Cognitive and emotional interactions between autistic child, mobile robot and therapist: a case report

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INTRODUCTION

Infantile autism is a neurodevelopmental disorder, which is characterised by difficulties in social and interpersonal communication as well as in processing own and other people's emotions (DSM-IV-TR, 2003). Emotional impairment is thought to be a consequence of deficits associated with different cognitive processes (Boddaert et al., 2004; Courchesne, 1997; Belin et al., 2000 for example).

As would be expected, a large number of functional neuroimaging studies have provided the basis for concluding that in autism the more impaired cortical areas are those that are involved in complex cognitive functions such as perception, as well as social interaction and emotion (Corbett et al., 2009; Castelli, 2005 for example).

In autism rehabilitation therapy, different approaches are based on the belief that artificial environments i.e., robots, seem to be more helpful than real environments in allowing autistic children to express social interest. In order to study effectively the robot-child interaction, researchers have used fixed (Kozima, and Yasuda, 2007; Michaud et al., 2007; Robins and Dautenhahn, 2007; Billard et al, 2008) or mobile (Dautenhahn, 2007; Giannopulu and Pradel, 2009a; Giannopulu and Pradel, 2009b; Giannopulu and Pradel, 2010) robots. With the exception of Robins and Dautenhahn (2007) study, so far, the previous studies have reported dyadic child-robot interaction. The focal point of the analysis was on a single mode of interaction. As far as we know, only two studies have reported multimodal interactions in dyadic relationships i.e., between the autistic child and a mobile robot in spontaneous free game play (Giannopulu and Pradel, 2009a; Giannopulu and Pradel, 2009b; Giannopulu and Pradel, 2010). Using the spontaneous free game play, once again, the present case study aims to examine the role of a mobile robot in the context of cognitive and emotional interaction of the autistic child with a third person: the therapist. The three-pronged interaction among the autistic child, the robot and the therapist will be investigated in spontaneous, free game play by means of a multimodal approach. We hypothesise that once child-robot interaction is established, the child will use the robot as a mediator to initiate the interaction with the therapist and express emotion.

METHOD

"A" is a right-handed young boy. The child was diagnosed with autism when he was 3 years old. The Childhood Autism Rating Scale (Schopler et al., 1980) has shown severe autism with a score of 43 points.

The study was approved by the local Ethical Committee and conforms to the Helsinki convention. The experiment took place in a room familiar to the child. The therapist who is familiar with the child was present in the room.

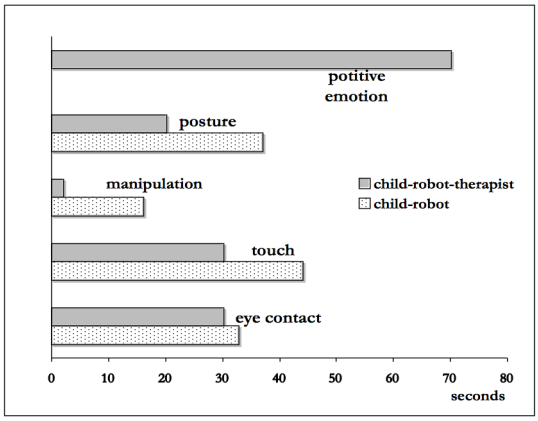
The duration of the session was 5 minutes. A mobile robot, called "GIPY-1", which is cylindrical-shaped was used (see also Giannopulu and Pradel, 2009a&b, 2010).

The robot was placed in the centre of the room. As in real social interaction, the child and the robot altered their responses. If the child approached, the robot moved back and conversely. If the child moved away from the robot, the robot followed the child in order to attract his attention. If the child remained motionless, the robot approached or turned itself around in order to focus the attention of the child. All movements of the robot were standardised.

The dependant variable was the time of child-robot interaction and child-robot-therapist. This was defined as the duration between the onset time and the offset time of each child's behaviour toward the robot. Five criteria were defined: 1) eye contact (looking at the robot), 2) touch (touching the robot without manipulating it), 3) manipulation (operating the robot), 4) posture (changing corporal position toward the robot) and 5) positive emotion (display of enjoyment). The duration of each criterion was calculated in seconds and was considered independently of the others. We summed up the duration corresponding to each criterion.

RESULTS

The duration time of child-robot interaction and child-robot-therapist interaction is presented here below.



Total duration of child-robot and child-robot-therapist interactions

The duration time of "eye contact" and of "touch" is quite similar in both situations. However the duration time of "manipulation", of "posture" and of "positive emotion" differ between the two situations. Positive emotion is more easily expressed when the child interacts with the therapist and the robot than when the child interacts only with the robot. Two independent judges unfamiliar with the aim of the study completed the observations of the game play skills. The inter-judge reliability was good (Cohen's kappa =0.63).

DISCUSSION

Consistent with our hypothesis, the child first establishes a relationship with the robot and then uses the robot as an "instrument" to initiate the interaction with the therapist. At first glance, our results are compatible with recent findings according to which artificial environments i.e., presence of a robot, are more effective than real environments in allowing autistic children to express social interest towards the robot (Dautenhahn, 2007; Robins and Dautenhahn, 2007; Kozima and Yasuda, 2007; Michaud et al., 2007; Billard et al, 2008 for example). In these studies, researchers have used robots for treating autistic children. However, the relationship between robot and child has been studied solely based on the analysis. With the exception of Robins and Bautenhahn' study (2007), so far, only a single mode of interaction have been utilized. All these studies have been conducted using fixed robots. Our results go beyond these findings because we have demonstrated, as far we know for the first time using a multimodal approach, that in spontaneous, free game play, an autistic child uses the robot to interact with the therapist and to express positive emotion. As such, on the one hand, we have shown that the child-robot interaction is based on a cognitive state and, on the other, that the child uses the robot as a mediator to express positive emotion playing with the therapist.

More precisely, in our study, the interaction between robot and child was analyzed using different criteria such as eye contact, manipulating, touch, posture. Consistent with our previous studies (Giannopulu and Pradel, 2009a; Giannopulu and Pradel, 2009b; Giannopulu and Pradel, 2010), we have demonstrated that visual, haptic, tactile perception and posture, i.e., multimodal perception, are on the basis of the interest the child displays towards the robot. This is because, in our approach, perception and cognition are considered to be a single domain rather than two distinct entities. The criteria we have chosen are assumed to represent the state of the child's cognitive processes, as expressed by the interest the child exhibits towards the robot in spontaneous, free game play (Giannopulu and Pradel, 2010). As our case study has shown, once this state is established, the child develops a triadic relation i.e., with the robot and the therapist, thereby displaying enjoyment, which is a positive emotion. The expression of positive emotion could be related to the emergence of a cognitive state, which is multimodal in our case. This expression appears when the child interacts with the therapist using the robot. This is not the case when the child interacts with the robot only. This is a very important finding when we consider that the subject of our case study "A" exhibited a score of 43 which corresponds to severe autism.

What is important is the "passage" from child-robot interaction to child-robot-therapist interaction. When "A" interacts with both the robot and the therapist, he changes his behavior. What causes this behavioral modification? We think that the robot as a mediator could bring about neuropsychological improvements to the autistic child. As the results have shown, the extent of that improvement seems to be smaller when the child interacts with the robot than when he interacts with the therapist. We believe that the child's reactions to the robot are very important in establishing child interest and are of paramount importance in robot therapy. In fact, this child-robot interaction could be thought of as the building block from which the relationship among humans may be developed. Consistent with this interpretation may be the fact that positive emotion is expressed only when the child interacts with the therapist via the robot. Positive emotion is quasi-absent when the child interacts with the mobile robot on a standalone basis. As such, this study is to our knowledge, one of the first to show that in spontaneous free game play the robot is a tool, which can help autistic children engage in social and emotional interaction with adults. It seems thus reasonable to infer that the three-pronged interaction i.e., child-robot-therapist could better facilitate the transfer of social and emotional abilities to real life. Considering the above, it would be fair to conclude that autism therapy using robots seems to be effective, safe and convenient.

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