Response Pattern of Child-Robot Interaction among Children with Cognitive Impairment

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Abstract. Children with cognitive impairments reported having an engaging initial response in child-robot interaction. However, the interaction modules for child-robot interaction vary and depend on the aim of the studies in the literature. In this study, we designed child-robot interaction modules in order to help children with cognitive impairment in improving their social interaction skills. Hence, we would like to report the overall pattern of their response for each module in 3 sessions of child-robot interaction. Their response pattern for each module is important in future behaviour analysis, especially with regards to their attention skills analysis and their eye contact engagement analysis during child-robot interaction.

Keywords: Robot, Cognitive Impairments, Child-Robot Interaction

1 Introduction

Robots have been actively used in recent years to help children with disabilities and special needs. Research suggest that children positively engaged with robots during child-robot interaction [7]. Moreover, according to some carers and teachers, children with cognitive impairment was observed to have difficulties to remain focus in human-human interaction. Children with special needs usually have some difficulties to interact with their peers, teachers and family members. Human-human intervention programs and therapy was proven to be conventionally effective to help these children to improve their social communication skills. However, teachers and therapists usually need some additional tools for intervention program or therapy session. Thus, human intervention therapy to improve social interaction difficulties such as lack of eye contact and poor attention skills can be amplified with the involvement of social robots. In this study, we used social robot LUCA (as shown in Figure 1 and designed child-robot interaction modules in the effort of helping them to improve their social interaction skills. Thus, their response towards the robot and interaction modules shall provide us more perspective and information for future child-robot interaction study. Next

section shall discuss about the experimental study in child-robot interaction and section 3 reports the finding of the study. The pattern of child's response in each module for the entire 3 session will be further elaborated.

Fig. 1: Figure shows a LUCA robot which was build based on OPSORO robot platform [11].

2 Child-robot interaction experiment

All experimental procedure has been given ethical approval on 30th July 2018 from Research Ethics Committee, Universiti Teknologi MARA (UiTM), Malaysia (REC reference number: 600-IRMI (5/1/6)). In this study, we collaborated with one of the schools in Putrajaya, Malaysia. This school has 92 children with special needs. 20 children diagnosed with cognitive impairments fulfilled our inclusion and exclusion criteria as described in Table 1.

Consent to participate in our study was also obtained from their parents or legal guardian prior to start the experiment. The protocol of the experiment was clearly explained to the teachers and therapist. A teacher or therapist would come to the experimental room with one child at a time. They would knock on the door, walk into the room and sit down in front of the robot. All interactions were recorded using five video cameras for later analyses. Once the child was seated and ready, the teacher would flash a card at the robot and the interaction with the robot was initiated. Each child was exposed to the robot for 3 consecutive sessions. Each session consists of 5 interaction modules. The 5 modules are as below:

– **Module 1: Introduction to the robot**
  The first module aimed to introduce the robot to the participant. The child

Inclusion criteria	Exclusion criteria
1)Age between 6 to 12 years 2)No evidence of self injury or aggressive behaviour 3)Able to speak in English or Malay 4)Diagnosed as having a Cognitive Impairment (level validated by attention skills via Children Colouring Trail Test: CCTT [8]) 5)Able to follow simple instructions in English or Malay	1)Child with mutism 2)Uncorrected hearing deficit 3)Uncorrected vision deficit 4)Unwillingness to participate

Table 1: Inclusion and exclusion criteria for all participants

was welcomed by LUCA using simple English language and some low valence non-verbal behaviour. The text to speech voice was generated using an online synthesizer [4].

- **Module 2: Facial expression game**
  This module was designed as a facial expression game and has been designed to help CWCI improve their attention skills [1, 10]. The dependent variable in this module is the time taken by the child to complete the task. In this module, the researcher controlled the robot and selected a range of different facial expressions such as happy, sad, angry. The children were invited by the robot to guess the expression, and they were allowed a second try if their initial answer was wrong. If their answer was still incorrect, the correct answer was given by the robot. The children were also expected to mimic the expression of the robot while maintaining eye contact with the robot.
- **Module 3: Song with facial expression game**
  In this module, a song was added to the facial expression game in order to encourage the children to play the facial expression game and make the interaction more engaging. Some children have some difficulties in distinguishing certain facial expressions. The music was chosen to match the emotions expressed by the robot and helped the children guess the facial expression, next to enhancing their attention span.
- **Module 4: Attention task**
  This module was developed to measure the attention skills of the child. These are very important skills, central to social interaction, learning and collaboration, and robots are believed to be able to improve these skills during Child-Robot Interaction [5, 12]. This session expected the child to look at a certain shape pasted on a board placed on the right (for example, an image of rectangle) and left (for example, an image of circle) of the robot. The child would need to perform a "matching task" in which the robot gave an instruction to look at at a shape (mounted to the left or right of the robot) and fixate their gaze for 3 seconds. For example, he/she would be required to look at the rectangle for 3 seconds.

[4] https://text-to-speech-demo.ng.bluemix.net/, (accessed on July to August 2018)

– **Module 5: Free style interaction**
Finally, module 5 was a free style interaction between the child and the robot. The child was given the chance to ask questions to the robot. The robot answered, with answers being typed in on a keyboard by a member of the research team and spoken by the robot. If children requested the robot to move, then these actions were performed when the robot had the capability to do so.

3 Results

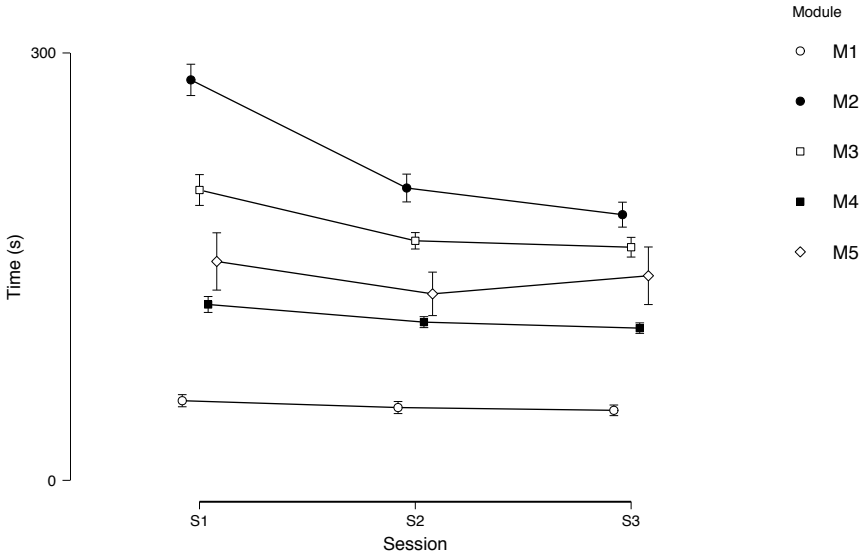

Fig. 2: Figure shows the overall results of child-robot interaction time for each module in Session 1, 2 and 3.

This section reports the overall response of child-robot interaction for children diagnosed with cognitive impairment. 5 modules was designed for this experiment. In module 1, children were only introduced to the robot. This is necessary in order to break the ice between the child and robot [2, 6] and to assure the following interactions are not influenced by the child being unfamiliar with the robot or the study setting. Neither behaviour nor tasks has been evaluated. Nevertheless, the average response time from all children was recorded around 60 seconds as shown in Fig. 2. In module 2, the overall response pattern showed that, children took less time to complete the tasks in session 2 and 3 as compared to their average completion time in session 1. This pattern suggested that their level of concentration and attention skills has been improved by taking less time

to complete the modules through-out the 3 consecutive sessions. This is however need to be further investigated and proofed statistically in the future study.

In module 3, the overall response pattern of the children were similar to the module 2. However, there were only a slight improvement between session 2 and 3 as compared to session 1. With the assistance of theme music, children have spent less time to complete the task in session 2 and 3 as compared to session 1. Earlier pilots and studies also found that music was an effective manner to draw children into the interaction [6, 9]. Thus, with the aid of a theme song, they would be able to successfully guess the facial expression providing positive encouragement. In module 4, there were only slight improvement (in time) to complete the tasks. Most of the children needed less time to complete the task in session 2 and 3 as compared to session 1, which we expected since the task were uncomplicated. Finally, the results for module 5 were difficult to be generalized since it was an open and free style of interaction. The pattern for their response in 3 different sessions were quite scattered. This module can be very useful to gauge their interest in and attention towards the robot, which serves as a measure of their focus in social interactions [3, 4]. Their overall response varies in each sessions. Nevertheless, our aim to see the engagement of each children interact with the robot was unexceptional. Most of the children showed their interest towards the robot and spent an average time of approximately 2 minutes in all session.

4 Conclusion and future work

The response from children diagnosed with cognitive impairments in child-robot interaction was suggestive. Based on our observation, they really spent an enjoyable time to interact with the robot. Task given by the robot was also uncomplicated. Thus, this motivate them to keep interact with the robot without any disappointment. The modules of child-robot interaction could be used in helping children with cognitive impairment to improve their social interaction skills. Despite the suggestive overall response, more analysis should be performed in the next juncture, especially with regards to their attention skills and interest towards child-robot interaction. Time completion task analysis could be used as a proxy to indicate their improvements in attention skills in module 2, 3 and 4 for each session. Moreover, interaction duration time could also be used as a proxy to measure their interest towards the robot in module 5. This can be really useful, especially for future behavior monitoring by therapist/carer, which could provide them with important information about the behaviour of children diagnosed with cognitive impairment (such as eye contact pattern and level of attention skills) in child-robot interaction.

Compliance with Ethical Standards: Ethical approval was granted from the Research Ethics Committee (REC), of Universiti Teknologi MARA, Malaysia (REC reference number: 600-IRMI (5/1/6)) prior to research commencement. Moreover, participant's official consent to participate in this study were granted

from all parents or guardians prior to start the experiment.

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Conflict of Interest: The authors declare that they have no conflict of interest.

Bibliography

[1] Adams A, Robinson P (2011) An android head for social-emotional intervention for children with autism spectrum conditions. In: Affective Computing and Intelligent Interaction, Springer, pp 183–190

[2] Bee N, André E, Tober S (2009) Breaking the ice in human-agent communication: Eye-gaze based initiation of contact with an embodied conversational agent. In: International Workshop on Intelligent Virtual Agents, Springer, pp 229–242

[3] Dautenhahn K (1999) Robots as social actors: Aurora and the case of autism. In: Proc. CT99, The Third International Cognitive Technology Conference, August, San Francisco, vol 359, p 374

[4] Dautenhahn K (2007) Methodology & themes of human-robot interaction: A growing research field. International Journal of Advanced Robotic Systems 4(1):15

[5] Huang CM, Thomaz AL (2010) Joint attention in human-robot interaction. In: AAAI Fall Symposium: Dialog with Robots

[6] Ismail LI, Shamsudin S, Yussof H, Hanapiah FA, Zahari NI (2012) Estimation of concentration by eye contact measurement in robot–based intervention program with autistic children. Procedia Engineering 41:1548–1552

[7] Ismail LI, Shamsudin S, Yussof H, Hanapiah FA, Zahari NI (2012) Robot-based intervention program for autistic children with humanoid robot nao: initial response in stereotyped behavior. Procedia Engineering 41:1441–1447

[8] Llorente AM, Voigt RG, Williams J, Frailey JK, Satz P, DElia LF (2009) Children's color trails test 1 & 2: test–retest reliability and factorial validity. The Clinical Neuropsychologist 23(4):645–660

[9] Peng YH, Lin CW, Mayer NM, Wang ML (2014) Using a humanoid robot for music therapy with autistic children. In: Automatic Control Conference (CACS), 2014 CACS International, IEEE, pp 156–160

[10] Pour AG, Taheri A, Alemi M, Meghdari A (2018) Human–robot facial expression reciprocal interaction platform: case studies on children with autism. International Journal of Social Robotics 10(2):179–198

[11] Vervisch T, Doms N, Descamps S, Vandevelde C, Verstockt S, Saldien J, et al (2017) Oto–a diy platform for mobile social robots in education. In: International Conference on Robotics and Education RiE 2017, Springer, pp 257–262

[12] Warren ZE, Zheng Z, Swanson AR, Bekele E, Zhang L, Crittendon JA, Weitlauf AF, Sarkar N (2015) Can robotic interaction improve joint attention skills? Journal of autism and developmental disorders 45(11):3726–3734