The next best friend?

How children perceive and relate to a social robot

van Straten, C.L.

Publication date
2021

Chapter 1

General Introduction

Social robots are becoming increasingly prevalent in people's daily lives (e.g., Cross et al., 2019). This increasing prevalence is illustrated, for example, by the World Economic Forum's report on the top 10 emerging technologies of 2019, which estimated the number of social robots to be sold until 2025 at about 65 million a year – taking social robot sales from $5.6 billion in 2018 to about $19 billion in 2025 (World Economic Forum, 2019). Back in 2016, KPMG estimated that the majority of social robots (to be) installed between 2015 and 2018 would be used for research purposes (KPMG, 2016). However, as social robots are also making their way from research laboratories into society (e.g., Jung & Hinds, 2018), it is expected that they will, in the near future, "affect millions of people's lives more directly and profoundly" (Jordan, 2016, preface).

Breazeal and colleagues (2016, p. 1) define social robots as robots that "interact with people in a natural, interpersonal manner – often to achieve positive outcomes in diverse applications such as education, health, quality of life, entertainment, communication, and tasks requiring collaborative teamwork." This definition suggests that the intended societal impact of social robots is an integral part of what social robots are. In addition, Breazeal et al. (2016) argue that in order to achieve the intended outcomes, social robots need to be able to engage people both cognitively and affectively. This cognitive and affective engagement facilitate the emergence of a social connection between humans and robots or, in other words, the formation of human-robot relationships (Strohkorb et al., 2016; Turkle et al., 2006). The development of human-robot relationships may thus be seen as a crucial component adding to social robots' societal potential (for an ethical discussion, see de Graaf, 2017).

Of all user groups of social robots, children are among the primary users (Sheridan, 2020). Children have a natural tendency to relate socially to non-human entities (Epley et al., 2007). For example, children can become deeply attached to dolls and stuffed animals (Yamaguchi & Moriguchi, 2020), and also tend to establish 'parasocial' relationships with television characters (e.g., Tukachinsky, 2014). With the introduction of so-called 'smart toys', scholars observed how children related to their Tamagotchi's (Bloch & Lemish, 1999) and Furby's (Marsh, 2019). To date, we also witness how children readily engage in social relationships with robots (see, e.g., Beran & Ramirez-Serrano, 2010; Kahn et al., 2012; Kory Westlund & Breazeal, 2019b; Weiss et al., 2009). Finally, as social robots are being developed that incorporate more sophisticated technologies, they will increasingly be able to respond to people appropriately and in a lifelike

manner – which makes the emergence of human-robot relationships only more likely in the future (Coeckelbergh, 2010; Fox & Gambino, 2021; Jecker, 2020), presumably also for children (Ligthart et al., 2019).

Against this background, there are at least two reasons to investigate the process of child-robot relationship formation. First, as suggested by Breazeal et al. (2016) and De Graaf (2017), the emergence of child-robot relationships may facilitate beneficial outcomes of children's interactions with social robots (see also Pearson & Borenstein, 2014; Vogt et al., 2017). Initial empirical evidence confirms this idea. For instance, Kory Westlund and Breazeal (2019a) found that child-robot relationship formation may increase children's learning outcomes when social robots are used as second-language tutors. As another example, children's sense of friendship with a robot was found to increase the effectiveness of a robot-mediated health intervention for children with diabetes (Sinoo et al., 2018). A deeper understanding of child-robot relationship formation may thus increase the potential of a wide range of societal child-robot interaction (CRI) applications.

Second, the development of relationships, and the social skills associated with their emergence and maintenance, are generally important to children's social development (Berk, 2014). Through their engagement in close relationships, children learn how to deal with themselves, others, and the (social) world around them (e.g., Hartup, 1989). As social robots increasingly enter children's everyday lives (e.g., Brink & Wellman, 2019), it is therefore important to study how and when children form social relationships with robots. Doing so will eventually enable us to understand how this new category of relationships may affect children's social development (Borenstein & Pearson, 2013).

In this dissertation, child-robot relationship formation is defined as the development of children's feelings of closeness toward and trust in a robot. Closeness and trust are key to interpersonal relationship formation in general (Berscheid & Regan, 2005), and children's peer friendships in particular (Bauminger-Zviely & Agam-Ben-Artzi, 2014). Closeness refers to feelings of connectedness and intimacy (Sternberg, 1987), while trust constitutes the belief that someone is benevolent and honest (Larzelere & Huston, 1980). While the perceived availability of (tangible) social support is important to children's friendships too (see Furman & Bierman, 1984), this dissertation primarily centers on the more universally applicable concepts of closeness and trust as key components of child-robot relationship formation.

Getting a Grip on Child-Robot Relationship Formation

A wealth of CRI studies has investigated children's encounters with social robots in, among others, education (e.g., Baxter et al., 2017), healthcare (e.g., Looije et al., 2016), and therapy contexts (e.g., de Korte et al., 2020), reflecting a "hunger for applications" in which interactions between children and social robots can have immediate, measurable effects (Belpaeme et al., 2013, p. 453). Although such application-centered studies generate crucial insights regarding the potential of social robots to be part of, and contribute to, children's daily lives, the tendency to study CRI in relation to specific, practical outcomes has, to some extent, fragmented the research field. This fragmentation is illustrated by the existence of various domain-specific review studies on social robots in, among others, education (e.g., Belpaeme et al., 2018; Mubin et al., 2013; van den Berghe et al., 2019), healthcare (e.g., Dawe et al., 2019; Malik et al., 2016; Moerman et al., 2019), and therapy for children with Autism Spectrum Disorder (e.g., Cabibihan et al., 2013; Ismail et al., 2019; Saleh et al., 2020).

However, no review study currently exists that provides an overview of the various features of CRI that affect the emergence of social relationships between children and social robots.[1] As a consequence, we lack comprehensive insights into the process of child-robot relationship formation. Moreover, several studies on CRI applications in the various subdomains tend to be motivated more strongly by practical than theoretical considerations (Baxter et al., 2016; see also Jones, 2016). As a result, it is difficult to understand how the findings of the studies complement each other in the broader, domain-independent context of child-robot relationship formation. Integrating previous research findings into an overarching framework may help to systematize the knowledge about child-robot relationship formation and clarify where additional (causal) evidence is required in order to expand this knowledge (see also Eyssel, 2017 in the broader context of social robotics; Krämer et al., 2011 on a theory of human-robot companionship). Therefore, the first objective of this dissertation is to review and organize extant empirical research to provide insights into the current knowledge on child-robot relationship formation.

· · · · · · · · · ·

1   At the exception of a meta-analysis by Stower et al. (2021) on children's trust in social robots, which was recently published online-first. However, the review study reported on in this dissertation was conceived in 2017 and published in 2020, when no review on child-robot relationship formation was available yet. The meta-analysis by Stower et al. (2021) is referred to in all chapters of this dissertation that had not yet been published at the time of its appearance.

A second current shortcoming of the CRI field relates to the lack of valid and reliable measurement instruments to assess child-robot relationship formation (see also Kory Westlund et al., 2018; Stower et al., 2021). More generally, studies on (children's) interactions with social robots do not always provide clear conceptual and operational definitions of the constructs under investigation, vary in the comprehensiveness with which they report methodological information, and often do not address the validity of measures being used. As a result, it is difficult to compare findings – which further obstructs theory-building (for similar claims, see Baxter et al., 2016; Eyssel, 2017; Oliveira et al., 2021; Stower et al., 2021). Kory Westlund et al. (2018) importantly provide four measures to assess child-robot relationship formation. However, measures are needed that can be used to more specifically assess the separate concepts associated with the development of child-robot relationships. The second objective of this dissertation is therefore to develop a set of validated self-report measures that can be used to assess children's closeness toward, trust in, and perceived social support from a social robot.

Transparency about Social Robots

Previous research focuses, among other things, on the question of how interactions between children and social robots may be shaped in order to encourage the emergence of child-robot relationships (see, e.g., Cañamero & Lewis, 2016; Kory Westlund & Breazeal, 2019b). However, the formation of child-robot relationships is also one of the reasons for concerns about children's increasingly frequent encounters with social robots. For instance, Kahn and colleagues (2013) warn against potentially detrimental effects of child-robot relationship formation on children's moral development. Similarly, Turkle (2006, 2017) argues that pretending social robots have feelings may harm children's development of empathic abilities. Finally, Sharkey and Sharkey (2020) propose that the (un)intentional creation of false beliefs about social robots may lead children to prefer robotic friends over peers and, thus, obstruct their relational development.

At the same time, Sharkey and Sharkey (2020) admit the speculative nature of existing concerns, stating that "because research based on limiting children's companions to robots to the exclusion of human friends is unlikely to receive ethical approval, there is little clear evidence of the detrimental effect on children as a consequence of long-term interactions with robot companions" (Sharkey & Sharkey, 2020, "When is deception wrong?", section 10). What can

be done, however, is investigating how the discouragement of children's unjust expectations about social robots may alter child-robot relationship formation. Moreover, it currently remains unclear how children's relationships with social robots compare to their relationships with humans, animals, and objects (e.g., Kory Westlund et al., 2018). Gaining detailed insights into children's perception of social robots and investigating how children's perception varies according to the way these robots are presented to them, can provide us with a better understanding of child-robot relationship formation.

There seem to be at least two ways in which children's perception of, and relationship formation with, social robots can be altered. First, children tend to believe that social robots have psychological capacities and engage in social relationships with them accordingly (for an overview, see Severson & Carlson, 2010). However, social robots' capacities for, among others, social processing, affect analysis, and even basic sensory processing (e.g., vision) currently remain limited (Celiktutan et al., 2018). Being transparent to children about today's social robots' lack of psychological capacities thus constitutes a first manner in which children's perception of, and relationship formation with social robots may be influenced.

Second, social robots are often still unable to autonomously engage in interactions with humans in a socially appropriate way (e.g., Tolksdorf et al., 2020). Therefore, CRI studies often rely upon the Wizard of Oz (WOZ) paradigm, in which social robots are teleoperated by a human in order to ensure that robots respond to children in a contingent and reliable manner (e.g., Stower et al., 2021; van den Berghe et al., 2019). While the WOZ paradigm allows researchers to study more advanced interaction scenarios, it may also affect children's responses to social robots (Stower et al., 2021). Thus, children's perception of and relationship formation with social robots may be altered by revealing social robots' teleoperated working (see Kory Westlund & Breazeal, 2016, for a research proposal).

Investigating how managing children's expectations may alter their social responses to robots seems especially timely in light of recently presented principles for responsible robotics, which state, among others, that "robots are manufactured artifacts [and] their machine nature should be transparent" (Boden et al., 2017, p. 127). That is, as the transparent presentation of social robots may increasingly become the standard, it is important to advance our understanding of how children perceive and relate to social robots in transparent contexts. In addition, if transparency alters children's responses to

social robots, it is important to study the effects of robot- and interaction-related features on children's perception of, and relationship formation with, social robots in transparent interaction scenarios. Therefore, the third objective of this dissertation is to investigate the effects of transparency about social robots' lack of human psychological capacities and teleoperated working on children's perception of, and relationship formation with, social robots.

Social Robots' Use of Interpersonal Communicative Processes

While the introduction of social robots in children's lives has only started recently, neither the idea that children relate socially to technological entities nor the critical discussion thereof are new (see, e.g., Turkle, 2007, on digital relational artifacts). However, in contrast to earlier technologies that evoked social responses from children, (humanoid) social robots are physically embodied and can communicate with us verbally, such that interactions with these robots increasingly resemble face-to-face interpersonal communication (Zhao, 2006). Accordingly, interactions with social robots are often constructed following interpersonal principles (e.g., de Graaf, 2017; Fox & Gambino, 2021), and interpersonal interaction patterns are suggested to encourage children's relationship formation with social robots (see, e.g., Kahn et al., 2010). At the same time, it remains largely unclear how exactly communicative processes for the formation of interpersonal relationships manifest themselves in interactions with social robots (e.g., Fox & Gambino, 2021; Westerman et al., 2020) and, by extension, how social robots' use of these processes may influence children's perception of, and relationship formation with, social robots.

The literature on interpersonal relationships discusses a variety of communicative processes that foster the emergence and development of a relationship. For two people to (initially) develop feelings of closeness and trust, at least two things seem to be of central importance: They should be open about themselves and they should show interest in the other (see, e.g., Knapp & Vangelisti, 2000). Openness about the self can be achieved by sharing more or less personal, self-related information with the other person (Culbert, 1967, as in Gilbert, 1976). Showing interest in someone else can be achieved, for example, by asking questions (Huang et al., 2017). These communicative processes are especially important to initial interactions when people still know little about each other (Berger & Calabrese, 1975). The fourth objective of this dissertation is therefore to clarify how a social robot's sharing of self-related information and question-asking affect how children perceive and relate to a social robot. By means

of experimental investigations of how interpersonal theory applies to CRI, this dissertation contributes to the body of theoretically grounded, empirical knowledge on child-robot relationship formation.

Dissertation Outline

The purpose of this dissertation is to facilitate a more thorough understanding of children's perception of, and relationship formation with, social robots. Its first part (i.e., chapters 2 and 3) focuses on providing a theoretical and methodological foundation for future research on child-robot relationship formation by means of a literature review and the development of valid and reliable measurement instruments. The second part (i.e., chapters 4 to 6) reports on three experimental studies that aim to elucidate how transparency about social robots, and social robots' use of communicative processes, affect how children perceive and relate to such robots. Table 1 provides an overview of the objectives of this dissertation and the chapters in which they are addressed.

Table 1

Overview of Objectives Addressed per Chapter

Chapter	Objective
2	Review of empirical research on child-robot relationship formation
3	Development and validation of self-report measures of child-robot relationship formation
4 & 5	Experimental investigation of the effects of transparency about a social robot's lack of human psychological capacities and teleoperated working on children's perception of, and relationship formation with, a social robot
5 & 6	Experimental investigation of the effects of a social robot's sharing of self-related information and question-asking on children's perception of, and relationship formation with, a social robot

Part 1: Theoretical and Methodological Foundation

To date, an overview is missing of the characteristics of children's interactions with social robots that have been associated with the emergence of child-robot relationships. Therefore, the literature review presented in chapter 2 organizes research on child-robot relationship formation into a framework that provides encompassing insights into robot- and interaction-related features, cognitive and experiential states, and demographic characteristics of children that have been associated with the development of children's closeness toward and trust in social robots. Moreover, the review contrasts findings on children's interactions

with humans, robots, and objects to clarify differences between children's social responses to each. Even though some patterns emerged from the literature, the review also points out inconsistencies between studies and, in line with other reviews of research on social robots (e.g., Oliveira et al., 2021; Stower et al., 2021), demonstrates that the relationships between concepts often require further investigation.

As mentioned before, the conclusive power of the research field is, among other things, hampered by a lack of valid and reliable measurement instruments for the assessment of child-robot relationship formation (see also Stower et al., 2021). Addressing this shortcoming, chapter 3 describes the development and validation of a set of three self-report scales that can be used to measure children's feelings of closeness toward, trust in, and perceived social support from a social robot. These measures were developed especially for use among children and can be used, together or separately, to assess child-robot relationship formation. The measures of closeness and trust that are presented in this chapter have been used in the studies reported on in chapters 4 to 6, that together constitute the second, experimental part of this dissertation.

Part 2: Experimental Studies on Children's Perception of and Relationship Formation with a Social Robot

While calls for responsible robotics are increasing and scholars are pointing to the potential risks of children's unjust expectations about social robots (e.g., Kahn et al., 2013; Sharkey & Sharkey, 2020; Turkle, 2006), the effects of being transparent about social robots' (limited) capacities remain largely unclear. Therefore, chapter 4 investigates whether being transparent to children about a robot's lack of human psychological capacities affects children's perception of, and relationship formation with, a social robot. From the philosophical literature on personhood, we identified five psychological capacities that are central to the distinction between humans and machines: intelligence, self-consciousness, emotionality, identity construction, and social cognition (see Hubbard, 2011, based on Dennett, 1988).

With an experiment among children aged 8 and 9 years old, we investigated whether transparent information (i.e., regarding a robot's lack of these capacities) altered children's rating of the robot's animacy, anthropomorphism, its social presence, and its similarity to themselves, as well as children's self-reported feelings of closeness toward, and trust in the robot. Given that the relationships between CRI-related concepts often remain to be further ascertained (e.g., Oliveira et al., 2021), we focus, throughout this dissertation, on the causal

investigation of direct effects of transparency and communicative processes on children's perception of, and relationship formation with, a social robot. Our findings may inform and inspire future research to investigate potentially more complex (e.g., mediation) patterns.

Subsequently, as the consequences of the WOZ paradigm for children's perception of, and relationship formation with, social robots are largely unknown (Kory Westlund & Breazeal, 2016; Stower et al., 2021), chapter 5 investigates the effects of being transparent to children about a robot's teleoperated working. Moreover, in order to advance our understanding of how interpersonal communication processes influence how children perceive and relate to a social robot, this chapter assesses the effects of a robot's engagement in self-description (i.e., telling children factual information about itself, as opposed to robots in general). An experiment was conducted among children aged 7 to 10. After the children had interacted with the robot, a survey was conducted that inquired about children's feelings of closeness toward and trust in the robot and their perception of the robot's animacy, autonomy, anthropomorphism, its social presence, and its similarity to themselves.

Finally, chapter 6 aimed to further elucidate the effects of a robot being open about itself and showing interest in its interaction partner on children's perception of a robot and their sense of relationship formation with it. In an experimental study among children aged 7 to 10, we investigated the effects of a robot's self-disclosure (i.e., the provision of relatively intimate, as opposed to factual, self-related information) and question-asking on children's perception of the robot's cognitive and affective perspective-taking abilities and social presence, as well as on child-robot relationship formation in terms of children's self-reported feelings of closeness toward and trust in the robot.

Chapters 2 to 6 of this dissertation have been published, accepted for publication, or submitted for publication in academic journals. Chapter 7 offers a general discussion of their findings and presents the main conclusions and implications of this dissertation. In addition, this final chapter reflects on potential ways for future work to further elucidate the process of child-robot relationship formation.

References

Bauminger-Zviely, N., & Agam-Ben-Artzi, G. (2014). Young friendship in HFASD and typical development: Friend versus non-friend comparisons. *Journal of Autism and Developmental Disorders*, *44*(7), 1733–1748. https://doi.org/10.1007/s10803-014-2052-7

Baxter, P., Ashurst, E., Read, R., Kennedy, J., & Belpaeme, T. (2017). Robot education peers in a situated primary school study: Personalisation promotes child learning. *PLoS ONE*, *12*(5). https://doi.org/10.1371/journal.pone.0178126

Baxter, P., Kennedy, J., Senft, E., Lemaignan, S., & Belpaeme, T. (2016). From characterising three years of HRI to methodology and reporting recommendations. *Proceedings of the Eleventh International Conference on Human-Robot Interaction*, 391–398. https://doi.org/10.1109/HRI.2016.7451777

Belpaeme, T., Baxter, P., De Greeff, J., Kennedy, J., Read, R., Looije, R., Neerincx, M., Baroni, I., & Coti Zelati, M. (2013). Child-robot interaction: Perspectives and challenges. *Proceedings of the International Conference on Social Robotics*, 452–459. https://doi.org/10.1007/978-3-319-02675-6_45

Belpaeme, T., Kennedy, J., Ramachandran, A., Scassellati, B., & Tanaka, F. (2018). Social robots for education: A review. *Science Robotics*, *3*(21). https://doi.org/10.1126/scirobotics.aat5954

Beran, T. N., & Ramirez-Serrano, A. (2010). Can children have a relationship with a robot? *Proceedings of the International Conference on Human-Robot Personal Relationships*, 49–56. https://doi.org/10.1007/978-3-642-19385-9_7

Berger, C. R., & Calabrese, R. J. (1975). Some explorations in initial interaction and beyond: Toward a developmental theory of interpersonal communication. *Human Communication Research*, *1*(2), 99–112. https://doi.org/10.1111/j.1468-2958.1975.tb00258.x

Berk, L. E. (2014). *Exploring lifespan development* (3rd ed.). Pearson.

Berscheid, E., & Regan, P. (2005). *The psychology of interpersonal relationships*. Pearson Education.

Bloch, L. R., & Lemish, D. (1999). Disposable love: The rise and fall of a virtual pet. *New Media and Society*, *1*(3), 283–303. https://doi.org/10.1177/14614449922225591

Boden, M., Bryson, J., Caldwell, D., Dautenhahn, K., Edwards, L., Kember, S., Newman, P., Parry, V., Pegman, G., Rodden, T., Sorrell, T., Wallis, M., Whitby, B., & Winfield, A. (2017). Principles of robotics: Regulating robots in the real world. *Connection Science*, *29*(2), 124–129. https://doi.org/10.1080/09540091.2016.1271400

Borenstein, J., & Pearson, Y. (2013). Companion robots and the emotional development of children. *Law, Innovation and Technology*, *5*(2), 172–189. https://doi.org/10.5235/17579961.5.2.172

Breazeal, C. L., Dautenhahn, K., & Kanda, T. (2016). Social robotics. In B. Siciliano & O. Khatib (Eds.), *Springer handbook of robotics* (pp. 1935–1971). Springer. https://doi.org/10.1007/978-3-319-32552-1_72

Brink, K. A., & Wellman, H. M. (2019). Technology as teacher. In S. R. Grimm (Ed.), *Varieties of understanding: New perspectives from philosophy, psychology, and theology* (pp. 139–166). Oxford University Press. https://doi.org/10.1093/oso/9780190860974.003.0008

Cabibihan, J. J., Javed, H., Ang, M., & Aljunied, S. M. (2013). Why robots? A survey on the roles and benefits of social robots in the therapy of children with autism. *International Journal of Social Robotics*, *5*(4), 593–618. https://doi.org/10.1007/s12369-013-0202-2

Cañamero, L., & Lewis, M. (2016). Making new "new AI" friends: Designing a social robot for diabetic children from an embodied AI perspective. *International Journal of Social Robotics*, *8*(4), 523–537. https://doi.org/10.1007/s12369-016-0364-9

Celiktutan, O., Sariyanidi, E., & Gunes, H. (2018). Computational analysis of affect, personality, and engagement in human-robot interactions. In M. Leo & G. M. Farinella (Eds.), *Computer Vision For Assistive Healthcare* (pp. 284–318). Academic Press. https://doi.org/10.1016/B978-0-12-813445-0.00010-1

Coeckelbergh, M. (2010). Artificial companions: Empathy and vulnerability mirroring in human-robot relations. *Studies in Ethics, Law, and Technology*, *4*(3). https://doi.org/10.2202/1941-6008.1126

Cross, E. S., Hortensius, R., & Wykowska, A. (2019). From social brains to social robots: Applying neurocognitive insights to human-robot interaction. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *374*(1771), 20180024. https://doi.org/10.1098/rstb.2018.0024

Culbert, S. A. (1967). The interpersonal process of self-disclosure: It takes two to know one. In J. T. Hart & T. Tomlinson (Eds.), *New directions in client-centered therapy*. Houghton Mifflin.

Dawe, J., Sutherland, C., Barco, A., & Broadbent, E. (2019). Can social robots help children in healthcare contexts? A scoping review. *BMJ Paediatrics Open*, *3*(1), e000371. https://doi.org/10.1136/bmjpo-2018-000371

de Graaf, M. M. A. (2017). An ethical evaluation of human–robot relationships. *International Journal of Social Robotics*, *8*(4), 589–598. https://doi.org/10.1007/s12369-016-0368-5

de Korte, M. W. P., van den Berk-Smeekens, I., van Dongen-Boomsma, M., Oosterling, I. J., den Boer, J. C., Barakova, E. I., Lourens, T., Buitelaar, J. K., Glennon, J. C., & Staal, W. G. (2020). Self-initiations in young children with autism during Pivotal Response Treatment with and without robot assistance. *Autism*, *24*(8), 2117–2128. https://doi.org/10.1177/1362361320935006

Dennett, D. (1988). Conditions of personhood. In M. F. Goodman (Ed.), *What is a person? Contemporary issues in biomedicine, ethics, and society* (pp. 145–167). Humana Press. https://doi.org/10.1007/978-1-4612-3950-5_7

Epley, N., Waytz, A., & Cacioppo, J. T. (2007). On seeing human: A three-factor theory of anthropomorphism. *Psychological Review*, *114*(4), 864–886. https://doi.org/10.1037/0033-295X.114.4.864

Eyssel, F. (2017). An experimental psychological perspective on social robotics. *Robotics and Autonomous Systems*, *87*, 363–371. https://doi.org/10.1016/j.robot.2016.08.029

Fox, J., & Gambino, A. (2021). Relationship development with humanoid social robots: Applying interpersonal theories to human/robot interaction. *Cyberpsychology, Behavior, and Social Networking*. https://doi.org/10.1089/cyber.2020.0181

Furman, W., & Bierman, K. L. (1984). Children's conceptions of friendship: A multimethod study of developmental changes. *Developmental Psychology*, *20*(5), 925–931. https://doi.org/10.1037/0012-1649.20.5.925

Gilbert, S. J. (1976). Empirical and theoretical extensions of self-disclosure. In G. R. Miller (Ed.), *Explorations in interpersonal communication* (pp. 197–216). Sage.

Hartup, W. W. (1989). Social relationships and their developmental significance. *American Psychologist*, *44*(2), 120–126. https://doi.org/10.1037/0003-066X.44.2.120

Huang, K., Yeomans, M., Brooks, A. W., Minson, J., & Gino, F. (2017). It doesn't hurt to ask: Question-asking increases liking. *Journal of Personality and Social Psychology*, *113*(3), 430–452. https://doi.org/10.1037/pspi0000097

Hubbard, F. P. (2011). "Do androids dream?": Personhood and intelligent artifacts. *Temple Law Review*, *83*(2), 405–473.

Ismail, L. I., Verhoeven, T., Dambre, J., & Wyffels, F. (2019). Leveraging robotics research for children with autism: A review. In *International Journal of Social Robotics* (Vol. 11, Issue 3, pp. 389–410). https://doi.org/10.1007/s12369-018-0508-1

Jecker, N. S. (2020). You've got a friend in me: Sociable robots for older adults in an age of global pandemics. *Ethics and Information Technology*. https://doi.org/10.1007/s10676-020-09546-y

Jones, R. A. (2016). "If it's not broken, don't fix it?" An inquiry concerning the understanding of child-robot interaction. *What Social Robots Can and Should Do: Proceedings of Robophilosophy 2016*, 89–98. https://doi.org/10.3233/978-1-61499-708-5-89

Jordan, J. (2016). *Robots*. MIT Press.

Jung, M., & Hinds, P. (2018). Robots in the wild: A time for more robust theories of human-robot interaction. *ACM Transactions on Human-Robot Interaction*, *7*(1), 1–5. https://doi.org/10.1145/3208975

Kahn, P. H., Gary, H. E., & Shen, S. (2013). Children's social relationships with current and near-future robots. *Child Development Perspectives*, *7*(1), 32–37. https://doi.org/10.1111/cdep.12011

Kahn, P. H., Kanda, T., Ishiguro, H., Freier, N. G., Severson, R. L., Gill, B. T., Ruckert, J. H., & Shen, S. (2012). "Robovie, you'll have to go into the closet now": Children's social and moral relationships with a humanoid robot. *Developmental Psychology*, *48*(2), 303–314. https://doi.org/10.1037/a0027033

Kahn, P. H., Ruckert, J. H., Kanda, T., Ishiguro, H., Reichert, A., Gary, H., & Shen, S. (2010). Psychological intimacy with robots? Using interaction patterns to uncover depth of relation. *Proceedings of the Fifth International Conference on Human-Robot Interaction*, 123–124. https://doi.org/10.1145/1734454.1734503

Knapp, M. L., & Vangelisti, A. L. (2000). *Interpersonal communication and human relationships* (4th ed.). Allyn & Bacon.

Kory Westlund, J. M., & Breazeal, C. L. (2019a). A long-term study of young children's rapport, social emulation, and language learning with a peer-like robot playmate in preschool. *Frontiers in Robotics and AI*, *6*(81). https://doi.org/10.3389/frobt.2019.00081

Kory Westlund, J. M., & Breazeal, C. L. (2019b). Exploring the effects of a social robot's speech entrainment and backstory on young children's emotion, rapport, relationship, and learning. *Frontiers in Robotics and AI*, *6*(54). https://doi.org/10.3389/frobt.2019.00054

Kory Westlund, J. M., & Breazeal, C. L. (2016). Transparency, teleoperation, and children's understanding of social robots. *Proceedings of the Eleventh International Conference on Human-Robot Interaction*, 625–626. https://doi.org/10.1109/HRI.2016.7451888

Kory Westlund, J. M., Park, H. W., Williams, R., & Breazeal, C. L. (2018). Measuring young children's long-term relationships with social robots. *Proceedings of the 13th Conference on Interaction Design and Children*, 207–218. https://doi.org/10.1145/3202185.3202732

KPMG. (2016). *Social robots: 2016's new breed of social robots is ready to enter your world*. https://assets.kpmg.com/content/dam/kpmg/pdf/2016/06/social-robots.pdf

Krämer, N. C., Eimler, S., von der Pütten, A., & Payr, S. (2011). Theory of companions: What can theoretical models contribute to applications and understanding of human-robot interaction? *Applied Artificial Intelligence*, *25*(6), 474–502. https://doi.org/10.1080/08839514.2011.587153

Larzelere, R. E., & Huston, T. L. (1980). The dyadic trust scale: Toward understanding interpersonal trust in close relationships. *Journal of Marriage and the Family*, *42*(3), 595–604. https://doi.org/10.2307/351903

Ligthart, M. E. U., Neerincx, M. A., & Hindriks, K. V. (2019). Getting acquainted for a long-term child-robot interaction. *Proceedings of the International Conference on Social Robotics*, 423–433. https://doi.org/10.1007/978-3-030-35888-4_39

Looije, R., Neerincx, M. A., Peters, J. K., & Henkemans, O. A. B. (2016). Integrating robot support functions into varied activities at returning hospital visits: Supporting child's delf-management of diabetes. *International Journal of Social Robotics*, *8*(4), 483–497. https://doi.org/10.1007/s12369-016-0365-8

Malik, N. A., Hanapiah, F. A., Rahman, R. A. A., & Yussof, H. (2016). Emergence of socially assistive robotics in rehabilitation for children with cerebral palsy: A review. *International Journal of Advanced Robotic Systems*, *13*(3), 135. https://doi.org/10.5772/64163

Marsh, J. (2019). The Uncanny Valley revisited: Play with the Internet of Toys. In G. Mascheroni & D. Holloway (Eds.), *The Internet of Toys: Practices, affordances, and the political economy of children's smart play* (pp. 47–66). Palgrave Macmillan. https://doi.org/10.1007/978-3-030-10898-4_3

Moerman, C. J., van der Heide, L., & Heerink, M. (2019). Social robots to support children's well-being under medical treatment: A systematic state-of-the-art review. *Journal of Child Health Care*, *23*(4), 596–612. https://doi.org/10.1177/1367493518803031

Mubin, O., Stevens, C. J., Shahid, S., Mahmud, A. Al, & Dong, J.-J. (2013). A review of the applicability of robots in education. *Technology for Education and Learning*, *1*(1). https://doi.org/10.2316/journal.209.2013.1.209-0015

Oliveira, R., Arriaga, P., Santos, F. P., Mascarenhas, S., & Paiva, A. (2021). Towards prosocial design: A scoping review of the use of robots and virtual agents to trigger prosocial behaviour. *Computers in Human Behavior*, *114*, 106547. https://doi.org/10.1016/j.chb.2020.106547

Pearson, Y., & Borenstein, J. (2014). Creating "companions" for children: The ethics of designing esthetic features for robots. *AI and Society*, *29*(1), 23–31. https://doi.org/10.1007/s00146-012-0431-1

Saleh, M. A., Hashim, H., Mohamed, N. N., Almisreb, A. A., & Durakovic, B. (2020). Robots and autistic children: A review. *Periodicals of Engineering and Natural Sciences*, *8*(3), 1247–1262. https://doi.org/10.21533/pen.v8i3.1457.g610

Severson, R. L., & Carlson, S. M. (2010). Behaving as or behaving as if? Children's conceptions of personified robots and the emergence of a new ontological category. *Neural Networks*, *23*(8–9), 1099–1103. https://doi.org/10.1016/j.neunet.2010.08.014

Sharkey, A., & Sharkey, N. (2020). We need to talk about deception in social robotics! *Ethics and Information Technology*. https://doi.org/10.1007/s10676-020-09573-9

Sheridan, T. B. (2020). A review of recent research in social robotics. *Current Opinion in Psychology*, *36*, 7–12. https://doi.org/10.1016/j.copsyc.2020.01.003

Sinoo, C., van der Pal, S., Blanson Henkemans, O. A., Keizer, A., Bierman, B. P. B., Looije, R., & Neerincx, M. A. (2018). Friendship with a robot: Children's perception of similarity between a robot's physical and virtual embodiment that supports diabetes self-management. *Patient Education and Counseling*, *101*(7), 1248–1255. https://doi.org/10.1016/j.pec.2018.02.008

Sternberg, R. J. (1987). Liking versus loving: A comparative evaluation of theories. *Psychological Bulletin*, *102*(3), 331–345. https://doi.org/10.1037/0033-2909.102.3.331

Stower, R., Calvo-Barajas, N., Castellano, G., & Kappas, A. (2021). A meta-analysis on children's trust in social robots. *International Journal of Social Robotics*. https://doi.org/10.1007/s12369-020-00736-8

Strohkorb, S., Huang, C. M., Ramachandran, A., & Scassettati, B. (2016). Establishing sustained, supportive human-robot relationships: Building blocks and open challenges. *Technical Report of the AAAI Spring Symposium*, 179–182.

Tolksdorf, N. F., Siebert, S., Zorn, I., Horwath, I., & Rohlfing, K. J. (2020). Ethical considerations of applying robots in kindergarten settings: Towards an approach from a macroperspective. *International Journal of Social Robotics*. https://doi.org/10.1007/s12369-020-00622-3

Tukachinsky, R. (2014). Parasocial relationships. In M. Eastin (Ed.), *Encyclopedia of Media Violence* (pp. 277–280). SAGE. https://doi.org/10.4135/9781452299655.n108

Turkle, S. (2006). A nascent robotics culture: New complicities for companionship. *American Association for Artificial Intelligence Technical Report Series*, 107–116. https://doi.org/10.4324/9781003074991-12

Turkle, S. (2007). Authenticity in the age of digital companions. *Interaction Studies*, *8*(3), 501–517. https://doi.org/10.1075/is.8.3.11tur

Turkle, S. (2017). Why these friendly robots can't be good friends to our kids. *The Washington Post*. https://www.washingtonpost.com/outlook/why-these-friendly-robots-cant-be-good-friends-to-our-kids/2017/12/07/bce1eaea-d54f-11e7-b62d-d9345ced896d_story.html

Turkle, S., Taggart, W., Kidd, C. D., & Dasté, O. (2006). Relational artifacts with children and elders: The complexities of cybercompanionship. *Connection Science*, *18*(4), 347–361. https://doi.org/10.1080/09540090600868912

van den Berghe, R., Verhagen, J., Oudgenoeg-Paz, O., van der Ven, S., & Leseman, P. (2019). Social robots for language learning: A review. *Review of Educational Research*, *89*(2), 259–295. https://doi.org/10.3102/0034654318821286

Vogt, P., de Haas, M., de Jong, C., Baxter, P., & Krahmer, E. (2017). Child-robot interactions for second language tutoring to preschool children. *Frontiers in Human Neuroscience*, *11*(73). https://doi.org/10.3389/fnhum.2017.00073

Weiss, A., Wurhofer, D., & Tscheligi, M. (2009). "I love this dog": Children's emotional attachment to the robotic dog AIBO. *International Journal of Social Robotics*, *1*(3), 243–248. https://doi.org/10.1007/s12369-009-0024-4

Westerman, D., Edwards, A. P., Edwards, C., Luo, Z., & Spence, P. R. (2020). I-it, I-thou, I-robot: The perceived humanness of AI in human-machine communication. *Communication Studies*, *71*(3), 393–408. https://doi.org/10.1080/10510974.2020.1749683

World Economic Forum. (2019). *Insight report: Top 10 emerging technologies 2019*. http://www3.weforum.org/docs/WEF_Top_10_Emerging_Technologies_2019_Report.pdf

Yamaguchi, M., & Moriguchi, Y. (2020). Developmental change in attachment objects during childhood. *Early Child Development and Care*. https://doi.org/10.1080/03004430.2020.1841756

Zhao, S. (2006). Humanoid social robots as a medium of communication. *New Media and Society*, *8*(3), 401–419. https://doi.org/10.1177/1461444806061951