Motor Noises and Auditory Sensitivity

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ABSTRACT

Robots make noises, and that can be a source of discomfort for some users, such as children diagnosed with Autism Spectrum Disorder. To understand better and evaluate the impact of motor noises in children-robot interaction, we propose to evaluate the children's sensory sensitivity by means of questionnaires used in clinical settings and to link it to the number of animations (presenting only motor sounds), controlled by the therapist, that occur in the interactions. This way, we can propose and design interventions that are more adapted to the specific needs of users.

CCS CONCEPTS

• H.1.2 [**User/Machine Systems**]: Human factors, human information processing • K.4.2 [**Social Issues**]: Assistive technologies for persons with disabilities

KEYWORDS

Sensory sensitivity, Human-Robot Interaction, Autism, Motor noises

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1 Introduction

Robots, as social companions, are a novel and complex source of sensory stimuli. In particular, they present motor noises and it is believed to affect the interactions with the user [1], [2]. It is utterly important to investigate motor noises in socially assistive robotics for children diagnosed with Autism Spectrum Disorders (ASD), as sounds can affect some individuals due to their auditory sensitivity. Indeed, children with ASD show, among other impairments, a hyper- or hypo-sensitivity to auditory stimuli [3], [4]. Robots were found to be promising interaction partners for children diagnosed with ASD, as their mechanical embodiment attract their interest and the predictability of their actions comforts the children [5], [6]. However, to our knowledge, no study investigated the effect of the motor noises on the course of the social interaction between children with ASD and a robot.

As reducing or canceling the motor sounds from robots is a difficult task given the current state of the motor technology and the available robots on the market, we aimed here to investigate their impact in socially assistive setups for children with ASD. This way, we can highlight and offer guidelines to design robot or robot interventions to minimize unwanted negative effects of the noises (for example, discomfort) or to use the motor sounds as a tool to attract the attention of the participants.

2 Proposed Approach

With young participants, and even more with participants with ASD, it is difficult to ask directly or via questionnaire how they feel or perceive audio stimuli, as it can be done with the general adult population. They might not understand the question or are unable to answer (see [7] on the challenges to design and test questionnaires for children), or the task to evaluate annoying rumors, as in [1] in which adults were asked to evaluate motor noises in an online survey, can be very long and tedious for them.

The approach we propose here is to evaluate the children's sensory sensitivity by means of questionnaires filled by the children's therapist or parents and to link it to the robot's motor events in the interaction. Different questionnaires enable to evaluate children or adults sensory sensitivity (for examples: the Sensory Profile Checklist (second edition) [8], the Sensory Profile [9] and the Sensory Perception Quotient [10]), and provide information on auditory sensitivity. This approach was previously used to assess the link between sensory sensitivity and social skills in children diagnosed with ASD (see [11] for a review) and in other works in socially assistive robotics [12], [13].

3 Application

3.1 Experimental protocol

In our research, we aimed to link sensory sensitivity, and more specifically auditory sensitivity, to motor events from the robot Cozmo (Anki Robotics) in a joint attention training for children diagnosed with ASD. We looked at the robot's animation of happiness and sadness, which were used as a reward in the interaction in the course of a joint attention training. The activity was based on a spatial attention cueing paradigm, with Cozmo delivering twelve joint attention cues: the robot turned and gazed at one of two present cubes, and the child had to indicate to the therapist which color was the cube that lit. The training occurred eight times across five weeks. The therapists were trained to control the robot in full autonomy (no experimenter was present on-site during the experiment). The reward animations were simple custom animations with a smile or a frowning face appearing on the LED display of Cozmo, and simple body movements (moving the "arms" ups and down with the face looking up for the happy animation, and small body movements to the left and right with the face looking down for the sad animation). Other than the motor sounds, the animations did not present auditory stimuli. The therapist was able to activate these animations to reinforce correct or incorrect answers, and at the end of the twelve trials as a reward to have participated. The therapist could skip the robot's animation if she/he considered that they did not provide reinforcement but a distraction (for example, if a child disliked the animations).

We recruited 36 children diagnosed with ASD (age = 5.69 years ± 1.06, 5 females) at the Piccolo Cottolengo Genovese di Don Orione (Genoa, Italy). Diagnosis of ASD was confirmed by the healthcare professionals of the institute, by means of the ADOS screening tool [14]. Parents or legal tutors provided a signed written informed consent. Our experimental protocols followed the ethical standards laid down in the Declaration of Helsinki and were approved by the local Ethics Committee (Comitato Etico Regione Liguria). Fourteen participants were excluded from the experiment because of discomfort with the setup, withdrawal of the study, or missing data. A total of 22 participants were considered for the present study. The full protocol is described in our paper [15].

3.2 Measurements

We used the Sensory Profile Checklist (second edition) [8] to assess the children's sensitivity in vision, audition, touch, smell, taste, proprioception, and vestibular perception. This questionnaire enables to clarify the strength and weakness of a child regarding their sensory profiles, with 20 questions per sense that explore the child's sensitivity. For each sense, we added the 20 items to obtain a score from 1 to 20, with a higher score corresponding to a higher sensitivity to the item.

We recorded how many times the animations were played on the robot during the whole training. For each participant we collected three values: 1) the total of animations played during the sessions, 2) the number of animations played as a reinforcement for a correct or incorrect answer, and 3) the number of animations played as a reward for the child to have participated.

4 Results

We used multiple linear regression analysis to test if the SPC scores in vision, hearing, touch, and proprioception (we discarded smell, taste, and vestibular perception in our analysis) were predictors of the children's exposure to the robot's animations.

We found a significant inverse correlation between the total of animation played as a reinforcement for a correct or incorrect answer and the participants' SPC scores ($R2=0.557, F(4,17)= 5.35, p<0.01$). We found that hearing sensitivity significantly predicted the performance ($\beta=-6.39, p<0.01$). We did not find significant relationships between the sensory sensitivity and the total number of animations played and the total of animation played at the end of the sessions.

5 Conclusion

We observed that the participants with higher hearing sensitivity were exposed to less animation during the joint attention trials than the less sensitive ones. The children's therapists, who were in charge to activate or not the animations, seemed to avoid providing feedback through the robot to the children with higher hearing sensitivity. However, the same pattern was not observed when the therapist had to display the conclusive animation of the robot when the training session was completed. This result suggests that children that have a high sensitivity in hearing might benefit from fewer animations from the robot, or in this context less noise from the robot's motors, during the training phase, not to trigger their sensitivity. However, as the animations were regulated by the therapist, there may have been other reasons not to play them during the training. Nonetheless, we believe that observing how the therapists led the interaction is a great indicator of how to design the robot's behaviors. These observations can inform on how to design reinforcement animations on robots during training, based on the participants' sensitivity. For example, children with higher auditory sensitivity could be presented a "quieter" robot, that would present fewer or shorter animations, causing less motor sounds.

To go further, the importance of motor sounds can be also investigated in the general population or other clinical conditions. Indeed, as highlighted by [16], auditory sensitivity is often discussed for population of individuals with ASD but it can be found in the general population, but the individuals' "comfort zones" differ and would be narrower for people diagnosed with ASD.

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