept of robots by showing them two photos (one of a humanoid robot and another of a non-humanoid robot) and the following definition: "A robot is defined as a machine which can assist humans in everyday tasks without

[2] Commission, E., Parliament, E. (2017), *Eurobarometer 87.1 (2017): TNS opinion*. GESIS data archive, Cologne. ZA6861 data file version 1.2.0. Accessed on 2019 August 12th. https://doi.org/10.4232/1.12922.

constant guidance or instruction, e.g. as a kind of co-worker helping on the factory floor or as a robot cleaner, or in activities which may be dangerous for humans, like search and rescue in disasters. Robots can come in many shapes or sizes and some may be of human appearance. Traditional kitchen appliances, such as a blender or a coffee maker, are not considered as robots" (Eurobarometer 87.1 questionnaire).

3.1 The dependent variable

Attitudes towards the acceptance of the robots for social assistance was assessed using the following questionnaire item: "…how do you feel about having a robot provide you services and companionship when you [are] infirm or elderly?" The answer options ranged from 1 (totally uncomfortable) to 10 (totally comfortable). Thus, a higher score reflected a more positive attitude towards the use of robots for welfare assistance. This was treated as a continuous variable. The mean score for the sample was 4.3 (SD=3.0).

3.2 The independent variables

The independent variables were chosen in concordance with the theoretical framework applied in previous studies (Gnambs, Appel, 2019; Hudson, Orviska, Hunady, 2017; Katz, Halpern, Crocker, 2015; Schermerhorn, Scheutz, Crowell, 2008; Taipale et al., 2015). The socio-demographic variables considered are the following: gender, measured as a dummy variable (female or male, the latter treated as a reference category); age, treated as a continuous variable (mean=48.2; SD=18.7); level of education, measured as the age (in years) at which full-time education ceased. The latter variable was analyzed as a categorical variable, according to the following three categories: low level of education (15 years old or younger–taken as the reference category); medium level of education (16–19 years old), and high level of education (20 years old or older). The category "still studying" was excluded from the analysis. The next socio-demographic variable considered was employment activity, which assessed the occupation of respondents at the time of the questionnaire; responses were recoded into: worker (e.g. farmer, fisherman, professional, shop owner, business proprietor, employed professional) (reference category); unemployed; house-person (e.g. responsible for the weekly shopping and looking after the home) and retired.[3] The response options for the variable "family condition" were: married or re-married; single but living with a partner; single; divorced or separated; or widowed. Importantly, in association with each of these response options, the respondent was required to indicate whether they

[3] "Still studying" was excluded from the analysis.

were living with or without children (including those from previous marriages/unions). For the analysis, the following categories were clustered: unmarried (reference category); (re)married/single with partner; divorced or separated; and widowed. The number of children in the family (aged less than 14 years old) was computed by summing the variable that measures "how many children less than 10 years old live in your household" and the variable "how many children aged 10 to 14 years old live in your household". These data were used as a dichotomous variable: family with children (less than 14 years old); and family without children (reference category). The variable "social class" constituted a self-reported evaluation of the social class each respondent considered themselves to belong to. The five possible response options (working class; lower middle class; middle class; upper middle class; higher class) were recoded into three categories: lower (which includes the working class and the lower middle class of society – taken as the reference category); middle class; and higher class (which includes the upper middle class and the higher class of society). The geographical dimension assessed the area where the interviewees declared to live; the response options were: rural area or village (reference category); small or medium-sized town; large town.

As a measure of technology experience, the analysis considered the variable that addresses AI knowledge, and which asks the respondent whether they have heard, read or seen anything about artificial intelligence in the previous 12 months. The positive responses of this dichotomic variable were used as the reference category. Each respondent was also asked to rate their overall attitudes towards robots and AI by choosing from the following options: very positive, fairly positive, fairly negative, or very negative. This variable was recoded as a dichotomized value prior to analysis (very positive and fairly positive recoded as "positive", being the reference category; fairly negative and very negative recoded as "negative"). Finally, previous or current use of robots in the home or workplace was assessed. Each of these independent variables had binary response options: "yes" and "no" ("no" being the reference category).

As a measure of the respondents' use of information and communication systems, the item that assessed the frequency of internet use was considered. This indicator, herein referred to as "internet use", was computed by summing[4] the responses to the following questions: do you use the internet at home, in the place of work, on a personal mobile device (laptop, smartphone, tablet, etc.), or elsewhere (school, university, cyber-café, etc.). Each variable comprised 4

[4] The sum was carried out by applying a numerical value to each recoded response option and then summing the values. These compute values were thus recoded as a binary variable with seldom/no access and Weekly/daily categories.

response categories that were: every day or almost every day, two or three times a week, about once a week (recoded as "everyday/almost every day" and "weekly"; "weekly" being the reference category), two or three times a month, less often, never, and I do not have internet access (recoded as seldom/no access).

For each independent variable, responses other than these categories were recoded as "missing" and were excluded from the analysis, as were all other missing values.

3.3 Analytical strategy

The statistical procedures included descriptive statistics and regression analysis to test the study hypotheses (95% CI). R software, version 3.6.1 (Package 'faraway'), was used to perform all the statistical tests reported.

Since the dependent variable was a continuous variable, a linear regression model was used (Gordon, 2015). The independent variables were introduced in two steps, according to the theoretical framework used in this study. In the first model, only the socio-demographic variables specifically linked to the hypothesis in question were included. In the second model, the measures of robot experience and the ICT indicator were added to investigate the effect of the variables "technology experience" and "internet use".

4. Results

4.1 Descriptive results

The descriptive results are reported in Table 1. Of the 27,901 respondents, 51.7% were women and 48.2% were men. The average age was 48 years (SD=18.7). In terms of education, 18.3% declared to have a low level of school education; 46.7% had a medium level of education, and 35% had a high level of education. Twenty-one percent of the respondents were unmarried (living with or without children), 63.7% were re-married or single with a partner, 6.9% were divorced or separated, and 8.1% were widowed. Roughly three-quarters of respondents (73.1%) reported to live with children (less than 14 years old).

Fifty-three percent were classified as workers, meanwhile approximately 8% were house-persons, 7.5% were unemployed, and 31% were retired. As far as social class is concerned, 44.6% reported to belong to the lower middle or working class, 47.2% considered themselves middle class, and 7.9% declared to pertain to the upper middle or higher class of society. Regarding living area, 30.3% declared to live in a rural area or village, 44.8% in a small or medium-sized town, and 24.9% in a large town.

TABLE 1. Descriptive statistics for categorical variables included in the analysis (weighted values).

	%
Gender	
Male	48.2
Female	51.8
Total	100.0
N	27901
Education	
Low education	18.3
Medium education	46.7
High education	35.0
Total	100.0
N	24639
Family condition	
Unmarried (living without children; living with children)	21.2
(Re-)married/single with partner ((re-)married living without children; (re-)married living with children from this marriage; (re-)married living with children from previous marriage; (re-)married living with the children from this marriage and from a previous marriage; living with partner without children; living with partner and children from this union; living with partner and children from a previous union; living with partner and children from this union and from a previous union)	63.8
Divorced or separated (divorced/separated: without children; divorced/separated: with children)	6.9
Widowed (living without children; living with children)	8.1
Total	100.0
N	27592
Children	
Family with children (less than 14 years old)	73.1
Family without children	26.9
Total	100.0
N	27898
Employment/Activity	
Worker (farmer, fisherman, professional [lawyer, etc.], shop owner, craftsman, etc., business proprietors, etc., employed professional [employed doctor, general management, etc.], middle management, etc., desk job, travelling, service job, supervisor, skilled manual worker, unskilled manual worker, etc.)	53.6
House-person/homemaker (responsible for weekly shopping, etc.)	7.8
Unemployed (and temporarily not working)	7.6
Retired	31.0
Total	100.0
N	25325
Social class	
Lower (the working class and lower middle class of society)	44.6
Middle	47.4
Higher (the upper middle class and higher class of society)	8.0
Total	100.0
N	26700
Living location/Degree of urbanisation	
Rural area or village	30.3
Small/medium-sized town	44.8
Large town	24.9
Total	100.0
N	27872

Continue

AI knowledge	
Yes	47.4
No	52.6
Total	100.0
N	27489
Robot opinion	
Positive	66.5
Negative	33.5
Total	100.0
N	25343
Experience of robots at home	
Yes	8.6
No	91.4
Total	100.0
N	27901
Experience of robots at work	
Yes	5.6
No	94.4
Total	100.0
N	27901
Internet use	
Weekly/daily	78.6
Seldom/no access	21.4
Total	100.0
N	27901

Forty-seven percent of respondents declared to have heard, read or seen something about artificial intelligence; and more than 65% expressed an overall positive view of robots and artificial intelligence. Of the people interviewed, 8.6% and 5.5% declared to have had experience of robots in the home and at work, respectively.

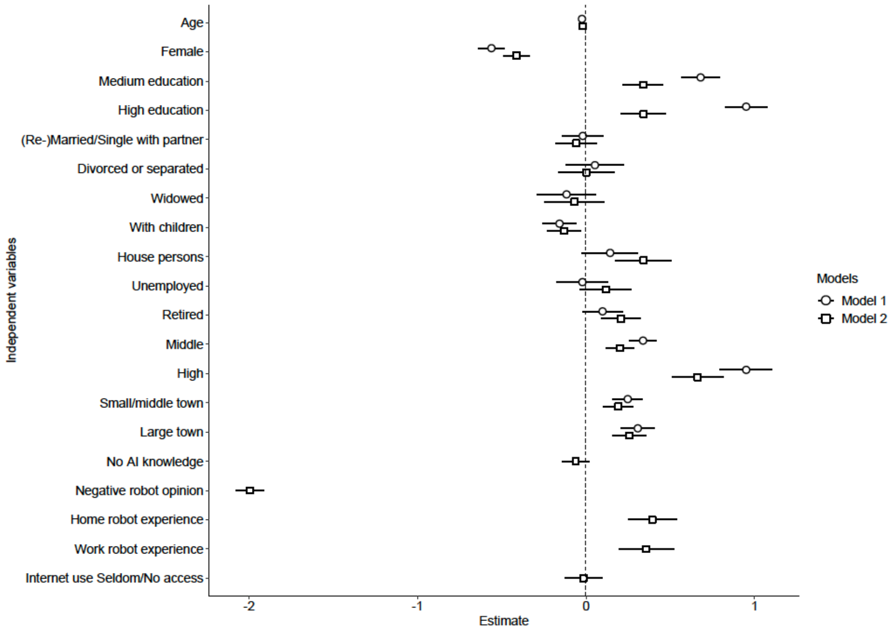
As far as internet use is concerned, the majority of respondents (78.58%) reported frequent use, while 21.42% accessed it monthly or less frequently or had no access at all.

4.2 Multivariate results

An understanding of the effects of the independent variables included in the regression models can be obtained by observing Figure 1 which plots the predicted average scores for each category of the independent variables – including the continuous independent age variable – with their 95% confidence intervals.

These data are the results of the linear regression and are presented in Table 2. Model 1 shows the simple association between socio-demographic variables and the outcome. Model 2 shows what happens when the variable "technology experience" and "internet use" were added to the model.

FIGURE 1. Estimated scores from linear regression models (with 95% confidence intervals).



Considering model 1, the estimated ß coefficients describe the amount of increase – or decrease – in acceptance of robots for social assistance that would be predicted by an increase of one unit in the predictor (if it is a continuous variable). When the predictor is a categorical variable the estimated ß coefficients describe the difference in mean of the two categories considered.

The effect of age is negligible, albeit significant. The predicted views about robots for social assistance for females is 0.561 points lower than for males, with all other independent variables being constant.

Education level has a positive and significant effect compared with a low education level, a medium education level increases the score regarding how comfortable respondents' feel about robots providing social care by 0.681 points, whereas having a high education level increases acceptance of social robots by 0.951 units. The presence of children in the household, compared with their absence, decreases the score of feeling comfortable about the use of robots for social assistance by 0.157 units. Being a house-person, compared with being a worker, increases the level of feeling comfortable about robots providing social care by 0.143 points. Social status is another dimension that positively influences the probability of robot acceptance for social assistance. Considering oneself middle class rather than lower class increased the score regarding how comfortable respondents' feel about having a robot for social assistance by 0.339 points. Comparing the low verses the high social classes, we can expect to see an increase in the dependent variable by 0.951 units. The last socio-demographic variable studied concerns living area; in this case, living in a small or medium-sized town rather than living in a rural area or village increases the level of accepting a robot for social assistance by 0.248 points; whereas living in a large town, once again compared with a rural area/village and maintaining all the other variables included in the model constant, increases the score of feeling comfortable about robots assisting the elderly or infirm by 0.308 points.

Family condition and some employment conditions such as being unemployed or retired were found to have no significant effect on the dependent variable.

In model two – which includes technology experience and ICT use in addition to the sociodemographic dimensions applied in model one – we can notice that the independent socio-demographic variables found to have a significant effect upon the dependent variable are the same as in model 1, with the exception for the employment condition of being retired. We can also notice that the net estimated effect of some variables, such as education and social class, slightly change, while others, such as age remain unchanged with respect to model one.

When technology experience and ICT are taken into account, being female predicted a decrease of 0.412 points in the score of feeling comfortable about having a robot for assisting the elderly or infirm compared with men.

Education has a positive effect on the dependent variable. Having a medium level of education compared with a low level of education was associated with a rise in the score of accepting social robots for social care by 0.338 units, whereas for people with a high education level the score of accepting such technology was 0.342 points higher in comparison with the population characterized by a low education level. The presence of children in the family – compared with their absence – decreases the effect of this independent variable on the output by 0.130 points.

Being a house-person – rather than being worker – increases the level of accepting a robot for social assistance by 0.348 points. A change in employment condition from being worker to being retired increased the level of social robot acceptance by 0.207 units.

TABLE 2. Linear regression models for willingness to accept social robots (CI = 95%).

		Model 1					Model 2				
		ß	SE (ß)	Standardized ß	Confidence interval (2.5%–97.5%)		ß	SE (ß)	Standardized ß	Confidence interval (2.5%–97.5%)	
Age	Years	-0.024***	(0.002)	-0.131	-0.027	-0.019	-0.021***	(0.002)	-0.115	-0.024	-0.017
Gender	Female	-0.561***	(0.040)	-0.092	-0.638	-0.482	-0.412***	(0.040)	-0.068	-0.489	-0.334
Education	Medium	0.681***	(0.058)	0.113	0.566	0.794	0.338***	(0.061)	0.055	0.219	0.457
	High	0.951***	(0.064)	0.153	0.825	1.075	0.342***	(0.068)	0.055	0.208	0.474
Family condition	(Re-)Married/single with partner	-0.019	(0.061)	-0.002	-0.138	0.100	-0.058	(0.061)	-0.008	-0.177	0.061
	Divorced or separated	0.053	(0.087)	0.004	-0.116	0.222	0.003	(0.086)	0.000	-0.165	0.170
	Widowed	-0.115	(0.089)	-0.011	-0.289	0.059	-0.069	(0.090)	-0.006	-0.245	0.107
Household composition	With children	-0.157***	(0.052)	-0.022	-0.257	-0.055	-0.130***	(0.051)	-0.018	-0.229	-0.029
Employment	House-person	0.143*	(0.085)	0.011	-0.022	0.309	0.342	(0.085)	0.026	0.174	0.508
	Unemployed	-0.021	(0.078)	-0.001	-0.173	0.131	0.117	(0.078)	0.009	-0.035	0.269
	Retired	0.099	(0.060)	0.015	-0.019	0.216	0.207***	(0.061)	0.032	0.088	0.325
Social Class	Middle	0.339***	(0.042)	0.056	0.257	0.420	0.200***	(0.042)	0.033	0.117	0.282
	High	0.951***	(0.079)	0.083	0.796	1.105	0.662***	(0.078)	0.059	0.509	0.814
Town size	Small/medium town	0.248***	(0.045)	0.040	0.160	0.336	0.192***	(0.045)	0.031	0.104	0.280
	Large town	0.308***	(0.050)	0.045	0.209	0.405	0.257***	(0.050)	0.038	0.160	0.354
Technology experience	AI knowledge: No						-0.062	(0.042)	-0.010	-0.143	0.019
	Robot opinion: Negative						-1.995***	(0.043)	-0.312	-2.078	-1.911
	Home Experience Robot: Yes, at home						0.395***	(0.073)	0.034	0.251	0.537
	Work Experience Robot: Yes, at work						0.358***	(0.083)	0.027	0.195	0.520
ICT use	Internet use: Seldom/No access						-0.015	(0.056)	-0.002	-0.125	0.095
Constant		4.662	(0.118)	0.00	4.431	4.892	5.627***	(0.121)	0.000	5.389	5.865
Observations		23,644					21,678				
R^2		0.058					0.153				
Adjusted R^2		0.057					0.152				

Note: *p<0.1; **p<0.05; ***p<0.01

Being in the middle or higher social class, compared with the lower class increased the score of accepting a robot for social assistance by 0.200 points and 0.662 points, respectively. Comparing the responses from those living in a rural area or village with those from small or medium-sized town, the latter were 0.192 points more likely to feel comfortable about having a robot provide social care. The comparison between rural areas/villages and large towns was even greater, with the latter being 0.257 points more likely to accept of social robots.

A positive opinion of robots has a considerable impact on the probability of expressing a positive attitude towards robots for social care; indeed, moving from a positive opinion of robots to a negative opinion decreased the level of feeling confident about social robot by 1.995 units.

The use of robots in the home or in the workplace, compared with their non-use, positively influenced whether respondents felt comfortable about robots assisting the elderly. The former increased the level by 0.395 units, whereas the latter increased it by 0.358 units.

The proportion of variance in the dependent variable which can be predicted from the independent variables is equal to 5.8% in model 1 and to 15.3% in model 2; while the adjusted R-square values are 5.7% and 15.2%, respectively.

5. Discussions and conclusions

The results affirm that gender influences attitudes towards robots for social assistance, in accordance with the literature: men are more likely to accept social robots for social services than women.

Both models corroborate the positive effect of education upon attitudes towards robots, as previously reported in the literature. A higher level of education corresponds with a higher probability that people feel comfortable about robots providing social care. Thus, education appears to have a significant role in the process of social robot acceptance.

The results also show that becoming older does not increase the level of acceptance towards social robots as has been stated in previous studies present in the literature. However, it is necessary to consider that the present research was not able to take into account whether respondents presented any health limitations or not, as was instead done in other studies, such as that by Kadylak and Cotten (2020). The findings of the present study did confirm, however, that retirees generally accept the use of robots in the domestic sphere as indicated by previous studies, but this is only valid if we consider a model that includes technological variables.

The results also corroborate that the place where people live affects perceptions about social robots, as pointed out in the literature. Those living in urban areas, especially big cities, are more comfortable about the idea of robots assisting the elderly with respect to those living in rural contexts. This can be considered a reflection of the normal "spread" of technological innovations. Nevertheless, it is necessary to consider the implications this could have on robot use. Although rural areas may be more family and community oriented with regards to social assistance, these areas usually suffer from other "issues" such as social isolation, a poor availability of public services, greater distances to social care centres, and poorer public transport, thus acceptance and consequently the use of social robots could benefit these areas in particular and ameliorate the limitations that tend to characterize rural areas. However, if people living in these areas present less favourable attitudes towards social robots, this might reduce the probability of them being introduced and used, leaving rural inhabitants with fewer opportunities to use such technology and reduce the consequence of this disadvantage associated with living area.

Being in a couple, compared with being single, does not appear to significantly influence attitudes towards robot acceptance. By contrast, having children reduces the probability of accepting robots for social assistance, and this could be because respondents expect to rely on their own offspring for such support.

The results of the regression model prove that having prior experience of robots has a positive effect on their acceptance. It appears that direct contact with technology generates confidence in it. More precisely, it is positive opinions resulting from past experience of robots – rather than simply experience of them – that has more influence on positive attitudes towards social robots. This result does not permit us to understand whether previous experience of technology influences users opinions about technology or whether opinions about technology influences the users' experience of them, thus the difference between these two variables needs to be investigated further.

The last hypothesis concerns whether ICT use – specifically, how frequent the internet is accessed – influences social robot acceptance. The findings do not reveal any significant association between attitudes towards robots for social assistance and the level of internet use. Thus, it was not possible to reject the null hypothesis stated above in the theoretical framework.

The findings obtained from the analyses herein reported add to our knowledge about social robot acceptance. Although it still not clear how the use of technology may interact with attitudes towards robots (Gnambs, 2019), from a sociological point of view, the results of this study are of great relevance because if the people expressing more positive attitudes towards social robots turn out to be those who actually adopt them in the future – as suggested by these regression models – then this will imply that these people will belong to the higher social classes, who are more educated, and who live in environments already supplied with better services, i.e. large towns, who are more likely to reap the potential benefits from social robots. Presuming that end-users actually benefit from the use of social robots, this could stand to increase the social inequality between those who are already more advantaged, which itself permits these people to be more open towards social robots for assistive care, and those who are instead are more reluctant toward this form of technology. This possibility should alert stakeholders in education, industry, and politics to consider this possible unfavourable outcome.

Due to the nature of the database, the interpretation of the results is also associated with certain limitations. The first concerns the features describing the respondents. The database offers no information about the social and health conditions of the people interviewed, thus we are unable to identify whether people with physical or health limitations, for example, are more or less open towards robots for social care than people who do not present these kinds of limitations. A second limit regards the photos of robots used in the survey. One of these does not represent a humanoid robot prototype of the last generation with strong human-like apparencies. This could have affected the respondents' opinions. Future Eurobarometer surveys could consider adding further questions in order to obtain additional data that would permit a deeper analysis of people's reactions to new technologies.

In this study, I investigate which dimensions influence the acceptance of robots in the field of social reproduction in Europe without considering the local differences that the living contexts present. However, some other research questions remain open with regard to this analysis. Future studies should explore the effects that the context – such as the EU countries and/or regions – play in order to investigate whether the effect of socio-demographic features and technological experience is unchanging across contexts (Li, Rau, Li, 2010; Turja, Oksanen, 2019), or whether citizens from certain contexts show more positive attitudes towards social robots that others. Furthermore, considering that the present study addressed attitudes towards robots used for social services, we must also bear in mind that the EU is characterized by different welfare systems, for a summary of the differences see, for example, Ferragina and Seeleib-Kaiser (2011). For example, social democratic regimes which typify the northern EU countries are subject to strong intervention by the state to promote equality through the redistribution of social security. On the other hand, the conservative regimes characterizing how welfare systems are organized in Germany, Italy and France are only subject to state intervention with regard to the distribution of maintenance benefits related to occupational status, and thus entail a medium level of government intervention. In liberal regimes, such as that of the United Kingdom, government interference is very limited, whereas the market plays a more relevant role. These different organizational models of the welfare systems in Europe should be taken into consideration in future studies to test whether they affect citizens' attitudes towards social robots for assistive care.

In summary, this analysis confirms some of the previous findings about the influence of socio-demographic variables on attitudes towards social robots; it also brings to light the novel finding that having children could reduce the probability of accepting robots for social assistance, and that it is positive opinions about robots, rather than experience of their use, which positively influences social robot acceptance. However, further studies are required to deepen the analysis of the relations between attitudes and the use of social robots in order to prevent that the use of such technology leads to the expansion of social inequality.

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