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Applying Service-Dominant Logic and Conversation Management Principles to Social Robotics for Autism Spectrum Disorder

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ABSTRACT

Anthropomorphism in social robots amplifies the big five human personality traits (extraversion, conscientiousness, neuroticism, openness to experience, and agreeableness), consequently aiding with the social motivation needs of consumers (especially individuals with autism spectrum disorder or ASD). According to the social motivation theory of autism, consumers with ASD show deficits in orienting toward social stimuli, engaging with humans, and maintaining social relations. Robotic anthropomorphism has been found to be positively related to the big five human personality types and robot likeability in human-robot interaction (HRI) situations. This research focuses on the conversational approach of social robotics using service-dominant approach. Conversation-based perspectives have been studied extensively in organizational and management literature; however, these perspectives have not been utilized in the context of social robots, HRI, and autism.

KEYWORDS

Anthropomorphism, Conversation Management, Human Personality Traits, Service Dominant Approach, Social Motivation, Social Robotics, Technology

INTRODUCTION AND REVIEW

Social robots have been known for their use in therapeutic applications for consumers with autism (Arora e al., 2021; Tapus, Ţăpuş, & Matarić, 2008; Libin & Libin, 2004). There is a scarcity of research exploring the interrelationships among robotic anthropomorphism, big five human personality traits (e.g., extraversion, agreeableness, conscientiousness, neuroticism, and openness), social motivation, and autism spectrum disorder. The purpose for this research is to demonstrate these interconnections in the context of conversation management studies. Robotic anthropomorphism can be defined as the human-like qualities of a social robot (e.g., robot's eyes, gaze, speech, etc.) (Bartneck, Kulic, & Croft, 2009), and it is related to the big five human personality traits. Anthropomorphism has been found to have a positive influence on people with autism spectrum disorder. Social robots with anthropomorphic features exhibit positive human-like qualities and characteristics, with the exception of negative qualities such as judgment and impatience. Research shows that robotic anthropomorphism influences the relationship between human personality traits and likeability of social robots (Arora

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et al., 2020; 2021), which may positively impact individuals with autism spectrum disorder during human-robot interactions through the personality traits of extraversion, agreeableness, and neuroticism.

Autism spectrum disorder can be defined as a developmental disorder characterized by difficulties to form and maintain social relationships by impairment of the ability to communicate verbally / non-verbally and through restricted interest / activities. Autism, or Autism Spectrum Disorder (ASD) is one of the five types of Pervasive Developmental Disorders (PDDs) that needs 'cognitive rehabilitation' as an educational process aimed at reducing the learning / cognitive disability within the limitations imposed by available resources, according to the Academy of Neurologic Communication Disorders and Sciences (ANCDS) (Beeson & Robey, 2012; Papadakis & Kalogiannakis, 2020) and Diagnostic and Statistical Manual of Mental Disorders: Fourth Edition (DSM-IV) (American Psychiatric Association, 1980; 2013). ASD is an early-onset, pervasive developmental disorder that manifests itself in anomalies in social communication and interaction along with abnormal restricted and/or repetitive patterns of behavior. Cognitive rehabilitation focuses on analysis and restoration of cognitive skills, such as orientation, insight, attention, memory, problem solving, and organization (American Psychiatric Association, Diagnostic and Statistical Manual of Mental Disorders, 2013). Social robots can work as 'therapy tools' to improve engagement and elicit novel social behaviors from people with autism (Scassellati et al., 2012).

Recent research shows that social motivational deficits are believed to have downstream effects on the development of social cognition; and as such, social cognition deficits in consumers with ASD have been rendered a consequence and not a cause of disrupted social interest (Chevallier et al., 2012). Social motivation refers to a human's need to interact with others and gain acceptance and validation. It can be studied at the behavioral, biological, and evolutionary levels (Chevallier et al., 2012). At a behavioral level, people adapt to the social world and find it rewarding. The two components of reward are wanting and liking, however, people with autism spectrum disorder lack the motivation to want. Individuals with ASD score lower on the friendship questionnaire which tests constructs such as pleasure in close friendships or enjoyment in interaction (Chevallier et al., 2012). At a biological level, specific regions of the brain play a significant role in specific aspects of social motivation, however, no region operates in isolation. At an evolutionary level, collaborative activities allow access to benefits that would otherwise be inaccessible. However, experimental evidence proposes that the preference for collaborative activities is diminished in autism spectrum disorder (Chevallier et al., 2012). Social robots can be used to improve interactions on all the aforementioned levels with consumers diagnosed with autism spectrum disorder.

From organizational management perspective, 'conversations' are means for gaining trust-worthy organizational collaborations. Social robots are characterized by anthropomorphism and conversational interfaces that can help in simulating human conversations. These conversational features of social robots help in cognitive rehabilitation for ASD individuals by engaging consumers in a reciprocal human behavior (Murtarelli, Gregory, & Romenti, 2021). Human-robot interaction (HRI) facilitated through the conversational management process facilitates decision making and improve quality of interactions. There is a scarcity of research in the field of social robotics based conversation management studies, human personality traits, social motivation, and robotic anthropomorphism and the way these concepts impact the social cognition of ASD individuals. Previous research have examined some of these relationships, however people (consumers) with autism spectrum disorder were not the focus of these studies. Though Kaplan Sanders, & Hancock (2021) discuss the extraversion-introversion trait and its impact on likability and anthropomorphism of social robots (Kaplan, Sanders, & Hancock, 2021), there are gaps that exist in social robotics research through conversational management and learning disabilities' perspectives. To bridge the identified research gaps, this study has the following objectives:

1. Examine how people with ASD exhibiting different personality types (Extraversion, Openness, Conscientiousness, Neuroticism, and Agreeableness) react uniquely / differently to social robots in terms of their social motivation needs.
2. Manage human-robot interaction (HRI) by integrating the current social robotics-based literature with conversation management and social motivation literature.
3. Develop theoretical and practical insights by investigating and integrating service-based dominant approach to social robots through the lenses of (a) anthropomorphism, (b) human personality traits, (c) conversation management, and (d) social motivation (cognition) in the context of autism spectrum disorder and other learning / cognitive disabilities.

The main purpose of this research is to focus on the big five human personality traits through robotic anthropomorphism, and how they have the potential to improve social motivation and cognition for ASD individuals. The research highlights the importance of social robotics for ASD individuals (or consumers) in the marketplace through conversation management studies. Previous research studies have shown that in high customer contact settings, service robots tend to do better than humans when performing standardized tasks, due to their mechanical and analytical nature (Reis et al. 2020). In this article, we propose a model of incorporating and integrating social motivation and conversation management principles in HRI implementation using social robots targeted at individuals with ASD and other learning disorders. Thereafter, we outline the managerial implications of our framework on consumers and businesses in the realm of social robotics.

THEORETICAL BACKGROUND

The big five personality traits is a metric of personality used to describe individuals. These personality traits are openness, conscientiousness, extraversion, agreeableness, and neuroticism. The first personality trait is 'extraversion', which can be defined as a personality trait or style characterized by a preference for or orientation to engaging socially with others. The second is the 'agreeableness' trait that indicates individual differences in general concern for social harmony. The third is the 'conscientiousness' trait, implying a desire to do a task well, and to make commitments to others seriously. The fourth is the 'openness' trait which includes aspects such as intellectual interest and creative imagination. The fifth and final trait is the 'neuroticism' personality trait defined as a state categorized by sadness, moodiness, and emotional volatility. These personality traits can be used to enhance the human characteristics (anthropomorphism) of the social robots in their interactions with humans (especially individuals with Autism Spectrum Disorder).

Research shows that people who are more autistic have a higher likeability to robots than those who are less autistic (Schweinberger et al., 2020). Their degree of autism was analyzed using an Autism Spectrum Quotient Test (Baron-Cohen et al., 2001; 2006). Recent studies on autism spectrum disorder and the big five personality traits found that there is a negative correlation between the severity of ASD and openness, conscientiousness, agreeableness, and extraversion. However, there is a positive correlation between the severity of ASD and neuroticism (Schwartzman et al., 2016). Research shows that individuals low in conscientiousness were more apt to allow the robot to approach closer than their counterparts who were high in conscientiousness which ultimately leads to a better interaction between the robot and the individual. People who are high in extraversion and emotional stability are more likely to anthropomorphize the robot more and feel closer to it (Schweinberger et al., 2020).

In contrast, individuals who are more severely affected by ASD have high neurotic tendencies. Hence, they tend to physically distance themselves from robots making the interaction more strained (Robert et al., 2020). It has also been found that high agreeableness predicted a positive interaction with robots. Damholdt et al. (2015) demonstrated that neuroticism and anthropomorphic thinking negatively correlated with mental relatedness. Cruz-Maya and Tapus (2016) found that individuals

who were higher in conscientiousness were better at being on time when they were reminded by a robot. These authors found that individuals high in agreeableness were trusting. Prior studies showed that trust decreased perceived risk (Pavlou, 2003; Robert et al., 2020) and increased the intention of technology use and perceived usefulness. Hence, it can be hypothesized that people with ASD who score higher in openness, conscientiousness, agreeableness, and extraversion will have less frequent positive interactions with a humanoid robot because these personality traits have a negative correlation with autism spectrum disorder. Conversely, neurotic people on the ASD spectrum will have more frequent worthwhile interactions with humanoid robots because there is a positive correlation between neuroticism and autism spectrum disorder (Schwartzman et al., 2016).

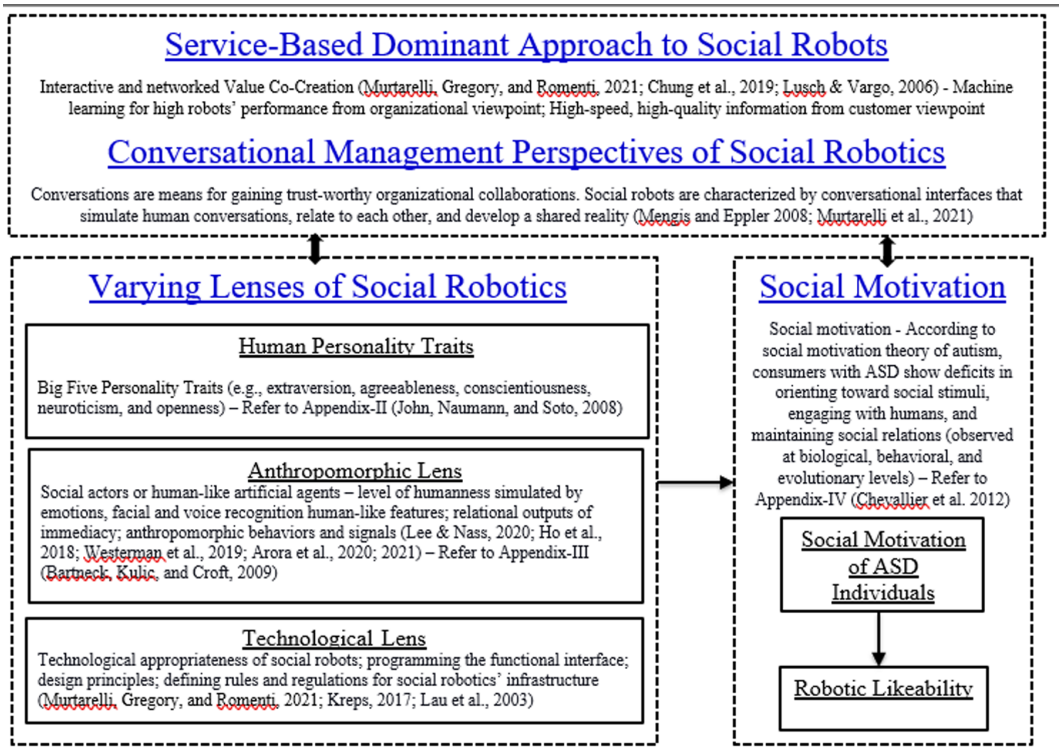
The extent of anthropomorphism of the social robots affects the degree of the impact of social motivation of people with ASD. Robot appearance is also an important factor that influences people's perceptions. Studies show that humanoid robots were preferred by people because of the robot's higher perceived control, greater friendliness, and more salient personality traits (Chee et al., 2012). Anthropomorphism is defined as "seeing the human in non-human forms" (Aggarwal & McGill, 2007, p. 468). From a conversational management perspective, the anthropomorphic lens is applied beyond the design principles for developing social robots. Social robots and chatbots can be thought of as 'social actors' that are characterized by the level of humanity and their communicative behavior in the technological / digital world (Murtarelli, Gregory, & Romenti 2021; Westerman, Cross, & Lindmark, 2019). Similar to anthropomorphic lens, the technological lens focuses on the functional interface of social robots with robotic design and development principles. For an agile development of social robots / chatbots, there is a need to define procedures and regulations for informational exchanges utilized by social robotics (Lau et al., 2003). Kreps (2017) emphasizes on the availability of customized information systems for social robotics integrated with data collection about users and their needs; adoption of a user-centric approach; assimilating visual appeals and high levels of interaction in the social bots resulting in continuous feedback; identification of users' emotions and shared information; and increased use of social for information exchanges and sharing. Technological lens is integrated with anthropomorphic perspective for the social robots' design and technological appropriateness for smooth and effective functioning of these social agents (Murtarelli et al., 2021).

In order to examine the relational value created via social robots, we use the service-dominant logic in addition to anthropomorphic and technological lenses. Følstad, Nordheim, & Bjørkli (2018) explore the relational value creation in the context of chatbots that can be influenced "by factors concerning the specific chatbot, specifically the quality of its interpretation of requests and advice, its human-likeness, its self-presentation, and its professional appearance" (p. 1) along with "factors concerning the service context, specifically the brand of the chatbot host, the perceived security and privacy in the chatbot, as well as general risk perceptions concerning the topic of the request" (Følstad et al., 2018, p. 1).

Figure 1 Relational value framework of social robotics is our proposed framework that examines human personality traits along with anthropomorphic and technological lenses with the underlying service-based dominant approach to social robotics in the context of ASD spectrum (adapted from Murtarelli, Gregory, & Romenti, 2021). Social robots function as 'companions' or 'pets' due to their conversational management capacities, when they utilize anthropomorphic signals integrated with human personality traits as outlined in the service-based dominant approach to social robots.

In the field of social robotics, creators and designers design robots with human (or living being) like characteristics to incite robotic anthropomorphism (e.g., Nao, the bipedal humanoid robot developed by SoftBank Robotics is used popularly in education and research) (Sung et al., 2007; Turkle, 2017; Scheutz, 2011) through technological lens (Murtarelli, Gregory, & Romenti 2021). Robotic anthropomorphism positively influences robot likeability in human-robot interaction (HRI) when technological lens focuses appropriately on the suitability and design factors (set forth during

Figure 1. Relational value framework of social robotics: service dominant approach to social robots



programming the functional interface) of social robots. Hence, anthropomorphic social robots with integrated big five human personality traits are more likable, and as such their interaction will aid in the social motivation of ASD individuals. The big five personality traits play a major role in the anthropomorphic features of social robots; they determine how human-like the social robots are. Social motivation is defined as the need for someone to interact with others and form social relations. According to the social motivation theory of autism, individuals with ASD show deficits in orienting toward social stimuli, engaging with humans, and maintaining social relations (Chevallier et al., 2012; Villaronga & Heldeweg, 2018). Typically developing (TD) peers have rewarding social interactions with humans while ASD individuals are comfortable interacting with educational-social robots for overcoming sensory barriers (Chevallier et al., 2012; Villaronga & Heldeweg, 2018). Consequently, the more anthropomorphic the robot is the more impact it will have on the social motivation of people with ASD. Therefore, we propose the following:

Proposition 1 – Anthropomorphic lens of social robotics (social robots with big eyes, gaze, voice, and facial recognition characteristics) with underlying service-based dominant approach (interactive nature of value co-creation process) leads to better social motivation of ASD individuals during their human-robot interaction (HRI) with the social robots.

Proposition 2 – Technological lens of social robotics (defining rules and regulations for social robotics' infrastructure along with design principles) with underlying service-based dominant approach (interactive nature of value co-creation process) leads to better social motivation of ASD individuals during their human-robot interaction (HRI) with the social robots.

Proposition 3 – Human Personality Traits (focusing on big five personality traits of (extraversion, conscientiousness, neuroticism, openness to experience, and agreeableness) with underlying

service-based dominant approach (interactive nature of value co-creation process) leads to better social motivation of ASD individuals during their human-robot interaction (HRI) with the social robots.

DISCUSSIONS

Autism spectrum disorder (ASD) is a developmental disorder that affects communication and behavior. Individuals with autism lack the motivation to want and the interest to socialize, they show deficits in orienting toward social stimuli, connecting with humans, and sustaining social relations. The **Autism Spectrum Quotient (AQ) Test** is a fifty-question test that measures for autistic traits in an individual. The test assesses an individual's response to change, emotions, level of observation, social cues, and settings (Baron-Cohen et al., 2001; 2006). Please refer to Appendix-I. Autistic individuals with higher levels of extraversion and conscientiousness, and lower levels of openness show a more positive response to Human-Robot Interaction. ASD individuals differ in their portrayal of big five personality traits and respond differently to varying human-robot interaction (HRI) situations. The **Big Five Personality Questionnaire** is composed of forty-four questions about a person's interest to which the responses range from "Agree strongly" to "Disagree Strongly". The questions assess your interest in communication, organization/ routine, creativity, etc. Understanding the big five personality traits of an individual can be instrumental especially when communicating with autistic individuals. The full questionnaire can be provided in Appendix-II (John, Naumann, & Soto, 2008).

Research shows that there is more likeability between robots and humans, especially individuals with autism as anthropomorphic characteristics increase. Anthropomorphism amplifies the big five personality traits in individuals with ASD. The **Godspeed questionnaire** measures human's perception of robots. The questionnaire contains five sections including anthropomorphism, animacy, likeability, perceived intelligence, and perceived safety. Each of these categories is rated on a scale of 1-5 from a less favorable response to a more favorable response. For example, the anthropomorphic features are rated on whether the robot appears fake/natural, machinelike/humanlike, unconscious/ conscious, artificial/ lifelike, and whether the robot is moving rigidly/ moving elegantly. The targeted characteristics on this questionnaire can give insight into how well the robots may be perceived by individuals with ASD and thus will be able to predict the effectiveness of using the robots to aid individuals with autism to communicate. The full questionnaire can be provided in Appendix-III (Bartneck, Kulic, & Croft, 2009).

Social motivation can be defined as the drive to interact with others socially and the ability to capture and sustain interest and attention. Anthropomorphism and the big five personality traits are all factors that influence social motivation. The **Social Motivation Questionnaire** is one created to measure the social motivation of individuals with autism spectrum disorder. The questionnaire is composed of twenty-eight questions aimed at understanding how social motivation impacts reward processing, social deficits, and consequently treatment outcomes (Schapp, 2016). The key areas investigated by this questionnaire are social drive, quality of overtures, social recognition, and behaviors that sustain an HRI. This questionnaire will help to measure the social interest and impact of social interaction in ASD individuals. The full questionnaire can be provided in Appendix-IV (Schapp, 2016).

With the underlying service dominant approach to social robotics, we have proposed an interactive and relational value creation in robots through conversation management where conversations serve "not only to exchange information, but also for conversation partners to relate to each other and develop a shared reality between them" (Mengis & Eppler 2008, p. 1290). Future research should focus on empirical research to further examine our proposed 'Relational Value Framework of Social Robotics' and enrich service-dominant logic literature along with conversation management literature by addressing human-personality traits, anthropomorphic and technology lenses in relation to social motivation of ASD individuals through social robotics. Future research efforts should examine

the interconnections and interrelationships among human personality traits, anthropomorphic and technological lenses of social robotics, and explore the theoretical insights provided by service-dominant logic and conversational management perspectives.

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APPENDIX 1

Psychologist Simon Baron-Cohen and his colleagues at Cambridge's Autism Research Centre have created the Autism-Spectrum Quotient, or AQ, as a measure of the extent of autistic traits in adults. In the first major trial using the test, the average score in the control group was 16.4. Eighty percent of those diagnosed with autism or a related disorder scored 32 or higher. The test is not a means for making a diagnosis, however, and many who score above 32 and even meet the diagnostic criteria for mild autism or Asperger's report no difficulty functioning in their everyday lives.

How to score: "Definitely agree" or "Slightly agree" responses to questions 2, 4, 5, 6, 7, 9, 12, 13, 16, 18, 19, 20, 21, 22, 23, 26, 33, 35, 39, 41, 42, 43, 45, 46 score 1 point. "Definitely disagree" or "Slightly disagree" responses to questions 1, 3, 8, 10, 11, 14, 15, 17, 24, 25, 27, 28, 29, 30, 31, 32, 34, 36, 37, 38, 40, 44, 47, 48, 49, 50 score 1 point.

Box 1. The AQ Test (Adapted from Baron-Cohen, et al. 2001; 2006)

		Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
1	I prefer to do things with others rather than				
	on my own.				
2	I prefer to do things the same way over and				
	over again.				
3	If I try to imagine something, I find it very				
	easy to create a picture in my mind.				
4	I frequently get so strongly absorbed in one				
	thing that I lose sight of other things.				
5	I often notice small sounds when others do				
	not.				
6	I usually notice car number plates or similar				
	strings of information.				
7	Other people frequently tell me that what I've				
	said is impolite, even though I think it is				
	polite.				
8	When I'm reading a story, I can easily				
	imagine what the characters might look like.				
9	I am fascinated by dates.				
10	In a social group, I can easily keep track of				
	several different people's conversations.				
11	I find social situations easy.				
12	I tend to notice details that others do not.				
13	I would rather go to a library than to a party.				
14	I find making up stories easy.				
15	I find myself drawn more strongly to people				
	than to things.				
16	I tend to have very strong interests, which I				
	get upset about if I can't pursue.				
17	I enjoy social chitchat.				
18	When I talk, it isn't always easy for others to				
	get a word in edgewise.				
19	I am fascinated by numbers.				
20	When I'm reading a story, I find it difficult to				
	work out the characters' intentions.				
21	I don't particularly enjoy reading fiction.				
22	I find it hard to make new friends.				
23	I notice patterns in things all the time.				
24	I would rather go to the theater than to a				
	museum.				
25	It does not upset me if my daily routine is				
	disturbed.				
26	I frequently find that I don't know how to				
	keep a conversation going.				
27	I find it easy to 'read between the lines' when				
	someone is talking to me.				
28	I usually concentrate more on the whole				
	picture, rather than on the small details.				
29	I am not very good at remembering phone				
	numbers.				
30	I don't usually notice small changes in a				

continued on following page

Box 1.. Continued

		Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
	situation or a person's appearance.				
31	I know how to tell if someone listening to me				
	is getting bored.				
32	I find it easy to do more than one thing at				
	once.				
33	When I talk on the phone, I'm not sure when				
	it's my turn to speak.				
34	I enjoy doing things spontaneously.				
35	I enjoy doing things alone.				
36	I find it easy to work out what someone is				
	thinking or feeling just by looking at their				
	face.				
37	If there is an interruption, I can switch back				
	to what I was doing very quickly.				
38	I am good at social chitchat.				
39	People often tell me that I keep going on and				
	on about the same thing.				
40	When I was young, I used to enjoy playing				
	games involving pretending with other				
	children.				
41	I like to collect information about categories				
	of things (e.g., types of cars, birds, trains,				
	plants).				
42	I find it difficult to imagine what it would be like to be someone else.				
43	I like to carefully plan any activities I				
	participate in.				
44	I enjoy social occasions.				
45	I find it difficult to work out people's				
	intentions.				
46	New situations make me anxious.				
47	I enjoy meeting new people.				
48	I am a good diplomat.				
49	I am not very good at remembering people's				
	date of birth.				
50	I find it very easy to play games with children				
	that involve pretending.				

APPENDIX 2

Big Five Human Personality Traits Questionnaire

(Adapted from John, Naumann, and Soto, 2008)

Instructions: Here are a number of characteristics that may or may not apply to you. For example, do you agree that you are someone who *likes to spend time with others?* Please write a number next to each statement to indicate the extent to which you agree or disagree with that statement(Box 2)

Box 2..

1 Disagree strongly	2 Disagree a little	3 Neither agree nor disagree	4 Agree a little	5 Agree Strongly

I see myself as someone who…….. (Box 3)

Box 3.

			24.	__	Is emotionally stable, not easily upset
1.	___	Is talkative	25.	__	Is inventive
2.	__ Tends to find fault with others		26.	__	Has an assertive personality
3.	__	Does a thorough job	27.	__	Can be cold and aloof
4.	__	Is depressed, blue	28.	__	Perseveres until the task is finished
5.	__	Is original, comes up with new ideas	29.	__ Can be moody	
6.	___	Is reserved	30.	__ Values artistic, aesthetic experiences	
7.	__	Is helpful and unselfish with others	31.	__	Is sometimes shy, inhibited
8.	__	Can be somewhat careless	32.	__	Is considerate and kind to almost
9.	__	Is relaxed, handles stress well			everyone
10.	__	Is curious about many different things	33.	__ Does things efficiently	
11. __		Is full of energy	34.	__	Remains calm in tense situations
12.	__	Starts quarrels with others	35.	__	Prefers work that is routine
13.	__	Is a reliable worker	36.	__	Is outgoing, sociable
14.	__	Can be tense	37.	__	Is sometimes rude to others
15.	__	Is ingenious, a deep thinker	38.	__	Makes plans and follows through
16.	___	Generates a lot of enthusiasm			with them
17.	__	Has a forgiving nature	39.	__ Gets nervous easily	
18.	__ Tends to be disorganized		40.	__ Likes to reflect, play with ideas	
19.	__	Worries a lot	41.	__	Has few artistic interests
20.	__	Has an active imagination	42.	__ Likes to cooperate with others	
21.	__ Tends to be quiet		43.	__	Is easily distracted
22.	__	Is generally trusting	44.	__	Is sophisticated in art, music, or literature
23.	__	Tends to be lazy			

BFI scale scoring ("R" denotes reverse-scored items): Extraversion: 1, 6R, 11, 16, 21R, 26, 31R, 36 Agreeableness: 2R, 7, 12R, 17, 22, 27R, 32, 37R, 42 Conscientiousness: 3, 8R, 13, 18R, 23R, 28, 33, 38, 43R Neuroticism: 4, 9R, 14, 19, 24R, 29, 34R, 39 Openness: 5, 10, 15, 20, 25, 30, 35R, 40, 41R, 44

APPENDIX 3

Godspeed Questionnaire (Adapted from Bartneck, Kulic, and Croft, 2009)

Anthropomorphism

Please rate your impression of robot on these scales (Box 4.)

Box 4.

Fake	1	2	3	4	5	Natural
Machinelike	1	2	3	4	5	Humanlike
Unconscious	1	2	3	4	5	Conscious
Artificial	1	2	3	4	5	Lifelike
Moving	1	2	3	4	5	Moving
rigidly						elegantly
Animacy						
Please rate your impression of the robot on these scales:						
Dead	1	2	3	4	5	Alive
Stagnant	1	2	3	4	5	Lively
Mechanical	1	2	3	4	5	Organic
Artificial	1	2	3	4	5	Lifelike
Inert	1	2	3	4	5	Interactive
Apathetic	1	2	3	4	5	Responsive
Likeability						
Please rate your impression of the robot on these scales:						
Dislike	1	2	3	4	5	Like
Unfriendly	1	2	3	4	5	Friendly
Unkind	1	2	3	4	5	Kind
Unpleasant	1	2	3	4	5	Pleasant
Awful	1	2	3	4	5	Nice

Perceived Safety

Please rate how you felt on these scales at the beginning (Box 5).

Please rate on these scales how you felt towards the end (Box 6).

Box 5.

Anxious	1	2	3	4	5	Relaxed
Agitated	1	2	3	4	5	Calm
Quiescent	1	2	3	4	5	Surprised

Box 6.

Anxious	1	2	3	4	5	Relaxed
Agitated	1	2	3	4	5	Calm
Quiescent	1	2	3	4	5	Surprised

APPENDIX 4

Social Motivation Questionnaire (SMQ) (Adapted from Schapp, 2016)

1. Makes attempts to get my attention to share his/her interests or enjoyment with me.
2. In a social situation, will attempt to play with other children instead of avoiding the group.
3. Actively avoids social interactions.
4. Tries to get my attention using both verbal and non-verbal communication in a way that seems typical for kids his/her age.
5. Without prompting from an adult, will initiate interactions with others with the purpose of being social.
6. Does not want to participate in activities that involve other children.
7. Will try to get my attention or interact with me, without being reminded to do so.
8. Plays with children his/her own age.
9. Shows me toys, objects, etc. just to share them with me, not to get help or make a request.
10. Prefers to play with other children rather than alone.
11. Shows me things that he/she finds interesting, not just to make a request or get help.
12. Engages in to and fro conversations with others.
13. Is interested in having friends.
14. Does not ask to have play dates with friends.
15. Asks to have play dates with friends.
16. Tries to share enjoyment with me.
17. Enjoys interacting with others.
18. Seeks out interactions with me (ex: smiles, makes noises, laughs).
19. I can have a conversation with my child in which he/she responds to me by building on what was said.
20. Shows empathy for others (ex: shows happiness or concern for others).
21. Will respond when others make small talk about things outside of my child's specific interests.
22. Approaches others appropriately to interact without being prompted.
23. Mostly talks about topics that interest him/her with little attempt to involve me in the conversation.
24. Does not notice or pay attention to the presence of other children or adults.
25. Talks about wanting to have friends.
26. Spends more time playing by him/herself than with others.
27. It is not concerning to my child that he/she is often alone.
28. Chooses to play with pets/animals instead of other children.

Note. Categories of SMQ: SD = Social Drive; QO = Quality of Overtures; BSI = Behaviors that Sustain an Interaction; SR = Social Recognition; O = Other; Relevance to Social Motivation: NR = Not Relevant; SR = Somewhat Relevant; ER = Extremely Relevant

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