# Evaluation of the Social Effects Child Robot Interaction has on Children

**Dominic Kim**
School of Engineering
University of Auckland
dkim157@aucklanduni.ac.nz

**ABSTRACT**

Robots are becoming increasingly common in society but have limited capability to interact with humans in an effective and appropriate manner. However, measurement of human robot interaction (HRI) has not been officially standardised[1], making cross study comparison very difficult. Therefore, many studies have been focused towards children, who are relatively more fundamental in terms of variety of actions performed. The major types of social HRI on which the studies are based on will be categorised. The use of robots to increase social stimulation in children is a field of study which has received much interest. Long term projects such as the Aurora project for autistic children have seen improvements in some children, due to the heterogenic quality of autism. Despite the lack of HRI standardisation child robot interaction (CRI) studies have shown that robots are effective in stimulation social responses from children. Children showed increased attention and enjoyment when interacting with robots in comparison to solitude. Although not as effective, some autistic children showed increased interaction with robots than with people or plain toys. Due to the difference in learning nature of autistic children, anthropomorphic robots proved to be effective in repetitive cognitive teaching children.

**AUTHOR KEYWORDS: HUMAN ROBOT INTERACTION, CHILDREN, AUTISM, ROBOT ASSISTED THERAPY, HCI METRICS, ROBOT SOCIALISATION**

## INTRODUCTION

The word ‘robot’ has connotations of an artificially created anthropomorphic piece of technology designed to aid humans to the contemporary man. Because robots excel at automating repetitive actions, there is much utilisation of robots in manufacturing work lines. Robots are also utilised in medial, hospitality and education fields to a lesser degree. Interactive robots in surgery and prosthetics are used in hospitals to treat patients more satisfactorily[2].

However, the acceptance of robots in this field is at a much slower rate than industrial robots. This is largely due to robots not being able to account for the vast permutations that human-robot interactions can lead to. Robots in manufacturing roles are closer to machines that have limited adaptability to their environment. Interactive robots are closer to being assistants and have a higher requirement of social skills[3].

This paper is going to evaluate the effects that human-robot interaction (HRI) has on children younger than fifteen years of age. Children are known to be more expressive than different age groups[4], which helps measure human-robot interactions; which is hard enough as it is.

As robotic technology advances, the level of anthropomorphism has been increasing to a surprising level. Robots are able to express human-like facial expressions to a level of replication which people are able to recognise. The different reactions children have between anthropomorphic robots and those which aren’t showed many differences. Children were more inclined to form emotional attachments to robots with more anthropomorphic features.

Robots are also used in psychological treatment/assistance of children with autism. Autism is a highly indefinable disability which is often specific to an individual. However, use of robots such as KASPAR[5] and Sony’s AIBO[6] in case studies have shown positive results, showing increased interaction and responsiveness. In some cases, children have shown more active interaction with robots than with their biological parents[7].

With robots becoming more and more integrated into daily life, HRI need to be scrutinized so that potential negative effects are removed wherever possible.

## DEFINITION OF HUMAN ROBOT INTERACTION

Human robot interaction is defined as the multidisciplinary study of human-robot interaction[8]. This is very vaguely defined because there are so many different types of ‘interactions’ that can occur. Like all sciences, the most fundamental component to study is to be able to measure the focus of an experiment. A common metric is required in order to standardise measurements made in HRI[1].

There are two main types of HRIs: task oriented and human oriented interaction. Navigation, perception, management, manipulation, and socialisation are all types of task-oriented human robot interaction; focused around completion of a task delegated by a human user. Task oriented robots are often assigned tasks and entrusted to complete the job successfully and efficiently [9]. The main form of HRI involved in this is the level of trust in the machine from the human user. This is a one-way type HRI.

Human oriented robots are more obliged to respond to human stimulation. They often equipped with sensors to perceive at least one of the five basic sensors: sight, audio, touch, taste, and smell. Visual and audio sensors are the most commonly utilised as visual perception and vocal communication are the senses most often used in human to human communication. Human oriented robots tend towards having more anthropomorphic features than robots that have comparatively less interaction with people.

Also, units are required for the different types of HRI in order to measure and compare results between case studies. The scope of this paper is focused on the social aspect of children-robot interaction. The following section will explain the various types of social interactions between children and robots and the difficulties involved in measuring them.

## TYPES OF SOCIAL CHILD ROBOT INTERACTION

The following categories on interaction were used in a study of the changes in behaviour of autistic children when stimulated by robotic toys[10]. Their actions were recorded and broken down into direct and indirect interactions into micro-behaviours. Direct actions are actions which are clearly directed at the robot, such as eye contact or physical contact. Indirect interactions are much harder to identify and measure because the focus of the action is unclear. For example, a child may make a noise because of basic biological needs such as hunger which may be mistaken as a response to the robot's coincidental action. Sometimes, there may be no target of an indirect action, which makes it difficult to measure.

### Eye Contact/Gaze

This is when direct visual contact is made between the robot and study participant. Visual perceptions can be recorded from the robot's visual sensors and analysed based on the length of time of eye contact. Eye contact is a form of social interaction in the form of successfully capturing the participant's attention during the gaze.

### Physical contact

A child will often make physical contact with the robot out of curiosity. This can be measured in length of contact or frequency depending on the type of contact. Observed intention of contact should be categorised wherever possible, as emotional reaction is shown strongly through physical actions. A child's inquisitiveness is strongly shown through this type of interaction[10]. Physical contact can be categorised into five different subtypes: irrelevant, expressive, symbolic, interactional, and referential gestures[11].

### Vocal stimulation

Vocal actions are highly dependent on the participant's ability to articulate their thoughts in an understandable language. Younger participants may not be able to formulate understandable words; so the focus has to be shifted to recording interjections and vocal exclamations. Older participants having a stronger command over linguistic articulation can be asked to participate in post test questionnaires.

### Operation

Some robots have pre-defined operations that interact with the user. For example, a dancing robot may have visual sensors to detect whether the user is correctly following the steps. The frequency and accuracy of robot operation can indicate a higher level of engagement and focal immersion.

### Ignorance

This is where the child seems uninterested in the robot. Very little to no actions are made or attempted to explore observe the robot. Minimal CRI occurs, resulting in an interaction downtime. This has strong implications that the user has lost interest and/or trust in the robot.

## CONTEMPORARY CASE STUDIES

Various studies have been conducted on children to investigate the behaviour and social bonding that occurs. Each case study involves observing a young child's interaction with a robot designed to assist them in some way; usually in the form of an entertainment as an interactive toy. The motive behind these case studies is to observe the possibility of robots being toys that interact with children in a way that benefits their social development. Robots are most likely never going to be able to replace a human caregiver, as robots unlikely to ever respond adequately to a child in the sensitive manner needed to engender secure attachment[12]. Nevertheless, studies have been carried out to observe the extent to which robots can act the role of an interactive play mate of children.

### Case study 1 – Robotic Dogs

Melson G et al.[7] conducted a study involving seventy-two children and the social effects two, forty-five minute playing sessions had on children. The two sessions were each with a robotic and living dog. Each session was video recorded without knowledge of the children. Results were taken in the form of a questionnaire after the test and a card sorting activity, where the child would be given laminated cards with coloured pictures of a humanoid robot, live dog, stuffed dog, and desktop computer. Simple questions such as "Is AIBO (the robotic dog) more like object A or object B?" would be asked and the child would match the picture of the dog they played with during the session to what they think is the closest match. The complexities of the questions were kept to a minimum in light of the participants' intellectual standards.

| Behavior | Robot dog ($N=72$) | | | | | | Live dog ($N=72$) | | | | | | Sign test $p$-value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total occurrences | Median | Range | | At least once | | Total occurrences | Median | Range | | At least once | | |
| | | | Min | Max | $n$ | % | | | Min | Max | $n$ | % | |
| Exploration as artifact | 254 | 2 | 0 | 18 | 43 | 60% | 37 | 0 | 0 | 5 | 17 | 24% | <.0005* |
| Proximity | 47 | 0 | 0 | 5 | 26 | 36% | 73 | 0 | 0 | 9 | 32 | 44% | .617 |
| Social touch | 276 | 2 | 0 | 22 | 45 | 63% | 1074 | 13 | 2 | 39 | 72 | 100% | <.0005* |
| General | 48 | 0 | 0 | 6 | 15 | 21% | 54 | 0 | 0 | 12 | 27 | 38% | .216 |
| Petting | 168 | 0 | 0 | 17 | 33 | 46% | 670 | 8 | 0 | 24 | 71 | 99% | <.0005* |
| Scratching | 29 | 0 | 0 | 7 | 12 | 17% | 317 | 4 | 0 | 21 | 53 | 73% | <.0005* |
| Kissing | 1 | 0 | 0 | 1 | 1 | 1% | 5 | 0 | 0 | 2 | 4 | 6% | .375 |
| Hug | 1 | 0 | 0 | 1 | 1 | 1% | 8 | 0 | 0 | 5 | 3 | 4% | .625 |
| Mistreatment | 6 | 0 | 0 | 3 | 3 | 4% | 8 | 0 | 0 | 3 | 4 | 6% | 1.000 |
| Verbal engagement | 397 | 2 | 0 | 33 | 59 | 82% | 534 | 7 | 0 | 26 | 62 | 86% | .200 |
| Salutation | 77 | 0 | 0 | 7 | 33 | 46% | 85 | 1 | 0 | 11 | 44 | 61% | .775 |
| General | 263 | 1 | 0 | 31 | 45 | 63% | 379 | 3 | 0 | 24 | 56 | 78% | .001* |
| Attempts at reciprocity | 1267 | 14 | 0 | 68 | 69 | 96% | 924 | 9 | 0 | 65 | 69 | 96% | .002* |
| Motioning | 189 | 1 | 0 | 28 | 43 | 60% | 149 | 1 | 0 | 13 | 39 | 54% | .341 |
| Directives | 301 | 2.5 | 0 | 22 | 48 | 67% | 248 | 1 | 0 | 20 | 44 | 61% | .127 |
| Questioning | 164 | 0 | 0 | 19 | 32 | 44% | 244 | 2 | 0 | 23 | 50 | 69% | .010 |
| Ball offering | 558 | 7 | 0 | 31 | 64 | 89% | 240 | 2 | 0 | 27 | 58 | 80% | <.0005* |
| Hand presentation | 55 | 0 | 0 | 5 | 29 | 40% | 43 | 0 | 0 | 4 | 23 | 32% | .499 |
| Apprehension | 26 | 0 | 0 | 6 | 13 | 18% | 8 | 0 | 0 | 5 | 4 | 6% | .006 |

*Note*. When the totals for higher level categories are higher than the sum of the totals for the subcategories, behaviors were coded at the higher level or other subcategories have been omitted.
*Statistically significant difference after adjusting for multiple comparisons using Holm's sequential Bonferroni method with family significance level .05.

**Table 1: Frequency of children's behavioural interactions toward robot dog and live do**

The results of the study showed that the children made social bonds with the robotic dogs. Although the majority of the participants responded that they acknowledged the robotic dog as a non-biological being, the actions made towards the AIBO suggested differently. The frequency of attempting reciprocity is significantly higher towards the robotic dog compared to the live dog. It should be noted that the AIBO model's exterior frame consists mainly of metal, highly different from a real dog. Despite the crude replication of a live dog, a significant amount of social touches were made. Younger children tend to infer life into objects that seems to express emotions and psychological features[13]. The high discrepancy of social touch frequencies in Table 1 can also be explained by the freedom of movement the live dog has in comparison to the robotic dog. The living dog is much more likely to be active towards the child, making it easier for the child to approach the dog. Over 60% of the children attributed emotional characteristics in the robot, some going as far as affirming to the question: "Can AIBO die?" This shows a high possibility of robotic pets being interactive toys with positive social impacts.

### Case Study 2 – Social Cat Robot

This study involved the observation of how children interact with a robot designed to semi-actively participate in a simple card guessing game[14]. The game was a high-low guessing game of six cards, one of which would be facing up and the other five facing down. The objective of the game was to guess whether the next card facing down would have a higher or lower value than the current faced up card. The iCat, a cat-shaped robot unable to make physical interactions would be positioned near the child and give audio stimulation appropriate to the situation. This was controlled in a 'Wizard of Oz' environment, where there would be a pilot controlling the actions of the cat outside of visual range. The children's actions were recorded for analysis and compared to different groups doing the same tasks in pairs or in solitude. The fairness of the game was programmed so that there would be a 50% win rate if the children made 'the logical decision'. The post test questionnaire reported that none of the seventy participants accused the system of being deterministic.

The results showed that the children preferred to play with the iCat over playing the game alone, but still preferred to play with a friend than with the iCat. This was reflective on the facial expressions and social actions towards the iCat while playing the game (figure 1). Also, younger children were more appreciative of the iCat's company than older children. This test has limited definite results because of the lacks of formalised measurement quantities for CRI, but showed promising prospects for interactive toys being utilised to improve social interaction while playing games.

The iCat did not show social bonding between the children and robot like the AIBO did in case study 1. Two arguments can be put forward here: 1. the iCat was outside of direct vision of the children. This decreases the amount of eye contact or visual stimuli the iCat can provoke to capture the attention of the children. It mainly relied on simple audio stimuli, such as encouragement when losing a game or clapping noises when they win, to communicate with the children. 2. The iCat has limited motion capabilities. It is able to form limited facial expressions, but it is placed outside of the children's direct visual range. The focus of the study was to observe different reactions children elicit when in company of a robot companion but because of the nature of the simple game, physical contact is unnecessary to engage or enjoy the game.

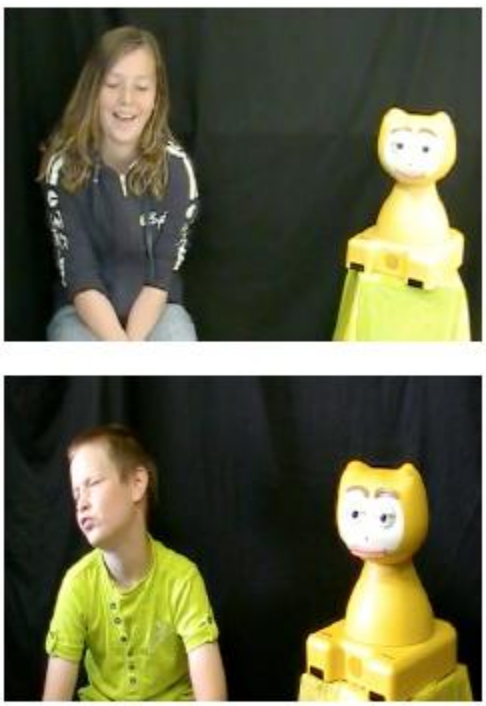

**Figure 1: 12 year old girl winning (top), 8 year old boy losing (bottom)**

**Case Study 3 – Anthropomorphic Robots**

A long-term study was conducted at an early childhood education centre to see the effects an anthropomorphic robot has on socialisation of toddlers[15]. The study was conducted for over five months where the quality of interaction between toddlers and robots was observed. The QRIO robot which was used in the study has multiple behavioural categories which stimulate interaction with the children. Once again, the sessions were video and audio recorded for analysis.

The study was conducted in three different phases: during phase I the robot is programmed to utilise its full interactive potential; during phase II the robot is dulled to produce highly predictable behaviour; and returned to its phase I status in phase III. The measure of quality of interaction is based on the level of visual contact, attempted vocal interactions and physical contact made with the robot.

Figure 2 shows that the robot was highly successful in having long term interaction with the toddlers during phases I and III. Quality of interaction was very high in situations where the robot would provide immediate feedback to the toddler's stimuli. For example, when the QRIO giggled immediately after being touched on the head showed better reactions compared to the robot waving back at the toddler after the toddler waves at the robot. Phase II had the robot repetitively dance to a pre-choreographed routine without interaction to the child. Children quickly lost interest in the robot.

This study shows the importance of quick feedback to stimuli during HRI. When response times become too long, social interaction cannot be established at a human-to-human level. A similar study using anthropomorphic robots in a Wizard of Oz environment gave positive results when the robot gave active feedback to the user[16]. Also, the gradual increase in quality of interaction is similar to that between people. Trust/interest is gained slowly in contrast to the rapid loss of trust/interest [9]. In normal children, the current level of anthropomorphism seems to have no large effect on CRI. Lipson and Gelman [13] state that by four years of age, people are able to distinguish between prototypical living and nonliving kinds based on biological properties. This could be the reason why anthropomorphic properties of robots are unable to fully deceive children into total immersion to believing the robots are real to form stronger relationships.

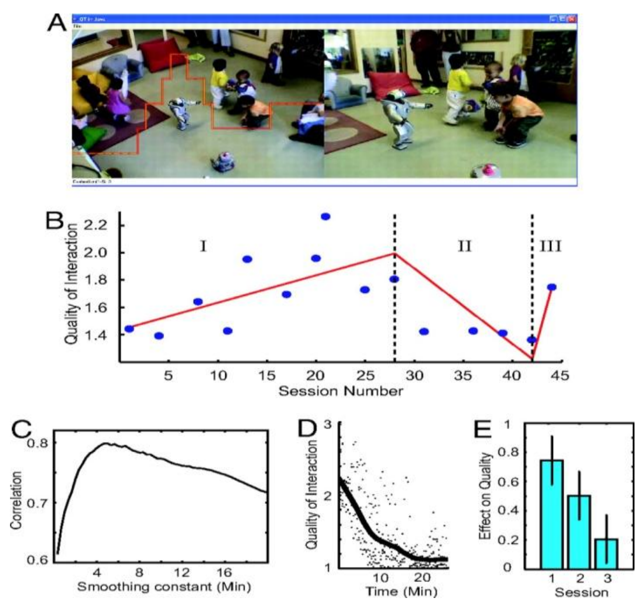

**Figure 2: Analyses of the quality of interaction**

## CHILD ROBOT INTERACTION IN CHILDREN WITH AUTISM

Children with autism are more likely to have difficulties communicating with other people[17]. Autism here refers to Autistic Spectrum Disorders (ASD) and is related to impaired development of communication and social interaction. Attempts at therapeutic treatment using robots such as the Aurora project[18] which is a long term project utilising robotic toys to conduct treatment studies on autistic children. Using anthropomorphic robots such as KASPAR, autistic children simulate specific scenarios or plays games to try to increase the level of interaction. The base theory behind this is to redirect the target of communication from humans to interactive robots which are hopefully easier to approach for autistic children.

[10] conducted a study where autistic children would be observed for changes in behaviour between a toy truck and an interactive robot. The robot was capable of simple navigation with collision avoidance and communication in short phrases. Interactive actions included following and chasing the child at comfortable speeds to try stimulate a reaction. The results show that in some cases the robot received much more attention than the toy truck. Figure 3 depicts the varying results that occurred amongst the seven participants.

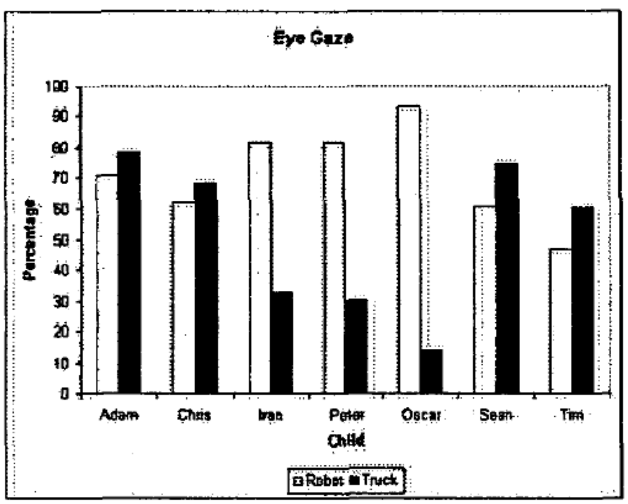


**Figure 3: Histogram showing comparative eye gaze behaviours in terms of percentages (total duration of eye gaze behaviour in relation to the duration of the section)**

The high variance and seeming randomness of results can be explained by the nature of autism. It is very specific to individuals causing varying results. Ivan, Peter and Oscar showed a large improvement in eye gaze towards the truck while the other four children showed similar visual interest in both toys.

Also, the paper states that eye gaze is not a definitive quantity to measure quality of interaction. Adam, the most able child out of the participants showed great interest in the robot and spent much of the session asking the supervisor about the mechanics of the robot, reducing the total eye gaze on the robot whilst it is clear that his focus is on the robot. Factoring in verbal interaction and focus, Adam's attention to the robot was 94.9% of the session length.

The results also show that every child had some sort of interest in the robot toy, even if it was not sustained for the whole period. Judging from eye gaze alone, the average eye gaze behaviour as a percentage of the total duration is approximately 60%. This is a positive conclusion as it is often difficult to grasp the attention of autistic children.

KASPAR is another toy used in supporting autistic children. [17] conducted a study on teaching autistic children about social physical contact etiquettes. A basic game would be played where KASPAR would react to different types of contact made by the child. Tickling the robot would cause it to laugh and forceful contact would cause the robot to express a sad face and turn away from the child.

Initial interactions showed that the children saw KASPAR as a toy without respecting it as an anthropomorphic robot. Aggressive explorative behaviour would be applied to the robot. However, with increased exposure to the robot's discomforting reactions to forceful actions the children respond to the robot's happy expression with laughter when treated with more appropriate contact. By using an anthropomorphic robot, it teaches the children that the types of contact made towards the robot will bring similar results when applied to other humans.

Robots are especially suiting for educating autistic children, because they generally learn at a slower pace and require much repetition. Humans cannot be subject to the actions autistic children apply to the robots whilst consistently reacting in the appropriate manner. Anthropomorphic features deceive the child to a degree to which they are able to correlate the similarities between the robot and humans while at the same time, being able to identify that the robot is a nonliving machine.

## CONCLUSION

Contemporary studies carried out on children have consistently shown improvements in increasing child attention towards the robot. The study using anthropomorphic robots at the kindergarten showed the effects of varying certain conditions on the quality of CRI. However, the lack of standardisation of HRI remains a problem. The various case studies are based on the same fundamental concept of HRI, but each have different methods of measuring interaction such as eye gaze, quality of interaction. This makes it very difficult for new academics to understand and make comparisons and correlations between the studies in the quantitative aspect. Furthermore, the quantities used in HRI are derived from human to human heuristics. This is suitable for anthropomorphic robots, but for those that aren't requires a different dedicated study of 'human to non-anthropomorphic robot interaction'. New academic areas such as the science of machine learning[19] and redefining ontology in retrospect of anthropomorphic robots[20] have appeared, which are directing towards formalising human robot interaction.

## REFERENCES


1. **Steinfeld, A., et al., *Common metrics for human-robot interaction*, in *Proceedings of the 1st ACM SIGCHI/SIGART conference on Human-robot interaction*2006, ACM: Salt Lake City, Utah, USA. p. 33-40.** http://dl.acm.org/citation.cfm?id=1121249
2. **Maali, Y. and A. Al-Jumaily. *Soft computing based biosignals in human machine interaction for assistive devices*. in *Advanced Information Management and Service (IMS), 2010 6th International Conference on*. 2010.** http://ieeexplore.ieee.org.ezproxy.auckland.ac.nz/stamp/stamp.jsp?tp=&arnumber=5713469
3. **Dautenhahn, K., *Socially Intelligent Robots: Dimensions of Human-Robot Interaction.* Philosophical Transactions: Biological Sciences, 2007. 362(1480): p. 679-704.** http://www.jstor.org.ezproxy.auckland.ac.nz/stable/pdfplus/20209878.pdf?acceptTC=true
4. **Chapman, A.J., *Social Facilitation of Laughter in Children.* Journal of Experimental Social Psychology, 1973. 9(6): p. 528-41.** http://www.eric.ed.gov/ERICWebPortal/detail?accno=EJ088953
5. **Dautenhahn, D.K., D.B. Robins, and J. Wearne. *KASPAR the robot*. [cited 2013 5th April]; Available from:** http://www.kaspar.herts.ac.uk/kaspar/kaspar-the-robot.htm.
6. **Corporation, S. *Sony Launches Four-Legged Entertainment Robot*. [cited 2013 5th April]; Available from:** http://www.sony.net/SonyInfo/News/Press_Archive/199905/99-046/index.html.
7. **Melson, G.F., et al., *Children's behavior toward and understanding of robotic and living dogs.* Journal of Applied Developmental Psychology, 2009. 30(2): p. 92-102.** http://www.sciencedirect.com/science/article/pii/S0193397308001329
8. ***Human Robot Interaction Organisation*. [cited 2013 6th April]; Available from:** http://humanrobotinteraction.org/.
9. **Saleh, J.A., F. Karray, and M. Morckos. *Modelling of robot attention demand in human-robot interaction using finite fuzzy state automata*. in *Fuzzy Systems (FUZZ-IEEE), 2012 IEEE International Conference on*. 2012.** http://ieeexplore.ieee.org.ezproxy.auckland.ac.nz/stamp/stamp.jsp?tp=&arnumber=6250792
10. **Dautenhahn, K. and I. Werry. *A quantitative technique for analysing robot-human interactions*. in *Intelligent Robots and Systems, 2002. IEEE/RSJ International Conference on*. 2002.** http://ieeexplore.ieee.org.ezproxy.auckland.ac.nz/stamp/stamp.jsp?tp=&arnumber=1043883
11. **Nehaniv, C.L., et al. *A methodological approach relating the classification of gesture to identification of human intent in the context of human-robot interaction*. in *Robot and Human Interactive Communication, 2005. ROMAN 2005. IEEE International Workshop on*. 2005.** http://ieeexplore.ieee.org.ezproxy.auckland.ac.nz/stamp/stamp.jsp?tp=&arnumber=1513807
12. **Sharkey, A. and N. Sharkey, *Children, the Elderly, and Interactive Robots.* IEEE Robotics & Automation Magazine, 2011. 18(1): p. 32-38.** http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=5751987&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D5751987
13. **Jipson, J.L. and S.A. Gelman, *Robots and Rodents: Children's Inferences About Living and Nonliving Kinds.* Child Development, 2007. 78(6): p. 1675-1688.** http://onlinelibrary.wiley.com/doi/10.1111/j.1467-8624.2007.01095.x/abstract
14. **Shahid, S., E. Krahmer, and M. Swerts, *Child-robot interaction: playing alone or together?*, in *CHI '11 Extended Abstracts on Human Factors in Computing Systems*2011, ACM: Vancouver, BC, Canada. p. 1399-1404.** http://delivery.acm.org/10.1145/1980000/1979781/p1399-shahid.pdf?ip=130.216.24.167&acc=ACTIVE%20SERVICE&key=C2716FEBFA981EF170F24D6534951B0D7F576284B32AF9B7&CFID=310754499&CFTOKEN=33090181&__acm__=1365572429_5b4854ae0000abd5ad9e0dab248e9d6e
15. **Tanaka, F., A. Cicourel, and J.R. Movellan, *Socialization between toddlers and robots at an early childhood education center.* Proceedings of the National Academy of Sciences, 2007. 104(46): p. 17954-17958.** http://tdlc.ucsd.edu/research/publications/Tanaka_etal_Socialization_2007.pdf
16. **Tony Belpaeme, P.E.B., Robin Read, Rachel Wood, Heriberto Cuayáhuitl, Bernd Kiefer, Stefania Racioppa, Ivana Kruijff-Korbayová, Georgios Athanasopoulos, Valentin Enescu,**

**Rosemarijn Looije, Mark Neerincx, Yiannis Demiris, Raquel Ros-Espinoza, Aryel Beck, Lola Cañamero, Antione Hiolle, Matthew Lewis, Ilaria Baroni, Marco Nalin, Piero Cosi, Giulio Paci, Fabio Tesser, Giacomo Sommavilla, Remi Humbert, *Multimodal Child-Robot Interaction: Building Social Bonds.* Journal of Human-Robot Interaction, 2012. 1(2): p. 33-53.**
http://humanrobotinteraction.org/journal/index.php/HRI/article/view/62/67

17. **Robins, B., K. Dautenhahn, and P. Dickerson, *Embodiment and Cognitive Learning – Can a Humanoid Robot Help Children with Autism to Learn about Tactile Social Behaviour?* 4th International Conference, ICSR 2012, Chengdu, China, October 29-31, 2012. Proceedings, 2012: p. pp 66-75.**
http://link.springer.com/content/pdf/10.1007%2F978-3-642-34103-8_7

18. **Dautenhahn, P.K., et al. *The AuRoRa Project - University of Hertfordshire*. [cited 2013 6th April]; Available from:** http://www.aurora-project.com/.

19. **Meltzoff, A.N., et al., *Foundations for a New Science of Learning.* Science, 2009. 325(5938): p. 284-288.**
http://www.sciencemag.org/content/325/5938/284.full.pdf

20. **Peter H. Kahn, J., et al., *The new ontological category hypothesis in human-robot interaction*, in *Proceedings of the 6th international conference on Human-robot interaction*2011, ACM: Lausanne, Switzerland. p. 159-160.**

http://dl.acm.org.ezproxy.auckland.ac.nz/citation.cfm?id=1957656