A humanoid robot for autism rehabilitation: Does IQ influence response in child-robot interaction?

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ABSTRACT – Recent advances show that robots have unlimited potential to help the disabled community by providing physical support, social engagement and even co-therapy in collaboration with another human. For children with autism, a robot in human shape might be able to help them to learn better and encourage social-communication skills. To prove this, the key initial step is to explore the initial response of children with autism when they interact with a humanoid robot in an experimental setting. We hypothesize that a robot's presence coupled with specific interplay shall attract the children's attention to engage in robot-based interaction. The initial responses will be utilized to seek association between responses to the robot with the children's intelligence level. Twelve autistic children with IQs between 44 and 107 were exposed to different interactions. Behavior evaluation showed that in the presence of the robot, lower autistic traits were recorded in the subscale of stereotyped behavior and communication. Also, children with IQs higher than 80 were more receptive to robot-based single exposure.

1. INTRODUCTION

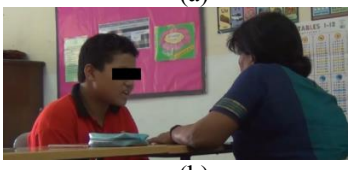
The work in this study is motivated by the fact that children with autism are naturally attracted to inanimate, interactive technological devices. Autism is a spectrum disorder characterized by stereotyped behavior and impaired communication and social skills. An individual can be diagnosed with autism as early as before the age of three years. Statistics estimate 1 in every 91 children in the United States [1] and 1 in every 600 children in Malaysia [2] are diagnosed with autism. Thus, there is an urgent need for suitable rehabilitation measures. Early intervention is critical to help children inflicted with autism lead productive lives [3].

Related work in autism intervention has reported positive responses where robots aid the children in areas of social skills [4], communication [5] and even act as playful companions [6] among others. As reported by Baron-Cohen [7] and Pierno et al. [8], people with autism cannot cope with systems of high variance such as social behaviour, conversation and human emotions. Hence, robots with simpler appearance offer minimal variance and stimuli to attract responses during interaction. Next, we seek to find the association between intelligent quotient (IQ) scores and response to robot intervention. IQ scores in autistic children have been recognized as a factor to indicate the success of a particular autism intervention program and also influence the outcome of a particular therapy.

2. METHODOLOGY

Twelve autistic children aged between 7 and 13 years old with IQs on the Stanford Binet between 44 and 107 were exposed to interaction with the humanoid robot NAO. The aim was to investigate the children's initial response a single, first time exposure to a robot and relate this to their intelligence level. As highlighted by Dautenhahn [9], establishing first impressions is important in HRI-based research. The effect of the first encounter between children with autism and a specific type of robot is important before embarking on long-term interactions. Total duration of interaction was 14 minutes and 30 seconds. Interaction contents were decided with advice from experienced clinicians in autism. As fast jerky motions can be dangerous [10], the robot was programmed to keep its movements simple and predictable (Figure 1 (a)).

(a)



(b)

Figure 1 Comparison of interaction with (a) a robot and (b) a familiar teacher, both done at child's school

Comparative observations were carried out on the same 12 subjects during school hours. This was to evaluate their typical behavior (Figure 1 (b)) for the same duration of contact time during the robot observation. The main difference between the two settings is that the robot was not present in the class

setting. A class teacher is present in both situations. The notion to carry out a comparative type of study on HRI has been mentioned in a recent study [9], where in the first setting the participant is exposed to the robot. In the second setting, the condition is different (no robot is involved), but it needs to be comparable to the first one. The purpose is to highlight the added value of robotic presence.

To assess the children's autistic characteristics, a behavior score sheet referenced to known and accepted autistic traits within usual practice parameters were formulated. 24 items of observation were identified and divided into subscales of stereotyped behavior, communication and social interaction [11].

3. RESULTS AND DISCUSSION

3.1 Response to a Robot

Qualitative results from video evaluations showed that 10 children responded positively with reduced autistic behavior in the subscale of stereotyped behavior and communication, compared with 7 children for the social interaction subscale. Technically, we concluded that the interaction scenario was not socially engaging enough for the children. Also, observations showed that during the interaction period with the robot, the children displayed less autistic behavior compared with their regular behavior in the classroom. Furthermore, the presence of the robot did not scare or intimidate the children. Keeping the programmed interaction simple and plausible is important, especially for the first session when the child meets the robot.

3.2 Association with IQ Level

IQ levels were grouped into impaired range (IQ < 80) and normal range (IQ>80). The IQ ranges were analyzed for association between subscales within the robot interaction setting. A paired sample *t*-test showed that children with higher IQ (within normal range) had shown lower autistic characteristics in all 3 subscales. However, the differences in the observed parameters were not statistically significant ($p>0.05$). Further analysis of IQ groups (normal range vs impaired range) in the different settings (robot setting vs classroom setting) showed further pattern of IQ difference after a single exposure. The children with IQ scores of more than 80 fared better in all subscales of autistic characteristics. Thus, autistic children with IQ score between 80 and 109 were found to give encouraging responses to the robot, resulting with less autistic traits across all three behavior subscales. However, this difference was only statistically significant ($p<0.05$) in the stereotyped behavior subscale.

4. CONCLUSION AND FUTURE WORKS

Though promising results were obtained in this experiment, the results of initial exposure requires further investigation involving more subjects and repetitive exposure in the future. Elements of two-way communication will be embedded in the robot scenarios to increase the children's participation. A face recognition algorithm has been developed to enhance the sociability of the robot during the initial interaction.

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