Can NAO Robot Improve Eye-Gaze Attention of Children with High Functioning Autism?

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This abstract presents the results of a preliminary study on understanding how humanoid robots can successfully improve social and communication skills among children with Autism Spectrum Disorders (ASD). Children with ASD experience deficits in appropriate verbal and nonverbal communication skills including motor control, emotional facial expressions, eye-gaze attention, and joint attention. Studies have shown that positive feedback from the robot on the participants' performance is an effective way to encourage children with ASD to communicate more. Other studies have also examined the use of affect recognition based on psychophysiological responses to modify the behaviors during a robotic game. However, there is limited information on the utility of humanoid robots' positive feedback in interventions for individuals with ASD.

The objective of this research study is to evaluate whether a humanoid robot (NAO) is able to improve eye-gaze attention, and joint attention skills in children with HFA. Eleven young children (verbal) and one child (non-verbal) with high functioning autism (HFA) ages 7-17 (M=11.5 years) have participated in this study. The study consists of two main games, and one special fun-based session where the children play with the humanoid robot. The games are called NAO Spy (NS) and the Find the Suspects (FTS) where during each game children were given opportunities to engage in eye-gaze attention, and joint attention during interactions with the NAO robot. For instance, during the games, NAO asked the participants a few simple questions and waited for them to answer and then touch one of the pressure sensors on his head to continue. Once the participant answered and touched the sensor, NAO asked the same questions again but asked the participant to look at him in the eye when answering the question. Videos of these sessions were recorded using external cameras an NAO's camera.

In this preliminary study, 344,963 frames total (about 11500 seconds, M = 235s in each session) were manually coded offline using the Continuous Measurement System. Every video frame was labeled either as "0" or "1". Label '0' represents when participants looked away from the robot, '1' represents when they were looking at the robot. Every time when '1' changes to '0' is considered as an eye-gaze shifting and vice versa. The total percentage of the eye-gaze duration and the frequency of shifting were calculated in each session. This was then compared with one another to show the improvement of eye-gaze attention.

Results: Participants spent, on average, approximately 50% of the session directing their gaze towards NAO (M=64%, range= 32-99%). Participants also engaged in frequent gaze shifts towards and away from NAO during the session (M=0.0075, range=0.0031-0.0152) indicating that they were directing their attention towards the robot and modulating their gaze during the sessions.

The results of the current study provide evidence that participants with ASD can learn to interact with the humanoid robot and engage in an important social-communicative behavior (i.e., making and maintaining eye contact). Results also show that participants learned to make and maintain increasing levels of eye contact across sessions with the humanoid robot suggesting that participants were engaging with and attending to the robot in ways that make the robot a potentially useful clinical tool. Across the three sessions, participants showed improvements in their gaze attention towards the robot suggesting they were paying attention to and looking at the robot in a similar way that one would expect they would look at a human clinician. This is particularly important with regards to the FTS game where the robot asked participants to look at his eyes while they answered a question. The gaze duration data from the FTS game show the most robust increases in gaze duration suggesting that participants may have been following the robot's directions and improving their gaze durations as a result. This is the most promising and exciting data because it shows that the robot may be useful in producing robust changes in clinically significant behaviors for the autism population.

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