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Gomez Esteban, Pablo; Bagheri, Elahe; Elprama, Shirley; Jewell, Charlotte; Cao, Hoang-Long; De Beir, Albert; Jacobs, An; Vanderborght, Bram

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Should I be introvert or extrovert?

A Pairwise Robot Comparison Assessing the Perception of Personality-based Social Robot Behaviors

Pablo G. Esteban · Elahe Bagheri · Shirley A. Elprama · Charlotte I.C. Jewell · Hoang-Long Cao · Albert De Beir · An Jacobs · Bram Vanderborght

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Abstract With this study we wanted to extend the research on personality traits and the similarity- and complementarity-attraction effects in HRI, and explore which demographic variables might affect them. For that purpose, we conducted a study with 46 participants under a pairwise robot comparison experimental design, combining verbal and non-verbal behaviors, and complementing the results with qualitative data. We found out that the similarity-attraction effect was supported although we could not find any demographic variable to predict it.

Keywords Human-Robot Interaction · Personality-attraction · Social Robotics · Robot-Assisted Therapy

1 Introduction

During the last two decades there have been an increasing number of projects employing social robots with the ambitious goal of increasing the well-being of vulnerable populations [1]. Robot-Assisted Therapy (RAT) has successfully been used for elderly care [2, 3, 4, 5], individuals on the autism spectrum [6, 7, 8, 9], or physical rehabilitation [10, 11].

Regardless of the therapeutic intervention, these social robots are expected to interact with a wide range of conditions and different patients, each of them with their own personal preferences and needs. Even if they may share the same pathology, their personal requirements (age, personality, cultural-background, etc.) can vary extensively. Therefore, as it is for therapists, it becomes crucial for robots to adapt their behaviors and interaction skills to the specific needs and preferences of the patients they interact with [12]. These robots should be capable of understanding the environment and the patient's intention and performance, and of following the therapeutic goals to perform a meaningful and personalized interaction in a social and engaging way using their embodiment to communicate and to react to their users [13, 14].

This research has been conducted as part of the imec.icon Robo-Cure project [15] which aims at exploring the possibilities of integrating a social robot in a hospital as an educational support for children with diabetes type 1. With the long-term goal of building adaptive robot behaviors that can fit the particular needs of the targeted end-users, we would like to further explore the personality-attraction effect in HRI by studying how parents react to different personalities in social robots, and how they perceive them to be used with their children for educational purposes.

According to the latest report of the World Health Organization, diabetes is a disease that affected more than 400 millions of people in 2014 [16]. The cases of diabetes type 1 have been increasing steadily during the past few decades [17, 18]. Children recently diagnosed with type 1 diabetes need to change their habits and learn how to count carbohydrate intake, monitor blood glucose, and be aware of their physical activity [16]. Children at a young age are still developing emotionally and cognitively, and this habituation process is complex. Therefore, children and their family are normally required to spend several days at the hospital being trained by therapists.

Pablo G. Esteban, Elahe Bagheri, Hoang-Long Cao, Albert De Beir and Bram Vanderborght
Robotics and Multibody Mechanics Research Group and Flanders Make, Vrije Universiteit Brussel, Brussels, Belgium
E-mail: pablo.gomez.esteban@vub.be

Shirley A. Elprama, Charlotte I.C. Jewell, and An Jacobs
imec-SMIT, Vrije Universiteit Brussel, Brussels, Belgium

Robots have already been used in this context, and it has been proven that interacting with social robots can help children to acquire these skills and knowledge [19, 20], by keeping them more motivated and engaged, and being more fun to use. In order to achieve more natural and engaging interactions, these robots should aim at building social bonds with children [21].

Under the Computers Are Social Actors (CASA) paradigm [22, 23], Nass and his colleagues found out that individuals have a tendency to apply social rules while interacting with computer agents the same way as if they were interacting with actual human beings. Personality is considered to be a vital factor in understanding interpersonal communications [24, 25], comprising individual's behavioral, cognitive and emotional patterns [26]. Nass and colleagues also discovered that individuals did not only recognize the personality of a computer agent, but they also applied personality-based social rules, as the similarity and complementarity hypotheses of personality attraction, within their interactions [27, 28]. The similarity-attraction effect holds that individuals feel closer to those who are perceived similar to themselves. Research has shown that similarity between people is associated with interpersonal attraction which increases the level of engagement and attention [29]. This effect has been demonstrated to be sufficient to spark initial attraction, and motivate further interactions [30, 31]. This similarity attraction effect can be referred to demographics, ethnicity, or personality among other characteristics [32, 33]. On the other hand, the complementarity-attraction effect claims the opposite, that individuals tend to be more attracted to those whose characteristics are perceived as complementary to their own [34, 35].

In the field of Human-Computer Interaction (HCI), both social rules have been claimed to be true. The similarity-attraction rule has been supported in situations when people interact with disembodied social actors [28, 36], while the complementarity-attraction rule is supported with embodied software agents [27]. Given that premise, as robots are, by definition, even more embodied than software agents, one would think that in the case of Human-Robot Interaction (HRI) the complementarity-attraction rule would hold. However, some studies, [37] and [38], explored the relationship between extroversion and introversion levels of the robot and the users within a therapeutic environment, finding that extroverts preferred to interact more with robots displaying behaviors considered as extroverted, while introverts preferred those displaying introverted behaviors. Similarly, Aly and Tapus [39], combined verbal and non-verbal behaviors to express the extroversion-introversion personality dimension, finding that humans prefer robots that express similar personalities to theirs. On the other hand, other researchers found that humans tended to believe that their personality was different from the robots [40], but more importantly, to the purpose of this manuscript, this study demonstrated that factors such as subject gender, age and technological experience were important in how subjects viewed their personality as being similar to the robot personality. [41] examined whether humans prefer robots that are similar or different from them regarding their personality. Authors found that individuals enjoyed interacting with a robot more when they had complementary personalities than when they are similar.

As shown, the research on personality attraction and HRI remains fragmented and lacks a coherent framework [42, 43], with some works claiming that there is a relationship between similarity and attraction [37, 38, 39] and others claiming the contrary [40, 41].

This study aims at advancing the research on the similarity- and the complementarity-attraction effects in HRI, by exploring which demographic variables might affect them. To achieve that, authors would like to extend the research done in this domain by combining verbal and non-verbal behaviors, utilizing a novel experimental design, pairwise robot comparison, and by utilizing qualitative data. Using a pairwise robot comparison makes it possible to reduce the habituation effect and to collect in-the-moment responses [44]. The qualitative data makes it possible to better understand what people thought of the robot interaction and what their thoughts were about the robot personalities. Therefore, through this study we would like to solve the following research questions:

- *Q1.* Is there a relationship between the Big Five questionnaire filled in about the participants themselves and the preference about the robot?
- *Q2.* Is there a relationship between demographic variables and the preference about the robot?
- *Q3.* Is there a relationship between demographic variables and the preference about the robot for their children?
- *Q4.* Is there a relationship between their personality preferences for themselves and those for their children?

In section 2 we analyze the literature to describe personality-based behaviors. In section 3 we define the studies we have carried out and the results obtained. Finally, in section 4 we include our conclusions.

2 Personality-based behaviors

Personality traits have been represented by multiple models but the most widely used [42] is the Big Five personality model [45], also known as the OCEAN model. It is composed of five different dimensions: Openness to experience, referring to the degree of curiosity and willingness to experience new events; Conscientiousness, reflecting the inclination to be self-aware of their actions; Extroversion, manifesting the tendency of someone being energetic and sociable; Agreeableness, pictures compassion and cooperativeness; and Neuroticism, reflects the tendency of someone being prone to psychological stress.

Among all these dimensions, the Extroversion one is considered to be the most influential and accurate trait on developing human peer relationships [46, 47, 48]. That is why it has been widely used in HCI [27, 28, 49] as well as in HRI [41, 50].

There have been many attempts to implement personality traits in social robots. Lee et al. [41] implemented the Extroversion dimension into an AIBO robot manipulating both verbal (loudness, frequency range, mean frequency, speech rate) and non-verbal (gestures, facial expressions, posture and body movement) behaviors.

On the other hand, van Dam [50] combined Extroversion with Agreeableness proving that people with higher values on both dimensions were more popular with their peers. She conducted this study by manipulating through Wizard-of-Oz both verbal (speech rate, volume and speech style) and non-verbal behaviors (facial expressions, gestures and body movement).

Considering all dimensions within the Big Five model, Craenen et al. [60] studied whether there is a relationship between the perceived quality of the interaction and perceived similarity, obtaining mixed results: 15 out of 30 participants preferred the similarity but 9 out of 30 preferred the complementarity. Their manipulation was mainly focused on gestures varying their speed and amplitude.

In addition to personality traits, it has also been studied other human characteristics that might influence peoples perception of the similarity-effect, e.g. Tay et al. [52] explored how people react to stereotypes regarding gender (male vs. female) and occupational role (security vs. healthcare) when matched with personality (extrovert vs. introvert). They manipulated robot's behaviors by taking the initiative of initiating (or not) the conversation, robot's appearance, moving speed, gesture type (wide-angle gestures and one or two arms gestures), speech rate, pitch and volume.

Literature says that extroverts have a tendency to speak louder, faster and with a higher pitch [41, 52, 53, 54, 55, 56]. Normally they do less pauses and use shorter sentences and poorer vocabulary [53, 54, 55], express more positive words [57], they are more incline to initiate conversations [52] and to speak more about themselves than about others [51]. Extroversion has been proved as a weak predictor of attention engagement [59]. Regarding gestures, they are usually wider, faster and occur more often than those coming from an introvert person [41, 52, 56, 58, 60]. Extroverts usually are more restless and perform more idle motions [41, 58]. Some studies found a relationship between human personality and proxemics, concluding that extroverted people are more tolerant of their personal space invasion than introverted people [37, 61]. Table 1 summarizes the insights obtained from the psychology and HRI literature.

3 Study design

We conducted two experiments. The first one was done with 22 children, and served as a pilot study to evaluate the protocol to be followed. The second one was conducted with 63 adults parents of children between 4 and 12 years old. This second study was organized in two different venues. The first venue consisted of an office where participants were called in groups that ranged from one to four participants. The second venue was a larger room where 39 participants attended the experiment at the same time. After analysing the results obtained in both venues, we could not find any significant differences between them so from now on we consider them as one single group.

The behaviors described in Table 1 have been implemented in a Pepper robot [63] with the possibilities and limitations that this entails. Therefore, we have adapted the insights from the literature to what can be implemented using naoQi SDK [64]. Gestures were selected among those available in the default animation library [65] which contains more than 100 variations. Given the requirements and purpose of the experiment the only feature that has been left aside is proxemics as the interaction between the robots and the participants would be static. Table 2 summarizes how the selected robotic features have been implemented. Parameters were tuned after several pilot studies.

Participants were seated in chairs in front of the presenter and two robots, see figures 1 and 2. The other researchers were placed strategically to avoid interrupting or interfering with the experiment. The two robots were given unfamiliar male Hawaiian names, Kekoa and

Robot feature	For extroverts	For introverts	Reference
Speech volume	80% of the maximum	20% of the maximum	[41, 51, 52, 53, 54, 55]
Speech speed	216 words/minute	184 words/minute	[41, 51, 52, 53, 54, 55, 56]
Speech pitch	90% of maximum	10% of maximum	[41, 51, 53, 54, 55, 56]
Speech style	Informal, fewer pauses, less faltering	Formal, more pauses, more faltering	[53, 54, 55]
Vocabulary used	Poorer	Richer	[53, 54, 55]
Topic selection	Not self-focused	Self-focused	[51]
Feedback given	Gives compliments	Shows dissatisfaction	[57]
Speech Syntax	Shorter and simpler sentences	Longer and more elaborate sentences	[51]
Random motion rate	Every 750-1500 ms	Every 1000-7000 ms	[41, 58]
Attention behavior	Hard to keep focus, switch often among different stimuli	Tend to be focused on a single event	[59]
Gestures	Wider and faster (50%-75% less time)	Slower and narrower gestures	[41, 52, 56, 58, 60]
Proxemics	More tolerant with personal space	Need their personal space	[37, 61, 62]

Table 1 Manipulation of the robot's extroversion dimension according to the literature.

Fig. 1 *Left side:* Picture taken during the pilot study. *Right side:* Setting for the pilot study with children.

Kanoa, to reduce possible gender biases. In the experiment sequence the robots would take turns explaining about diabetes. At the end of the sequence, the participants were asked to fill in a questionnaire responding about which robot they preferred and why. The robot that would start the interaction was switched, as well as the personalities, to counterbalance for possible influence on the opinion of the participants. The total duration of the experiment was about 30 minutes.

3.1 Pilot Study

This pilot study was performed with 22 children between the age of 6 and 7 years old (M = 6.8, SD = 0.4) from a primary school. Of the 22 children, 13 were girls (59.1%) and 9 boys (40.9%). Before the experiment, parents completed an informed consent and demographic and personality questionnaires about their children.

Robot feature	For extroverts	For introverts
Speech volume	100% of the maximum	50% of the maximum
Speech speed	100% of the maximum	80% of the maximum
Speech pitch	50% of maximum	20% of maximum
Speech syntax, style, topic selection and vocabulary used	Are you comfortable? (pause) We are going to tell you about diabetes type one. Let's start. Children who have type 1 diabetes have to pay a little more attention to what they are eating and doing than children without diabetes. The pancreas is an organ in your belly. That organ helps your body process food. It also makes insulin. Insulin is kind of like a key that opens the doors to the cells of the body. It lets the glucose in.	Hopefully you are comfortable (pause) during the next few minutes (pause) my friend and I (pause) are going to tell you a little bit more about diabetes type one. Let's begin. Children who have type 1 diabetes (pause) have to be more cautious about what they are eating and doing (pause) than children without diabetes The pancreas is a long flat gland in your abdomen (pause) that helps your body digest food. It also produces insulin. Insulin can be seen (pause) as a key that opens the doors to the cells of the body. It lets the glucose in.
Feedback given	You have been a great audience!	I hope you enjoy it as much as we did.
Random motion	Random motion expressed through arms, body and head	Random motion expressed through the arms
Attention behavior	100% of speed, reactive to all stimuli, unengaged	10% of speed, limited reactive stimuli, fully engaged
Gestures	Wider and faster (50%-75% less time)	Slower and narrower gestures

Table 2 Our manipulation of the robot's extroversion dimension.

From the personality questionnaires, filled in by the parents of the children, we found out that 2 children were introverts (9.1%) and 20 children were extroverts (90.9%). All girls were classified as extrovert (based on their score), while 2 boys were introvert and 7 were extrovert.

Results showed that the introverted robot was preferred by 8 (36.4%) participants, whereas 14 (63.6%) participants preferred the extrovert robot. Boys (6 out of 9) preferred the introvert robot, while girls (11 out of 13) preferred the extrovert robot. We qualitatively analyzed the reasons why the children preferred one or the other robot. Some answers contained multiple themes and themes came up in varying frequencies. The majority of the children preferred the extrovert robot. However, we saw that there was a difference in the preference between the boys and the girls, where boys had a preference for the introvert robot and the girls had a preference for the extrovert robot. This leads us to believe that the gender attributed to a robot has a considerable effect on the preference of the child. For further details in this study, see [66].

3.2 Experimental study

The experiment was conducted with 63 participants, out of them 17 were filtered out due to missing data, ending up with 46 participants between 29 and 54 years old (M = 40.6, SD = 6.18). Before participating in the study participants had to give their consent and complete a questionnaire in which socio-demographic data and the Big Five questions related to Introvert and Extrovert personality were collected [67]. From the first questionnaire, we obtained that 22 were males (47.8%) and 24 females (52.2%), 16 did not have university studies (34.8%), 22 finished university studies (47.8%) and 8 of them achieved a doctorate (17.4%), 29 (63%) had

Fig. 2 *Left side:* Participants being interviewed after the sequence with the robot. *Right side:* Setting for the experimental study.

no previous experience with robots at all, and 17 (37%) had interacted with a robot either at home or at work. From the personality questionnaire, we divided the personalities scores obtained in the questionnaire by half categorizing those with lower scores to the introvert dimension, and those with higher scores as extroverts. Given that categorization we ended up with 37 participants ranked as extroverts (80.4%) and 9 as introverts (19.6%).

At the end of the sequence, the participants were asked to fill in a third questionnaire in which we collected the participants preferred robot, socio-demographic data regarding their child (if they had several children we asked them to focus on one child) and the Big Five questions related to Introvert and Extrovert personality of their child. Once this last questionnaire was completed the participants were asked whether they would want to participate in a short interview, if they did then an interview would be held.

3.3 Results

After analysing the collected data, we observed that 32 of the participants (69.6%) preferred the extroverted robot, while 14 (30.4%) opted for the introverted one, see figure 3. Correlating the preferred robot with their personality, we found out that 31 (67.4%) chose a similar personality, while 15 (32.6%) chose the complementary one. However, we could not find any correlation between following the similarity or the complementarity approach and any demographic variable.

The participants were also asked about their children. Following the selection criteria they all have children between 4 and 12 years old (M = 7.72, SD = 2.52). Among them, 24 were boys (53.3%) and 21 girls (46.7%). They were asked to fill in a personality questionnaire about one of their children, ending up with 36 extroverts children (80%) and 9 introverts (20%). When thinking about that particular child, they selected 30 times the extroverted robot (65.2%) and 16 times the introvert one (34.8%).

		Personality Participant		
		Extrovert	Introvert	Total
Chosen Personality	Extroverted	27	5	32
	Introverted	10	4	14
Total		37	9	46

Fig. 3 Comparing the personality selected against their personality: 31 opted for the same one, while 15 chose the opposite one.

3.3.1 Quantitative Analysis

1. *Is there a relationship between the Big Five questionnaire filled in about the participants themselves and the preference about the robot?*

An independent samples t-test was conducted to compare the participants score in the Big Five questionnaire and the preference about the robot, $t(44) = 0.287$, $p = 0.775$, Cohens d = 0.089. We could not find a relationship in the scores for the extroverted robot (M = 28.09, SD = 4.74) or the introverted robot (M = 27.64, SD = 5.27) conditions.

2. *Is there a relationship between demographic variables and the preference about the robot?*

After running logistic regression, we could not find a demographic variable that can be used to predict the preference about the robot. However, after a deeper look using the Chi-Square test, it seems that people

with no previous experience with robots (at home or at work) have a tendency to choose the extroverted robot (79.3%), while those with some experience do not have a strong preference (52.9% chose the extroverted robot and 47.1% the introverted one), see figure 4. However, this finding has no significant difference and the effect size is small ($p = 0.097$, $\phi = 0.277$).

		Use of a robot before		
		No	Yes	Total
Chosen Personality	Extroverted	23	9	32
	Introverted	6	8	14
Total		29	17	46

Fig. 4 People without any previous experience with robots tend to choose the extrovert robot, while those with already some experience do not have a strong preference.

3. and 4. *Is there a relationship between demographic variables and the preference about the robot for their children? And, is there a relationship between their personality preferences for themselves and those for their children?*

Regarding how people choose a robot for their children, logistic regression, see figure 6, indicates that the age of the child ($p = 0.045$, OR = 0.493, CI = [0.246, 0.984]) and previous experiences with robots ($p = 0.028$, OR = 0.034, CI = [0.002,0.690]) are good predictors, although in the second case the effect size is quite small.

		Use of a robot before		
		No	Yes	Total
Chosen Personality for Kid	Extroverted	23	7	30
	Introverted	6	10	16
Total		29	17	46

Fig. 5 Those with some previous experience with robots preferred the introvert robot, whereas those who were interacting with the robot for the first time were more inclined to the extrovert one.

Having a deeper look into the correlations of the variables, Chi-Square test shows that parents tend to choose for their children based on their previous use of robots ($p = 0.012$, $\phi = 0.386$): those with previous experience prefer the introverted robot for their children, while those with no experience prefer the extroverted one, see figure 5, which associated with the findings in figure 4, lead us to think that they tend to choose for their children the same personality as for themselves ($p = 0.008$, $\phi = 0.41$), see figure 7.

Finally, Fisher-Exact tests indicates that parents tend to choose for their children based on their level of education ($p = 0.024$, Cramers V = 0.407): those without a doctorate prefer an extroverted robot for their children, and those with a doctorate prefer an introverted one, see figure 8.

3.3.2 Qualitative Analysis

We conducted 12 post-experiment interviews with a total of 18 participants. The interview groups ranged from one participant to four participants and lasted between 10 to 30 minutes long, see figure 2.

The interviews were analyzed in a content-driven manner in a thematic analysis to ensure that in context meaning was not lost [68]. Out of the analysis five main themes emerged namely, expressiveness as main factor for robot preference by the participant, robot as an assistant teacher, what improvements to make to have better robots for educational purposes with children and trust in a robot teacher. There were also two minor themes that came through, the appearance of the robot and the appropriate target group. Saturation was reached in the analysis.

1 *Expressiveness as main factor for robot preference by the participant*

The main reason that participants preferred one robot over another (be it introvert or extrovert) was related to the expressiveness of the robot. Participants indicated that they believed that their preferred robot was more understandable, that the robot explained aspects more clearly or that the voice was more pleasant to listen to.

Participant (int. 5): "the voice of Kekoa was a bit more pleasant"

Participant (int. 2): "but at least his voice was more clear"

One participant (int. 4) made an interesting remark that embodies the general tendency to prefer one robot over another namely, that *"for me, thats very personal what your ear likes"*. The quote indicates that the biggest aspect in the choice of preference is in the speech or audibility of the robot, but that the choice in itself will then depend from person to person.

2 *Robot as an assistant teacher*

This study was conducted as part of the imec.icon Robo-Cure project which evaluates the use of robots as educational support in hospitals for children with diabetes type 1. As a result, the idea of a robot teacher was an aspect that would come up in discussion. The majority of participants agreed that if a robot should have a role in a classroom then it would be as an assistant or as an extra and not as a substitute to the human

	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B) Lower	Upper
Gender Participant(1)	-1.883	1.178	2.553	1	.110	.152	.015	1.532
Personality Participant(1)	-1.663	11181.844	.000	1	1.000	.190	.000	.
Chosen Personality(1)	-22.134	11181.843	.000	1	.998	.000	.000	.
SimilarityApproach(1)	-22.176	11181.843	.000	1	.998	.000	.000	.
Personality Kid(1)	-.104	1.331	.006	1	.938	.902	.066	12.246
Gender Kid(1)	1.382	1.250	1.223	1	.269	3.984	.344	46.154
Age of kid	-.708	.353	4.019	1	.045	.493	.246	.984
Level of education	.790	.829	.907	1	.341	2.203	.434	11.185
Use of a robot before(1)	-3.380	1.536	4.845	1	.028	.034	.002	.690
Constant	28.965	15944.496	.000	1	.999	3.795E+12		

Fig. 6 After running logistic regression, we might observe that *Age of child* and *Use of a robot before* are good predictors.

		Chosen Personality		
		Extroverted	Introverted	Total
Chosen Personality for Kid	Extroverted	25	5	30
	Introverted	7	9	16
Total		32	14	46

Fig. 7 9 out of 14 introverts selected the introverted robot for their children, while 25 out of 32 extroverts did the same.

		Level of education			
		No University	University	Doctorate	Total
Chosen Personality for Kid	Extroverted	13	15	2	30
	Introverted	3	7	6	16
Total		16	22	8	46

Fig. 8 Apparently, those who achieved a doctorate have a stronger preference for introvert robots than those who did not.

teacher and that it should not be used throughout the day but at short intervals.

Participant (int. 5): "but I think, as an extra, it could work just fine"

Participant (int.10): "I think, if it will be for a whole day, I think it would be a bit weird. But I think if it would just be for like a lesson. [] Then I think it would be okay."

Participants that were positive to the idea also gave suggestions about the ways in which the robots could be used as an assistant teacher. The robot could help children individually for instance, the children that needed extra explanation as well as the children that could use some more challenging schoolwork. It could also be used to verify if the children have really understood the lesson or task, to boost a child their confidence or as entertainment. Few participants asked why this would be necessary and also stated that this would be just as effective and cheaper using a video or tablet instead.

After analysing participants' opinions and reactions we might say that there is not common ground among them but a variety of ideas for how to implement robots as educational assistants. That reflects that it is still important to emphasize what the added value of such a tool is.

3 *Robots need to be more adapted/considerate towards children to successfully deliver educational content to children*

Participants were also keen to let us know what they believed needed to be modified in order to improve the robot interaction for children. The most common response was that the robots needed to be more interactive. This meant that the robot needed to be able to have a conversation, so answer any possible questions that children might have, and that it could use more visual aspects in its explanation (e.g. Pepper has a tablet).

Participant (int. 1): "it should be more interactive. I can imagine that they have a lot of questions that they would like to ask."

Participant (int. 8): "Yeah, interaction" Interviewer: "and do you mean dialogue? Like what you mentioned before? Or, do you also mean other ways?" Participant (int. 8): "Yeah. Now you just get the information across. But if I have a question, [and] even afterwards."

There were also participants who noted that there was a need to create a connection with the children first, to make them feel at ease and to earn their trust. In order to do this the integration of a robot needs to be preceded by a slow introduction.

Participant (int. 5): "and for them [the children], to make them feel at ease, there has to be a connection."

Participant (int. 7): "and that they come to the school. And try to get the trust from the children. Go slow. Not too fast."

4 *Trust in a robot teacher*

Trust in a robot teacher raised some interesting reflections from participants, most would trust the hardware aspect of the robot, because that needs to be tested before it is put on the market.

Participant (int. 3): "so, if they have passed all the tests and controls that are demanded in those places. Then I assume that it is safe."

However, the participants were more cautious with trusting the software aspect, because, for instance, the person making the software is not known. In addition, participants would not trust the robot as a teacher on its own, it should always be supervised by a human.

Participant (int. 5): "I think the start of a chain, is always a human being. S, if I trust this human being, in his professional way of teaching. Then I think, there is no problem. Because the robot is always the output of human being."

5 *The appearance of the robot*

The participants were quite positive about the appearance of the robot mentioning that they were similar to children and that they looked friendly.

Participant (Int. 8): "They are like children."

Participant (Int. 2): "I think they look attractive to children."

6 *The appropriate target group*

It was clear to the participants that this method would not be suitable for all ages, below four years old would be too scary and for children above 12 it might not be interesting anymore. In addition, it would need to be adapted to the specific age group.

Participant (Int. 9): "because an eleven-year-old and a four-year-old, you cannot treat them the same way."

4 Discussion

This research was conducted as part of the imec.icon Robo-Cure project which seeks to evaluate the use of robots as educational support in hospitals for children with diabetes type 1. For that purpose, we aimed to explore how parents of children between 4 and 12 years old perceived the use of social robots with personalities in an educational context.

Within that context, with this study we wanted to advance the research on the similarity- and the complementarity-attraction effects in HRI, and explore which demographic variables might affect them. To do so, we conducted an experiment with 46 participants where we combined verbal and non-verbal behaviors such as speech, gesturing, attention behavior and random motions; we utilized a novel experimental design, pairwise robot comparison [44], to reduce the habituation effect; and we complemented the experimental study with interviews to collect qualitative data.

We found out that the majority of people who came to the experiment were extroverts (80.4%) and prefer to interact with extrovert robots (69.6%), therefore supporting the similarity-attraction effect (67.4%). However, we could not find any relationship between the participants' personality score in the Big Five questionnaire and his/her preference about the robot. Although, certain demographic variables such as the age of the child, their previous experience with robots, and their level of education seemed to be valuable indicators that would support the similarity-attraction theory, after having a deeper look into those demographic variables, we could not find any that can be used to predict the preference about the robot or the attraction effect followed. These results are in line with previous research [43].

From the qualitative data, we could discern that the level of expressiveness was shown to be the most important factor on the choice of a robot. The robot needs to reflect comfort through its gestures and voice, and that depends from person to person. That is aligned with another theme that emerged from the interviews: the belief that robots should adapt their behaviors to the different needs of the target user.

This lack of correlation supports the idea that the similarity-attraction effect might have been oversimplified in previous studies. The similarity-attraction effect has many dimensions [32]. Within this study, as in the most of HRI studies, we have explored the personality one, but there are others like ethnics, demographics, attitudinal, etc. Implementing some of these dimensions into a robot seems to be unrealistic but some others should be addressed. At least, more dimensions should be considered in relation to the personalities of the robot. Limited to the extroversion-introversion dimension we have implemented a complete study by combining verbal and non-verbal behaviors such as speech, gesturing, attention behavior and random motions, and we conclude that this was not sufficient to find significant results. Therefore, further research in this topic would be needed to shed light on which are the precise types of similarities and dissimilarities that affect the most the experience in human-robot interaction.

Compliance with Ethical Standards

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References

1. C. Breazeal, "Social robots for health applications," in *IEEE International Conference of the Engineering in Medicine and Biology Society*, 2011, pp. 5368–5371.
2. R. Kachouie, S. Sedighadeli, R. Khosla, and M.-T. Chu, "Socially assistive robots in elderly care: a mixed-method systematic literature review," *International Journal of Human-Computer Interaction*, vol. 30, no. 5, pp. 369–393, 2014.
3. S. Bedaf, G. J. Gelderblom, and L. De Witte, "Overview and categorization of robots supporting independent living of elderly people: what activities do they support and how far have they developed," *Assistive Technology*, vol. 27, no. 2, pp. 88–100, 2015.
4. E. Torta, F. Werner, D. O. Johnson, J. F. Juola, R. H. Cuijpers, M. Bazzani, J. Oberzaucher, J. Lemberger, H. Lewy, and J. Bregman, "Evaluation of a small socially-assistive humanoid robot in intelligent homes for the care of the elderly," *Journal of Intelligent & Robotic Systems*, vol. 76, no. 1, pp. 57–71, 2014.
5. D. O. Johnson, R. H. Cuijpers, J. F. Juola, E. Torta, M. Simonov, A. Frisiello, M. Bazzani, W. Yan, C. Weber, S. Wermter *et al.*, "Socially assistive robots: a comprehensive approach to extending independent living," *International journal of social robotics*, vol. 6, no. 2, pp. 195–211, 2014.
6. H. Cao, P. G. Esteban *et al.*, "Robot-enhanced therapy: Development and validation of a supervised autonomous robotic system for autism spectrum disorders therapy," *IEEE Robotics Automation Magazine*, 2019, accepted for publication, https://doi.org/10.1109/MRA.2019.2904121.
7. P. G. Esteban *et al.*, "How to build a supervised autonomous system for robot-enhanced therapy for children with spectrum disorder," *Paladyn Journal of Behavioral Robotics*, vol. 8, no. 1, pp. 18–38, 2017.
8. F. Sartorato, L. Przybylowski, and D. K. Sarko, "Improving therapeutic outcomes in autism spectrum disorders: Enhancing social communication and sensory processing through the use of interactive robots," *Journal of psychiatric research*, vol. 90, pp. 1–11, 2017.
9. C. A. Huijnen, M. A. Lexis, R. Jansens, and L. P. de Witte, "Mapping robots to therapy and educational objectives for children with autism spectrum disorder," *Journal of Autism and Developmental Disorders*, vol. 46, no. 6, pp. 2100–2114, 2016.
10. J. C. González, J. C. Pulido, and F. Fernández, "A three-layer planning architecture for the autonomous control of rehabilitation therapies based on social robots," *Cognitive Systems Research*, vol. 43, pp. 232–249, 2017.
11. F. Martí Carrillo, J. Butchart, S. Knight, A. Scheinberg, L. Wise, L. Sterling, and C. McCarthy, "Help me help you: a human-assisted social robot in paediatric rehabilitation," in *Proceedings of the 28th Australian Conference on Computer-Human Interaction*, 2016, pp. 659–661.
12. H.-L. Cao, P. G. Esteban, A. De Beir, R. Simut, G. van de Perre, D. Lefeber, and B. Vanderborght, "A survey on behavior control architectures for social robots in healthcare interventions," *International Journal of Humanoid Robotics*, vol. 14, no. 04, p. 1750021, 2017.
13. C. Breazeal, "Emotion and sociable humanoid robots," *International Journal of Human-Computer Studies*, vol. 59, no. 1-2, pp. 119–155, 2003.
14. T. Fong, I. Nourbakhsh, and K. Dautenhahn, "A survey of socially interactive robots," *Robotics and autonomous systems*, vol. 42, no. 3-4, pp. 143–166, 2003.
15. Robo-Cure, "Robo-Cure website," https://www.imec-int.com/en/what-we-offer/research-portfolio/robo-cure, 2016, accessed online 18-April-2019.
16. W. H. Organization *et al.*, *Global report on diabetes*. World Health Organization, 2016.
17. C. C. Patterson, G. G. Dahlquist, E. Gyürüs, A. Green, G. Soltész, E. S. Group *et al.*, "Incidence trends for childhood type 1 diabetes in europe during 1989–2003 and predicted new cases 2005–20: a multicentre prospective registration study," *The Lancet*, vol. 373, no. 9680, pp. 2027–2033, 2009.
18. J. Tuomilehto, "The emerging global epidemic of type 1 diabetes," *Current diabetes reports*, vol. 13, no. 6, pp. 795–804, 2013.
19. J. B. Janssen, C. C. van der Wal, M. A. Neerincx, and R. Looije, "Motivating children to learn arithmetic with an adaptive robot game," in *International Conference on Social Robotics*, 2011, pp. 153–162.
20. A. Coninx, P. Baxter, E. Oleari, S. Bellini, B. Bierman, O. B. Henkemans, L. Cañamero, P. Cosi, V. Enescu, R. R. Espinoza *et al.*, "Towards long-

term social child-robot interaction: using multi-activity switching to engage young users," *Journal of Human-Robot Interaction*, vol. 5, no. 1, pp. 32–67, 2016.
21. T. Belpaeme, P. Baxter, R. Read, R. Wood, H. Cuayáhuitl, B. Kiefer, S. Racioppa, I. Kruijff-Korbayová, G. Athanasopoulos, V. Enescu *et al.*, "Multimodal child-robot interaction: Building social bonds," *Journal of Human-Robot Interaction*, vol. 1, no. 2, pp. 33–53, 2013.
22. B. Reeves and C. I. Nass, *The media equation: How people treat computers, television, and new media like real people and places.* Cambridge university press, 1996.
23. C. Nass and Y. Moon, "Machines and mindlessness: Social responses to computers," *Journal of social issues*, vol. 56, no. 1, pp. 81–103, 2000.
24. J. A. Daly and J. C. McCroskey, *Personality and interpersonal communication.* Sage Beverly Hills, CA, 1987.
25. M. J. Beatty and J. McCroskey, "Interpersonal communication as temperamental expression: A communibiological paradigm," *Communication and personality: Trait perspectives*, pp. 41–68, 1998.
26. P. J. Corr and G. Matthews, *The Cambridge handbook of personality psychology.* Cambridge University Press, 2009.
27. K. Isbister and C. Nass, "Consistency of personality in interactive characters: verbal cues, non-verbal cues, and user characteristics," *International journal of human-computer studies*, vol. 53, no. 2, pp. 251–267, 2000.
28. C. Nass and K. M. Lee, "Does computer-synthesized speech manifest personality? experimental tests of recognition, similarity-attraction, and consistency-attraction." *Journal of experimental psychology: applied*, vol. 7, no. 3, pp. 171–181, 2001.
29. P. Torrente, M. Salanova, and S. Llorens, "Spreading engagement: On the role of similarity in the positive contagion of team work engagement," *Revista de Psicología del Trabajo y de las Organizaciones*, vol. 29, no. 3, pp. 153–159, 2013.
30. G. L. Clore and B. Baldridge, "Interpersonal attraction: The role of agreement and topic interest." *Journal of Personality and Social Psychology*, vol. 9, no. 4, p. 340, 1968.
31. D. Byrne, W. Griffitt, and D. Stefaniak, "Attraction and similarity of personality characteristics." *Journal of Personality and social Psychology*, vol. 5, no. 1, p. 82, 1967.
32. D. A. Infante, A. S. Rancer, and D. F. Womack, *Building communication theory*, 1997.
33. V. Blankenship, S. M. Hnat, T. G. Hess, and D. R. Brown, "Reciprocal interaction and similarity of personality attributes," *Journal of Social and Personal Relationships*, vol. 1, no. 4, pp. 415–432, 1984.
34. T. Leary, *Interpersonal diagnosis of personality: A functional theory and methodology for personality evaluation.* Wipf and Stock Publishers, 2004.
35. H. S. Sullivan, *The interpersonal theory of psychiatry.* Routledge, 2013.
36. C. Nass, Y. Moon, B. J. Fogg, B. Reeves, and C. Dryer, "Can computer personalities be human personalities?" in *ACM Conference companion on Human factors in computing systems*, 1995, pp. 228–229.
37. A. Tapus, C. Ţăpuş, and M. J. Matarić, "Userrobot personality matching and assistive robot behavior adaptation for post-stroke rehabilitation therapy," *Intelligent Service Robotics*, vol. 1, no. 2, p. 169, 2008.
38. A. Tapus and M. J. Mataric, "Socially assistive robots: The link between personality, empathy, physiological signals, and task performance." in *AAAI spring symposium: emotion, personality, and social behavior*, 2008, pp. 133–140.
39. A. Aly and A. Tapus, "Towards an intelligent system for generating an adapted verbal and nonverbal combined behavior in human–robot interaction," *Autonomous Robots*, vol. 40, no. 2, pp. 193–209, 2016.
40. S. Woods, K. Dautenhahn, C. Kaouri, R. Boekhorst, and K. L. Koay, "Is this robot like me? links between human and robot personality traits," in *5th IEEE-RAS International Conference on Humanoid Robots*, 2005, pp. 375–380.
41. K. M. Lee, W. Peng, S.-A. Jin, and C. Yan, "Can robots manifest personality?: An empirical test of personality recognition, social responses, and social presence in human–robot interaction," *Journal of communication*, vol. 56, no. 4, pp. 754–772, 2006.
42. L. Robert *et al.*, "Personality in the human robot interaction literature: A review and brief critique," in *Proceedings of the 24th America's Conference on Information Systems*, 2018, pp. 16–18.
43. E. P. Bernier and B. Scassellati, "The similarity-attraction effect in human-robot interaction," in *IEEE 9th International Conference on Development and Learning (ICDL)*, 2010, pp. 286–290.
44. H.-L. Cao, L. C. Jensen, X. N. Nghiem, H. Vu, A. De Beir, P. G. Esteban, G. Van de Perre, D. Lefeber, and B. Vanderborght, "Dualkeepon: a human–robot interaction testbed to study linguistic features of speech," *Intelligent Service Robotics*,

vol. 12, no. 1, pp. 45–54, 2019.
45. R. R. McCrae and P. T. Costa Jr, "Personality trait structure as a human universal," *American psychologist*, vol. 52, no. 5, pp. 509–516, 1997.
46. L. A. Jensen-Campbell, K. A. Gleason, R. Adams, and K. T. Malcolm, "Interpersonal conflict, agreeableness, and personality development," *Journal of Personality*, vol. 71, no. 6, pp. 1059–1086, 2003.
47. R. A. Lippa and J. K. Dietz, "The relation of gender, personality, and intelligence to judges' accuracy in judging strangers' personality from brief video segments," *Journal of Nonverbal Behavior*, vol. 24, no. 1, pp. 25–43, 2000.
48. D. C. Dryer, "Getting personal with computers: how to design personalities for agents," *Applied artificial intelligence*, vol. 13, no. 3, pp. 273–295, 1999.
49. Y. Moon and C. Nass, "How real are computer personalities? psychological responses to personality types in human-computer interaction," *Communication research*, vol. 23, no. 6, pp. 651–674, 1996.
50. I. van Dam, "Meet my new robot best friend: an exploration of the effects of personality traits in a robot on enhancing friendship," Master's thesis, University Utrecht, 2015.
51. F. Mairesse, M. A. Walker, M. R. Mehl, and R. K. Moore, "Using linguistic cues for the automatic recognition of personality in conversation and text," *Journal of artificial intelligence research*, vol. 30, pp. 457–500, 2007.
52. B. Tay, Y. Jung, and T. Park, "When stereotypes meet robots: the double-edge sword of robot gender and personality in human–robot interaction," *Computers in Human Behavior*, vol. 38, pp. 75–84, 2014.
53. K. R. Scherer, *Personality markers in speech.* Cambridge University Press, 1979.
54. A. Furnham, *Language and personality.* John Wiley & Sons, 1990.
55. J.-M. Dewaele and A. Furnham, "Extraversion: The unloved variable in applied linguistic research," *Language Learning*, vol. 49, no. 3, pp. 509–544, 1999.
56. P. Borkenau and A. Liebler, "Trait inferences: Sources of validity at zero acquaintance," *Journal of personality and social psychology*, vol. 62, no. 4, pp. 645–657, 1992.
57. J. W. Pennebaker and L. A. King, "Linguistic styles: Language use as an individual difference," *Journal of personality and social psychology*, vol. 77, no. 6, pp. 1296–1312, 1999.
58. B. H. La France, A. D. Heisel, and M. J. Beatty, "Is there empirical evidence for a nonverbal profile of extraversion?: a meta-analysis and critique of the literature," *Communication Monographs*, vol. 71, no. 1, pp. 28–48, 2004.
59. G. Matthews, J. S. Warm, L. E. Reinerman, L. K. Langheim, and D. J. Saxby, "Task engagement, attention, and executive control," in *Handbook of individual differences in cognition.* Springer, 2010, pp. 205–230.
60. B. Craenen, A. Deshmukh, M. E. Foster, and A. Vinciarelli, "Do we really like robots that match our personality? the case of big-five traits, godspeed scores and robotic gestures," in *Proceedings of the 27th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN), Nanjing, China*, 2018.
61. L. Takayama and C. Pantofaru, "Influences on proxemic behaviors in human-robot interaction," in *IEEE/RSJ International Conference on Intelligent Robots and Systems*, 2009, pp. 5495–5502.
62. R. Gockley and M. J. MatariĆ, "Encouraging physical therapy compliance with a hands-off mobile robot," in *Proceedings of the 1st ACM SIGCHI/SIGART conference on Human-robot interaction*, 2006, pp. 150–155.
63. A. Pandey and R. Gelin, "A mass-produced sociable humanoid robot: pepper: the first machine of its kind," *IEEE Robotics & Automation Magazine*, no. 99, pp. 1–1, 2018.
64. SoftBank, "Naoqi SDK website," http://doc.aldebaran.com/2-5/naoqi, "Accessed online 03-August-2020".
65. ——, "Default Animation Library website," http://doc.aldebaran.com/2-5/naoqi/motion/alanimationplayer-advanced.html, accessed online 03-August-2020.
66. C. I. Jewell, S. A. Elprama, A. Jacobs, P. G. Esteban, E. Bagheri, and B. Vanderborght, "Why children prefer extrovert or introvert robots: A pilot study using pairwise robot comparison," in *14th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*, 2019, pp. 590–591.
67. I. Mervielde, V. Buyst, and F. De Fruyt, "The validity of the big-five as a model for teachers' ratings of individual differences among children aged 4–12 years," *Personality and Individual Differences*, vol. 18, no. 4, pp. 525–534, 1995.
68. R. E. Boyatzis, *Transforming qualitative information: Thematic analysis and code development.* sage, 1998.