Physiological Signal Analysis for Emotion Estimation of Children with Autism Spectrum Disorder

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Introduction

The diagnosis of Autism Spectrum Disorder (ASD) in children is based on human observations by a clinician. The medical evaluation assesses deficits in social communication, social interaction, and restricted, repetitive behaviors. Robotic technology can assist in quantitatively measuring the observations to be used as a future tool for autism diagnosis and intervention. Our project explores this technology to produce robotic partners that can adapt to the needs of the ASD population. This way, such robots could serve as instructors or learning peers. A friendly, partner robot, specifically designed for children with ASD could be used to investigate the effect of therapy and the connection between the motor, sensory, and emotional cortex in the brains of children with ASD.

Background

Affective computing is the study and development of systems and devices that can recognize, interpret, process, and simulate human emotions [1]. We envision our robots to interpret physiological signals and appropriately adapt to the emotional responses of a user. Research has found that physiological pattern recognition can potentially aid in assessing and quantifying emotions. Thus, one of the purposes in this research is to analyze physiological data collected from human subjects to show its relationship to changes in emotional reactions during different activities.

Method

To collect data, we conducted a human-subjects study with six patients with a diagnosis of ASD in the age range 8-12 years that participated in a 12-week social skills group organized by the University of Louisville Autism Center (ULAC). A robot intervention part (see Fig 1) was added onto the group's schedule with a focus on initiations and short scripted conversations. Our data collection includes the robot interaction time and the remainder of the group session, including a baseline recording. The device used to collect data is the Empatica E4 wristband shown in Fig 2, which supports several physiological signals. An E4 was placed on two of the subjects. The subjects were divided into two groups of three and each group interacted with a different robot. The robots used in this study were the NAO robots pictured in Fig 3. The room where the interaction was conducted is illustrated in Fig 1, where C stands for Clinician whose role was to intervene if necessary, E stands for Engineer who controlled the robot, S stands for Subject, and R stands for Robot. E4 and Kinect sensors are also pictured.

- Baseline time: quiet sitting time
- Chat time: time for subjects to practice their social skills with no mediation from clinician
- Robot time: time for subjects to practice conversation initiations with the NAO robot

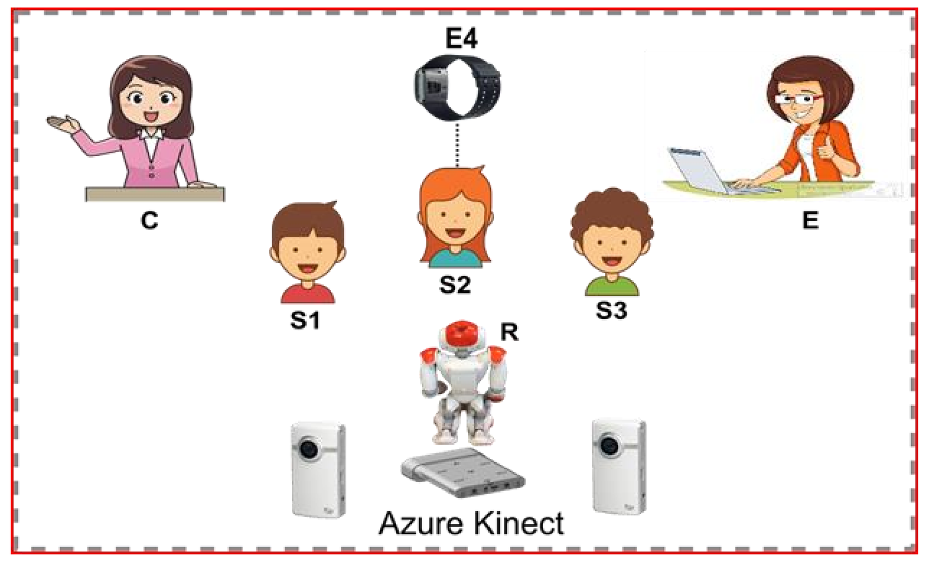

Figure 1. Robot interaction room set up

Figure 2. Empatica E4 wristband

Figure 3. NAO robot

Results

For our primary analysis, we chose to assess how heart rate (HR) varies across different activities during the intervention at ULAC. The same analysis was performed in all sessions and the results were consistent to what is shown in Figs 4 and 5. HR can indicate how a person's muscular and central nervous system reacts to varying behaviors [2]. We considered three moments of the intervention at ULAC: baseline time, chat time, and robot time.

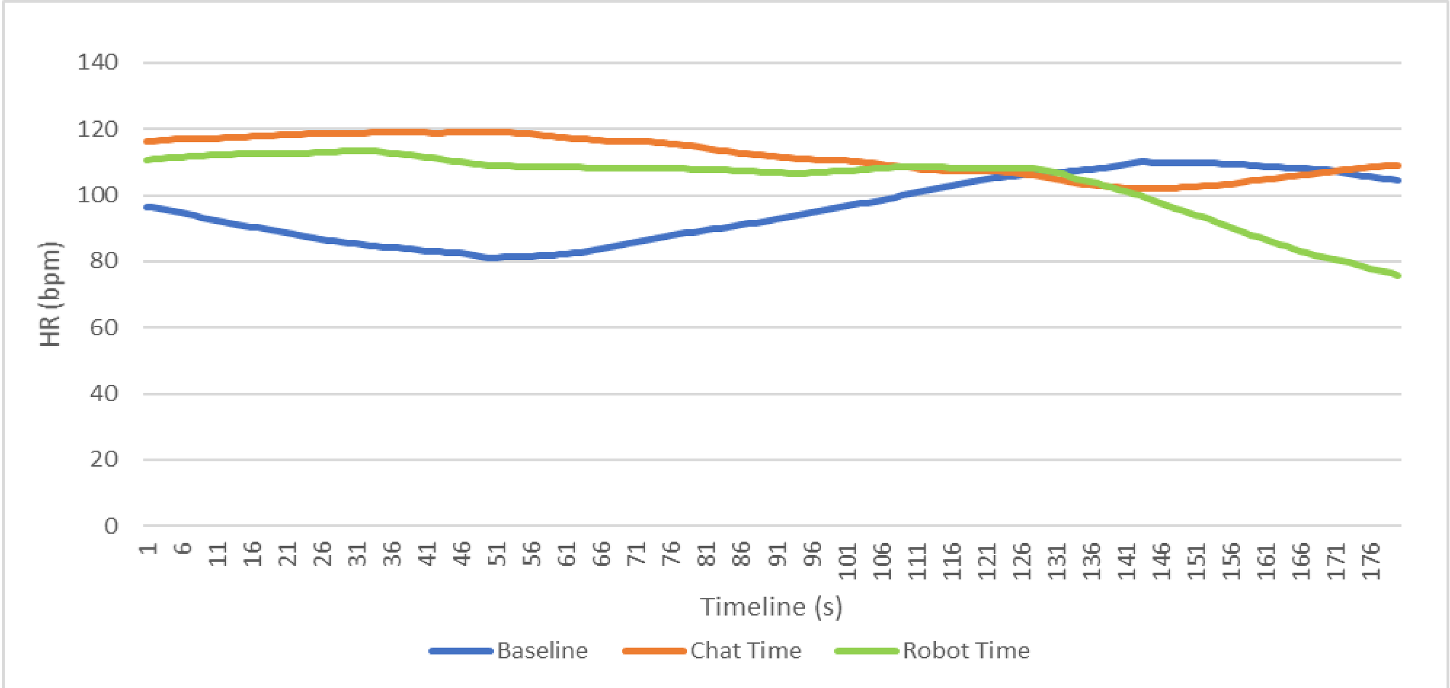

Figure 4. Comparison of heart rate signals for Participant 1 (P1)

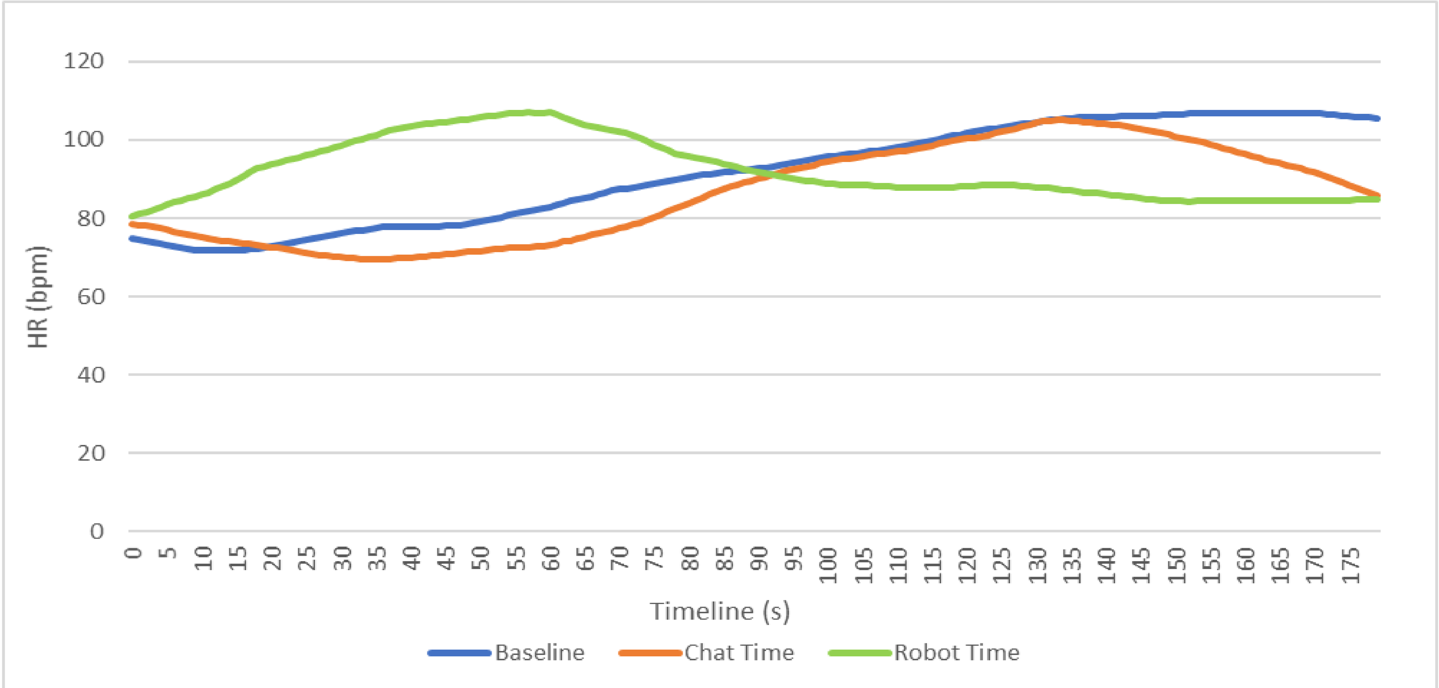

Figure 5. Comparison of heart rate signals for Participant 2 (P2)

Results

Participants	Baseline (M)	Baseline (SD)	Chat Time	Robot Time
P1	95.87	10.02	111.77*	104.17*
P2	91.50	12.64	86.37*	92.13

Table 1. Mean HR results as beats per minute (bpm)
*$p < 0.05$ for a paired sample t-test comparison to Baseline
For P2, Robot time is statistically the same as Baseline.

Conclusions

As summarized in Table 1 the comparison of the mean HR shows a statistical difference between different activities that the children engaged in. It also shows one instance in which the means are the same. These results are significant and can support broader research that utilizes the E4 wristband to collect physiological signals that can be linked to changes in emotions. In future work, additional features from signals collected by the E4 (e.g., maximum amplitude of phasic activity of galvanic skin response, mean of skin temperature) will be processed, analyzed, and used to train a Machine Learning algorithm. An accurate emotion estimator can ultimately allow a robot to adapt interactions with children with ASD based on these signals and make decisions during an intervention accordingly.

References

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2) Groden, J., Goodwin, M. S., Baron, M. G., Groden, G., Velicer, W. F., Lipsitt, L. P., Hofmann, S. G., and Plummer, B. (2005). "Assessing cardiovascular responses to stressors in individuals with autism spectrum disorders," Focus on Autism and Other Developmental Disabilities, vol. 20, no. 4, pp. 244-252.

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