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Dayle David, Meggy Hayotte, Pierre Th rouanne, Fabienne
d'Arripe-Longueville, Isabelle Milhabet

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25 DiSalvo, Gemperle, Forlizzi and Kiesler (2002) measured anthropomorphic design, whereas
26 other researchers have measured the anthropomorphism of mental states (Epley et al., 2007;
27 Waytz et al., 2014). Thus, based on these two approaches (i.e., essential and superficial;
28 Waytz et al., 2014), the existing tools (e.g., *Mind Attribution*, Waytz et al., 2010), and the
29 relevant literature (e.g., Fink, 2012), we identified five categories of characteristics that can be
30 used to measure the degree of anthropomorphism specifically in social robots: appearance,
31 behavior, cognition, emotion, and morality. We adopted an integrative approach to the
32 anthropomorphism of social robots to develop and validate a Social Robot
33 Anthropomorphism (SRA) scale on the attribution of mental states (emotion, morality, and
34 cognition) and appearance and behavior to robots. In addition, most studies have used
35 English-speaking samples to be able to publish internationally (e.g., 67% of the studies
36 published in *Journal of Personality and Social Psychology* are with American samples;
37 Henrich et al., 2010, p.63), which has resulted in limited French-language tools and, for
38 example, greater difficulty in studying French attitudes toward technology. Notably, culture
39 plays a role in these attitudes (e.g., Bartneck et al., 2005). This scale was designed to be
40 administered to French-speaking samples, to be understood and adapted to these people. This
41 scale will then make it possible to question new samples of people and to better understand to
42 what extent they anthropomorphize social robots based on their representations.

43

44 **1.1 The phenomenon of anthropomorphism**

45 Anthropomorphism is characterized by cognitive and motivational factors (Epley et
46 al., 2007), three of which stand out: *Sociality*, *Effectance* and *Elicited agent Knowledge*,
47 known as the SEEK model (Epley et al., 2007). According to this model, humans use their
48 easily accessible knowledge and are motivated by their needs to both build relationships and
49 predict their environment when they attribute human characteristics to nonhuman agents.

50 Humanizing a social robot may be a way to maintain predictability and control (Waytz et al.,
51 2010) because once human characteristics have been attributed to the robot, meaning can be
52 given to its actions. This model seems to be consistent with the theses developed by Guthrie
53 (1993): anthropomorphism enables us to explain things that we do not understand (i.e., the
54 thesis of familiarity), while at the same time reducing the discomfort we feel in the face of
55 things that do not look like us (i.e., the comfort thesis). Anthropomorphism, by introducing
56 greater familiarity, may facilitate human-robot interaction (HRI), making the interactions
57 more "natural." Yet, the humanization of robots can then create expectations about their
58 behaviors, intentions, and actions (Bartneck et al., 2009) that are likely to cause discomfort,
59 instability or threat (e.g., Złotowski et al., 2017). For example, one can attribute evil intentions
60 to a robot or think that it takes initiatives without our control, and so on. Under these
61 conditions, being able to measure anthropomorphism would allow, for example, to test
62 Guthrie's (1993) comfort and familiarity theses from both an academic (e.g., building new
63 knowledge, testing other factors, etc.) and engineering (e.g., improving Human-Robot
64 interactions) perspectives. More generally, anthropomorphism helps to: (a) understand how
65 people interact with nonhuman agents (Chin et al., 2005), (b) improve the way people
66 perceive nonhuman agents (Epley et al., 2008), (c) make sense of the actions and behaviors of
67 nonhuman agents (Waytz et al., 2010), and (d) provide clarifications and insights into
68 relationships between humans (e.g., dehumanization, Epley et al., 2008; Waytz et al., 2010).
69 Anthropomorphism thus has advantages while being associated with fears.

70

71 **1.2 Framework**

72 **1.2.1 Appearance**

73 Today's robots, especially social ones, tend toward a more humanlike appearance
74 (Spatola, 2019). Robot appearance is understood to mean the visual appearance, sound, smell,

75 and feel (e.g., the static aspect of the robot; von Zitzewitz et al., 2013). Furthermore, it is
76 possible to distinguish several forms of robots: functional, anthropomorphic, zoomorphic, and
77 caricatured (Fong et al., 2002). The anthropomorphic appearance remains preferable because
78 it facilitates interactions with humans (Złotowski et al., 2015). Indeed, many aspects of
79 nonverbal communication are understandable only by their similarity to the human body
80 (Hegel et al., 2008). However, when robots look neither too human nor too mechanical, this
81 can cause discomfort. This theory of the "Uncanny Valley" (Mori, 1970), although often
82 cited, has also been criticized (e.g., Bartneck et al., 2007) and has not always been
83 demonstrated experimentally (e.g., Burleigh et al., 2013). In any case, whichever design is
84 chosen, a humanlike appearance always has an important place in the design of robots,
85 especially because it is strongly linked to the perception of intelligence and intentions (Hegel
86 et al., 2008). One study even showed that the degree to which robots are humanlike has a
87 significant impact on people's cortical activity associated with the theory of mind (i.e., the
88 ability to attribute mental states to others). The more humanlike the robot they were faced
89 with, the more the participants inferred its intentions (Hegel et al., 2010). Anthropomorphic
90 design combined with social robotics has an impact on the way people perceive, interact and
91 build a relationship with robots (Fink, 2012).

92

93 **1.2.2 Behavior**

94 Similar to appearance, robot behaviors also play a role in the humanlike qualities
95 attributed to them. By behaviors, we mean movements, nonverbal and verbal
96 communications, social behaviors and interactions (e.g., the dynamic aspect of the robot; von
97 Zitzewitz et al., 2013). The appearance and behaviors of robots can facilitate acceptability and
98 interactions with them (Fink, 2012). In fact, robots with humanlike behaviors are treated with
99 more empathy and less severity than machinelike robots (Bartneck et al., 2010). Along the

100 same line, cheating robots (Short et al., 2010) or robots that move at the speed of a person
101 (Morewedge et al., 2007) are perceived as more human.

102

103 **1.2.3 Cognition**

104 Robotics and HRI engineers have long sought to develop a cognitive architecture as
105 close as possible to the human cognitive model (Hiatt & Trafton, 2010) in order to integrate a
106 theory of mind inside the robot (Baron-Cohen, 1991). To have a natural HRI, the robot has to
107 reason like humans, even if it does not fully understand the human cognitive model (Guitton
108 et al., 2012). On the user side, to represent a robot's actions, people need to perceive the robot
109 as having cognitive processes like those of humans (Stenzel et al., 2012). However, this
110 cognitive autonomy in robots worries people (Carpenter, 2013; Dinet et al., 2015). Indeed, the
111 more the robot is autonomous, the less control they have over it (Lombard & Dinet, 2015).

112

113 **1.2.4 Emotion**

114 Anthropomorphism also involves the attribution of emotions. There are two categories
115 of emotions: primary emotions (e.g., joy, fear, sadness) and secondary emotions (e.g., pride,
116 compassion, nostalgia). We share primary emotions with animals, whereas secondary
117 emotions implicate higher-order mental processes of self-awareness and are considered to be
118 "uniquely human" (Demoulin et al., 2004; Leyens et al., 2003; Leyens et al., 2001). The
119 measurement of secondary emotions is often used in work on dehumanization (i.e., the
120 inverse process of anthropomorphism, Epley et al., 2008; Epley, Waytz et al., 2008; Epley et
121 al., 2007; Kwan & Fiske, 2008). It has been shown that people tend to deny secondary
122 emotions to the members of an outgroup (Leyens et al., 2003). This amounts to attributing an
123 incomplete human nature (Leyen et al., 2001). On the design side, the expression of facial
124 emotions on robots helps give them credibility (Tielman et al., 2014), creates a desire to

125 interact with them (Breazeal, 2003), and can provide feedback on their adaptation to a given
126 situation and interaction (Cañamero & Fredslund, 2001). Recently, attempts have also been
127 made to build artificial empathy into robots, similar to human empathy (Asada, 2015; Pepito
128 et al., 2020; Pereira et al., 2011).

129

130 **1.2.5 Morality**

131 Moral norms are important in human interactions and are an essential characteristic of
132 human sociality (Malle et al., 2015). According to these authors, moral norms have three
133 functions for groups and societies: guidance, predictability, and coordination (i.e., What
134 should I do? What is supposed to happen? Who is going to do what?; Malle et al., 2015). One
135 consequence of anthropomorphism is the creation of moral consideration in robots (Waytz et
136 al., 2010). For example, should they be held accountable for their actions? Gebhard, Nevers
137 and Billman-Mahecha (2003) assert that the anthropomorphic nature of a nonhuman agent
138 allows it to be moralized. Indeed, morality is a uniquely human capacity, but people expect
139 robots to act morally (Malle et al., 2015).

140

141 **1.3 Measurements of anthropomorphism**

142 Several tools have been developed to measure anthropomorphism, mostly in the field
143 of HRI. Most have not been systematically validated, and for some scales, only internal
144 consistency has been checked (e.g., *Mind Attribution subscale*, Eyssel & Kuchenbrandt, 2012;
145 *Godspeed Questionnaire*; Bartneck et al., 2009; *Anthropomorphism subscale*; Eyssel et al.,
146 2011; *Mind Attribution*; Waytz et al., 2010; *Dimensions of Mind Perception*, Gray et al.,
147 2007). Some scales have demonstrated satisfactory psychometric qualities: the *Individual*
148 *Differences in Anthropomorphism Questionnaire* (IDAQ; Waytz et al., 2010), the
149 *Anthropomorphic Tendencies Scale* (ATS; Chin, et al., 2005), the *Robotic Social Attributes*

150 *Scale* (RoSAS; Carpinella et al., 2017), and the *Human-Robot Interaction Evaluation Scale*
151 (HRIES; Spatola et al., 2020). However, the IDAQ (Waytz et al., 2010) and the ATS (Chin et
152 al., 2005) measure the dispositional trait of anthropomorphism. They do not focus on the
153 anthropomorphism attributed to robots, but to all kinds of objects. In contrast, the RoSAS
154 (Carpinella et al., 2017) and HRIES (Spatola et al., 2020) are adapted to social robots. These
155 scales measure the anthropomorphism attributed to robots only through the prism of
156 "attribution of uniquely human traits" found in the literature on dehumanization (Haslam,
157 2006). These measures do not consider the specific characteristics of social robots, which
158 often have a humanoid or zoomorphic appearance (Breazeal et al., 2008) (see Table 1). In
159 other words, to the best of our knowledge, no scale to date has adopted an integrative
160 approach to the anthropomorphism of social robots that embraces both their *superficial* and
161 *essential* characteristics. To bridge this gap, in the present study we considered the five
162 following dimensions: appearance, behavior, cognition, emotion and morality.

163

164 **Table 1**

165 *Anthropomorphism scales that demonstrate satisfactory psychometric qualities*

Scale	Authors	Measure of anthropomorphism
ATS	Chin et al. (2005)	Four dimensions: "extreme" anthropomorphic tendencies, anthropomorphism toward a god or higher power, anthropomorphic toward pets, and inappropriate irritation
IDAQ	Waytz et al. (2010)	Each of three types of agent (animal, nature, technology) evaluated on seven items (e.g., mind, consciousness, usefulness, etc.)
RoSAS	Carpinella et al. (2017)	Three dimensions reflecting social judgments of robots: warmth, competence and discomfort
HRIES	Spatola et al. (2020)	Four dimensions: sociability, disturbance, agency and animacy

166 *Notes.* ATS, Anthropomorphism Tendency Scale; IDAQ, Individual Differences in
167 Anthropomorphism Questionnaire; RoSAS, Robotic Social Attributes Scale; HRIES, Human-
168 Robot Interaction Evaluation Scale.
169

170 **1.4 Overview**

171 In this paper, we develop an anthropomorphism scale adapted to social robots (SRA)
172 and validate it in a French sample. The key contribution of this study is that it integrates the
173 various theoretical considerations of the anthropomorphism of social robots. The SRA scale
174 was inspired by measures in the literature and brings a new and more global approach by
175 taking into consideration five dimensions: appearance, behavior, cognition, emotion and
176 morality. Thus, the main objective of the study is to provide an anthropomorphism scale
177 adapted to social robots and their specificities (e.g., communication skills, human appearance)
178 that is able to meet the most rigorous psychometric tests for reliability and validity, according
179 to recent recommendations (e.g., Boateng et al., 2018).

180 The rest of the article proposes first the procedure for the scale development and the
181 results and then the procedure for the validation testing and the results. The next section
182 concerns the participants who contributed to both the reduction in items (i.e., development
183 section) and the scale validation.

184

185 **2 Procedure and participants**

186 **2.1 Procedure**

187 Several steps were conducted in accordance with recommendations for scale
188 validation (Boateng et al., 2018): (a) development of the SRA scale (i.e., item selection,
189 content clarity analysis, item reduction), and (b) validation of the scale (i.e., tests of
190 dimensionality, reliability and construct validity). Participants responded online to several
191 questionnaires for the development and validation steps. ~~All completed the 31 initial items of~~

192 ~~the scale~~. Then, for the construct validity tests, they completed an acceptability scale (e-
193 Health Acceptability Scale; Hayotte et al., 2020) and the French-validated version of the
194 Negative Attitude toward Robots Scale (NARS; Dinet & Vivian, 2015), both of which are
195 detailed in the validation section. Participants also provided sociodemographic data and
196 information concerning their familiarity with (Goudey & Bonnin, 2016), anxiety about
197 (Goudey & Bonnin, 2016), and aesthetic appreciation of social robots (adapted from Eyssel &
198 Kuchenbrandt, 2012). The questions were designed to elicit descriptions of the participants’
199 characteristics. In addition, a second sample of the participants completed the SRA scale
200 twice, 4 weeks apart, to assess the temporal stability of the scale. Therefore, there were two
201 samples: first one for the development of the scale (e.g., item reduction) and its validation
202 (e.g., tests of dimensionality , internal consistency, and construct validity) and a second,
203 smaller one, to evaluate the stability of the responses over time of the scale (i.e., these
204 participants answered the scale twice at 4 weeks apart).

205

206 **2.2 Exclusion procedure**

207 To ensure the validation of the SRA scale for any social robot, participants were asked
208 to refer to the definition of a social robot: “Social robots are robots that have the specificity of
209 interacting with humans but also of having an often humanoid or animal appearance.” No
210 further description or visual representation of a social robot was given. Despite this definition,
211 some participants responded to the questionnaire thinking of robots that do not fit the given
212 definition. When this occurred, the participant was excluded. For this purpose, a free text box
213 was added at the end of the questionnaire asking: “*Which robot did you think of when*
214 *answering the survey questions?*”. All participants who indicated that they had represented
215 something other than a social robot (e.g., chatbot, conversational agent, cleaner robot or
216 nothing) when completing the questionnaire were then excluded.

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2.3 Development and validation: first sample (N = 450)

The first sample was initially made up of 587 French-speaking participants from an English recruitment platform (Prolific Academic). According to the exclusion procedure, 137 participants were excluded from this first sample. These participants completed an online survey and financial compensation was offered for taking part in the study (£7.40 per hour). Only two inclusion criteria were used: (a) must be at least 18 years old, and (b) must be fluent in French. Since the entire study was in French, so the researchers pre-screened the "fluency in French" as a parameter for recruiting participants on the English platform (Prolific Academic).

This sample used to test the dimensionality, internal consistency, and construct validity of the scale consisted of 450 participants. The ages of the participants ranged from 18 to 78 years ($M = 28.9$, $SD = 9.8$) and women accounted for 45.1% of the sample. Among the 450 participants, 29.3% had never interacted with a social robot in any social context. Overall, however, the participants rated themselves as being familiar with this kind of technology ($M = 5.1$, $SD = 1.4$, on a scale from 1-Very unfamiliar with these technologies to 7-Very familiar with these technologies) and not very anxious about general technologies ($M = 2.0$, $SD = 1.1$, on a scale from 1-Strongly disagree to 7-Strongly agree). In addition, they evaluated the aesthetics of social robots in a positive way ($M = 4.72$, $SD = 1.1$, on a scale from 1-Strongly disagree to 7-Strongly agree). In an exploratory approach, the relationships between anthropomorphism and these last three measures were investigated. No significant correlation was found between the global anthropomorphism score and techno familiarity ($r = -.00$, $ns.$). Conversely, positive and significant correlations were found between anthropomorphism and anxiety ($r = .11$, $p < .05$), and between anthropomorphism and attractiveness for the aesthetics of robots ($r = .31$, $p < .01$).

243 2.4 Test-retest: second sample (N = 56)

244 For the test-retest reliability analysis, the sample composition was performed in two
245 steps. First, participants from the sample 1 (N = 587) were contacted to complete the SRA
246 scale a second time four weeks later. Among these, 50 completed the SRA scale a second
247 time. Nonetheless, 19 participants were excluded according to the exclusion procedure. In the
248 second step, since the French-speaking population on the English platform was exhausted, the
249 use of another online French platform (Crowd Panel) was necessary to complete the sample.
250 The same inclusion criteria as above were used and 36 participants from this French platform
251 completed the two phases (test-retest). Among them, 11 participants were excluded (i.e., 5
252 according to the exclusion procedure; 6 could not be associated between time 1 and time 2
253 because of incorrect codes or no second response). Finally, of the 86 participants who
254 responded a second time to the SRA scale ($N_{\text{Prolific}} = 50$; $N_{\text{Crowd}} = 36$), 30 were excluded.
255 Finally, the second sample consisted of 56 French-speaking participants and was partially a
256 subsample from the first sample ($N_{\text{Prolific}} = 31$; $N_{\text{Crowd}} = 25$). Their ages ranged from 19 to 73
257 years ($M = 36.3$, $SD = 13.9$) and women accounted for 42.9 % of the sample. Of the 56
258 participants, 16.1 % had an interaction with a social robot at some time in their life.

259 All participant characteristics for both samples are presented in Table 2.

260

261 **Table 2**

262 *Sociodemographic characteristics of samples*

Characteristics	Sample 1 (N = 450) n (%)	Sample 2 (N = 56) n (%)
Sex		
Female	203 (45.1)	24 (42.9)
Male	243 (54)	32 (57.1)
Other	4 (0.9)	0
Highest educational level		
Without diploma	6 (1.3)	0

Less than high school	22 (4.9)	5 (8.9)	263	
High school	95 (21.1)	6 (10.7)	264	
University or postgraduate degree	327 (72.7)	45 (80.4)	265	
Professional status				
Unemployed	27 (6)	5 (8.9)	266	
Student	159 (35.3)	10 (17.9)	267	
Employed	261 (58)	38 (67.9)	270	
Retired	3 (0.7)	3 (5.4)	271	
Interaction				
Interaction experience with a robot	132 (29.3)	9 (16.1)	268	3 D evelo pment of the SRA scale
Interaction with non-social robot	30 (22.7)	4 (44.4)	269	
Convention, tradeshow context	29 (22)	0	270	
Shopping mall context	12 (9.1)	1 (11.1)	271	
Entertainment context (show, hotel, restaurant, airport, museum, science center)	18 (1.4)	3 (33.3)	272	
Professional context	12 (0.9)	1 (11.1)	273	
Educational context	8 (6.1)	0	274	
Other context	11 (8.3)	0	275	
Interaction context not specified	12 (9.1)	0	276	
Characteristics	Sample 1 (<i>N</i> = 450) <i>M</i> (<i>SD</i>)	Sample 2 (<i>N</i> = 596) <i>M</i> (<i>SD</i>)		
Age	28.9 (9.8)	35.1 (14.3)	277	
Technological objects (phone, computer, tablets)	3.5 (2.1)	4 (3.8)	278	

279 study was pre-registered, and an update has also been put online on the OSF platform
280 (https://osf.io/qkyjf/?view_only=09b7e6a688564c8784ebc36732f895c4, May 2020).

281

282 **3.1 Method**

283 **3.1.1 Item selection**

284 A committee of five experts in social psychology and cognitive ergonomics (e.g.,
285 experts in the validation of psychometric tools, in the concepts of mind perceptions, human-
286 machine interaction, etc.) was put in place and met several times in order to reinforce the
287 content validity (DeVellis, 2017). Thirty-one initial items were selected in five dimensions
288 (appearance: APP, behavior: BEH, cognition: COG, emotion: EMO, and morality: MOR).
289 Most of the selected items were from previous research (see Table 3). Specifically, some

290 items were selected directly from existing scales and not modified (COG3, COG5, COG6,
291 EMO2, EMO4, EMO5, EMO7, EMO8, MOR1, MOR2, and MOR4), and some were reversed
292 (COG4 and COG6). Other items were created and adapted by drawing on the existing scales
293 and the literature (APP1, APP2, APP3, APP4, APP5, COM1, BEH2, BEH3, BEH4, BEH5,
294 EMO1, EMO3, COG1, COG2, COG7, COG8, MOR3, and MOR5). Most of the modified
295 items were initially rated on the Osgood scales (e.g., Machinelike to Humanlike, Bartneck et
296 al., 2009). They were transformed to correspond to statements that the participants positioned
297 themselves on using a Likert scale (e.g., from Strongly Disagree: 1 to Strongly Agree: 7).
298 New items were created to balance the number of items per subdimension. Finally, all items
299 were translated into French.

300

301 **3.1.2 Content clarity analysis**

302 Some of the items on the SRA scale were taken from English language tools. They
303 were therefore translated by a professional academic translator, and a pre-test was conducted
304 with other participants beforehand (i.e., different participants from those in samples 1 and 2
305 presented above) to verify the clarity of all the items (methodology inspired by Vallerand,
306 1989). Participants were asked to indicate whether the items were understandable using a 7-
307 point Likert scale.

308

309 **3.1.3 Item reduction**

310 The 5-factor structure of the SRA scale (i.e., appearance, behavior, cognition, emotion,
311 morality) was guided by theory and previous work (e.g., Bartneck et al., 2009; DiSalvo et al.,
312 2002; Fink, 2012; Gray et al., 2007; Leyens et al., 2001; Waytz et al., 2010). Following the
313 recommendations of Jackson, Purc-Stephenson and Gillapsy (2009), this hypothesis of a 5-
314 factor structural model prompted us to directly conduct a confirmatory factor analysis. For the
315 item reduction, we retained the hypothesis of a 5-factor correlated model. The

316 recommendation is to retain items with factor loadings greater than .40 (Raykov &
317 Marcoulides, 2011) or even greater than .50 (Hair et al., 2014). Thus, to examine the factor
318 loadings of the items, we selected a minimum of .40.

319

320 **3.2 Results**

321 **3.2.1 Content clarity analysis**

322 A content clarity analysis was performed with 15 participants on the preliminary 31-
323 item version of the scale. Their ages ranged from 18 to 68 years ($M = 31.8$, $SD = 13.4$),
324 women accounted for 66.7 % of the sample and most of them are employed (73.3%).
325 Participants were asked to indicate whether the items were understandable using 7-point
326 Likert scales. The analysis showed an acceptable clarity score (i.e., mean range from 4.2 to
327 6.8, $M = 5.4$, $SD = 0.8$). No item scored less than 4, so items were not modified or rephrased.

328

329 **3.2.2 Item reduction**

330 We conducted structural equation modeling with the 5-factor correlated model on
331 sample 1 ($N = 450$) to examine the factor loadings of the 31 items (see Table 2). Nine items
332 with standardized factor loadings less than .40 were deleted: APP2, BEH2, BEH3, COG1,
333 COG2, COG3, COG7, COG8, MOR5. In addition, after examination by the committee two
334 other items were deleted for their redundancy: APP5 (redundant with APP1) and EMO6
335 (redundant because too generic compared to the other items of the subscale). After reduction,
336 the SRA scale was composed of 20 items and five dimensions (i.e., appearance, behavior,
337 cognition, emotion, and morality).

338

339 **Table 3**

340 *The 31 items that were used for the development of the SRA scale. The 20 items that were*
 341 *retained for the final version are marked in bold*

Item code	Item (English translation in brackets)	Source	Factor-loading
<i>Appearance</i>			
APP1	Un robot ressemble physiquement à un être humain. [A robot looks like a human being.]	Machinelike vs. Humanlike (Bartneck et al., 2009)	.79
APP2*	Un robot a la forme d'un objet. [A robot looks like an object.]	Original	.26
APP3	Un robot a la forme d'une personne. [A robot looks like a person.]	Original	.85
APP4	Un robot a une apparence humaine. [A robot is humanlike.]	Not very Humanlike vs. very Humanlike (DiSalvo et al., 2002).	.93
APP5	Un robot ressemble physiquement à une machine. [A robot is machinelike.]	Machinelike vs. Humanlike (Bartneck et al., 2009)	.45
<i>Behavior</i>			
BEH1	Un robot se comporte de manière naturelle. [A robot behaves naturally.]	Fake vs. Natural (Bartneck et al., 2009)	.75
BEH2	Un robot interagit avec son environnement. [A robot interacts with its environment.]	Original	.38
BEH3*	Un robot se déplace de manière saccadée. [A robot moves jerkily.]	Moving rigidly vs. Moving elegantly (Bartneck et al., 2009)	.34
BEH4	Un robot se comporte comme un humain. [A robot behaves like a human.]	Fink (2012)	.70
BEH5*	Un robot se comporte de manière mécanique. [A robot behaves like a machine.]	Mechanical vs. Organic, (Bartneck et al., 2009)	.49
<i>Cognition</i>			
COG1	Un robot prend des décisions. [A robot makes decisions.]	Original	.31
COG2	Un robot résout des problèmes. [A robot solves problems.]	Original	.18
COG3	Un robot a une mémoire. [A robot has memory]	Agency dimension, (Gray et al., 2007)	.17
COG4*	Un robot n'a pas de conscience. [A robot does not have consciousness.]	Experience dimension (Gray et al., 2007).	.49
COG5	Un robot a ses propres pensées. [A robot has thoughts of its own.]	Waytz et al. (2010)	.78
COG6	A robot a des intentions. [A robot	Waytz et al. (2010)	.56

Item code	Item (English translation in brackets)	Source	Factor-loading
	has intentions.]		
COG7*	Un robot ne raisonne pas. [A robot does not reason.]	Original	.26
COG8*	Un robot ne réfléchit pas. [A robot does not think.]	Original	.37
Emotion			
EMO1	Un robot ressent de la compassion. [A robot feels compassion.]	Leyens et al. (2001)	.81
EMO2	Un robot ressent de la joie. [A robot feels joy.]	Experience dimension (Gray et al., 2007)	.91
EMO3	Un robot ressent de la culpabilité. [A robot feels guilt.]	Leyens et al. (2001)	.89
EMO4	Un robot ressent de la peur. [A robot feels fear.]	Experience dimension (Gray et al., 2007)	.68
EMO5	Un robot a des désirs. [A robot has desires.]	Waytz et al. (2010)	.75
EMO6*	Un robot ne ressent pas d'émotion. [A robot does not have emotions.]	Waytz et al. (2010)	.53
EMO7	Un robot a de l'espoir. [A robot has hope.]	Eyssel & Kuchenbrandt (2012)	.76
EMO8	Un robot ressent du plaisir. [A robot feels pleasure.]	Experience dimension (Gray et al., 2007)	.82
Morality			
MOR1	Un robot a une moralité. [A robot has morals.]	Agency dimension (Gray et al., 2007)	.72
MOR2	Un robot a un libre arbitre. [A robot has free will.]	Waytz et al. (2010)	.61
MOR3	Un robot suit les mœurs de la société. [A robot follows the mores of society.]	Original	.51
MOR4	Un robot a des valeurs et des normes. [A robot has values and standards.]	Waytz et al. (2010)	.68
MOR5*	Un robot ne peut pas résoudre un dilemme moral. [A robot cannot solve a moral dilemma.]	Malle et al. (2015)	.26

342 *Notes.* * reversed items. APP, Appearance; BEH, Behavior; COG, Cognition; EMO, Emotion;
343 MOR, Morality.

345 **4 Validation of the SRA scale**

346 **4.1 Methods**

347 **4.1.1 Measures**

348 *Social Robot Anthropomorphism (SRA) scale*

349 The SRA scale is composed of 20 items and divided into five dimensions: (a)
350 Appearance, (b) Behaviour, (c) Cognition, (d) Emotion and (e) Morality, as explained above.
351 Participants were asked to rate their agreement with the proposals on 7-point Likert-type
352 scales, from Strongly Disagree (1) to Strongly Agree (7).

353

354 *eHealth Acceptability Scale*

355 Theoretical models of technology acceptability start from the premise that behavioral
356 intention depends on the perceptions of the usefulness and ease-of-use of the technology
357 (Venkatesh & Bala, 2008). The measure used in this research was the *eHealth Acceptability*
358 *Scale* (Hayotte et al., 2020). This measure was adapted from the *Unified Theory of*
359 *Acceptance and Use of Technology* (UTAUT2; Venkatesh et al., 2012) and has recently been
360 validated in French. Confirmatory factor analyses provided an acceptable fit to the data (χ^2_{188}
361 = 632.4, $p < .001$; TLI = .90; CFI = .92; RMSEA = .07). For the purposes of the study, we
362 replaced “eHealth” with “social robots” in the formulation of the items. This scale is
363 composed of eight dimensions: (a) Performance Expectancy, (b) Effort Expectancy, (c) Social
364 Influence, (d) Facilitating Conditions, (e) Hedonic Motivation, (f) Price Value, (g) Habits, and
365 (h) Behavioral Intention. Participants were invited to rate the 25 items of the scale using 7-
366 point Likert-type scales from Strongly Disagree (1) to Strongly Agree (7).

367

368 *Negative Attitudes toward Robots Scale (NARS)*

369 Attitudes toward robots are mainly studied through the score obtained on the NARS
370 (Nomura et al., 2006), which measures attitudes regarding interactions, social aspects and

371 emotions at play with a robot. An attitude allows us to anticipate people's behavioral intention
372 (Dinet & Vivian, 2015). The French version of this scale (Dinet & Vivian, 2015) includes 17
373 items divided into three dimensions: (a) Interaction, (b) Social, and (c) Emotion. Participants
374 were asked to indicate their degree of agreement with the statements using 7-point Likert-type
375 scales from Strongly Disagree (1) to Strongly Agree (7).

376

377 *Sociodemographic measures*

378 Sociodemographic data were self-reported by the participants at the end of the
379 questionnaire. The data included age, sex, level of education and professional status.
380 Additional questions were also added about: (a) the type of robot they had imagined while
381 answering the SRA scale (for details see Participants section), (b) whether they had ever had
382 experience interacting with a social robot, and if so in what context, and (c) the number of
383 mobile phones, computers, or tablets they owned.

384

385 **4.1.2 Statistical analyses**

386 All statistical analyses were conducted with IBM SPSS and AMOS version 23.0.0
387 (IBM Corporation). The recruitment platforms do not allow missing data.

388

389 *Tests of dimensionality*

390 Following the methodology of Myers et al. (2014), we tested several models,
391 essentially statistically testing different hypothesized relationships between the observed
392 measures and the underlying factors (Byrne, 2005). Specifically, we tested four structural
393 models of our scale: a unidimensional model (Model 1), a first-order 5-factor correlated
394 model (Model 2), a hierarchical second-order model (Model 3), and a bifactor confirmatory
395 model (Model 4). According to Dunn et al. (2020), the *unidimensional model (Model 1)*
396 implies that a score is given on a single scale measuring a unitary trait (e.g., here, a global

397 anthropomorphism score). This model focuses exclusively on the attribution of
398 anthropomorphism in general. The *first-order correlated model (Model 2)* assumes that the
399 latent factors Appearance, Behavior, Cognition, Emotion and Morality are correlated without
400 a general factor. Here, the model focuses exclusively on specific anthropomorphism
401 attributions. The *hierarchical second-order model (Model 3)* assumes that anthropomorphism
402 is a higher-order factor and that Appearance, Behavior, Cognition, Emotion and Morality are
403 a series of independent subordinate factors that subgroups of items focus on. This model
404 focuses on overall anthropomorphism and considers specificities. Finally, the *bifactor*
405 *confirmatory model (Model 4)* assumes a direct relationship between anthropomorphism (i.e.,
406 general factor) and the observed variables. However, each observed variable is associated
407 both with anthropomorphism and with a subgroup of the item set (e.g., here, appearance,
408 behavior, cognition, emotion and morality). This model, like the previous one, focuses on
409 anthropomorphism and considers the specificities (see Figure 1).

410 In addition, the recommendation with factor analysis is to retain items with a factor
411 loading greater than .40 (Raykov & Marcoulides, 2011) or .50 (Hair et al., 2014). To examine
412 the factor loading of the items, we conducted covariance-based structural equation modeling
413 (CB-SEM) with a 5-factor model. This type of equation is recommended when the objective
414 is to test or confirm a theory (Astrachan et al., 2014). Thus, to test the dimensionality of our
415 SRA scale, we conducted a series of confirmatory factor analyses using maximum likelihood
416 estimations (frequently used in SEM; Dong & Peng, 2013) following the methodology of
417 Myers et al. (2014). Several fit indices were reported to assess the goodness of fit for each
418 model (Hu & Bentler, 1999; Sun, 2005): (a) chi-square (significant values, $p < .01$), (b) chi-
419 square over degrees of freedom (significant values < 3), (c) root mean square residual (RMR),
420 (d) Akaike information criterion (AIC), (e) root mean square error of approximation (RMSEA

421 < .08) and its 90% confidence interval, (f) comparative fit index (CFI > .90), (g) Tucker-
 422 Lewis index (TLI > .90).

423

424

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427 **Figure 1**

428 *Illustrations of the four tested models*

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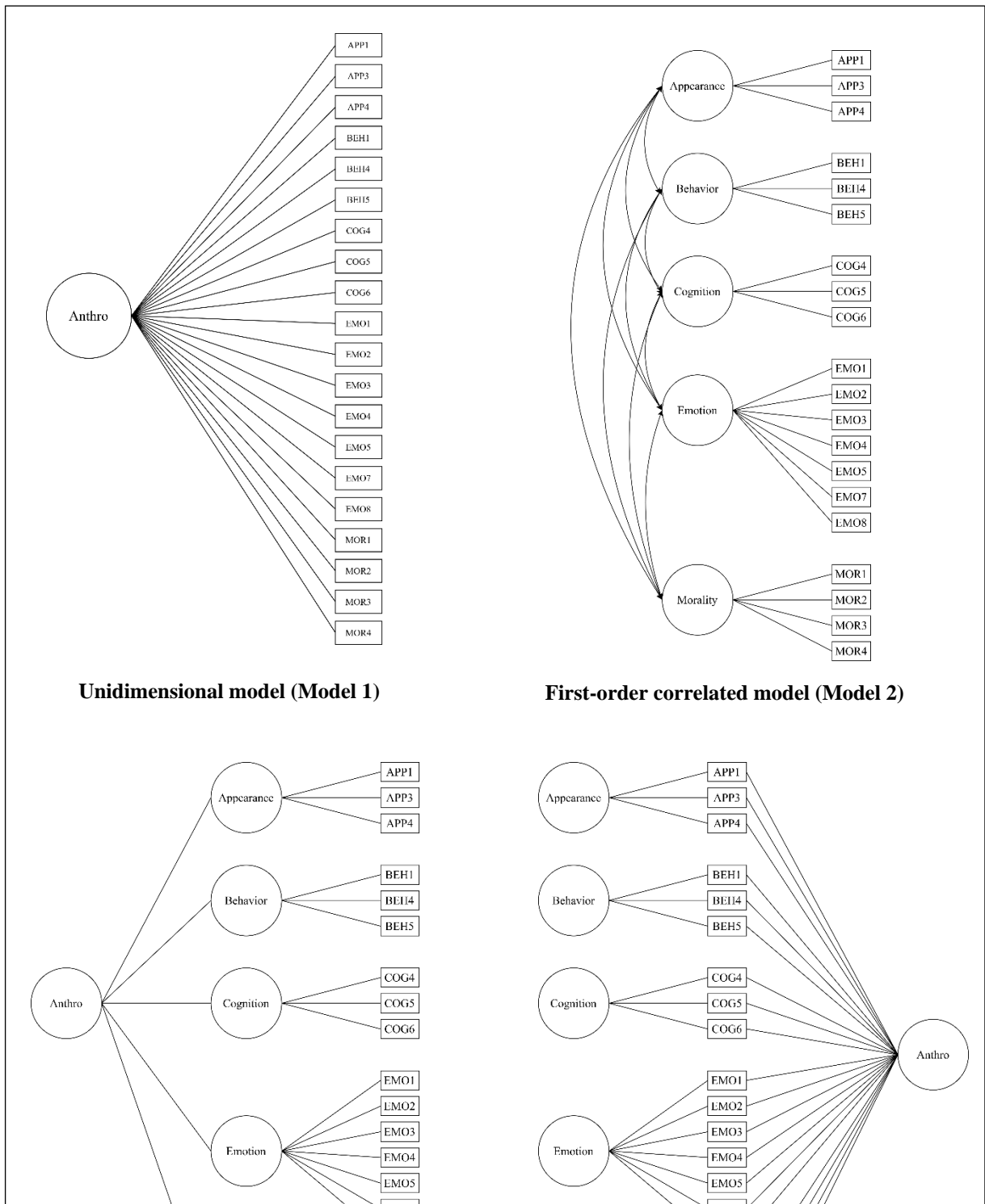
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Bifactor confirmatory model (Model 4)

454 ***Tests of reliability***

455 First, Cronbach's alphas for the whole scale and each subscale were assessed for
456 internal consistency. A threshold of .70 is considered satisfactory (Nunnally, 1978) but .60 can
457 be considered marginally acceptable (Taber, 2018). Second, a test-retest was performed to
458 assess the stability of the responses over time. Participants in sample 2 ($N = 56$) completed the
459 questionnaire twice 4 weeks apart (i.e., acceptable interval; Marx et al., 2003). We calculated
460 the interclass correlation coefficient (ICC) and the 95% confidence interval of the ICC and
461 performed Student's *t*-tests. We expected $ICC > .75$ (Koo & Li, 2016) and the absence of
462 significant differences in the Student's *t*-tests.

463

464 ***Tests of construct validity***

465 We assessed Pearson correlations between conceptually relevant measures (technology
466 acceptability and NARS) and the SRA scale. At the time of the study, no other
467 anthropomorphism scale had been validated in French. Only the HRIES (2020) has been
468 published in French. However, the processing of the SRA scale data was already completed at
469 the time of publication. NARS and the eHealth Acceptability Scale have been validated in
470 French, thus we were able to study the links between anthropomorphism and acceptability.
471 We hypothesized that the SRA scale would be positively correlated with technology
472 acceptability and negatively correlated with NARS. People may evaluate a humanlike robot

473 more positively than a functional robot (Fink, 2012) and perceive it as more pleasant (i.e.,
 474 improved interaction, predictability, and credibility) (Waytz et al., 2010). Further,
 475 anthropomorphism promotes the feeling of familiarity by reducing uncertainty (Złotowski et
 476 al., 2015) and this results in more acceptance of the robot (Fink, 2012).

477

478 **4.2 Results**

479 **4.2.1 Tests of dimensionality**

480 Following the methodology of Myers et al. (2014), we successively tested our models.
 481 Table 4 presents the fit indices for the unidimensional (Model 1), first-order correlated model
 482 (Model 2), hierarchical second-order (Model 3), and bifactor confirmatory (Model 4) models.
 483 All models used 20 items under five factors (i.e., appearance, behavior, cognition, emotion).
 484 Model 1 (i.e., unidimensional model) did not present good fit indexes. Model 2 (i.e.,
 485 correlated first-order model) presented limited but acceptable fit indexes. Model 3 (i.e.,
 486 hierarchical second-order model) presented limited fit indexes. Last, Model 4 (i.e., bifactor
 487 confirmatory model) showed the best fit indexes ($\chi^2_{139} = 313.86$, $p < .001$, RMSEA = .053
 488 [.045-.061], CFI = .97, TLI = .95). The factorial structure of the SRA scale enabled us to
 489 extract a global anthropomorphism score from the 20-item scale (i.e., mean score on the
 490 whole 20-item SRA scale) or a score for each of the five subscales.

491

492 **Table 4**

493 *Fit indices for the structural equation models (N = 450)*

	χ^2 (df)	p	AIC	RMR	RMSEA	RMSEA CI 90%	CFI	TLI	$\Delta\chi^2$ (df)	Δp
Model 1	1528.24 (169)	<.01	1610.24	.252	.134	.128-.140	.73	.69	N/A	N/A
Model 2	595.85 (159)	<.01	697.85	.119	.078	.072-.085	.91	.90	932.39 (10)	<.01
Model 3	749.89 (164)	<.01	841.88	.176	.089	.083-.096	.88	.86	154.04 (5)	<.01

Model 4	313.86 (139)	<.01	455.86	.069	.053	.045-.061	.97	.95	436.03 (25)	<.01
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494 *Notes.* Model 1, unidimensional; Model 2, first-order all-factor correlated; Model 3,
495 hierarchical second-order; Model 4, bifactor confirmatory; AIC, Akaike information criterion;
496 RMR, root mean square residual; RMSEA, root mean square error of approximation; TLI,
497 Tucker-Lewis index; CFI, comparative fit index; N/A, not applicable.
498

499 4.2.2 Tests of reliability

500 Model 4, as explained above, focused on both general anthropomorphism and its
501 specificities, and we therefore assessed the internal consistency of the scale as a whole and its
502 subscales. Cronbach’s alphas ranged from .61 to .93 in sample 1 ($N = 450$) for the five SRA
503 scale factors ($\alpha_{\text{Appearance}} = .89$, $\alpha_{\text{Behavior}} = .66$, $\alpha_{\text{Cognition}} = .61$, $\alpha_{\text{Emotion}} = .93$, $\alpha_{\text{Morality}} = .73$). The
504 behavior and cognition dimensions did not reach the satisfactory threshold of .70
505 recommended by Nunally (1978) and will thus need to be improved and retested. However,
506 they both achieved internal consistency above .60, which remains marginally acceptable
507 (Taber, 2018). The SRA scale still showed good internal consistency for the 20-item SRA (α
508 = .90).

509 Then, we assessed the test-retest reliability in sample 2 ($N = 56$) with a mean interval
510 of 4 weeks. The Student’s paired t -test showed no significant differences in the scores from
511 time 1 to time 2. Moreover, the intraclass correlations between time 1 and time 2 were strong
512 and significant (see Table 5). These results indicate the satisfactory stability of the SRA scale
513 over time.

514

515 **Table 5**

516 *Test-retest reliability indices for the tested models ($N = 56$)*

Subscales	Score mean (<i>SD</i>) T1	Score mean (<i>SD</i>) T2	Student's t-test	p	ICC [95% CI]	p
Appearance	4.2 (1.2)	4.0 (1.4)	1.34	.19	.81 [.68 - .89]	.001
Behavior	3.2 (1.0)	3.0 (1.0)	1.20	.23	.86 [.76 - .92]	.001
Cognition	2.4 (1.2)	2.5 (1.1)	-0.27	.79	.79 [.64 - .88]	.001

Emotion	1.8 (1.0)	1.8 (1.0)	-0.13	.90	.90 [.82 - .94]	.001
Morality	2.7 (1.1)	2.6 (1.1)	0.92	.36	.80 [.66 - .88]	.001
<i>Overall 20-item SRA</i>	2.6 (0.8)	2.6 (0.8)	0.95	.34	.90 [.84 - .94]	.001

517

518 **4.2.3 Tests of construct validity**

519 Pearson’s correlations ($N = 450$) between the SRA scale and the conceptually relevant
520 measures (technology acceptability and NARS) were calculated (see Table 6). Results showed
521 that anthropomorphism was positively and significantly related to technology acceptability as
522 expected ($r = .38, p < .01$). More specifically, the Performance Expectancy ($r = .36, p < .01$),
523 Social Influence ($r = .34, p < .01$), Habits ($r = .39, p < .01$), and Behavioral Intention ($r = .36,$
524 $p < .01$) subscales of the acceptability scale had satisfactory correlations with
525 anthropomorphism. In addition, results showed that anthropomorphism was negatively and
526 significantly related to NARS ($r = -.20, p < .01$) but only the Emotion subscale of the NARS
527 was satisfactory ($r = -.41, p < .01$). Overall, the construct validity remained satisfactory
528 despite its limitations.

	M (SD)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1. SRA 20-item	2.70 (0.83)	-																		
2. SRA APP	3.72 (1.10)	.484**	-																	
3. SRA BEH	3.17 (1.02)	.663**	.611**	-																
4. SRA COG	2.63 (1.23)	.741**	.157**	.302**	-															
5. SRA EMO	1.84 (1.02)	.855**	.179**	.400**	.641**	-														
6. SRA MOR	2.85 (1.23)	.770**	.164**	.358**	.518**	.578**	-													
7. UTAUT2 25-item	3.58 (0.89)	.369**	.222**	.341**	.264**	.281**	.279**	-												
8. UTAUT2 PE	3.69 (1.37)	.357**	.232**	.308**	.260**	.258**	.281**	.808**	-											
9. UTAUT2 EE	4.52 (1.04)	.126**	.175**	.209**	.060	.029	.096*	.706**	.446**	-										
10. UTAUT2 SI	2.56 (1.42)	.340**	.149**	.307**	.244**	.293**	.242**	.747**	.572**	.344**	-									
11. UTAUT2 FC	4.60 (1.18)	.075	.148**	.180**	.034	-.015	.043	.630**	.323**	.695**	.296**	-								
12. UTAUT2 HM	4.45 (1.21)	.256**	.185**	.225**	.172**	.143**	.247**	.752**	.602**	.577**	.428**	.453**	-							
13. UTAUT2 PV	3.19 (1.07)	.205**	.100*	.185**	.143**	.201**	.121*	.479**	.251**	.249**	.289**	.265**	.211**	-						
14. UTAUT2 HT	2.02 (1.10)	.387**	.087	.241**	.306**	.416**	.277**	.735**	.599**	.284**	.685**	.241**	.399**	.327**	-					
15. UTAUT2 BI	3.30 (1.53)	.359**	.180**	.284**	.281**	.291**	.276**	.844**	.753**	.424**	.603**	.368**	.612**	.303**	.685**	-				
16. NARS 17-item	3.95 (0.86)	-.294**	-.134**	-.252**	-.250**	-.196**	-.271**	-.412**	-.297**	-.329**	-.252**	-.303**	-.350**	-.177**	-.239**	-.393**	-			
17. NARS INT	3.26 (1.09)	-.100*	-.130**	-.162**	-.076	.017	-.122**	-.365**	-.232**	-.393**	-.156**	-.389**	-.308**	-.160**	-.144**	-.301**	.833**	-		
18. NARS SOC	4.31 (0.91)	-.209**	-.044	-.213**	-.173**	-.174**	-.169**	-.203**	-.175**	-.104*	-.149**	-.095*	-.160**	-.082	-.136**	-.239**	.765**	.457**	-	
19. NARS EMO	4.35 (1.22)	-.408**	-.142**	-.237**	-.363**	-.331**	-.366**	-.413**	-.304**	-.272**	-.302**	-.222**	-.365**	-.180**	-.296**	-.404**	.813**	.509**	.445**	-

532 *Notes.* SRA, Social Robot Anthropomorphism; APP, Appearance; BEH, Behavior; COG, Cognition; EMO, Emotion; MOR, Morality; UTAUT2,
533 Unified Theory of Acceptance and Use Technology; PE, Performance Expectancy; EE, Effort Expectancy; SI, Social Influence; FC, Facilitating
534 Condition; HM, Hedonic Motivation; PV, Prince Value; HT, Habit; BI, Behavioral Intention; NARS, Negative Attitudes toward Robots Scale;
535 INT, Interaction; SOC, Social; EMO, Emotion.

536 * $p < .05$, ** $p < .01$, *** $p < .001$

538 **5 Discussion**

539 In this article, we propose a new measure of anthropomorphism that is adapted to
540 social robots and can be used in French samples. This study adopts an integrative approach to
541 anthropomorphism by taking into consideration the existing conceptualizations of
542 anthropomorphism attributed to this new technology. This psychometric tool was designed
543 primarily to measure perceptions *a priori*, but also *posteriori*, after an interaction with a robot.
544 Thus, it evaluates people's perceptions of the degree of physical, behavioral and mental
545 humanity granted to social robots.

546 The Social Robot Anthropomorphism scale includes 20 items distributed into five
547 dimensions (Appearance, Behavior, Cognition, Emotion and Morality). The results showed
548 the good fit indices and internal consistency of the 5-factor bifactor confirmatory model. This
549 model assumes a direct relationship between a general factor and the variables and each
550 variable is also associated with subscales (Dunn et al., 2020). Therefore, the SRA scale
551 assesses a global score of a robot's degree of anthropomorphism while making it possible to
552 measure specific dimensions. However, we found that the behavior and cognition dimensions
553 had limited internal consistency and will need to be fleshed out to make them more robust. As
554 it stands, it is certainly possible to use the SRA scale in its entirety or to assess specific
555 features such as the appearance, emotions and morals of robots. In addition, the test-retest
556 reliability over a period of 4 weeks showed stable responses over time (i.e., nonsignificant
557 differences for the *t*-tests and satisfactory ICC). Finally, the evaluation of construct validity
558 showed a positive and significant relationship with technology acceptability and a negative
559 and significant relationship with negative attitudes toward robots (NARS), as expected. These
560 results are in the same direction of Guthrie's (1993) comfort thesis and familiarity thesis. The
561 construct validity remains fragile, however, and will require further validation. Indeed, we
562 could have confirmed the construct validity by comparing it to a measure of

563 anthropomorphism in French such as the HRIES (Spatola et al., 2020). However, as explained
564 above, this scale was published at the time of our data collection. We also showed that
565 anthropomorphism has a positive effect on the human-robot interaction. However, precaution
566 must be taken with regard to the study sample. Some in the sample were already familiar with
567 this technology (e.g., some participants had previously had a first interaction with a social
568 robot, see Table 3). But familiarity reduces negative attitudes toward technology (Złotowski
569 et al., 2015) and previous experience is a moderator of acceptability (Venkatesh et al., 2003).
570 Also, the literature on the links between anthropomorphism and attitudes is nuanced. For
571 example, Zafari and Koeszgi (2020) showed that attributing a greater capacity for action to a
572 robot would lead to more negative attitudes. Based on these elements, we consider that the
573 validation procedure resulted in satisfactory psychometric properties.

574 There are other limitations than those outlined above. First, the scale was presented to
575 the participants with no visual representation or the actual presence of a social robot.
576 Participants were given only a description at the beginning of the questionnaire. However,
577 proposing different appearances of robots when designing a questionnaire makes it possible to
578 offer a tool that is relevant for a greater diversity of robots (Phillips et al., 2018; Spatola et al.,
579 2020). In addition, a possible perspective would be to conduct a study to test the validity of
580 the SRA scale using the ABOT database. This database visually presents a large panel of
581 existing robots more or less anthropomorphic. Moreover, the scale was designed to measure a
582 general attitude toward robots and not an attitude in a particular context (Goudey & Bonnin,
583 2016). The anthropomorphism of a robot, and how it is perceived, may depend on the social
584 context in which it is encountered. Bartneck et al. (2010) showed that patients during a
585 medical checkup felt more comfortable with a machinelike robot than a humanlike robot.
586 Second, it is a strength to have validated the scale in French but this validation must be
587 extended to other languages. Indeed, attitudes toward robots may also depend on culture

588 (Bartneck et al., 2005). It is therefore necessary to validate this scale in different languages to
589 enable cross-cultural comparisons and thus boost research in the field. Finally, the last
590 limitation of this study is the difference in financial compensation between the participants
591 recruited on the English platform (£7.40/h) and those recruited on the French platform
592 (€12/h). We made the choice to switch to the French platform "Crowd Panel" when the
593 French-speaking sample on the English platform was exhausted. This difference may have
594 influenced the participants' motivation to respond. However, in a study by Buhrmester et al.
595 (2011), financial compensation was manipulated, and the authors reported no difference in the
596 response quality. On the other hand, participant recruitment is longer when the financial
597 compensation is lower.

598 In summary, this study is a step forward in the field of HRI as it provides a new tool
599 that integrates the conceptualizations of anthropomorphism reported in the literature. This
600 new scale, which demonstrates satisfactory psychometric properties, presents
601 anthropomorphism as the process of attributing *superficial* (e.g., appearance) and *essential*
602 (e.g., mind) human characteristics. Anthropomorphism, particularly toward social robots, is
603 therefore a complex phenomenon that is difficult to define, as demonstrated by the many
604 ways it can be determined (Epley et al., 2007). An interesting point is that anthropomorphic
605 social robots prompt people to imagine that these robots are more advanced than they are, and
606 the people then attribute more mind and abilities to them. Yet, these robots also lead them to
607 imagine that technology in general is more advanced than it is (Złotowski et al., 2015), and
608 the perception of mind in a nonhuman agent can modify how we interact with it (Waytz, et
609 al., 2010).

610 This psychometric tool can be used for both academic and professional purposes. In
611 the academic field, this scale could facilitate further investigation of the links between
612 acceptability and anthropomorphism, as these links are still unclear in the literature. For

613 professionals, this scale could enable engineers to test whether their interaction scripts tend
614 toward "natural" interactions, and marketing professionals could use this anthropomorphism
615 measure as a criterion for consumption (or not), particularly in sectors in which companies
616 play on their customers' affections to promote their products. Although several studies have
617 shown the positive effects of product anthropomorphism on sales (e.g., cars and cellular
618 phones; Landwehr et al., 2001), Goudey and Bonnin (2016) showed that the
619 anthropomorphism of intelligent products such as companion robots does not necessarily lead
620 to their acceptance by consumers.

621

622 **References**

- 623 Asada, M. (2015). Towards Artificial Empathy. *International Journal of Social Robotics*, 7, 19–33.
624 <https://doi.org/10.1007/s12369-014-0253-z>
- 625 Astrachan, C. B., Patel, V. K., & Wanzenried, G. (2014). A comparative study of CB-SEM and PLS-
626 SEM for theory development in family firm research. *Journal of Family Business Strategy*,
627 5(1), 116-128. <https://doi.org/10.1016/j.jfbs.2013.12.002>
- 628 Baron-Cohen, S. (1991). Precursors to a theory of mind: Understanding attention in others. *Natural*
629 *theories of mind: Evolution, development and simulation of everyday mindreading*, 1, 233-
630 251. Basil Blackwell.
- 631 Barrett, J. L., & Keil, F. C. (1996). Conceptualizing a non-natural entity: Anthropomorphism in God
632 concepts. *Cognitive Psychology*, 31(3), 219–247. <https://doi.org/10.1006/cogp.1996.0017>
- 633 Bartneck, C., Bleeker, T., Bun, J., Fens, P., & Riet, L. (2010). The influence of robot
634 anthropomorphism on the feelings of embarrassment when interacting with robots. *Paladyn,*
635 *Journal of Behavioral Robotics*, 1(2), 109-115. <https://doi.org/10.2478/s13230-010-0011-3>
- 636 Bartneck, C., Kanda, T., Ishiguro, H., & Hagita, N. (2007). Is the uncanny valley an uncanny cliff?. In
637 *The 16th IEEE international symposium on robot and human interactive communication*, 368-
638 373. <https://doi.org/10.1109/ROMAN.2007.4415111>

639 Bartneck, C., Kulić, D., Croft, E., & Zoghbi, S. (2009). Measurement instruments for the
640 anthropomorphism, animacy, likeability, perceived intelligence, and perceived safety of
641 robots. *International Journal of Social Robotics*. <https://doi.org/10.1007/s12369-008-0001-3>

642 Bartneck, C., Nomura, T., Kanda, T., Suzuki, T., & Kennsuke, K. (2005). Cultural Differences in
643 Attitudes Towards Robots. *Proceedings of the AISB Symposium on Robot Companions: Hard*
644 *Problems And Open Challenges In Human-Robot Interaction*, Hatfield, 1-4.
645 <https://doi.org/10.13140/RG.2.2.22507.34085>

646 Boateng, G. O., Neilands, T. B., Frongillo, E. A., Melgar-Quiñonez, H. R., & Young, S. L. (2018).
647 Best Practices for Developing and Validating Scales for Health, Social, and Behavioral
648 Research: A Primer. *Frontiers in public health*, 6, 149.
649 <https://doi.org/10.3389/fpubh.2018.00149>

650 Breazeal, C. (2003). Toward sociable robots. *Robotics and autonomous systems*, 42(3-4), 167-175.
651 [https://doi.org/10.1016/S0921-8890\(02\)00373-1](https://doi.org/10.1016/S0921-8890(02)00373-1)

652 Brent, E., & Thompson, G. A. (1999). Sociology: Modeling social interaction with autonomous
653 agents. *Social Science Computer Review*, 17(3), 313-322.
654 <https://doi.org/10.1177/089443939901700306>

655 Brotherton, R., & French, C.C. (2015). Intention Seekers: Conspiracist Ideation and Biased
656 Attributions of Intentionality. *PLoS ONE*, 10(5). <https://doi.org/10.1371/journal.pone.0124125>

657 Burleigh, T. J., Schoenherr, J. R., & Lacroix, G. L. (2013). Does the uncanny valley exist? An
658 empirical test of the relationship between eeriness and the human likeness of digitally created
659 faces. *Computers in human behavior*, 29(3), 759-771.
660 <https://doi.org/10.1016/j.chb.2012.11.021>

661 Byrne, B. M. (2005). Factor Analytics Models: Viewing the Structure of an Assessment Instrument
662 From Three Perspectives. *Journal of Personality Assessment*, 85(1), 17-32.
663 https://doi.org/10.1207/s15327752jpa8501_02

664 Cañamero, L., & Fredslund, J. (2001). I show you how I like you-can you read it in my face?
665 [robotics]. *IEEE Transactions on systems, man, and cybernetics-Part A: Systems and*
666 *humans*, 31(5), 454-459. <https://doi.org/10.1109/3468.952719>

667 Carpenter, J. (2013). Just Doesn't Look Right: Exploring the Impact of Humanoid Robot Integration
668 into Explosive Ordnance Disposal Teams. In Luppicini, R. (Eds.), *Handbook of Research on*
669 *Technoself: Identity in a Technological Society*, 609-636.
670 <http://doi:10.4018/978-1-4666-2211-1.ch032>

671 Carpinella, C., Wyman, A.B., Perez, M.A., & Stroessner, S.J. (2017). The Robotic Social Attributes
672 Scale (RoSAS): Development and Validation. In *Proceeding of the 2017 ACM/IEEE*
673 *International Conference on Human-Robot Interaction (HRI)*, 254-262.
674 <https://doi.org/10.1145/2909824.3020208>

675 Chin, M. G., Yordon, R. E., Clark, B. R., Ballion, T., Dolezal, M. J., Shumaker, R., & Finkelstein, N.
676 (2005). Developing and Anthropomorphic Tendencies Scale. In *Proceedings of the Human*
677 *Factors and Ergonomics Society Annual Meeting*, 49(13), 1266–1268.
678 <https://doi.org/10.1177/154193120504901311>

679 Demoulin, S., Leyens, J.-P., Paladino, M.-P., Rodriguez-Torres, R., Rodriguez-Perez, A., & Dovidio,
680 J. F. (2004). Dimensions of "uniquely" and "non-uniquely" human emotions. *Cognition and*
681 *Emotion*, 18(1), 71–96. <https://doi.org/10.1080/02699930244000444>

682 DeVellis, R. F. (2017). *Scale development: Theory and applications* (4th ed., Vol. 26). Thousand
683 Oaks, CA: Sage

684 Dinet, J., Spaeter, E., & Sakorafakas, A. (2015). The negative attitudes towards androids: Beyond the
685 Uncanny Valley and psychological alternatives. In *Proceedings of International Psychological*
686 *Applications Conference and Trends, InPACT 2015*, 215-218.
687 <https://files.eric.ed.gov/fulltext/ED563381.pdf>

688 Dinet, J., & Vivian, R. (2015). Perception et attitudes à l'égard des robots anthropomorphes en
689 France : validation d'une échelle d'attitudes. *Psychologie française*, 60(2), 173-189.
690 <https://doi.org/10.1016/j.psfr.2015.05.002>

691 DiSalvo, C.F., Gemperle, F., Forlizzi, J., & Kiesler, S.B. (2002). All robots are not created equal: the
692 design and perception of humanoid robot heads. In *Proceedings of the Conference on*
693 *Designing Interactive Systems: Processes, Practices, Methods, and Techniques, DIS*, 321–
694 326. <https://doi.org/10.1145/778712.778756>

695 Dong, Y., & Peng, C. Y. (2013). Principled missing data methods for researchers. *SpringerPlus*, 2(1),
696 222. <https://doi.org/10.1186/2193-1801-2-222>

697 Dunn, K. J., & McCray, G. (2020). The place of the bifactor model in confirmatory factor analysis
698 investigations into construct dimensionality in language testing. *Frontiers in psychology*, 11,
699 1357. <https://doi.org/10.3389/fpsyg.2020.01357>

700 Epley, N., Akalis, S., Waytz, A., & Cacioppo, J. T. (2008). Creating Social Connection Through
701 Inferential Reproduction: Loneliness and Perceived Agency in Gadgets, Gods, and
702 Greyhounds. *Psychological Science*, 19(2), 114–120.
703 <https://doi.org/10.1111/j.1467-9280.2008.02056.x>

704 Epley, N., Waytz, A., Akalis, S., & Cacioppo, J. T. (2008). When We Need A Human: Motivational
705 Determinants of Anthropomorphism. *Social Cognition*, 26(2), 143-155.
706 <https://doi.org/10.1521/soco.2008.26.2.143>

707 Epley, N., Waytz, A., & Cacioppo, J. T. (2007). On Seeing Human: A Three-Factor Theory of
708 Anthropomorphism. *Psychological Review*, 114(4), 864-886.
709 <https://doi.org/10.1037/0033-295X.114.4.864>

710 Eyssele, F., & Kuchenbrandt, D. (2012). Social categorization of social robots: Anthropomorphism as a
711 function of robot group membership. *British Journal of Social Psychology*, 51(4), 724–731.
712 <https://doi.org/10.1111/j.2044-8309.2011.02082.x>

713 Eyssele, F., Kuchenbrandt, D., & Bobinger, S. (2011). Effects of anticipated human-robot interaction
714 and predictability of robot behavior on perceptions of anthropomorphism. In *HRI 2011 -*
715 *Proceedings of the 6th ACM/IEEE International Conference on Human-Robot Interaction*,
716 61–67. <https://doi.org/10.1145/1957656.1957673>

717 Fink, J. (2012). Anthropomorphism and human likeness in the design of robots and human-robot
718 interaction. In *International Conference on Social Robotics*, 199-208. Springer, Berlin,
719 Heidelberg. https://doi.org/10.1007/978-3-642-34103-8_20

720 Fong, T., Nourbakhsh, I., & Dautenhahn, K. (2003). A survey of socially interactive robots. *Robotics*
721 *and autonomous systems*, 42(3-4), 143-166. [https://doi.org/10.1016/S0921-8890\(02\)00372-X](https://doi.org/10.1016/S0921-8890(02)00372-X)

722 Gebhard, U., Nevers, P., & Billmann-Mahecha, E. (2003). Moralizing trees: Identity,

723 anthropomorphism and children's relationships to nature. In S. Clayton & S. Opatow (Eds.),
724 *Identity and the natural environment. The psychological significance of nature*, 91-112.
725 Cambridge: MIT Press.

726 Goudey, A., & Bonnin, G. (2016). Un objet intelligent doit-il avoir l'air humain ? Etude de l'impact de
727 l'anthropomorphisme d'un robot compagnon sur son acceptation. *Recherche et Applications*
728 *En Marketing*, 31(2), 3–22. <https://doi.org/10.1177/0767370115617914>

729 Gray, H. M., Gray, K., & Wegner, D. M. (2007). Dimensions of mind perception. *Science*, 315(5812),
730 619. <https://doi.org/10.1126/science.1134475>

731 Guitton, J., Warnier, M., & Alami, R. (2012). Vers une gestion des croyances pour la planification
732 Homme - Robot. *Journées Francophones sur la planification, la décision et*
733 *l'apprentissage pour le contrôle des systèmes, JFPDA 2012*. Villers-lès-Nancy: France.
734 <https://hal.inria.fr/hal-00736219/document>

735 Guthrie, S. E. (1993). *Faces in the clouds: A new theory of religion*. New York: Oxford University
736 Press.

737 Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2014). *Multivariate Data Analysis*. Pearson
738 New International Edition. Harlow, UK.

739 Haslam, N. (2006). Dehumanization: An integrated review. *Personality and Social Psychology*
740 *Review*, 10, 252–264. https://doi.org/10.1207/s15327957pspr1003_4

741 Hayotte, M., Thérouanne, P., Gray, L., Corrion, K., & d'Arripe-Longueville, F. (2020). The French
742 eHealth Acceptability Scale Using the Unified Theory of Acceptance and Use of Technology
743 2 Model: Instrument Validation Study. *Journal of medical Internet research*, 22(4), e16520.
744 <https://doi.org/10.2196/16520>

745 Hegel, F., Eyssel, F., & Wrede, B. (2010). The social robot "Flobi": Key concepts of industrial design.
746 In *Proceedings of the IEEE International Workshop on Robot and Human Interactive*
747 *Communication*, 107–112. <https://doi.org/10.1109/ROMAN.2010.559869>

748 Hegel, F., Krach, S., Kircher, T., Wrede, B., & Sagerer, G. (2008). Understanding social robots: A
749 user study on anthropomorphism. In *Proceedings of the 17th IEEE International Symposium*

750 on Robot and Human Interactive Communication, *RO-MAN*, 574–579.
751 <https://doi.org/10.1109/ROMAN.2008.4600728>

752 Henrich, J., Heine, S., & Norenzayan, A. (2010). The weirdest people in the world? *Behavioral and*
753 *Brain Sciences*, 33(2-3), 61-83. <https://doi.org/10.1017/S0140525X0999152X>

754 Hiatt, L. M., & Trafton, J. G. (2010). A cognitive model of theory of mind. In *Proceedings of the*
755 *10th International Conference on Cognitive Modeling*, 91-96. Philadelphia, PA: Drexel
756 University.

757 Hu, L. & Bentler, P. M. (1999) Cutoff criteria for fit indexes in covariance structure analysis:
758 Conventional criteria versus new alternatives. *Structural Equation Modeling: A*
759 *Multidisciplinary Journal*, 6(1), 1-55. <https://doi.org/10.1080/10705519909540118>

760 Hurley, A. E., Scandura, T. A., Schriesheim, C. A., Brannick, M. T., Seers, A., Vandenberg, R. J., &
761 Williams, L. J. (1997). Exploratory and confirmatory factor analysis: Guidelines, issues, and
762 alternatives. *Journal of Organizational Behavior*, 18(6), 667-683.
763 [https://doi.org/10.1002/\(SICI\)1099-1379\(199711\)18:6<667::AID-JOB874>3.0.CO;2-T](https://doi.org/10.1002/(SICI)1099-1379(199711)18:6<667::AID-JOB874>3.0.CO;2-T)

764 Koo, T. K., & Li, M. Y. (2016). A guideline of selecting and reporting intraclass correlation
765 coefficients for reliability research. *Journal of chiropractic medicine*, 15(2), 155-163.
766 <https://doi.org/10.1016/j.jcm.2016.02.012>

767 Kwan, V. S., & Fiske, S. T. (2008). Missing links in social cognition: The continuum for Nonhuman
768 agents to dehumanized humans. *Social Cognition*, 26(2), 125-128.
769 <https://doi.org/10.1521/soco.2008.26.2.125>

770 Landwehr, J. R., McGill, A. L., & Herrmann, A. (2011). It's Got the Look: The Effect of Friendly and
771 Aggressive "Facial" Expressions on Product Liking and Sales. *Journal of Marketing*, 75(3),
772 132–146. <https://doi.org/10.1509/jmkg.75.3.132>

773 Leyens, J. P., Cortes, B., Demoulin, S., Dovidio, J. F., Fiske, S. T., Gaunt, R., Paladino, M. P.,
774 Rodriguez-Perez, A., Rodriguez-Torres, R., & Vaes, J. (2003). Emotional prejudice,
775 essentialism, and nationalism: The 2002 Tajfel Lecture. *European Journal of Social*
776 *Psychology*, 33(6), 703-717. <https://doi.org/10.1002/ejsp.170>

777 Leyens, J. P., Rodriguez-Perez, A., Rodriguez-Torres, R., Gaunt, R., Paladino, M. P., Vaes, J., &
778 Demoulin, S. (2001). Psychological essentialism and the differential attribution of uniquely
779 human emotions to ingroups and outgroups. *European Journal of Social Psychology*, 31(4),
780 395-411. <https://doi.org/10.1002/ejsp.50>

781 Lombard, J., & Dinet, J. (2015). Attitudes vis-à-vis des robots et perception de leur autonomie : vers la
782 création d'une Echelle de Perception de l'Autonomie des Robots (EPAR). *Actes du Huitième*
783 *Colloque de Psychologie Ergonomique, EPIQUE 2015*, 151-161. Aix-en-Provence : France.

784 Malle, B. F., Scheutz, M., Arnold, T., Voiklis, J., & Cusimano, C. (2015). Sacrifice one for the good
785 of many? People apply different moral norms to human and robot agents. *In Proceedings*
786 *of the 2015 ACM/IEEE International Conference on Human-Robot Interaction (HRI)*, 117-
787 124. Portland, OR: USA. <http://dx.doi.org/10.1145/2696454.2696458>

788 Marx, R. G., Menezes, A., Horovitz, L., Jones, E. C., & Warren, R. F. (2003). A comparison of two
789 time intervals for test-retest reliability of health status instruments. *Journal of Clinical*
790 *Epidemiology*, 56(8), 730-735. [https://doi.org/10.1016/s0895-4356\(03\)00084-2](https://doi.org/10.1016/s0895-4356(03)00084-2)

791 Morewedge, C. K., Preston, J., & Wegner, D. M. (2007). Timescale bias in the attribution of mind.
792 *Journal of Personality and Social Psychology*, 93(1), 1–11.
793 <https://doi.org/10.1037/0022-3514.93.1.1>

794 Mori, M. (1970). Bukimi no tani [The uncanny valley]. *Energy*, 7(4), 33-35.

795 Nass, C., & Moon, Y. (2000). Machines and mindlessness: Social responses to computers. *Journal of*
796 *Social Issues*, 56(1), 81–103. <https://doi.org/10.1111/0022-4537.00153>

797 Nomura, T., Kanda, T., & Suzuki, T. (2006). Experimental investigation into influence of negative
798 attitudes toward robots on human–robot interaction. *Ai & Society*, 20(2), 138-150.
799 <https://doi.org/10.1007/s00146-005-0012-7>

800 Nunnally, J.C. (1978). *Psychometric Theory*. New York: McGraw-Hill.

801 Pepito, J. A., Ito, H., Betriana, F., Tanioka, T., & Locsin, R. C. (2020). Intelligent humanoid robots
802 expressing artificial humanlike empathy in nursing situations. *Nursing Philosophy*, 21(4),
803 e12318. <https://doi.org/10.1111/nup.12318>

804 Pereira A., Leite I., Mascarenhas S., Martinho C., Paiva A. (2011) Using Empathy to Improve Human-
805 Robot Relationships. In: Lamers M.H., Verbeek F.J. (eds) *Human-Robot Personal*
806 *Relationships*. Lecture Notes of the Institute for Computer Sciences, Social Informatics and
807 Telecommunications Engineering, vol 59. Springer, Berlin, Heidelberg.
808 https://doi.org/10.1007/978-3-642-19385-9_17

809 Phillips, E., Zhao, X., Ullman, D., & Malle, B. F. (2018). What is Human-like?: Decomposing Robots'
810 Human-like Appearance Using the Anthropomorphic roBOT (ABOT) Database. In
811 *Proceeding of the 2018 ACM/IEEE International Conference on Human-Robot Interaction*,
812 105-113. Chicago, IL: USA. <https://doi.org/10.1145/3171221.3171268>

813 Raykov, T., & Marcoulides, G. A. (2011). *Introduction to psychometric theory*. New York, NY:
814 Taylor & Francis Group.

815 Schilhab, T. S. S. (2002). Anthropomorphism and mental state attribution. *Animal Behavior*.
816 Academic Press. <https://doi.org/10.1006/anbe.2002.2001>

817 Short, E., Hart, J., Vu, M., & Scassellati, B. (2010, March). No fair!! an interaction with a cheating
818 robot. In *Proceedings of the 2010 ACM/IEEE International Conference on Human-Robot*
819 *Interaction (HRI)*, 219-226. <https://doi.org/10.1145/1734454.1734546>

820 Spatola, N., Kühnlenz, B., & Cheng, G. (2020). Perception and evaluation in human-robot interaction:
821 The Human-Robot Interaction Evaluation Scale (HRIES): a multicomponent approach of
822 anthropomorphism. *International Journal of Social Robotics*.
823 <https://doi.org/10.1007/s12369-020-00667-4>

824 Stenzel, A., Chinellato, E., Bou, M. A. T., del Pobil, Á. P., Lappe, M., & Liepelt, R. (2012). When
825 humanoid robots become human-like interaction partners: Corepresentation of robotic actions.
826 *Journal of Experimental Psychology: Human Perception and Performance*, 38(5), 1073–1077.
827 <https://doi.org/10.1037/a0029493>

828 Sun, J. (2005) Assessing Goodness of Fit in Confirmatory Factor Analysis. *Measurement and*
829 *Evaluation in Counseling and Development*, 37(4), 240-256.
830 <https://doi.org/10.1080/07481756.2005.11909764>

831 Taber, K.S. (2018). The Use of Cronbach's Alpha When Developing and Reporting Research
832 Instruments in Science Education. *Research in Science Education*, 48, 1273–1296.
833 <https://doi.org/10.1007/s11165-016-9602-2>

834 Tielman, M., Neerincx, M., Meyer, J. J., & Looije, R. (2014). Adaptive emotional expression in robot-
835 child interaction. In *Proceedings of the 2014 ACM/IEEE International Conference on*
836 *Human-Robot Interaction (HRI)*, 407-414. Bielefeld: Germany.
837 <https://doi.org/10.1145/2559636.2559663>

838 von Zitzewitz, J., Boesch, P. M., Wolf, P., & Riener, R. (2013). Quantifying the human likeness of a
839 humanoid robot. *International Journal of Social Robotics*, 5(2), 263-276.
840 <https://doi.org/10.1007/s12369-012-0177-4>

841 Venkatesh, V., & Bala, H. (2008). Technology acceptance model 3 and a research agenda on
842 interventions. *Decision sciences*, 39(2), 273-315.
843 <https://doi.org/10.1111/j.1540-5915.2008.00192.x>

844 Venkatesh, V., Morris, M., Davis, G., & Davis, F. (2003). User Acceptance of Information Technology:
845 Toward a Unified View. *MIS Quarterly*, 27(3), 425-478. <https://doi.org/10.2307/30036540>

846 Venkatesh, V., Tong, J. and Xu, W. (2012). Consumer Acceptance and Use Of Information
847 Technology: Extending the Unified Theory of Acceptance and Use of Technology. *MIS*
848 *Quarterly*, 36(1), 157-178. <https://doi.org/10.2307/41410412>

849 Waytz, A., Cacioppo, J., & Epley, N. (2010). Who sees human? The stability and importance of
850 individual differences in anthropomorphism. *Perspectives on Psychological Science*, 5(3),
851 219-232. <https://doi.org/10.1177/1745691610369336>

852 Waytz, A., Gray, K., Epley, N., & Wegner, D. M. (2010). Causes and consequences of mind
853 perception. *Trends in Cognitive Sciences*, 14(8), 383-388.
854 <https://doi.org/10.1016/j.tics.2010.05.006>

855 Waytz, A., Heafner, J., & Epley, N. (2014). The mind in the machine: Anthropomorphism increases
856 trust in an autonomous vehicle. *Journal of Experimental Social Psychology*, 52, 113–117.
857 <https://doi.org/10.1016/j.jesp.2014.01.005>

858 Waytz, A., Morewedge, C. K., Epley, N., Monteleone, G., Gao, J. H., & Cacioppo, J. T. (2010).
859 Making sense by making sentient: effectance motivation increases anthropomorphism. *Journal*
860 *of Personality and Social Psychology*, 99(3), 410–435. <https://doi.org/10.1037/a0020240>

861 Zafari, S., & Koeszegi, S.T. (2020) Attitudes Toward Attributed Agency: Role of Perceived Control.
862 *International Journal of Social Robotics*. <https://doi.org/10.1007/s12369-020-00672-7>

863 Złotowski, J., Proudfoot, D., Yogeewaran, K., & Bartneck, C. (2015). Anthropomorphism:
864 Opportunities and Challenges in Human–Robot Interaction. *International Journal of Social*
865 *Robotics*, 7(3), 347–360. <https://doi.org/10.1007/s12369-014-0267-6>

866 Złotowski, J., Yogeewaran, K., & Bartneck, C. (2017). Can we control it? Autonomous
867 robots threaten human identity, uniqueness, safety, and resources. *International*
868 *Journal of Human-Computer Studies*, 100, 48-54.
869 <https://doi.org/10.1016/j.ijhcs.2016.12.008>