Emotion recognition in robots in a social game for autistic children

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Abstract. This paper provides a framework for a social game that has as a goal improving the social interaction skills through associative play. It describes the design of the game platform and an ongoing study on the perception of emotional expression from motion cues for communication and social coordination. Especially, children with autism spectrum disorders are targeted, since they will benefit most from behavioral training that may improve their social skills. The promising results from two stages of this work are shown.

1 Introduction

The ability to recognize a behaviour within a social context is the foundation of social interaction. The nonverbal ways for conveying socially relevant information include facial expressions and body movements [4][13]. Neurological studies suggest that understanding nonverbal communication of facial expressions and body movements involves the mirror neuron system. However, Montgomery and Haxby [11] showed that these two forms of nonverbal social communication have distinct representations within that system, so it is plausible to study them separately. We focus on body movement as means of conveying social information.

The aim of this work is teaching of socially relevant behaviours to children through games. Simple and most obvious value of games is enjoyment and the sharing of social experiences with others [8]. In addition, play is widely used as a preferred educational activity for younger children. Especially, we target autistic children, since they are marked by delays in social development [4] and will benefit most of such training.

More specifically, there is evidence that individuals with autistic spectrum disorders do not interpret social messages that motion conveys as typical people do. Moore, Hobson, and Lee [12] found that 14- year-old individuals with autism have deficits in perceiving emotion related attitudes and subjective states, given the motion cues of a point-light-walker display [2][12]. This finding reveals a deficit in perceiving mental states based on motion cues. Klin [8] found autism specific differences in people's descriptions of the Heider and Simmel task [6]. Heider and Simmel [6] showed to subjects actions of simple geometric figures. The subjects were asked to narrate the perceived actions. The subjects reported to see that geometric figures had goals, desires, intentions and emotions. Klin [8] conducted an experiment with sixty participants with autism that were asked to provide narratives describing Heider and Simmel's animation. He found differences at interpreting social motion in autistic people, suggesting the important developmental question of whether people with autism would have typical precursors to this ability to perceive social information in motion cues.

In this paper, featuring several studies, we want to investigate the following question: even if autistic children can not recognize the social cues naturally, are we able to teach them socially relevant emotional expressions by motion cues through rule-based learning. Therefore we developed and tested a game that includes initial emotional behaviours on robots for training autistic children. The emotional robotic behaviors were additionally tested and optimized on a follow up study.

2 Game design

Play is the preferred activity of every child. In an investigation of social play behaviour Parten [14] distinguishes between several types of play, depending on the level of social involvement of the children, namely *solitary independent play, parallel activity, associative play, and cooperative or organized supplementary play.* These play behaviors were found typical for different age groups. Autistic children are most often observed to be engaged in *solitary independent play* and some in *parallel activity*, even when their age progresses.

In *solitary independent play* the child plays alone and independently with toys that are different from those used by the other children and s/he makes no effort to get close to other children. S/he pursues her/his own activity without reference to what others are doing. In *parallel activity* the child plays independently, but the activity chosen naturally brings him/her among other children. The child plays with toys that are like those which the other children are using, but does not try to influence/modify the activity of nearby children.

In *associative play* the child plays with other children. There is a greater level of awareness of the peers and there is a borrowing and loaning of play material; there is evident interaction, as for instance, following one another with trains or wagons; mild attempts to control which children may or may not play in the group are present as well.

Most autistic children stay within *solitary independent play* or *parallel activity* even when their age progresses. We aim to shift the autistic play from *solitary independent play* or *parallel activity* towards the mid ground between *parallel activity* and *associative play* through a game. Teaching all the elements of the *associative play* to autistic children is too ambitious goal. We aim to stimulate parallel play with elements of *associative play*. To narrow the scope and make the right design choices, a good overview of the existing literature was made, as well as observations and interviews with caretakers were performed. The following problems were identified: inability to share and socially interact, inability to understand expression of emotion and link them to context, preference to learn by teaching and logic rather than by trial and error.

To account for these problems, a combined approach of a game that will require negotiations and working towards a common goal, together with recognition of emotional states was made. The game uses a storyline that describes various situations involving different emotions. Recognizing the emotion will make the children command a robot, by their collective physical behavior. In response, the robot displays movements representing the emotions that the storyline refers to. In slightly different scenario the recognized emotion has to be changed. The bottom line of the game is that the children have to identify the correct emotion based on the story and movement. The teacher can use different by complexity storylines referring to an emotion, that will consequently be acted by the movement of the robot. With this multivalent approach we aimed at an integrated understanding of the acted emotion.

For the purpose of the game the following system was developed. A huge round disk that could accommodate several children was made (Figure 1). The disc can control the movement of a robot by being tilted in a certain direction. The robot in the game situations is drawn as a small green object near the platform. It resembles the shape and the size of the e-puck robot [5] that was used for this experiment. The e-puck is a two-wheel mobile robot that was originally developed at Swiss Federal Institute of Technology (EPFL). The robot is equipped with a dsPIC processor and can be controlled by blue tooth through the computer, or a very simple program can be uploaded on the dsPIC processor. We used computer-mediated control.

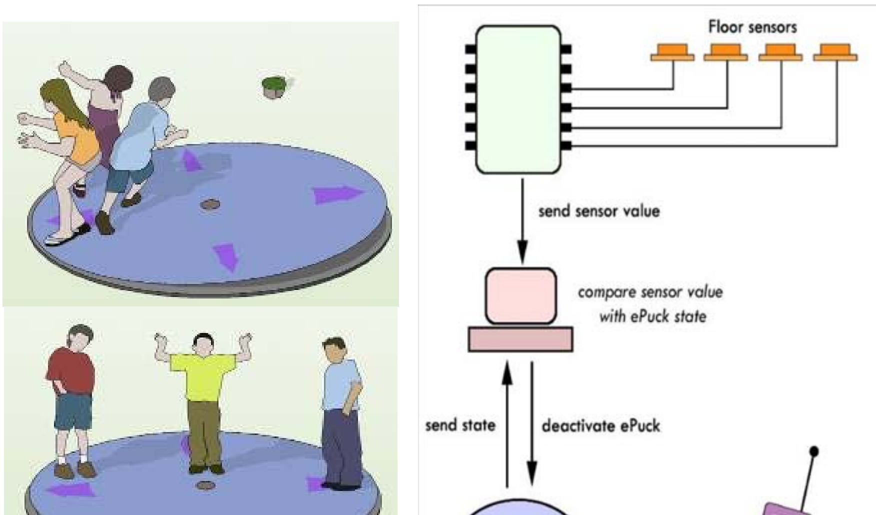

Figure 1 Game situations and flowchart of the game platform. The robot in the game situations is drawn as a small green object near the platform.

The children, standing on top of the platform, had to negotiate their positions since a single child could not tilt the disc. Once multiple children moved to the right position and the disc tilted at that direction, the corresponding behaviour of the robot was triggered. To change the robot emotional behavior, the children had to agree on their next position and move together. When conflicting views occur, it was an opportunity for the children to learn to negotiate and get aware that they need others' help.

3 Emotional behaviours in perspective

The emotional behaviours of the robot were central in this work. The aim of the designed game was not to create a framework in which autistic persons can directly recognize emotions, but rather an appealing platform and a game which can further be used to teach emotional behaviors. A study by Pierno and colleagues [15] concludes that visuomotor priming proceeds normally in children with autism when primed by a robot. This finding is consistent with other results demonstrating that people with autism perform at normal to superior levels at tasks presented in a repeatable and predictable formats established by a robot or a computer [16][17]. However, autistic children will most probably fail to recognise the emotional behaviors at first.

At the first stage of the project robot behaviours were created only based on observations of humans. As expected, the behaviours were not recognized by the autistic children during the user tests. The reasons for that could be either the lack of social understanding of autistic children, or the poor design of the behaviours. To clarify the reason for that, and improve the design of emotional behaviors so they can be used for teaching social skills, a follow-up study was conducted that focused on the construction of the emotional behaviours. To target this problem specifically, a control user group of 42 typically developing children was tested. The new behaviours were designed after an extensive literature review on dance [3] and Laban movement analysis, and on animation and deducting emotions from recorded human motion [1].

The outcome of the tests showed a good recognition of several basic emotions (Figure 2). It is important to mention that the children were not provided with a list of emotions to choose from. After the first user test there were occasions of decreased recognition for two behaviours. This chart shows the recognition rate in percents of better designed emotional behaviours of each test.

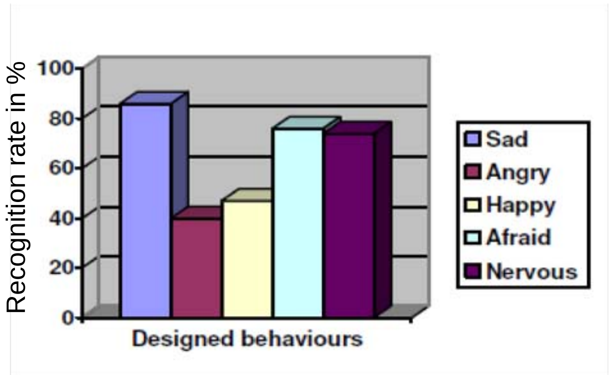

Figure 2 Recognition rate of basic emotions.

4 Discussion

A framework and the available results of an ongoing work on designing game for teaching emotional behaviours to autistic children with autonomous robots is presented. Two tasks, one of designing the game and the other of designing emotional behaviors were pursued. The second task is considerably more challenging, and its solution requires a multidisciplinary approach. Therefore the behaviors were redesigned several times based on the research findings from different disciplines related to movement analysis. Compared to related studies, we have reached a considerably better recognition rate on the 3 of 5 emotional behaviors, and we are currently working on further optimization the whole spectrum of behaviors. The final behaviors so far are tested on typically developing children of similar age as the autistic children, and further testing with autistic children and training is forthcoming.

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References

[1] Amaya, K., Emotion from motion, 1996 Graphics Interface.

[2] Blake R, Turner LM, Smoski MJ, Pozdol SL, Stone, WL (2003) , Visual recognition of biological motion is impaired in children with autism. *Psychol Sci* 14:151–157.

[3] Camurria, A.; Lagerl, I.; Volpe, G., Recognizing emotions from dance movements, 2003

[4] Diagnostic Criteria for Autistic Disorder, Indiana Resource Center for Autism, Indiana Institute on Disability and Community, Indiana University. Retrieved Feb. 27, 2007

[5] E-puck education robot, http://www.e-puck.org.

[6] Heider, F., & Simmel, M. (1944). An experimental study of apparent behavior. *American Journal of Psychology*, 57, 243–259.

[7] Hobson, P. (1993). Understanding persons: The role of affect. In S. Baron-Cohen, H. Tager-Flusberg, & D. J. Cohen (Eds.), *Understanding other minds: Perspectives from autism* (pp. 204–227). Oxford, UK: Oxford University Press.

[8] Klin, A. (2000). Attributing social meaning to ambiguous visual stimuli in higher-functioning autism and Asperger syndrome: The Social Attribution Task. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, 41, 831–846.

[9] Melamed, L.., 'Games for Growth', *In Celebration of play*, Pg 162, London 180: Croom Helm Ltd.

[10] Michotte, A. (1963). *The perception of causality.* Oxford: Basic Books.

[11] Montgomery, K. J. and Haxby, J. V., Mirror Neuron System Differentially Activated by Facial Expressions and Social Hand Gestures: A Functional Magnetic Resonance Imaging Study, *Journal of Cognitive Neuroscience* 20:10, pp. 1–12.

[12] Moore, D., Hobson, R. P., & Lee, A. (1997). Components of person perception: An investigation with autistic, non-autistic retarded and typically developing children and adolescents. *British Journal of Developmental Psychology*, 15, 401-423.

[13] Parr, L. A., Waller, B. M., & Fugate, J. (2005). Emotional communication in primates: Implications for neurobiology. *Current Opinion in Neurobiology*, 15, 716–720.

[14] Parten, M. (1932). Social participation among preschool children. *Journal of Abnormal and Social Psychology*, 27, 242-269.

[15] Andrea C. Pierno, Morena Mari, Dean Lusher, Umberto Castiello, Robotic movement elicits visuomotor priming in children with autism, NeuropsychologiaVolume 46, Issue 2, , 2008, Pages 448-454.

[16] Robins, B., Dautenhahn, K., Dickerson, P., & Stribling, P. (2004). Robotmediated joint attention in children with autism. *Interaction Studies*, *5*, 161–198.

[17] Werry, I., Dautenhahn, K., Ogden, B., & Harwin, W. (2001). Can social interaction skills be taught by a social agent_ The role of a robotic mediator in autism therapy. In M. Beynon, C. L. Nehaniv, & K. Dautenhahn (Eds.), *Cognitive Technology: Instruments of Mind: 4th International Conference, CI 2001*, Warwick, UK, August 6–9, 2001,