“If it’s not broken, don’t fix it?” An inquiry concerning the understanding of child-robot interaction

Raya A. Jones[1]
Cardiff University, UK

Abstract. Ethical standpoints regarding robots for children are polarized, yet there is insufficient evidence to substantiate either position. This is compounded by the multiplicity of lenses through which child-robot interactions are investigated. This paper explores implications for translating knowledge from robotics to developmental psychology. The concept of a ‘care-receiving robot’ is a case in point, favorably reviewed here though the manner of its testing discloses the need for a conceptual framework that takes into robotics, processes of child development, sociocultural expectancies about optimal development, and factors affecting research priorities.

Keywords. Child-robot interaction, care-receiving robot, child development, epistemology

1. Introduction

The technology has advanced since *Robots for Kids* [1] was published in 2000, the book’s descriptive content might be dated, but the normative remains constant: robots are designed, marketed and evaluated for what they can do for us. The present inquiry looks askance at that narrative. How can we tell whether robots are ‘good’ or ‘bad’ for us?

The tension between the descriptive and normative is particularly acute in the case of robots for young children. Ethical standpoints are polarized between technological utopianism and dystopian forebodings: beliefs in likely benefits ‘push’ for the technology, fears of psychological damage to children ‘pull’ in the other direction; and yet there is insufficient empirical evidence for substantiating either position. There is a ‘catch 22’ situation: psychologists cannot describe the actual impact on child development until the technology becomes ubiquitous enough to have an impact.

The situation is further compounded by the multiplicity of lenses through which phenomena of child-robot interaction (CRI) can be investigated, as the following aims to demonstrate. Following a statement of the problem and the inquiry’s focus, this paper draws upon available research to explore implications for translating empirical

[1] Dr Raya Jones, Reader, School of Social Sciences, Cardiff University, Glamorgan Building, King Edward VII Avenue, Cardiff CF10 3WT, UK. Email: JonesRA9@cardiff.ac.uk

knowledge from robotics to developmental psychology, and tentatively proposes a conceptual framework for understanding CRI phenomena.

2. The Problem in Focus

Social issues are increasingly recognized among the problems defining the engineering field of human-robot interaction (HRI). Whereas sociologists typically seek to describe the impact of technology on society and persons, engineers usually want to know how to design robots that will be desirable for society and persons. Wright Mills defined the sociological imagination as a stance that construes social phenomena in terms of what these reveal about the workings of a society [2]. The technological imagination transpires as a stance predisposed towards construing social issues in terms of their implications for technology [3]. There is also a psychological imagination, a stance inclined to interpret social phenomena and to utilize robotics in terms of what these may reveal about mind and behavior at individual and group levels. The psychological imagination is further fragmented into what cognitive, developmental, social and clinical psychologists typically want to know.

2.1. What Are We Looking at?

Latour has demonstrated how objects of scientific study, which are taken to be objective elements of the natural world (atoms, microbes, molecules, neutron stars etc.), come into our ken in laboratory procedures, various instruments, methods of archiving, and mathematical formulations [4]. A similar caveat applies to CRI as an object of study. Since few children have opportunities to meet robots in everyday life, the phenomenon of interest is often created for the purpose of investigating it.

Investigators construct CRI phenomena not only by bringing robots to children (or children to robots) but also by manipulating the independent variables; so much so that it could be queried whether we are looking at the same phenomenon across studies. Available studies differ in terms of robots' characteristics (e.g. physical appearance), modality (real robots versus pictures or videos) and duration (from brief laboratory exposures to long-term relationships with privately owned robot pets). On the 'child' side, available studies can be sorted most conspicuously according to (a) age group and (b) presence/absence of autism. Other demographic and individual factors (e.g. gender, culture/nationality, ethnicity, religion, socioeconomic status, personality, intelligence) could conceivably be associated with particular patterns of CRI. Inquiries about those are seldom raised apropos children, perhaps because studies are concerned either with robot design—hence seeking 'universals' of the child-as-user—or with child development, hence seeking psychological universals.

Scientific problems sometime intersect across robotics and developmental psychology in ways that create the impression of a common ground. For instance, psychologists investigating the development of children's reasoning about living/non-living entities sometime use pictures and videos of robots [5, 6], methods that cannot predict children's interaction with real robots. There is robust evidence that by age 4 most children make clear distinctions between prototypical living and non-living kinds, and tend to designate robots to the inanimate group. Yet research documenting children's attributions of aliveness to robot pets with which they actually interact suggests the emergence of a new ontological category that disrupts current animate/inanimate distinctions [7-9].

Researchers' own ontological positions also influence what is looked at (and how). Some cognitive scientists deploy robot simulations towards knowledge of learning mechanisms in infancy, such as imitation (see contributions in [10]). Reciprocally, developmental robotics utilizes knowledge informed by Vygotskian theory about how children learn towards designing for machine learning [11]. The belief that children and robots are interchangeable in terms of learning mechanisms conceptualizes the generic child from the mechanistic standpoint that is eschewed by the Vygotsky-inspired sociocultural movement in developmental psychology. The core metatheory of the respective research programs 'spins' likely constructions of CRI phenomena in ways that protect incommensurable ontologies.

Consequently, there are pragmatic challenges of translating empirical knowledge obtained in one context into useful data in another context. The case presented in Section 3 illustrates the limitations of mapping roboticists' findings onto the interests of developmental psychology.

2.2. Present Focus

The first five years of life involve momentous achievements across all domains of human development. This age group corresponds to the Early Years Foundation Stage (EYFS) of the national curriculum in Britain. By age 5 children should be able to count from 1 to 20, use everyday language to describe size, weight, capacity, position, etc., and so forth. Some of these skills can be practiced with interactive devices. There are already many toys that incorporate early learning features. Robotic toys could be an upgrade. A more controversial issue is whether robots could enhance EYFS skills listed under personal, social and emotional development: self-confidence and self-awareness; managing feelings and behavior; and making relationships.

There is robust evidence in support of robot interventions for promoting social skills among school-aged autistic children [12]. Their efficacy could be due to the symptomatic social impairments attributed to the so-called 'broken mirror' (referring to the mirror neurons system, which facilitates imitation and empathy). Whereas autistic children respond better to robots than to people, non-autistic infants are innately attuned to human beings, are likely to follow an adult's gaze more readily than a robot's [13] and by middle childhood, prefer peers to robot playmates [14]. Providing robot companions to typically-developing children might be driven by a naïve expectation that the young child will practice social skills with the robot. Yet these interactions might alter the child's social-moral attunement to the world. Research with children who had robot pets indicates lowered empathy with living animals [15].

Hence, *if it's not broken, don't fix it*. A question mark follows the maxim in the title so as to avoid preemptive rejections of the technology. We simply don't know yet. The only claim that can be made with confidence is that providing for the EYFS is not an engineering matter of harnessing knowledge about how young children naturally develop and then building machines to 'fix' or enhance what comes naturally. The application of robotics in this age group raises ethical and scientific issues deserving a comprehensive treatment beyond this paper's scope. The site of tensions is sampled here with attention to a lack of calibration across epistemologies.

3. The Care-Receiving Robot (CRR)

The concept of a CRR was developed by Tanaka and associates [16-20]. Although they present it as a kind of robot, 'care-receiving' is an emergent property of the interaction event, reflecting caretaking behavior that some children sometime spontaneously apply to small humanoids such as QRIO (Sony) and NAO (Aldebaran Robotics). CRR trials demonstrate how opportunities to interact with robots can elicit the kind of prosocial attitudes that caregivers and educators seek to promote.

3.1. Background

Tanaka's idea grew out of a longitudinal study, the RUBI project, that placed robots in an American university's crèche for several months [21]. Having observed how toddlers aged between 1½ and 2 years interacted with QRIO (e.g. showing concern when it fell down; putting a blanket over it when it was turned off), Tanaka reasoned that the robot's size—smaller than a toddler—induced them to take care of it [16, 17].

Later in Japan, NAO was placed for three days in an English learning class for 3- to 6-year-olds, attended by 2-5 children per session. It was teleoperated to participate as a learner in vocabulary-learning games [18, 19]. An increase of caretaking instances correlated with the robot's behavior: on Day 1 it answered all the questions correctly whereas on Day 3 it answered everything incorrectly. The children spontaneously took it upon themselves to teach the robot. Interestingly, the average of correct answers was higher when the children were tested 3-5 weeks later than it was in a post-test on the same day as the experiment. Parents reported that their children had enjoyed the experience so much they continued to play the game at home for days afterwards, which meant rehearsing the vocabulary.

Subsequently NAO was placed in a private school of English in Japan [20]. Children aged between 4 and 8 drew shapes along with NAO in a game designed to enhance their English vocabulary. An experimental condition in which the robot was incapable of learning was associated with the smallest gains in the child's learning. There was no significant difference in learning across experimental conditions in which the robot either answered everything correctly or was capable of learning.

3.2. Evaluation

The tangible evidence for learning outcomes is encouraging, albeit based on very small samples. The explanation could lie in the edutainment value. Nevertheless, if something helps, why not use it?

One obstacle is that robots are very expensive, and at present are not autonomous enough to behave in the manner that the robots appeared to the children in the CRR studies. The robots were teleoperated by an unseen operator, and required a battery of hardware installed throughout the premises. A researcher had to be present in the classroom to safeguard the children and robots. To recommend investing in making these teaching aids both affordable and serviceable without considerable in-situ technical support requires robust evidence that robots have a positive impact on child outcomes, and that the effect can be attributed uniquely to the CRR; that is, that similar outcomes cannot be achieved by creating opportunities for peer tutoring, for instance.

The question of what the CRR 'does' is not answerable merely through quantifiable outcomes. When putting a blanket on QRIO with a 'night-night' or teaching NAO correct

English vocabulary, the child must build in mind two intentional states: self-as-caregiver and other-as-dependent; self-as-teacher and other-as-pupil. Young children commonly experience themselves in positions of dependence and ignorance. Opportunities for experiencing the other side of the power relation are crucial for personal, social and emotional development. Young children proactively make these opportunities in make-believe.

Children build a sense of their own personhood by entering shared contexts of experience, within which they acquire behavioral and attitudinal repertoires. They practice those repertoires in sociodramatic play. Suitably designed robots may serve a similar function as do traditional dolls, with whom the child could play roles such as parent, teacher, doctor, etc., with the artifact imaginatively positioned in complementary roles. Research by Kahn and associates (e.g. [9]) comparing preschoolers' interactions with the robot dog AIBO and a stuffed toy dog has documented similar affectionate behavior towards both objects. Meaningful differences in the interaction patterns reflected children's reactions to AIBO's interactive capacity. A sophisticated robot companion might seem like a playmate rather than a plaything, but it would not become a *significant other* for the child unless the 'voice' of the robot (experienced as another person) becomes differentiated from others with whom the child regularly interacts.

Looking forward to a technologized future in which this could happen, Ramey insists that it behooves on us to accept the artificial as having a self [22]. He frames this imperative as an unexpected ethical dilemma for social robotics: the field "needs to recognize that there is a reciprocal relationship of selves … that serves as the basis for all forms of social behavior and cognition in human beings" (p.137). Unlike ethical issues concerning the propriety of using robots—which can have solutions that entail tweaking the product or creating legislations to regulate its uses—the resolution of Ramey's 'dilemma' lies in changing our attitudes to robots. It begs the question, why aspire to create artificial persons in the first place? Turkle's worry about the readiness to relinquish important relationships to robots, the so-called 'robotic moment' [23], may be recalled.

Against the backdrop of those speculative arguments, the CRR idea transpires favorably as straightforward. Critical issues come to the fore when the CRR is considered in relation to child development. In various papers disseminating the RUBY project the principal investigators, Tanaka and Movellan, made strong claims based on impressions of toddler behavior. According to the abstract of [21] the results indicate that the technology is "surprisingly close to achieving autonomous bonding and socialization with human toddlers for sustained periods of time and that it could have great potential in educational settings assisting teachers and enriching the classroom environment." However, as one psychologist put it, "To speak of 'bonding' in the sense of the Tanaka study—that the children liked the robots and had fun with them—is a choice of language that implies some connection with psychological research and theory but actually has none" ([24], p.236).

Dialogue with child development may begin at a pragmatic level. Tanaka's commonsense rationale has intuitive appeal, but the exposition of the concept could benefit from attention to the developmental trajectory. For instance, the finding in [20] that children learned just as well by observing the robot as by teaching it may cast doubts in the need for CRR; but the reported analysis did not distinguish between the age groups. Four-year-olds are developmentally quite different from 8-year-olds. Pretend play, such as caring for dolls, is typical of the preschool age group but less common in middle childhood. Younger children may benefit from a CRR in ways that cease to be relevant for older children.

4. Epistemological Biases

In engineering, the HRI field is distinctive in its emphasis on creating real systems and evaluating them by means of experiments with human subjects [25]. A proof-of-concept ethos nonetheless lingers in field trials. In the CRR studies, the concept 'care-receiving robot' was proven to work by the fact that children displayed caretaking behaviors. On its own, this confirmation does not constitute evidence for effects on child development. This and other biases reflect investigative and interpretative frameworks that are appropriate for what roboticists seek to know but are limited, if not misplaced, with respect to understanding the implications for child development.

Subtle biases can enter studies that test hypotheses about CRI in ways that inadvertently prompt an exaggerated impression of the robot's significance as a psychological 'other' for the child—a kind of 'false positive'. In [26], 18-month-olds who had seen a robot interacting in a social-communicative manner with an adult were subsequently more likely to follow its gaze than did infants in other conditions (robot movement, passive adult; robot-adult mismatch; passive robot). The researchers underline the robot's 'social' inclusion; yet the study demonstrates the necessity of a human agent as a source of social referencing for the infant. Hypothetically, if it were replicated with another human enacting the same scenarios as did the robot, infants might follow this person's gaze in all experimental conditions.

The 'false positive' is compounded with naïve assumption that similar behaviors must have the same psychological significance. For instance, investigators who measured the length of time that autistic children looked at NAO and at a teacher reported that the robot engaged the children in more 'eye contact' than did the teacher [27]. This construes CRI as an authentic interpersonal interaction although the robot might simply be an object of curiosity to the child. To make eye contact, the child must feel that the robot is looking back at him or her. We cannot tell whether it happens unless the child tells us (which could be difficult in the case of severely autistic children).

The effectiveness of robots in education depends partly on whether they can sustain the child's interest. Longitudinal studies repeatedly found that children grew bored with the robot after a few sessions [28, 29]. Roboticists typically tackle the problem by adding novel features to the robot so as to rekindle children's interest. The observed glitch is converted into a technical challenge (how to change the robot so as to attract the child). Investigating the likelihood that children grow bored because they cannot see the point of having the robot around may lead to reframing the problem as the challenge of how to change the child's perception and motivation. This begs the question of why should children be encouraged to be interested in robots in the first place.

Another example: 8- and 12-year-olds who played a game alone, with a peer and with a robot (iCat) said they had more fun playing with the robot than alone, but not as much fun as playing with a friend [14]. The researchers recommend that more work should be done in order to achieve the same level of satisfaction when playing with robots as with peers. This again begs the question, why? Shouldn't we encourage children to play with peers rather than robots? A child-centered standpoint would recommend more work on combatting issues such as social isolation and bullying—problems that do not have technological fixes.

5. Conceptual Framework

The above alludes to misalignment of investigative modes across disciplines. It is as if people look at the same object through different lenses. Since each lens is appropriate in its context, 'one lens fits all' is not a solution. Instead, a first step towards coherence is to identify constellations of processes, influences, interests and so forth, which form conditions for understanding CRI. Lenses through which CRI can be approached broadly constellate into four domains (Figure 1):

- Technological research and development in robotics;
- Processes of child development;
- Normative expectancies about child development (cultural values, beliefs and childrearing practices);
- Pragmatic, political and economic factors that influence research priorities.

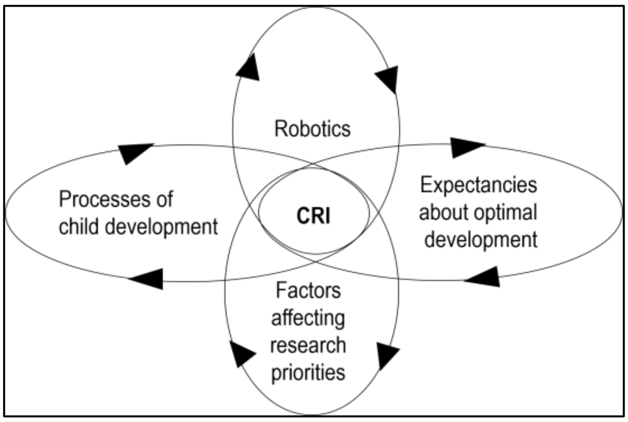

Figure 1. Domains impacting on the understanding of child-robot interaction (CRI).

5.1. Processes of Child Development

Ethical arguments often attend selectively to scientific knowledge. Pro-robot arguments tend to refer to cognitive learning [30, 31] whereas arguments against robots tend to draw upon theories of social-affective development [32, 33]. Developmental psychology emphasizes the 'whole' child even though psychologists may specialize in particular aspects of development. The core premise is threefold [34]:

- A human being is a complex whole which is a part of a larger system.
- Development means an increasing differentiation into subsystems and their organised integration.
- Developmental differentiation and integration happens as the child participates with others in cultural practices.

Bronfenbrenner describes human development as unfolding through *proximal processes:* progressively more complex reciprocal interactions between the individual child and the persons, objects, and symbolic resources constituting his/her immediate environment [35]. To have an impact on development, the interaction must be fairly regular over extended periods. Through engaging in routine activities and interactions, children learn to make sense of their world and to construct their own niche in it. Accordingly, robots may play a role in proximal processes when and if they enter the child's world on a regular basis.

Children's everyday contact with robots is likely to occur within family and school settings already immersed in hi-tech lifestyles and reflecting the values and attitudes of tomorrow's adults. A study of 3-year-olds' interactions with present-day technologies at home found that parents' previous experiences with technology and their beliefs about its educational potential were particularly significant towards how they made technologies available for their children [36]. Growing up with robots might change the proximal processes through changing familial and classroom relationships, and also change normative expectancies.

5.2. Normative Expectancies

Childrearing and educational practices are embedded within cultural structures. Domains of cross-cultural comparison include: collectivism/individualism; power distance between adult and child; children's place in family and culture; and beliefs about how children learn [37]. In North America, the production and acceptance of child-focused robotics is driven by individualistic childrearing practices that are focused on cognitive stimulation and acceleration in the early years as well as increasing adaptation to interactions with technology [15]. In Japan, child-focused robotics is influenced by a different history and cultural attitudes to robots in conjunction with traditional collectivist childrearing practices that emphasize socialization [16].

There is likely marketing potential for robot companions that facilitate remote monitoring of children. The risk is that busy parents might leave their infant child safe-yet-alone with the robot for long periods of time [32]. Yet even if parents use the technology responsibly, these gadgets introduce new forms of surveillance and social control; and, in turn, may alter future generations' beliefs about good parenting.

Do we desire a society in which parent-child relationships are mediated by robots? The following may illustrate the query. A Japanese team developed a 'sociable trash box' (STB): a litterbin that runs after children urging them to pick up their litter [38]. It sounds like a good idea. Yet, getting children to comply with a robot is not quite the same as telling the child, "Do as I'm telling you." Through the lens of robotics, a foreseeable drawback is that children might get bored and ignore the STB—glitches that invite design solutions. Through the lens of child development, the issue translates into the exigency of ascertaining the STB's effectiveness in bringing about stable changes in child conduct. In contradistinction, the sociological lens of 'expectancies' directs attention to how the introduction of such gadgets might interact with adults' powers to socialize children.

5.3. Factors Affecting Research Priorities

While the industry is keen to invest in widening applications for its products, robots are not yet commonplace enough for CRI to become a 'burning issue' in developmental psychology and therefore to persuade funding agencies to sponsor large-scale research initiatives into CRI. Politics of research funding as well as specific scholarly interests of those who are awarded research grants shape how CRI phenomena become constructed in actual research, and consequently what is known or understood about children and robots.

6. Closing Reflection

Discussing the concept of history, Walter Benjamin meditated upon a Klee painting ('Angelus Novus') showing an angel fixedly staring at us [39]. Benjamin imagines a storm blowing from Paradise and catching the angel with such violence that the angel cannot close his wings. "The storm irresistibly propels him into the future to which his back is turned, while the pile of debris before him grows skyward. This storm is what we call progress." (p.393).

In a way we are like this angel when seeking to understand what a future with robots might hold. The storm we call technological progress irresistibly propels us into a future we cannot see, while we stare at debris of old ontologies piling up. Pessimistically, seeking to establish whether robots will enhance or undermine child development might feel like rummaging in debris. Optimistically, there is scope for building a coherent framework that could accommodate divergent epistemologies. Problematizing their differences is a first step.

References

[1] A. Druin & J.A. Hendler (Eds.). *Robots for Kids: Exploring New Technologies for Learning*. Morgan Kaufmann, San Francisco. 2000.

[2] C.W. Mills, *The Sociological Imagination* (4th edition), OUP, New York, 1999

[3] R.A. Jones. *Personhood and Social Robotics*, Routledge, London. 2016.

[4] B. Latour, *Pandora's Hope*. Harvard University Press, Cambridge, MA. 1999.

[5] J.L. Jipson & S.A. Gelman, Robots and rodents: Children's inferences about living and nonliving kinds, *Child Development* **78** (2007), 1675–1688

[6] R.L. Severson & S.M. Carlson, Behaving as or behaving as if? Children's conceptions of personified robots and the emergence of a new ontological category, *Neural Networks* **23** (2010), 1099–1103.

[7] M.M. Saylor, M. Somanader, D.T. Levin & K. Kawamura. How do young children deal with hybrids of living and non-living things: The case of humanoid robots. *British Journal of Developmental Psychology* **28** (2010), 835–851.

[8] P.H. Khan Jr., B. Friedman, D.R. Pérez-Granados & N.G. Freier, Robotic pets in the lives of preschool children, *Interaction Studies* **7** (2006), 405-436.

[9] P.H. Kahn Jr., H.E. Gary & S. Shen, Children's social relationships with current and near-future robots. *Child Development Perspectives* **7** (2013), 32–37

[10] C.G. Prince, Special Issue on Developmental Robotics: Can experiments with machines inform theory in infant development? *Infant and Child Development* **17** (2008), 1–5

[11] M. Mirolli & D. Parisi, D. Towards a Vygotskyan cognitive robotics: The role of language as a cognitive tool, *New Ideas in Psychology* **29** (2011), 298–311

[12] B. Scassellati, H. Admoni & M. Mataric, Robots for use in autism research. *Annual Review of Biomedical Engineering* **14** (2012), 275–94.

[13] Y. Okumura, Y. Kanakogi, T. Kanda, H. Ishiguro & S. Itakura. Infants understand the referential nature of human gaze but not robot gaze. *Journal of Experimental Child Psychology* **116** (2013), 86-95.

[14] S. Shahid, E. Krahmer & M. Swerts. Child-robot Interaction: Playing Alone or Together? In CHI 2011, May 7–12, 2011, Vancouver, BC, Canada. (pp. 1400-1404)

[15] Melson, G. F. (2010). Child development robots: Social forces, children's perspectives. *Interaction Studies* 11: 227– 232

[16] F. Tanaka & T. Kimura, The use of robots in early education: a scenario based on ethical consideration, *The 18th IEEE International Symposium on Robot and Human Interactive Communication*, Toyama, Japan, Sept. 27-Oct. 2, 2009. (pp. 558-560)

[17] F. Tanaka & T. Kimura, Care-receiving robot as a tool of teachers in child education. *Interaction Studies* **11** (2010), 263–268

[18] M. Ghosh & F. Tanaka, F. The impact of different competence levels of care-receiving robot on children. *Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems.* September 25-30, 2011. San Francisco (pp. 2409-2415)

[19] F. Tanaka & S. Matsuzoe, S. Children teach a care-receiving robot to promote their learning: field experiments in a classroom for vocabulary learning. *Journal of Human-Robot Interaction* **1** (2012), 78-95.

[20] S. Matsuzoe & F. Tanaka, How Smartly Should Robots Behave? Comparative Investigation on the Learning Ability of a Care-Receiving Robot. *The 21st IEEE International Symposium on Robot and Human Interactive Communication*. September 9-13, 2012. Paris, France. (pp. 339-344)

[21] F. Tanaka, A. Cicourel & J.R. Movellan. Socialization between toddlers and robots at an early childhood education center. *PNAS* **104** (2007), 17954–17958

[22] C.H. Ramey, "For the sake of others": the personal ethics of human–android interaction. *Proceedings of the CogSci 2005 Workshop: Toward Social Mechanisms of Android Science*, Stresa, Italy. (pp. 137–48)

[23] S. Turkle, *Alone Together*, Basic Books, New York, 2011.

[24] J. Mercer. Themes and variations in development: Can nanny-bots act like human caregivers? *Interaction Studies* **11** (2010), 233–237.

[25] M.A. Goodrich & A.C. Schultz, Human–robot interaction: A survey, *Foundations and Trends in Human–Computer Interaction* **1** (2007), 203–275.

[26] A.N. Meltzoff, R. Brooks, A.P. Shonb & R.P.N. Raob, "Social" robots are psychological agents for infants: A test of gaze following, *Neural Networks* **23** (2010), 966–972.

[27] L.I. Ismail, S. Shamsudina, H. Yussofa, F.A. Hanapiahc & N.I. Zaharid, Estimation of concentration by eye contact measurement in robot-based intervention program with autistic children, *Procedia Engineering* **41** (2012), 1548–1552.

[28] T. Kanda , T. Hirano , D. Eaton & H. Ishiguro, interactive robots as social partners and peer tutors for children: a field trial, *Human–Computer Interaction*, **19** (2004), 61-84

[29] T. Salter, K. Dautenhahn & R. Boekhorst, Robots moving out of the laboratory: Detecting interaction levels and human contact in noisy school environments, *Proceedings of the 2004 IEEE International Workshop on Robot and Human Interactive Communication*. (pp. 563–568). Kurashiki, Okayama, Japan, September 20–22, 2004

[30] J.R. Movellan, J. R., Warning: The author of this document may have no mental states. Read at your own risk, *Interaction Studies* **11** (2010), 238 – 245

[31] P. Marti, Robot companions: Towards a new concept of friendship? *Interaction Studies* **11** (2010), 220-226

[32] N. Sharkey & A. Sharkey, A., The crying shame of robot nannies: An ethical appraisal. *Interaction Studies* **11,** (2010), 161 – 190

[33] C. Zoll & C. Spielhagen, C. Changing perspective: From avoiding harm to child's best interests. *Interaction Studies* **11** (2010), 295 – 301

[34] W.F. Overton, Developmental psychology: Philosophy, concepts, methodology. In: R.M. Lerner, (Ed.) *Theoretical models of human development*, (6th ed., pp. 18-88), John Wiley & Sons, Hoboken, NJ, 2006.

[35] U. Bronfenbrenner & P.A. Morris, The ecology of developmental processes. In W. Damon & R. M. Lerner (Eds.), *Handbook of child psychology, Vol. 1: Theoretical models of human development* (5th ed., pp. 993–1023). Wiley, New York, 1998.

[36] L. Plowman, O. Stevenson, C. Stephen & J. McPake, Preschool children's learning with technology at home. *Computers & Education* **59** (2012), 30–37.

[37] A.G. Halberstadt & F.T. Lozada, Emotion development in infancy through the lens of culture. *Emotion Review* **3** (2011), 158–68.

[38] Y. Yamaji., T. Miyake, Y. Yoshiike, P. Ravindra,, S. De Silva, & M. Okada, STB: Child-dependent sociable trash box,. *International Journal of Social Robotics* **3** (2011), 359–70.

[39] W. Benjamin, W. *Selected Writings, Vol. 4: 1938-1940.*: Harvard University Press, Cambridge, 2003.