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The acceptability of social robots: A scoping review of the recent literature

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Introduction

Many articles in the field of social robotics start by noting the rapid rise of this technology, for example, "Many social robots have emerged in public places to serve people [...]" (e.g., Fu et al., 2021), or "The Socially Assistive Robot (SAR) is a fast-emerging technology [...]" (e.g., Conti et al., 2019). Indeed, they are being introduced more and more into our daily lives but are they as well integrated and accepted as such articles imply, given that the integration of social robots into everyday life does not necessarily increase their acceptance (Bartneck et al., 2005; de Graaf et al., 2016). For human-robot cooperation to be successful, it must not only be physically safe (De Santis et al., 2008) but also psychologically comfortable for the person (Zanchettin et al., 2013) and socially acceptable. Thus, in this paper, we are especially interested in understanding how the literature of the last ten years has addressed the study of social robots' acceptability, how researchers assess the acceptability of social robots and the conclusions that have been drawn. Many studies show the efficiency and relevance of these robots in different areas of life with the aim of improving quality of life (e.g., Abdollahi et al., 2017; Fridin & Belokopytov., 2014; Koay et al., 2007). However, people are also expressing concerns about the introduction of this technology. These concerns, in part, stem from a whole collective imagination around social robots (e.g., *Technology Takeover* scenario, Strait et al., 2017; *The Frankenstein syndrome*, Kaplan, 2004) and "possibly dangerous science" (Coiffet, 1993) (e.g., *soft threat* and *hard threat*, Salvini, 2015; *identity threat* and *realistic threat*, Zlotovski, 2017).

This set of observations led us to carry out a rapid scoping review of recent literature based on a rigorous and transparent approach in the choice of inclusion criteria to select the articles. We present below definitions of social robots and what is meant by acceptability, the careful procedure of the selected articles and the results and conclusions that emerge from them.

32 **The social robots**

33 In the present article, social robots are understood as robots with social interaction
34 capabilities (Breazeal, 2003) that generate social responses in users (de Graaf et al., 2016).
35 These robots communicate verbally and non-verbally with people (Naneva et al., 2020). We
36 include, in our study articles which respected this conception of social robot (i.e., see Sarrica et
37 al., 2020, for a systematic review on the definition of social robots). Specifically, they can
38 exhibit human and social characteristics (i.e., conversation, gestures, personality) (Fong et al.,
39 2003). In addition, these robots mostly have a humanoid appearance to facilitate interaction
40 (Eyssel et al., 2011) and adaptation to the environment (Spatola, 2019), but this is not always
41 the case (e.g., the seal robot named Paro) (Breazeal et al., 2009). Naneva et al (2020) define
42 social robots as "physically embodied artificial agents". Finally, social robots are also called in
43 the health domain "socially assistive robots" (SAR, e.g., Winkle et al., 2020) and sometimes
44 "companion robots" when they have an affective component (van Oost & Reed, 2011).

45 Social robots are a special technology in the sense that they are uniquely designed for
46 the purpose of accompanying and assisting people in their daily lives, and thus find themselves
47 integrated in various domains as close to people as possible, even in their most private moments.

48

49 **The acceptability of social robots**

50 The acceptability of any new technology may be determined by the study of its use.
51 Studying the acceptability of a technological device may refer to studying the determinants that
52 make it acceptable or not to the potential user before its actual use (Terrade et al., 2009).
53 However, the study of acceptability can also extend to the acceptance/adoption of the device
54 and its integration into everyday life. Several researchers agree that there are several moments
55 for examining acceptability. Indeed, acceptability includes three phases on a temporal
56 continuum (e.g., Bobillier-Chaumon & Dubois, 2009; Reekink-Boulanger, 2012; Terrade et al.,
57 2009): (a) *a priori* acceptability, (b) acceptance, and (c) appropriation. *A priori* acceptability
58 refers to the study of acceptability before the device is even used. In this phase, the subjective
59 representations of the technology are observed. It begins with the first descriptions of the device
60 until the first interactions with it (Pasquier, 2012). Here, users form their first judgments about
61 the technology (Bobillier-Chaumon & Dubois, 2009). Then comes the acceptance phase that
62 begins when users have their first experiences with the device (Terrade et al., 2009). Bobillier-
63 Chaumon and Dubois (2009) refer to the real adoption behaviours of users. In this phase,
64 objective measures of acceptability can be noted but also subjective measures concerning
65 perceptions after use or satisfaction with the use of the device (e.g., Pasquier, 2012). Finally,

66 Barcenilla & Bastien (2009) define the appropriation phase as the study of the integration of
67 the technology into everyday life, and how individuals appropriate the object. This is referred
68 to as the adoption of the technology. It is an a posteriori analysis of uses (Benedetto-Meyer &
69 Chevallet, 2008).

70 However, this distinction between the phases of the acceptability is rarely found in
71 English-language articles. Researchers use the term "acceptance" to both refer to pre- and post-
72 interaction perceptions and judgments. Often the terms "acceptability" and "acceptance" are
73 used interchangeably (e.g., Krägeloh et al., 2019). In this article, we will make the distinction
74 as much as necessary. Otherwise, we will use the term "acceptability" to refer to the phases of
75 acceptability in general as described above.

76 The main objective of a usage study is to understand the determinants and reasons why
77 a technology is adopted. The idea being that the judgments made about a technology will predict
78 the intention to use the device (e.g., Pasquier, 2012; Reekink-Boulanger, 2012; Venkatesh et
79 al., 2003). In addition, the work of Ajzen (1985) and the *Theory of Planned Behaviour* (TPB)
80 showed that the intention to use can be considered as a predictor of usage behaviour. Thus, to
81 predict usage behaviour, one would need to measure the intention to use of potential users.
82 Intention to use depends mainly on the perceived usefulness of the device as well as the
83 perceived ease of use, among others (Bröhl et al., 2016). Finally, Terrade et al., (2009) divide
84 the study of the use of a device into three notions: the utility (i.e., adequacy between the
85 functionalities of the device and the needs of the user), the usability (i.e., ease of use of the
86 device) as well as the social acceptability (i.e., the social context of integration). Thus, different
87 models have emerged to assess acceptability. Davis (1985) developed the *Technology*
88 *Acceptance Model* (TAM) based on the TRA (Theory of Reasoned Action) and TPB (Theory
89 of Planned Behaviour) with perceived usefulness and perceived ease of use as the main
90 dimensions. Venkatesh et al (2003) later developed the *Unified Theory of Acceptance and Use*
91 *of Technology* (UTAUT) which is based on a multitude of theories (e.g., Innovation Diffusion
92 Theory, Rogers, 2010). In this model, acceptability is measured by performance expectancy,
93 effort expectancy, and social influence, which together form direct determinants of intention to
94 use. Finally, it is also measured by intention and facilitating conditions, which form direct
95 determinants of use behaviour. Reekink-Boulanger (2012) specifies that the TAM is an
96 individual approach, while the UTAUT is an organizational approach. These models are still
97 often used today. However, there are many variants of these models and many other ways to
98 assess the acceptability of technologies.

99

100 In this paper, the acceptability of social robots is determined through the study of their
101 use, whether a priori or posteriori of the interaction with social robot. We are not focused on a
102 particular social robot or on a way of assessing acceptability, hence the rather broad definition,
103 aiming to provide a description of the trends in recent research concerning the acceptability of
104 social robots. We have focused on the last 10 years because attitudes towards technologies
105 change rapidly, especially depending on the context (e.g., the COVID-19 pandemic seems to
106 favour the acceptability of social robots, Ghafurian et al., 2021). Thus, a rigorous approach is
107 used to identify articles from the last ten years that focus on the acceptability of social robots,
108 in order to extract the observations and conclusions that the authors draw.

109

110 **Method**

111 Several files were uploaded to the Open Science Framework (OSF) open-source
112 platform¹: a) the scoping review protocol (i.e., registered after data collection), b) the PRISMA
113 checklist adapted to scoping reviews, c) the Excel file with the selected articles (with
114 inclusion/exclusion criteria) and the calculated percentages, d) the table summarizing the
115 conflict of interest statement and funding sources of each selected article, and finally e) the
116 table with the data extracted by each of the three authors for five randomly selected articles (see
117 the "Reliability of the data extraction" section for details).

118

119 **The choice to perform a scoping review**

120 A scoping review uses several similar processes to systematic reviews (i.e., both use
121 rigorous and transparent methods to identify the relevant literature for the research question)
122 (DiCenso et al., 2010). A scoping review is used to synthesize and describe the literature on a
123 topic (i.e., an overview), while a systematic review “attempts to collate empirical evidence” for
124 a focused research question (Pham et al., 2014). Specifically, Daudt et al. (2013, p.8) define a
125 scoping review by “*scoping studies aim to map the literature on a particular topic or research
126 area and provide an opportunity to identify key concepts; gaps in the research; and types and
127 sources of evidence to inform practice, policymaking and research*”. To summarize, the choice
128 to perform a scoping review is based on the intention to synthesize research in the field, and in
129 an underlying way, proposes a reflection on what is generally decried in the literature.

130 Furthermore, Tricco et al. (2016) propose that scoping review allows for the formulation
131 of a hypothesis, while systematic review allows for the testing of that hypothesis. In this context,

¹ https://osf.io/wybyq8/?view_only=6689e79a131a47f6aff624abd7a4e037

132 the hypothesis of our scoping review could be formulated as “social robots may not be as
133 accepted as the literature suggests”. Specifically, we focused on the acceptability of social
134 robots according to three aims: a) explore existing empirical research on the three phases of
135 acceptability; b) identify the used measures; c) select reference literature from 2010 to 2020. In
136 this study, we propose to address this hypothesis in a descriptive and narrative manner, treating
137 these questions more as “general themes” than as “well-defined processes” as expected in a
138 systematic review (Sucharew & Macaluso, 2019). For all these reasons, it seems that a scoping
139 review is relevant.

140 Finally, because there are no guidelines as such concerning this kind of review (Brien
141 et al., 2010), our methodology is inspired by the Preferred Reporting Items for Systematic
142 Reviews and Meta-Analyses (i.e., PRISMA methodology) and Naneva et al.’s (2020) paper
143 (i.e., a systematic review about attitudes, anxiety, trust, etc. towards social robots). PRISMA
144 (Tricco et al., 2018) released a checklist for scoping reviews in 2018 (see OSF for checklist
145 items and associated pages). We would like to highlight that the development of a scoping
146 review is not a less rigorous adaptation of a systematic review: they are two approaches with
147 different objectives (Pham et al., 2014).

148

149 **The research methodology**

150 *Data sources*

151 The following electronic databases were searched, using pre-specified search terms, for
152 peer-reviewed articles and unpublished literature: PsycINFO, PsycARTICLES and Psychology
153 database (ProQuest). In addition, Google Scholar was used to identify relevant gray literature
154 (i.e., literature that rarely available through normal publishing channels such as conference
155 papers, Petticrew et al., 2006) and articles not found in the previously mentioned electronic
156 databases. Indeed, Google Scholar represents a non-negligible complement to traditional search
157 methods (Haddaway et al., 2015). However, its use is debated (Haddaway et al., 2015; Sarrica et
158 al., 2020). As the search results on this platform are classified by "relevance" according to
159 Google's algorithm, it is difficult to extract the same results from one user to another (Sarrica
160 et al., 2020). Thus, because the search results become less and less relevant to the object of
161 study as the pages go by, but also for data management reasons, only the first 10 pages identified
162 have been considered as observed in the literature (e.g., Naneva et al., 2020).

163 We focused on these databases because (a) they are relevant to the focus of the study,
164 which is acceptability, and some of the models have their origins in social psychology models
165 (e.g., TPB, Ajzen, 1991), and (2) for consistency with Naneva et al.'s (2020) method. However,

166 we did not consider other relevant databases such as IEEE Xplore for example due to
167 organizational and human constraints. We still followed the recommendation to conduct
168 searches in at least two databases². This scoping review is therefore non-exhaustive.

169

170 *Search strategy*

171 The protocol of Naneva et al (2020) (adapted to a systematic review) was used as a basis
172 for this scoping review because it concerns the same object of study: social robots. However,
173 this protocol had to be adapted to our problematic, that of the present scoping review. Thus, the
174 authors, forming a committee of experts in social psychology and cognitive ergonomics, with
175 the help of professional librarians (n = 3) from the university, selected the different filters and
176 search terms developed above to apply to the databases (i.e., the search terms and databases
177 were adapted from Naneva et al., 2020). The data collection was carried out during August
178 2020 concerning the databases from ProQuest: PsychINFO, PsycARTICLES and Psychology
179 Database. The following parameters were selected: multi-field search, search in the abstract and
180 in date range over the last 10 years. We conducted four separate searches with the following
181 search terms: ab(socia*robot*) AND accept* (n = 147); ab(compan* robot*) AND accept* (n
182 = 15); ab(humanoid robot*) AND accept* (n = 33); ab(assis* robot*) AND accept* (n = 81).
183 These four searches include 276 articles.

184 As part of Google scholar platform, the search terms were: “social robot”,
185 “acceptability” and “acceptance”, with the filters 2010-2020 and 100 as the maximum number
186 of results. ~~Also, the filter “last 10 years” (2010-2020) was used.~~ Data collection was carried out
187 during November 2020 included 100 articles.

188 Finally, authors exported the 376 articles found in the databases into an Excel table
189 with their metadata (e.g., author, title, DOI, etc.). The articles from the ProQuest database and
190 Google scholar were separated in two different Excel files.

191

192 **Article selection**

193 *Types of studies included*

194 Only studies that explicitly state that they measure the acceptability of social robots
195 were included. Authors did need not explicitly specify that they used a “social robot” (or
196 “assistive robot” or “companion robot”) for a study to be eligible. The acceptability focuses on
197 the social robot, but whether yes or not the articles use a "social robot" (i.e., really interact with

² <https://guides.library.unisa.edu.au/ScopingReviews/HowtoSearch>

198 a robot) in the articles was assessed at the full-text review stage. By social robot, we meant:
199 "physically embodied artificial agents" (Naneva et al., 2020) that have communication and
200 social interaction capabilities (Breazeal, 2005). In addition, by acceptability, we meant both a
201 priori and a posteriori and we considered three phases: a priori acceptability (i.e., before
202 interaction), acceptance (i.e., after the first interactions) and adoption of the technology (i.e.,
203 integration into daily life) (Terrade et al., 2009). All studies where the authors claimed to
204 measure acceptability were eligible. However, articles in which the authors interpreted their
205 results as acceptability without any direct measure of acceptability were not. The clarification
206 of these concepts allowed us to sort the articles in a second phase. Indeed, it was only during
207 the application of the inclusion/exclusion criteria that we referred to the selected definitions of
208 social robots and acceptability. Thus, these definitions did not influence the identification phase
209 of the articles in the databases.

210 All studies with quantitative, qualitative, or mixed data were included, including field
211 and laboratory studies, questionnaires, interviews, observations, or theses and pilot studies.
212 Qualitative studies are, here, approaches by interviews, observations, open-ended questions,
213 etc., even if they can be recorded for the purpose of statistical treatment (Denzin & Lincoln,
214 2000). Book chapters, systematic reviews, meta-analyses, and other articles without real
215 measures of acceptability were excluded. Participant characteristics or types of exposure were
216 not inclusion/exclusion criteria. Instead, the type of exposure to a robot (e.g., video, pictures,
217 or real interaction) and which robot specifically were identified and noted. Finally, we are
218 interested in all studies exploring the acceptability of social robots, whether their design
219 incorporates comparators or control groups. Qualitative studies are treated and synthesized in
220 the same way as quantitative studies in this paper. This is because our article aims to describe
221 the current state of the art and not to perform a meta-analysis.

222

223 *Selection*

224 The 376 articles retrieved, using the described search strategy, and recorded in Excel
225 files with their metadata, were subjected to several filters. The first filter was to remove
226 duplicates and non-English language articles. The second was to remove articles that did not
227 consist of qualitative or quantitative studies (e.g., reviews). Finally, the third screening
228 consisted of a more thorough reading of the articles according to the inclusion criteria.

229 The lead author alone evaluated the eligibility of each article according to the chosen
230 inclusion criteria, that is (a) the object of study was the social robot and (b) acceptability was
231 measured (coded 1-Yes and 0-No in the Excel files). The results and the reasons for

232 inclusion/exclusion will be presented in the following sections using the PRISMA Flow
233 Diagram (Moher et al., 2009; Tricco et al., 2018).

234 *ProQuest database.* Separate searches of the various ProQuest databases yielded 276
235 articles. Of these 276 articles, 81 articles were removed directly before extraction into the Excel
236 file because they were duplicates (N = 195). Once the 195 articles were extracted and imported
237 into the Excel table, 15 more articles were removed (N = 180) due to being duplicates. Three
238 articles were excluded because they were not written in English (N = 177), 63 articles were also
239 not kept because they were off topic³ (i.e., misleading title or abstract) (N = 114), eight articles
240 were excluded because there was no social robot or other type of robot (N = 106), and 47 articles
241 did not measure acceptability (N = 59). Also, three articles were excluded from the selection
242 because they did not measure the acceptability of the robot, but the acceptability of its voice,
243 its humor or the therapeutic treatment mediated by the robot (N = 56). Finally, eight articles
244 were removed because they were scale or model validation but did not assess the acceptability
245 of a robot per se (N = 48) and 19 articles were literature reviews, book chapters, etc., so they
246 were excluded as well (N = 29). Finally, a total of 29 articles from these databases were selected
247 (Table 1).

248 *Google scholar.* On Google scholar, 100 articles from the first 10 pages were extracted
249 (following Naneva et al., 2020). However, 12 were excluded because of duplication with
250 previous databases (N = 88) as well as six that were duplicates within Google scholar itself (N
251 = 82). In addition, two articles were not included because they were too close to two other
252 papers (not duplicates but almost), so only the most recent of each was kept (N = 80), and two
253 articles were also excluded because they were not written in English (N = 78), 15 were
254 identified as off topic (N = 63), 22 articles did not use a social robot (N = 41), nine articles were
255 not retained because they did not measure acceptability (N = 32) and 12 articles were excluded
256 because they were literature reviews, book chapters, and others (N = 20). Finally, one article
257 was excluded because it was a model validation (N = 19). The final number of articles retained
258 from Google scholar was 19 (Table 2).

³ Articles about the acceptability of non-social robots (e.g., surgical robot, vacuum cleaner robot) were counted in the "Did not use social robots" section. Articles about social robots whose acceptability is not measured were counted in the "Did not measure acceptability" section. Finally, articles on any other topic (e.g., decision making and smart wheelchair, Ghorbel et al., 2018) and/or not related to social robot and acceptability measurement (e.g., adaptation of a surgical robot, Nessi et al., 2016) were counted in the "off topic" section (see Fig. 1 for a summary of the results).

Table 1*Articles selected from ProQuest database*

N°	Title	Type of study	Social robots	Interaction	Acceptability measures	Type of Sample	Sample nationality	Sample size
1	How physical presence overrides emotional effects in HRI: testing the transfer of emotions and emotional coping in interaction with a humanoid social robot (Spekman, Konijn & Hoorn, 2021)	QT	NAO (SoftBank Robotics, with ZORA software, QBMT/Zorabots)	Yes	4 items intention to use (Spekman et al., 2021). <i>After interaction</i>	Students	Netherlands	N _{study1} = 101 N _{study2} = 110
2	Sharing experiences to help a robot present its mind and sociability (Fu, Yoshikawa, Iio, Ishiguro, 2021)	QT, QL	CommU robot (Osaka University and Vstone Co.,Ltd.)	Yes	1 item level of acceptance (Fu et al., 2021) and observations. <i>Before and after interaction</i>	Students	Not specified	N = 24
3	On the perceptions and acceptance of artificially intelligent robotics and the psychology of the future elderly (Gessl, Schlögl, Mevenkamp, 2019)	QT	SRA (Social Assistance Robots), <i>robot's name is not specified (BOT is the robot's name in script)</i>	No, <i>script with two images</i>	34 items The Almere model (Heerink, 2011). <i>After script</i>	Participants around the age of 65 between 2030-2060	German-speaking, Austria	N = 188
4	Are future psychologists willing to accept and use a humanoid robot in their practice? Italian and English student's perspective (Conti, Cattani, Di Nuovo & Di Nuovo, 2019)	QT	NAO (SoftBank Robotics)	Yes	36 items acceptance questionnaire (Heerink et al., 2009). <i>After presentation (oral or oral and video) and interaction</i>	Student in psychology	Italy, UK	N = 158

N°	Title	Type of study	Social robots	Interaction	Acceptability measures	Type of Sample	Sample nationality	Sample size
5	Self-efficacy and acceptance of robots (Latikka, Turja & Oksanen, 2019)	QT	NAO (SoftBank Robotics, ZORA); Paro (AIST) and 2 other non-social robots: lifting and telepresence robots (<i>the last robot is a social robot for researchers</i>)	No, survey based on participants previous experience with robots	9 items Almere model, functional and social acceptance (Heerink et al., 2010).	Care work staff with firsthand experience with assistive robots	Finland	N = 501
6	Mutual shaping in the design of socially assistive robots: a case study on social robots for therapy (Winkle, Caleb-Solly, Turton & Bremmer, 2020)	QT, QL	Pepper (SoftBank Robotics)	No, Pepper demonstration and pictures of Buddy, Miro, Kismet and NAO.	focus group, discussion, and 7 items based on UTAUT (Venkatesh et al., 2003). <i>UTAUT used before/after focus group discussion and demonstration,</i>	Therapists	UK	N = 19
7	Robotic services acceptance in smart environments with older adults: user satisfaction and acceptability study (Cavallo, Esposito, Limosani, Manzi, Bevilacqua, Felici, Di Nuovo, Cangelosi, Lattanzio & Dario, 2018)	QT	Robot-Era SCITOS G5 (DORO and CORO) (METRA-labs), DustCart platform (ODO), Ferri et al. (2010)	Yes	4 items ad hoc acceptance questionnaire and 10 items System Usability Scale (Cavallo et al., 2018). <i>After interaction</i>	Older adults	Italy	N = 45
8	A Multi-perspective evaluation of a service robot for seniors: the voice of different stakeholders (Bedaf, Marti, Amirabdollahian & de Witte, 2018)	QL, QT	Care-o-Bot 3 (Fraunhofer Institute for Manufacturing Engineering and Automation)	Yes	27 items about scenario and Interviews. <i>After interaction scenario</i>	Older adults, professional caregiver, informal carers	Netherlands	N_(questionnaire) = 10 N_(interviews) = 27

N°	Title	Type of study	Social robots	Interaction	Acceptability measures	Type of Sample	Sample nationality	Sample size
9	A phased framework for long-term user acceptance of interactive technology in domestic environments (de Graaf, Ben Allouch & van Dijk, 2018)	QL, L	Karotz (Softbank Robotics)	Yes	Interviews. <i>From 2 weeks before interaction to 6 months after interaction</i>	All coming	Netherlands	N = 21
10	A pilot study exploring staff acceptability of a socially assistive robot in residential care facility that accommodates people under 65 years old (Loi, Bennett, Pearce, Nguyen, Lautenschlager, Khosla & Velakoulis, 2018)	QT, L	Betty (PaPeRo, NEC),	Yes	17 items acceptance questionnaire (Khosla & Chu, 2013; based on TAM, Davis, 1989). <i>Before and after interaction (12 weeks)</i>	Professional caregivers	Australia	N _{pre-questionnaire} = 24 N _{post-questionnaire} = 8
11	The adoption of care robots in homecare: a survey on the attitudes of Finnish home care personnel (Rantanen, Lehto, Vuorinen & Coco, 2018)	QT	<i>Care robot's name is not specified</i>	No, <i>care robot in general</i>	83 items – Attitudes towards robot (based on TPB, Ajzen, 1991) (Rantanen et al., 2018)	Professional caregivers	Finland	N = 200
12	Evaluation of companion robot based on field tests with single older adults in their homes (Zsiga, Tóth, Pilissy, Péter, Dénes & Fazekas, 2017)	QT, L	Kompaï (Robosoft)	Yes	Satisfaction, usefulness, reliability (, Zsiga et al., 2017) and logs of robots (objective acceptance). <i>Number of items not specified. After interactions (logs) for 3 months.</i>	Older adults	Hungary	N = 8
13	A comparative study of the perceptions of k-12 teachers on the use of socially assistive robots in the classroom (Bietz, 2018)	QT	NAO (SoftBank Robotics)	Yes	36 items UTAUT (Venkatesh et al., 2003). <i>After interaction</i>	Teachers	USA (Pennsylvania and South Carolina)	N = 56

N°	Title	Type of study	Social robots	Interaction	Acceptability measures	Type of Sample	Sample nationality	Sample size
14	Personality factors and acceptability of socially assistive robotics in teachers with and without specialized training for children with disability (Conti, Commodari & Buono, 2017)	QT	NAO (SoftBank Robotics)	No, <i>video clip</i>	29 items UTAUT (Venkatesh et al., 2003). <i>After video</i>	Teachers	Italy	N = 114
15	Human Robot engagement and acceptability in residential aged care (Khosla, Nguyen & Chu, 2017)	QT, QL	Matilda (RECCSI and NEC)	Yes	11 items adapted to Almere model (Heerink et al., 2010) and engagement reactions (video recorded and coded). <i>After interaction</i>	Older adults with dementia	Australia	N = 115
16	A long-term autonomous robot at a care hospital: a mixed methods study on social acceptance and experiences of staff and older adults (Hebesberger, Koertner, Gisinger & Pripfl, 2017)	QT, QL, L	SCITOS robot (METRA-labs)	Yes	15 items social acceptance (Hebesberger et al., 2017), observations and interviews. <i>After interaction (questionnaire and interviews)</i>	Older adults and professional caregivers	Australia	N _(questionnaire) = 70 N _(interviews) = 10
17	Acceptance of social robots by elder people: does psychosocial functioning matter? (Baisch, Kolling, Schall, Rühl, Selic, Kim, Rossberg, Klein, Pantel, Oswald & Knopf, 2017)	QT	Paro (AIST)	Yes, and <i>video clip of Paro and Giraff telepresence robot</i>	2 items anxiety, 3 items intention to use, 3 items perceived ease of use (Heerink et al., 2009). <i>After interaction and after video clip</i>	Older adults	Germany	N = 31
18	Older users' acceptance of an assistive robot: Attitudinal changes following brief exposure (Beer, Prakash, Smarr, Chen, Hawkins, Nguen, Deyle, Mitzner, Kemp & Rogers, 2017)	QT, QL	PR2 robot (Willow Garage)	Yes	12 items Opinions Questionnaire (Beer et al., 2017, based on TAM, Davis, 1989) and interviews. <i>Opinions Questionnaire used before and after interaction</i>	Older adults	USA	N = 12

N°	Title	Type of study	Social robots	Interaction	Acceptability measures	Type of Sample	Sample nationality	Sample size
19	Robovie as a Mascot: a qualitative study for long-term presence of robots in a shopping mall (Sabelli & Kanda, 2016)	QL	Robovie (ATR)	Yes	Interviews and observations. <i>After interaction</i>	All coming in a mall	Japan	$N_{\text{interview}} = 67$
20	Long-term evaluation of a social robot in real homes (de Graaf, Ben Allouch & van Dijk, 2016)	QT, QL, L	Karotz (Softbank Robotics)	Yes	Interviews and social robots acceptance (de Graaf & Ben Allouch, 2013), media influence (based on Karahanna & Limayem, 2000), trust (adapted to McCroskey & Teven, 1999), cost (adapted to Brown & Venkatesh, 2005), use attitudes (Heerink et al., 2010), use intention (Moon & Kim, 2001), actual use (Venkatesh & Davis, 2000), Habit (LaRose & Eastin, 1994), etc. <i>Number of items not specified. Duration from 2 weeks before interaction to 6 months after interaction</i>	All coming	Netherlands	$N_{\text{(questionnaires)}} = 102$ $N_{\text{(interviews)}} = 21$
21	Are you ready for robots that care for us ? Attitudes and opinions of older adults towards socially assistive robots (Pino, Boulay, Jouen & Rigaud, 2015)	QT, QL	Kompai (Kompai Robotics), Paro (AIST), etc. (Pearl, Mamoru-kun, Eve, Telenoid, Nexi, Geminoid F, iCat)	No, <i>powerpoint presentation and video clip</i> Yes, <i>with RobuLab but not a social robot</i>	Questionnaire based on Almere Model (Heerink et al., 2010), SAR acceptance (Beer et al., 2011), and focus group. <i>Number of items not specified. After presentation and demonstration</i>	Older adults with mild cognitive impairment, informal caregivers, and healthy older adults	France	$N_{\text{(questionnaire, focus)}} = 25$

N°	Title	Type of study	Social robots	Interaction	Acceptability measures	Type of Sample	Sample nationality	Sample size
22	Methodological issues in scenario-based evaluation of human-robot interaction (Xu, Ng, Tan, Huang, Tay & Park, 2015)	QT	Social robot, <i>social robot's name is not specified (The robot name is Mika in the description)</i>	Yes, <i>and with text and video scenario</i>	Almere Model (Heerink et al., 2010). <i>Number of items not specified. After interaction, text, or video (study 1)</i> Attitude component model (Xu et al., 2015, based on several theories, e.g., TPB, Ajzen & Fishbein, 1980). <i>After interaction, text, or interactive video (study 2)</i>	Older adults	Not specified	N _{study1} = 45 N _{study2} = 69
23	Sharing a life with Harvey: exploring the acceptance of and relationship building with a social robot (de Graaf, Ben Allouch & Klamer, 2015)	QL, L	Karotz (Softbank Robotics)	Yes	Interviews. <i>After each usage phase (3 phases, 10 days per phase)</i>	Older adults	Not specified	N = 6
24	Development of a socially believable multi-robot solution from town to home (Cavallo, Limosani, Manzi, Bonaccorsi, Esposito, Di Rocco, Pecora, Teti, Saffiotti & Dario, 2014)	QT, QL	Era-robot, SCITOS (METRA-labs)	Yes, <i>and video clip</i>	6 items Questionnaire adapted to UTAUT, (Venkatesh et al., 2003), 3 items about aesthetics acceptability and interviews. <i>After interaction and video clip</i>	Older adults	Italy	N _(questionnaire, interview) = 35
25	When stereotypes meet robots: the double-edge sword of robot gender and personality in human-robot interaction (Tay, Jung & Park, 2014)	QT	Social robot, <i>name not specified</i>	Yes	17 items augmented Theory of Planned Behaviour (based on Ajzen & Fishbein, 1980), 8 items affective evaluations (based on Crites et al., 1994), 8 items cognitive evaluations (based on Crites et al., 1994). <i>After interaction</i>	Young adults and students	Singapore	N = 164

N°	Title	Type of study	Social robots	Interaction	Acceptability measures	Type of Sample	Sample nationality	Sample size
26	Acceptance and attitudes toward a human-like socially assistive robot by older adults (Louie, McColl & Nejat, 2014)	QT	Brian 2.1 (ASB)	No, <i>live demonstration</i>	18 items Robot Acceptance questionnaire (adapted Almere model, Heerink et al., 2010). <i>After demonstration</i>	Older adults	Canada	N = 46
27	Domestic robots for older adults: attitudes, preferences and potential (Smarr, Mitzner, Beer, Prakash, Chen, Kemp & Rogers, 2014)	QT, QL	PR2 robot (Willow garage)	No, <i>video clip</i>	12 items Robot Opinion Questionnaire (Smarr et al., 2014, based on Davis, 1989) and group interviews. <i>Robot Opinion Questionnaire used before and after interviews, video clip and discussion.</i>	Older adults	USA (Atlanta)	N_(interviews, questionnaires) = 21
28	Am I acceptable to you? Effect of a robot's verbal language forms on people's social distance from robots (Kim, Kwak & Kim, 2013)	QT, QL	Nettoro robot (<i>name of the manufacturer is not specified</i>)	Yes	64 items Perceived social distance with robots (based on Wiggins et al., 1988), and expressed social distance (physical and verbal). <i>After interaction</i>	Students in engineering college	Korea	N = 60
29	Looking forward to a "robotic society"? (Weiss, Igelsböck, Wurhofer & Tscheligi, 2011)	QT, QL	HOAP-3 and HRP-2 (Fujitsu Automation)	Yes	14 items of social acceptance of robots (Weiss et al., 2009) and interviews. <i>After interaction</i>	Non-expert and expert from the industry	European countries	N _(interviews, questionnaires) = 58

Notes. QT: quantitative study; QL: qualitative study; L: longitudinal study. Articles in bold have been removed after discussion among the authors.

Table 2*Articles selected from Google Scholar*

N°	Title	Type of study	Social robots	Interaction	Acceptability measures	Type of Sample	Sample nationality	Sample size
1	Embodiment into a robot increases its acceptability (Ventre-Dominey, Gilbert, Bosse-Platiere, Farnè, Dominey & Pavani, 2019)	QT	iCub (RobotCub) and Reeti (Robopec)	Yes	Social acceptance (Likeability and Closeness), likeability and Inclusion of the Other in the Self scale (IOS, based on Aron et al., 1992) for closeness. <i>Number of items not specified. Before and after manipulation</i>	All comers Healthy and right-handed subjects	Not specified	N _{study1} = 16 N _{study2} = 16
2	Robot enhanced therapy for children with autism disorders (Peca, Coeckelbergh, Simut, Costescu, Pintea, David & Vanderborght, 2016)	QT	NAO (Softbank Robotics) Keepon (Beat bot and Wow!) Probo (Robotics & Multibody Mechanics Group) Kaspar (University of Hertfordshire) Iromec (EU project IROMEC) Pleo (Innvo Labs)	No, <i>video clip</i>	12 items Ethical Acceptability (Peca et al., 2016) (ethical acceptability for use, of human-like interaction and of non-human appearance). <i>After video clip</i>	All comers	Websites of autism organizations from Romania, Belgium, Netherlands, United Kingdom, and U.S.A.	N = 394
3	Acceptability of robot assistant in management of Type 1 diabetes in children (Al-Taee, Kapoor, Garrett & Choudhary, 2016)	QT	NAO (Softbank Robotics)	Yes	10 items overall acceptability based on specific attributes or services offered by the robot (Al-Taee et al., 2016). <i>After interaction</i>	Children with type 1 diabetes	Not specified	N = 37

N°	Title	Type of study	Social robots	Interaction	Acceptability measures	Type of Sample	Sample nationality	Sample size
4	Design impact of acceptability and dependability in assisted living robotic applications (Cavallo, Limosani, Fiorini, Esposito, Furferi, Governi & Carfagni, 2018)	QT, QL	Astro, SCITOS (METRA-labs),	Yes	27 items acceptance questionnaire (Heerink et al., 2009) and focus-group. <i>After interaction</i>	Elderly people	Not specified	N _(questionnaire) = 15
5	Can a service robot which supports independent living of older people disobey a command? (Bedaf, Draper, Gelderblom, Sorell & de Witte, 2016)	QL	Care-O-bot (Fraunhofer Institute for Manufacturing Engineering and Automation)	No, text and video clip	Focus group. <i>After scenario and video</i>	Older people, informal carers and care professionals	Netherlands, United Kingdom and France	N = 122
6	Parent's judgments of the acceptability and importance of socially interactive robots for intervening with young children with disabilities (Dunst, Trivette, Priorr, Hamby & Emblar, 2013)	QT	Keepon (Beat bot and Wow!), Popchilla (Interbots) , Cosmobot (AnthroTronix, Inc.), Kaspar (University of Hertfordshire)	No, <i>video clip</i>	12 items social validity judgments (based of Foster & Mash, 1999) Acceptability is measured with likelihood of using robot (easy to use, interesting and fun) (Dunst et al., 2013). <i>Number of items not specified.</i> <i>After video</i>	Parents and other primary caregivers of children	Not specified	N = 108
7	Acceptability of robots to assist the elderly by future designers: a case of Guangdong Ocean University Industrial Design Students (Huang & Liu, 2019)	QT, QL	ElliQ robot (Intuition Robotics Ltd.)	No, <i>video clip</i>	41 items acceptance questionnaire (Heerink et al., 2009) and interviews. <i>After video</i>	Students in industrial design	China	N _(questionnaire) = 58 N _(interviews) = 10

N°	Title	Type of study	Social robots	Interaction	Acceptability measures	Type of Sample	Sample nationality	Sample size
8	Acceptability of a companion robot for children in daily life situation (Johal, Adam, Fiorino, Pesty, Jost & Duhaut, 2014)	QT, QL	Reeti (Robopec) and Nao (Softbank Robotics)	Yes	Interview (feelings during interaction and appraisal of the robot) and 1 item acceptability of robot in 6 problem-situations (coaching, playing, guarding, etc.) (Johal et al., 2014). <i>After interaction</i>	All comers in Innorobot 2013 robotic show (Lyon, FR)	Not specified	N _(interviews, questionnaire) = 22
9	Adherence and acceptability of a robot-assisted pivotal response treatment protocol for children with autism spectrum disorder (van den Berk-Smeekens, van Dongen-Boomsma, De Korte, Den Boer, Oosterling, Peters-Scheffer, Buitelaar, Barakova, Lourens, Staal & Glennon, 2020)	QT, L	NAO (Softbank Robotics)	Yes	Likeability of robot as acceptability measure (robot appearance, robot's movements and speech, game play, etc.) (van den Berk-Smeekens et al., 2020). <i>Number of items not specified.</i> <i>After each therapy session/interaction (20-weeks)</i>	Children with ASD and parents	Netherlands	N = 25
10	A social robot for autonomous health data acquisition among hospitalized patients: an exploratory field study (van der Putt, Boumans, Neerincx, Rikkert & de Mul, 2019)	QT, QL	Pepper (Softbank Robotics)	Yes	Acceptance questionnaire based on Almere model (Heerink et al., 2010) <i>number of items not specified</i> and interviews. <i>After interaction for older patients but without interaction for nurses interviews</i>	Patients' hospitals (Franciscus & Vlietland hospitals) and nurses	Not specified	N _(questionnaire) = 35 N _(nurses interviews) = 5
11	Testing social robot acceptance: what is you could be assessed for dementia by a robot? A pilot study (Cormons, Pellier, Fiorino, Poulet & Pesty, 2020)	QL	Pepper (Softbank Robotics)	Yes	Interviews <i>After interaction</i>	Students (non-computer scientist students)	France	N = 7

N°	Title	Type of study	Social robots	Interaction	Acceptability measures	Type of Sample	Sample nationality	Sample size
12	A multicenter survey about companion robot acceptability in caregivers of patients with dementia (D'Onofrio, Sancarlo, Oscar, Ricciardi, Casey, Murphy, Giuliani & Greco, 2017)	QT	Mario (Kompaï robotics)	No, <i>video clip</i>	15 items acceptability (Sancarlo et al., 2017) MARIO questionnaire. <i>After video clip</i>	Caregivers of dementia patients	Italy, Ireland	N = 130
13	Identifying factors that influence the acceptability of smart devices: implications for recommendations (Zhan, Zukerman & Partovi, 2018)	QT	NAO (Softbank Robotics), AIBO (Sony), realistic humanoid robot (and other not social robots)	No, <i>informational sheet and video clip</i>	Acceptability in daily life, acceptability of the device by task (Zhan et al., 2018). <i>Number of items not specified. After informational sheet and video</i>	All comers	Australia (majority)	N = 136
14	The role of personality factors and empathy in the acceptance and performance of a social robot for psychometric evaluations (Rossi, Conti, Garramone, Santangelo, Stafa, Varrasi & Di Nuovo, 2020)	QT	Pepper (Softbank Robotics)	Yes	41 items Almere Model (Heerink et al., 2010) <i>Before and after interaction</i>	Older people	Italy	N = 21
15	A social robot in shopping mall: studies on acceptance and stakeholder expectations (Niemelä, Heikikilä, Lammi & Oksman, 2019)	QT, QL	Pepper (Softbank Robotics)	Yes, <i>and video clip in study 3, and Pepper's picture in study 2 in one experimental condition</i>	Focus group (Study 1), 5 items Acceptance survey (Niemelä et al., 2019; e.g., attitude, interaction, intention to use) (Study 2), and interviews (Study 3). <i>Before and after interaction (study 2)</i>	Consumers and Store managers and mall managers	Southern Finland	N _(focus group) = 10 N _(questionnaire) = 506 N _(interview) = 11

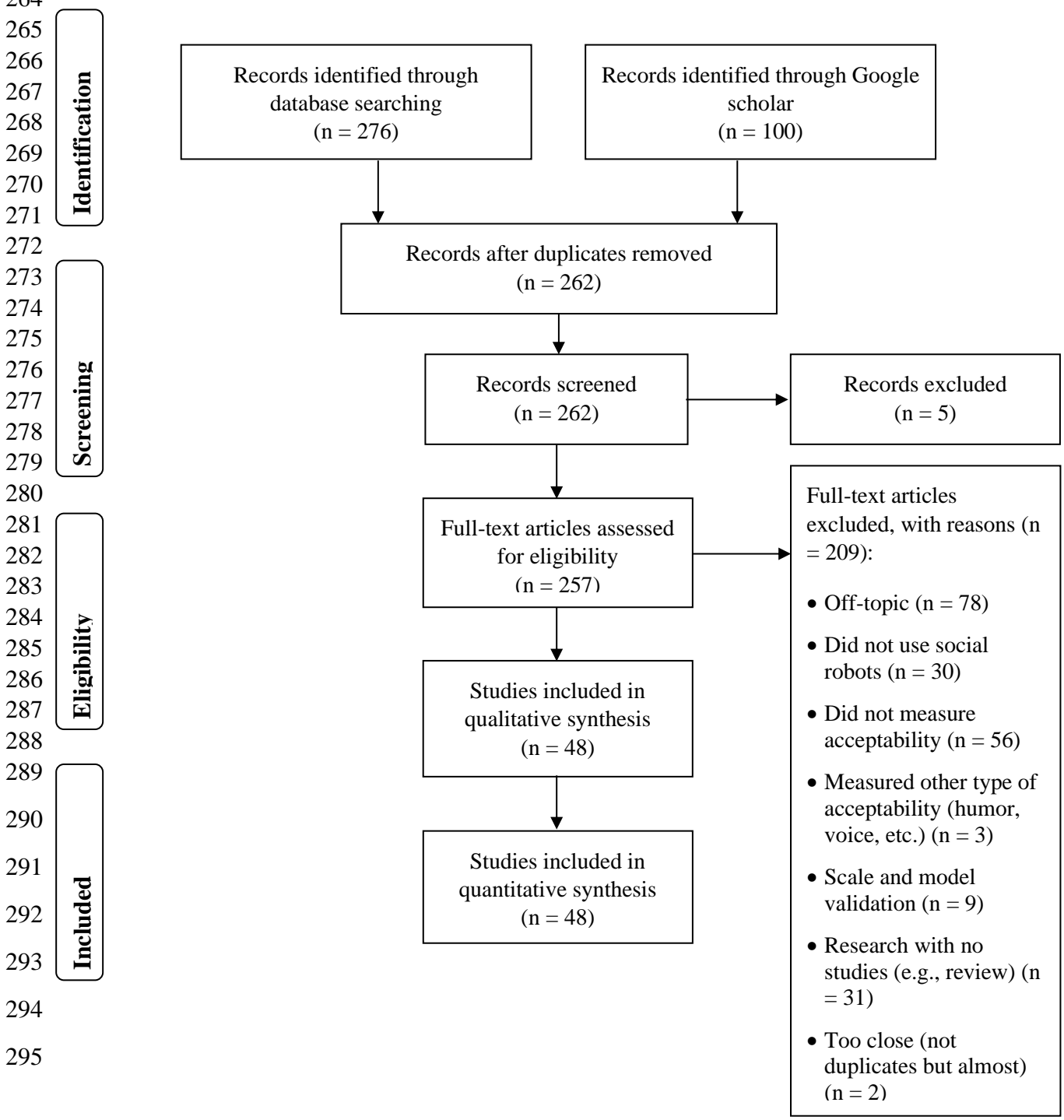
N°	Title	Type of study	Social robots	Interaction	Acceptability measures	Type of Sample	Sample nationality	Sample size
16	Social acceptability of opportunistic behaviour of an assistant robot in human-robot everyday collaboration (Kushnirenko & Kirsch, 2014)	QT, QL	PR2 robot (Willow garage)	No, <i>video and Morse simulator</i>	Social acceptability (adapted to Godspeed questionnaire, Bartneck et al., 2009), 1 item willingness to buy the robot, and open questions about robot behaviours. <i>After video and simulator</i>	All comers	Not specified	N = 33
17	Changes in technology acceptance among older people with dementia: the role of social robot engagement (Ke, Wei-qun Lou, Cheng-kian Tan, Yi Wai, Lok Chan, 2020)	QT, QL, L	Kabochan (Pip)	Yes	16 items Senior Technology Acceptance Model (Chen & Chan, 2014) and observations (behavioural engagement). <i>Before (1 week before introduction to Kabochan) and after interaction (till week 32)</i>	Older people with dementia	China	N = 103
18	Playing a Memory Game with a socially assistive robot: a case study at a long-term care facility (Louie, McColl & Nejat, 2012)	QT	Brian 2.1 (ASB)	Yes	18 items Technology Acceptance model (Heerink et al., 2009). <i>After interaction</i>	Elderly participants	Canada	N = 22
19	User-centered design and evaluation of a mobile shopping robot (Doering, Poeschl, Gross, Bley, Martin & Boehme, 2015)	QT, QL	TOOMAS (SCITOS A5, MetraLabs)	Yes	1 item future intention to use (based on Venkatesh et al., 2003) <i>Before and after interaction.</i> 2 items satisfaction, and objective usability by observations (Doering et al., 2015).	Store customers	Germany	N _{study1} = 210 N _{study2} = 39 N _{study3} = 94

Notes. QT: quantitative study; QL: qualitative study; L: longitudinal study. Articles in bold were subsequently removed after discussion among the authors.

255 *PRISMA Flow Diagram*

256 The PRISMA diagram presents the inclusion and exclusion procedures performed after
 257 combining the articles from the databases and those from Google scholar. The diagram allows
 258 us to understand our selection of 48 articles in total for 376 articles initially identified (Fig.1).
 259 This synthesis aims to give a descriptive overview, a picture, of where we are in the study of
 260 acceptability of social robots.

261
 262 **Figure 1**
 263 *The PRISMA Flow Diagram of the scoping review from Moher et al. (2009)*



296 **Data extraction**

297 The extraction of data from the articles was done at the same time as the final sorting.
298 Thus, each of the Excel files (ProQuest database and Google Scholar) contained the metadata
299 of the articles: title of the article, authors, abstract, year of publication, link, DOI (Digital Object
300 Identification), original language of the article, etc. Then at the end of each Excel file and for
301 each article the following data were extracted: (1) whether there is an interaction with a social
302 robot (1 = Yes; 0 = No), (2) the name of the robot, (3) if no, the type of exposure (e.g., video,
303 picture), (4) acceptability measure used (e.g., UTAUT, TAM, etc.), (5) secondary measures
304 (e.g., satisfaction, attitudes, etc.), (7) type of article, (e.g., quantitative, etc.), (8) if the study is
305 longitudinal (1 = Yes, 0 = No) and (9) authors' conclusions. In addition, sample nationality,
306 sample size, sample type (e.g., students) and funding/conflict of interest were extracted in a
307 second step on two Word tables. None of the articles were excluded for lack of data. Finally,
308 all 48 items and their data were added to a single clean Excel file.

309

310 **Reliability of the data extraction**

311 To ensure the reliability of the data extracted by the lead author, five articles were
312 randomly selected from the resulting Excel database of 48 articles. The other two authors
313 independently reviewed these five articles, using the same information for data extractions.
314 Eleven data items were extracted by both authors: 1) whether there is a social robot (1 = Yes, 0
315 = No), 2) whether there is a real interaction with the robot (1 = Yes, 0 = No), 3) the name of the
316 social robot used, 4) whether there is an acceptability measure (1 = Yes, 0 = No), 5) the
317 acceptability measure used, 6) the type of study (e.g., quantitative), 7) whether the study is
318 longitudinal (1 = Yes, 0 = No), 8) the type of sample (e.g., older adults), 9) the sample
319 nationality (e.g., Netherlands), 10) the sample size and 11) whether there is a conflict of interest.

320 The other two authors have noted relatively the same data: 90.91% and 81.82%
321 similarity between first author and the second and third authors, respectively (see the table of
322 data extracted by all authors on OSF).

323 However, differences were identified from: a) inaccuracies in the articles themselves
324 (e.g., van den Berk-Smeekens et al., 2020, state that their sample size is 25 participants, but do
325 not specify whether it is children, children's parents, or both), b) oversights (e.g., the second
326 author forgot to record the nationalities of the samples for two articles), c) inaccuracies between
327 authors (e.g., in the study by Beer et al., 2017, there is a measure of acceptability before and
328 after interaction with the robot, for author 3 it should be considered a longitudinal study, but
329 not for authors 1 and 2), d) errors found in the data extraction of the lead author (e.g., in the

330 article by Beer et al. (2017) the sample size is not 6 participants as noted by author 1 but 12, of
331 which 6 were men). Also, there was a discussion between the authors regarding the "social"
332 capabilities and thus the legitimacy of the PR2 robot as a social robot particularly used in the
333 article by Beer et al. (2017). The authors ruled that PR2 is not to be considered a social robot.
334 Indeed, the robot has no verbal communication capabilities and is further described as a mobile
335 manipulator, as is the Care-o-Bot (e.g., Bedaf et al., 2016; Bedaf et al., 2018). Thus, after a final
336 check of the data, five articles were finally removed because they used one of these two robots.
337 The number of selected articles is therefore 43: 26 articles from ProQuest (see details Table 1)
338 and 17 from Google Scholar (Table 2). The reliability of the data extraction is therefore to some
339 extent assured.

340

341 **Results**

342 **Included studies**

343 Percentages were calculated to describe the relevant data (all results details Table 3). A
344 total of 43 articles were included in this description of the current state of the art. Specifically,
345 60.47% ($n = 26$) came from the databases named above and 39.53% from Google scholar ($n =$
346 17). In these articles, most of the samples were from Italy (13.95%), and
347 Netherlands/UK/Australia (9.30% each). It should be noted that 20.93% of the articles did not
348 explicitly specify the nationality (or language) of their sample. In addition, the samples were
349 mainly composed of elderly people (32.56%), health professionals (16.28%), all comers
350 (16.28%) and seven articles offered their studies to students (16.28%), two to children (4.65%)
351 and two to teachers (4.65%). The rest of the articles had other types of samples (13.95%, e.g.,
352 customers, parents, etc.). Finally, all articles ($N = 43$) were published between 2010 and 2020.

353 The average sample size was 101.23 ($S.D = 119.6$) participants for quantitative studies
354 (e.g., questionnaires) and 22.92 ($S.D = 19.7$) participants for qualitative studies (e.g.,
355 interviews). Furthermore, several of the 43 articles offered more than one study (i.e., Doering
356 et al. 2015; Niemelä et al., 2019; Spekman et al., 2021; Ventre-Dominey et al., 2019; Xu et al.,
357 2015; these articles present more than one study). Thus, of all the studies ($N = 50$), 54% were
358 quantitative, 12% were qualitative, and 34% had a mixed methodology. Finally, eight studies
359 (16%) out of the fifty were longitudinal (e.g., repeated measures over time) but six studies
360 (12%) were on the long-term⁴. Indeed, two longitudinal studies were removed from this

⁴ The study of acceptability over a long period of time (greater than two months as recommended in the literature; de Graaf et al., 2015; Sung et al., 2009).

361 category (i.e., "long-term") because they did not investigate the acceptability of the social robot
362 beyond two months. The study by de Graaf et al. (2015) was conducted over 30 days and the
363 study by Hebesberger et al. (2017) was conducted over approximately 15 days. Before two
364 months, there would still be a novelty effect that would influence the degree of acceptability of
365 the social robot (e.g., de Graaf et al., 2015). In addition, of the 50 studies, only 36% were
366 conducted in ecological⁵ contexts (vs. 64% in laboratory or other contexts⁶). These results show
367 that most of the studies presented in the selected articles of our scoping review have been
368 conducted rather in laboratory contexts, with little ecological and long-term focus.

369

370 **Social robots**

371 *Social robots used*

372 Different social robots were used in the selected articles. The three most presented
373 robots in the studies are NAO the small humanoid robot from Softbank Robotics (23.26%),
374 followed by the Era-robot (or SCITOS from METRA-lab, 16.28%) as well as Pepper the "big
375 brother" robot of NAO (11.63%). Other robots were also used, such as Karotz (Softbank
376 Robotics), Paro (AIST), Kompaï (Robosoft) (6.98% each, of the 43 articles) and many others
377 less frequently (all data on OSF). We note that among the most common we find mainly
378 humanoid robots with human physical characteristics such as a head, a trunk, arms, etc.
379 However, Karotz and Paro are zoomorphic robots. In addition, it seems that NAO was mostly
380 used with children as a therapeutic mediator (e.g., Al-Tae et al., 2016) or as an educational
381 support (e.g., Bietz, 2018). As for the ERA robots, they seemed to be used with elderly people
382 as assistive robots (e.g., Hebesberger et al., 2017). Concerning Pepper, it was used both in the
383 health domain (e.g., Cormons et al., 2020) and in the service domain (e.g., Niemelä et al., 2019).

384

385 *Exposure to social robots*

386 The type of exposure is an important aspect, given that for a social robot the evaluation
387 criteria involve aesthetics, emotions, social mechanisms, and social structures (Xu et al., 2015;
388 Young et al., 2011). In short, more complex, and complete aspects than other technologies.
389 Thus, regarding the way the robot was used in the studies, real interaction was most common
390 (62.79%), followed using video clips showing the robot (11.63%). In addition, eight articles out

⁵ Studies that were conducted under ecological conditions (i.e., real-life situations, field studies in a shopping mall, school, home care, etc.; e.g., van der Putt et al., 2019).

⁶ Studies that were conducted in laboratory conditions (e.g., Spekman et al., 2021), in simulated environments (e.g., laboratory that replicates a home environment, Cavallo et al., 2018), or, with a sample of interest (e.g., with managers of shopping malls) without participants being in real-world conditions (e.g., Niemelä et al., 2019).

391 of the 43 selected (18.60%) provided mixed types of exposure in their studies (e.g., interaction
392 and video or text and video, etc.). Finally, the other articles presented their robot(s) via a
393 demonstration (2.33%) and without any visual presentation (4.65%). Xu et al. (2015) propose
394 a framework that illustrates the level of fidelity and interactivity of the scenario media used to
395 present the robots. For example, real interaction is a high-fidelity and high-interactivity medium
396 in contrast to presenting the robot through text or images, which are low-fidelity, low-
397 interactivity media.

398

399 **The assessment of acceptability**

400 *Measures of acceptability used*

401 Because, Naneva et al. (2020) have reviewed the issues of trust, attitudes, anxiety, and
402 so on, towards social robots and Krägeloh et al. (2019) have conducted a review and critique of
403 social acceptability measures, we focused less on social acceptability and more on how studies
404 of the uses of social robots measure their acceptability. Of the studies described in the 43
405 articles selected, 9.30% used only the Almere model (Heerink et al., 2010) to measure
406 acceptability, or its original version the Acceptance Questionnaire (Heerink et al., 2009). The
407 use of the Almere model increases to 16.28% when considering articles that use it alone and
408 those that use it in addition to observations (e.g., Khosla et al., 2017) or interviews (e.g., van
409 der Putt et al., 2019). This questionnaire is an adaptation of the UTAUT (Venkatesh et al.,
410 2003), validated in an elderly population, and incorporating social interaction variables to
411 explain intention to use (Heerink et al., 2010). The original version of the questionnaire consists
412 of thirteen constructs (anxiety, attitudes towards technology, facilitating conditions, intention
413 to use, perceived adaptiveness, perceived sociability, etc.) and 41 items on 5-point Likert scale
414 from 1-Totally disagree to 5-Totally agree. Heerink et al. (2010) state that the explained
415 variance for intention to use is between 59% and 79%, and between 49% and 59% for actual
416 use. The UTAUT (Venkatesh et al., 2003), or its adapted or shortened versions, was also used
417 to measure the acceptability of social robots, as was the TPB (Theory of Planned Behaviour;
418 Ajzen, 1985), each at the level of 4.65% of studies. However, UTAUT often needs to be
419 adapted to contexts and robots (e.g., Cavallo et al., 2014). The original version of UTAUT
420 included eight constructs (performance expectancy, effort expectancy, social influence,
421 intention to use, etc.) and 31 items with an explained variance between 69% and 70%.

422 Finally, 2.33% of the articles assessed acceptability in their studies through
423 questionnaires based on the TAM (Davis, 1985). Of the selected articles, nine (20.93%) of them
424 assessed acceptability by other means such as their own questionnaire (e.g., D’Onofrio et al.,

425 2017) or by a single item (e.g., Fu et al., 2021). In addition, 18 articles (41.86%) measured
426 acceptability by mixed methodologies (e.g., Almere model questionnaire and interviews, van
427 der Putt et al., 2019). Finally, three articles (6.98%) assessed the acceptability of social robots
428 through interviews only (e.g., de Graaf et al., 2018).

429

430 In addition, regarding qualitative studies, it would appear that focus groups (e.g.,
431 Cavallo et al., 2018; Niemelä et al., 2019; Pino et al., 2015; Winkle et al., 2020) and interviews
432 (e.g., Cavallo et al., 2014; Cormons et al., 2020; de Graaf et al., 2015; de Graaf et al., 2018;
433 Hebesberger et al., 2017; Huang & Liu, 2019; Johal et al., 2014; Niemelä et al., 2019; Sabelli
434 & Kanda, 2016; van der Putt et al., 2019; Weiss et al., 2011) have been the most commonly
435 used methods. Observations also appeared as a method of measuring acceptability in the
436 selected articles (e.g., positive reactions, Fu et al., 2021; engagement, Khosla et al., 2017;
437 physical and verbal distance, Kim et al., 2013).

438 Topics included user experience (e.g., de Graaf et al., 2015; Hebesberger et al., 2017),
439 robot functionality (e.g., Cavallo et al., 2018; Sabelli & Kanda, 2016); the usefulness of the
440 robots (e.g., Huang & Liu, 2019; Pino et al., 2015); or more broadly, concerned with people's
441 opinions about the use of these robots (e.g., advantage/disadvantage, Cormons et al., 2020; de
442 Graaf et al., 2018). Finally, we observed in the qualitative studies notions and concepts
443 addressed in the (quantitative) acceptability measurement models (e.g., interaction satisfaction,
444 de Graaf et al., 2018; engagement, Khosla et al., 2017; usability, Pino et al., 2015; ease of use,
445 de Graaf et al., 2015; effectiveness, Cormons et al., 2020). In general, the qualitative studies
446 seemed to be in the same direction as the quantitative studies. For example, Loi et al. (2018)
447 show in their quantitative study that there is an increase in acceptability of the social robot after
448 the interaction. Winkle et al's (2020) qualitative study also shows that after a robot presentation,
449 people change their discourse (e.g., before: "*the social robot is limited*"; "*I am very doubtful*";
450 after: "*I think there is definitely a potential (...)*"). Other example, some quantitative studies
451 show that older people have rather positive attitudes towards social robots (e.g., Zsiga et al.,
452 2017). These findings are also found in qualitative studies (e.g., de Graaf et al., 2015).

453

454 *A priori acceptability, acceptance, and adoption*

455 As a reminder, the acceptability process is described in three phases. Thus, when studies
456 proposed to evaluate the acceptability of the robot before interaction or without real interaction,
457 we considered this as a priori acceptability. When the participants of the studies were able to
458 interact with the robot, we considered this the acceptance phase. Finally, when the acceptability

459 was measured over several months, we defined this as the adoption phase. Thus, in our corpus
460 of articles we found that most articles that measured the acceptance of a social robot (74.42%),
461 followed by the a priori acceptability (51.16%) and finally the adoption (6.98%). We noted that
462 nine of the studies (20.93%) measured the acceptability before and after the interaction with the
463 robot. This is to observe the changes of attitudes after interaction with it (e.g., Loi et al., 2018)
464 or to verify that the new scenario presenting the robot increases its acceptability (e.g., Kim,
465 2013).

466

467 **Acceptability in the last 10 years**

468 *Main domain*

469 The field of application of the articles was mainly health (60.47%), followed by the
470 domestic field (6.98%), service (6.98%) and finally education (4.65%)⁷. Nine articles did not
471 present a specific field (20.93%). We can observe that social robots and their acceptability have
472 been studied over the last ten years mainly for the accompaniment and assistance of people,
473 especially older people, in nursing homes or at home with the objective of maintaining
474 autonomy (e.g., Cavallo et al., 2018; Zsiga et al., 2017).

475

476 *Level of acceptability*

477 The articles selected using our inclusion criteria are all aimed at evaluating the level of
478 acceptability of social robots. Next, we address the conclusions they drew.

479 What emerges from our literature review is that most studies in the last few years show
480 that people accept social robots (67.44%). Indeed, people had rather positive attitudes towards
481 these devices (e.g., van der Putt, 2019). In several articles (e.g., Zsiga et al., 2017), we
482 understand that the elderly adults were quite open and positive towards the idea of being
483 assisted by social robots. However, the opinions of healthcare personnel often differed (e.g.,
484 Rantanen et al., 2018). In general, they were not in favour of leaving the elderly in the hands of
485 social robots for several reasons. These include the fear of dehumanizing the elderly, the fear

⁷ The "health" category includes articles that propose studies with elderly people, health professionals and/or caregivers and others in a medical context (hospital, nursing home, or at home to maintain autonomy) (e.g., Hebesberger et al., 2017). Studies presented in healthcare at home and assistive services were counted in this category (e.g., Zsiga et al., 2017). The "domestic" category includes articles that propose studies with an "all coming" sample in a daily life context (e.g., de Graaf et al., 2018). The "education" category includes all articles that propose studies in a school context with teachers, children and/or parents (e.g., Bietz, 2018). The "service" category includes articles that offer studies to professionals and/or clients in contexts such as shopping centers, etc. (e.g., Sabelli & Kanda, 2016).

486 of being replaced a little more by robots and accepting them for medication reminders but not
487 for physical tasks.

488 However, the remaining 32.56% were not articles that demonstrated the unacceptability
489 of robots. Only 11.63% of the selected articles depicted social robots as not quite accepted, and
490 in some of these cases, the acceptability could be described as ambivalent (e.g., Hebesberger et
491 al., 2017). In other words, some aspects of robots are recognized as benefits, while others
492 remain a threat. For example, Johal et al. (2014) show that parents accept social robots as a
493 playmate for their children, just like toys. On the other hand, they do not accept them as
494 storytellers at night, or as babysitters. Parents are afraid of being replaced or losing their special
495 moments with their children.

496 Finally, 20.93% of the articles did not indicate the level of acceptability of social robots
497 (i.e., do people accept or not the presented social robot?). In fact, these articles focused on the
498 factors that increase or decrease the acceptability of the robot after an experimental
499 manipulation. Xu et al. (2015) show that robot acceptability changes depending on the
500 presentation medium (real interaction vs. interactive video vs. video vs. text). Kim et al. (2013),
501 for example, observe that when the robot calls the user by name and uses more familiar speech,
502 this increases its acceptability. Finally, as an example, Tay et al. (2014) show that when the
503 robot has a gender and personality that matches a stereotype about professional roles, the robot
504 is more accepted.

505 The high acceptability of social robots found from these selected articles could come
506 from industrial and financial interests. However, out of the 43 articles, 18 (41.86%) declared
507 no conflict of interest and 58.14% did not specify, which does not mean that there was a conflict
508 of interest.

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520 **Table 3**
 521 *Summary of the main results of the scoping review ($N_{articles} = 43$)*

	<i>n</i>	<i>%</i>
Included Studies		
<i>Databases</i>		
PsychInfo, PsychArticles, Psychology database	26	60.47
Google Scholar	17	39.53
<i>Sample nationality or language</i>		
Italy	6	13.95
Netherland/UK/Australia	4	9.30
Finland	3	6.98
Not specified	9	20.93
<i>Sample characteristics</i>		
Elderly people	14	32.56
Caregivers (informal and professional)/All coming/Students	7	16.28
Children/Teachers	2	4.65
Other (e.g., customers, parents, non-expert, etc.)	6	13.95
Social Robots		
<i>Social robots used</i>		
NAO (Softbank Robotics)	10	23.26
Era-Robot (METRA-lab)	7	16.28
Pepper (Softbank Robotics)	5	11.63
<i>Exposure to social robots</i>		
Real interaction	27	62.79
Video	5	11.63
Mixed (e.g., interaction and video)	8	18.60
Demonstration	1	2.33
Without visual presentation (e.g., robot in general or based on previous experiences)	2	4.65
Acceptability		
<i>Measures</i>		
Almere Model (Heerink et al., 2010) / Acceptance Questionnaire (Heerink et al., 2009)	4	9.30
UTAUT (Venkatesh et al., 2003) / Theory of Planned Behavior (Ajzen, 1985)	2	4.65
Other (e.g., own questionnaire or single item)	9	20.93
Interview, discussion, focus-group	3	6.98
Mixed (e.g., Almere model and interview)	18	41.86

	<i>n</i>	%
<i>Acceptability phase</i>		
A priori acceptability	22	51.16
Acceptance	32	74.42
Adoption	3	6.98
Acceptability in the last 10 years		
<i>Main domain</i>		
Health	26	60.47
Domestic/Service	3	6.98
Education	2	4.65
Not specified	9	20.93
<i>Level of acceptability</i>		
Accepted	29	67.44
Not quit accepted (e.g., ambivalent acceptability)	5	11.63
Not specified	9	20.93
	<i>n</i>	%
Type of studies (N_{studies} = 50)		
Quantitative	27	54.00
Qualitative	6	12.00
Mixed (quantitative and qualitative)	17	34.00
Longitudinal	8	16.00
Long-term (> 2 months)	6	12.00
Ecological context	18	36.00
Laboratory or other context (e.g., simulated environment)	32	64.00

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524 **Discussion**

525 Our review of the recent literature of the past decade allows us to make a state of the art
526 regarding the question of the acceptability of social robots. This rapid review of the literature
527 is not intended to be systematic but descriptive.

528 Results show that a priori acceptability and acceptance are the two most evaluated
529 phases of the acceptability process. This shows how difficult it is to measure acceptability under
530 ecological conditions and over the long term. However, it is in this third phase of adoption that
531 people decide to continue or stop using the device (de Graaf et al., 2018). Indeed, the evaluation
532 of the technology changes over time (Peters & Ben Allouch, 2005) especially with the effects
533 of novelty and simple exposure (de Graaf et al., 2016). We also know that in the long run, the
534 ordinary use of a technology may be different from the use for which it was initially designed

535 (Pasquier, 2012). In addition, in the acceptability literature, it is shown that there can be a gap
536 between the pre-use and post-use beliefs of the technology (de Graaf et al., 2018). In recent
537 years, research has focused on identifying the factors favouring the acceptability of social
538 robots, hence the numerous studies involving a before/after interaction measurement found
539 among the selected articles. Users may have expectations about the technology, and then realize
540 that it ultimately does not match their needs (i.e., perceived usefulness, for example, is a crucial
541 determinant of acceptability, de Graaf et al., 2019). But in the papers we selected, it seems that
542 having an interaction with the robot improves its acceptability level compared to the pre-
543 interaction level (e.g., Loi et al., 2018). Most of selected articles measure acceptance (i.e.,
544 following an interaction with the robot) and the novelty effect could explain in part why we
545 find a rather high percentage of acceptability. Therefore, to the question “are social robots
546 accepted?”, we would be tempted to answer “yes” in view of the high percentage of positive
547 attitudes and openness to social robotics found in the articles. However, we can only affirm that
548 this acceptability is measured in the short term, often in laboratory conditions (e.g., Louie et al.,
549 2014) and is only interpretable in these conditions and contexts. It is the long-term studies that
550 will allow us to rule on the adoption and the use of these social robots.

551 Our second question focused on how to measure acceptability. Again, the objective here
552 was not to make a systematic review of acceptability measures of social robots but to observe
553 which tools have been the most used in the last ten years. As previously explained, the most
554 common measure is the Almere model (Heerink et al., 2010). This tool is tailored to the desire
555 and demand for assistance to the elderly. Beyond this context, the Almere Model (Heerink et
556 al., 2010) is an adaptation of the UTAUT (Venkatesh et al., 2003), which was also used in many
557 of the selected articles. This measure seems to be complete, being based on eight different
558 theories and models (TRA, TAM, Motivation Model, TPB, Combined TPB and TAM, Model
559 of PC utilization, Innovation Diffusion Theory, Social Cognitive Theory). UTAUT (Venkatesh
560 et al., 2003) not only brings together usage variables but also integrates social variables.
561 However, this measurement tool has been validated for technologies that are not very invasive
562 (e.g., database application, online meeting manager) and often in a professional context (e.g.,
563 telecom services, public administration) (Venkatesh et al., 2003). This may explain why the
564 UTAUT was often modified or adapted in the articles selected (e.g., Winkle et al., 2020).
565 Because social robots are a particular technology (i.e., anthropomorphic, social interaction
566 capabilities), their specificities must be taken into account when assessing their acceptability.
567 Indeed, they are more than just machines or tools and can be perceived as “*post-human agents*”

568 (Leroux & Labruto, 2012, p. 8). The acceptability of social robots is a field that is still new and
569 where suitable tools are still lacking (Krägeloh et al., 2019).

570 This synthesis allows us to understand, in a general way, that over the last ten years the
571 scientific articles about acceptability of social robots have been mainly oriented towards the
572 health field. Indeed, our descriptive results all point to health and mainly to the well-being of
573 the elderly. The most common sample type is elderly people, the most frequent acceptability
574 measure is the Almere model (Heerink et al., 2010), adapted to the aging population, and three
575 robots most presented in the studies are robots designed for accompaniment and daily
576 assistance. This is understandable in the face of an increasingly aging population, understaffed
577 nursing homes and the resulting impact on public finances (e.g., Rantanen et al., 2018).
578 Maintaining the independence and autonomy of elderly people becomes a necessity, as well as
579 searching for possible alternatives. It seems then that the research fields are in adequacy with
580 the societal problems. The demand being strong, it seems relevant to study the acceptability of
581 social robotics in the health field. Moreover, according to the selected articles, elderly people
582 are rather favourable to this robotic assistance (e.g., Cavallo et al., 2018). Although they are not
583 the most knowledgeable members of the public about new technologies, the elderly know that
584 the social robots can help them and facilitate their daily life, and maybe even allow them to stay
585 in their house. However, can we say that social robotics as an alternative is acceptable? Note
586 that the verb "to accept" has several meanings. Accepting an object can refer to a real choice or
587 to an imposed and constrained choice (Batellier, 2015). Wu et al. (2014) demonstrated that
588 older adults perceived robots as "*necessary evil*" that they would accept if they had no other
589 choice. Ultimately, the relatively high level of acceptability of social robots may not be a result
590 of real enthusiasm but rather a default choice (i.e., "better than nothing") in the face of societal
591 problems (e.g., understaffed care institutions). Furthermore, on the side of health care personnel
592 (e.g., informal, and professional caregivers), attitudes seem to be not very positive about the
593 integration of social robots with the elderly, especially because they fear being substituted by
594 the robots (Rantanen et al., 2018). They then point to the dehumanization of residents (e.g.,
595 fewer human social interactions) and the technical limitations of robots (e.g., robots are not
596 capable of helping a person move) (Rantanen et al., 2018). Finally, Bedaf et al. (2016) notably
597 explain the tension between "user autonomy" and "promotion of long-term independence". The
598 robot must be autonomous enough to respond to the demands of the elderly person. On the other
599 hand, if the robot does too much, it risks eroding the person's abilities. We can also draw a
600 parallel with the field of education. Children are rather favourable to the use of social robots;
601 however, parents express some reluctance for fear of missing special moments (Johal et al.,

602 2014). In addition, teachers seem to have positive attitudes towards social robots within the
603 classroom as an educational support (Conti et al., 2017). Remember that for social robotics to
604 be successfully and appropriately integrated, it is important that professionals (health,
605 education, and others) accept it (e.g., Conti et al., 2017).

606 The scoping review has several limitations and one of them is that we did not focus on
607 the social acceptability of social robots. Indeed, we have chosen to focus on acceptability from
608 the point of view of the study of their use rather than from the point of view of social and ethical
609 judgments. This is mainly because a review about the issue of trusts, attitudes, and anxiety
610 (Naneva et al., 2020) and another about critique of social acceptability measures have recently
611 been published (Krägeloh et al., 2019). Here, the aim was to provide an update on progress, not
612 an exhaustive review but enough to capture a picture of acceptability in recent years. This leads
613 us to several other limitations in relation to the scoping review methodology. Each of the
614 limitations presented below may have reduced the scope of the literature. In other words, the
615 number of articles identified, and therefore, its reliability.

616 The first limitation is the number of databases considered and their use. Increasing the
617 number of databases would have allowed us to identify more articles even if we were within
618 the recommendations (i.e., at least two databases minimum). We have used only two databases
619 mainly to ensure the feasibility of the rapid scoping review but also to allow better data
620 management and the non-reporting of a meta-analysis. This choice was made because a recent,
621 synthetic, and descriptive review was more aligned with the research questions of this article.
622 Similarly, regarding Google Scholar, we extracted only the first 100 results from the platform
623 (i.e., following Naneva et al., 2020 and Sarrica et al., 2020), which may have also reduced the
624 scope. For example, Hadaway et al. (2015) propose to focus on the first 200 or even 300 results
625 to identify more gray literature. Finally, the 2010-2020 filter was relevant at the time of the
626 scoping review. Today (2022), it is not impossible that other articles have been published
627 demonstrating changes in attitudes towards social robots. Other methodological weaknesses
628 appear, notably, we did not conduct a critical appraisal. Because scoping reviews aim to provide
629 an overview and the protocol may change during the review, the assessment of the risk of bias
630 is not mandatory (Munn et al., 2018; Peters et al., 2015; Sucharew & Maculoso, 2019). Indeed,
631 in scoping review methodology there is a degree of liberty regarding the bias assessment.
632 Finally, the last limitation of this review is that the search was not performed by multiple
633 independent researchers. Verifying the article selection with multiple researchers enables us to
634 increase the reliability of the results (Munn et al., 2018) but this checking was only performed

635 on a few articles. Thus, we can only guarantee the reliability of the scoping review to a certain
636 extent.

637 In summary, this scoping review has allowed us to formulate a hypothesis and a
638 reflection concerning the acceptability of social robots. We have partially answered it, at least,
639 in a descriptive and narrative way. However, we have not tested it and collected empirical
640 evidence. The acceptability of robots, understood as the study of the intention of use or usage
641 and presented through the three phases of the same continuum (i.e., a priori acceptability,
642 acceptance, and adoption), would deserve a more thorough analysis of the literature (i.e., a
643 systematic review of the literature). Indeed, while in the literature the terms acceptability and
644 acceptance are often used interchangeably (Krägeloh et al., 2019), these phases do not involve
645 the same determinants of use. A priori acceptability, acceptance and adoption of new
646 technologies differ methodologically and epistemologically (Reekink-Boulanger, 2012).
647 However, these different moments of evaluation share a common goal of identifying the
648 processes underlying the adoption of a technology (e.g., Alexandre et al., 2018). The
649 complementarity of these different approaches helps to show the dynamic, progressive and
650 complex nature of the adoption of technological devices (Bobillier-Chaumon & Dubois, 2009)

651 652 **Conclusion**

653 Although the acceptability of technologies and how we perceive them is rapidly
654 evolving, it seemed that the high rate of acceptability in this literature review was not in line
655 with the concerns of the public. People express concerns about robots assisting people in
656 vulnerable situations or even their children (see Public Attitudes Towards Robots, European
657 Commission, 2012). They also express concerns about the possible and progressive substitution
658 of human workers by robots (e.g., Strait et al., 2017). These observations open the door to new
659 questions, notably that of their democratization and integration as a tool for improving the
660 quality of life and not as an alternative in the absence of any societal solution. In fact, even if
661 their acceptability were proven, this would not make their introduction automatically acceptable
662 and free of justifications.

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