EVALUATING KANSEI EMOTION RESPONSES IN HUMAN-ROBOT INTERACTION WITH LOW-COST ROBOTS IN EDUCATIONAL SETTING

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ABSTRACT: Recent studies on human-robot interaction (HRI) is rapidly revolving. In a kindergarten setting, robots can become an important social interface for children, but the cost involved in implementing such robots can be high. This study aims to explore children's emotional responses when interacting with RoboBuilder (a humanoid) and My Keepon (a toy-like robot) in a kindergarten setting. Both are inexpensive robots. Four children aged four and five years old took part in the HRI observation. Firstly, the children were exposed to a RoboBuilder dancing to a musical tune. The children then interacted with My Keepon by touching it and responding to its sounds. Videos of interactions were analyzed and scores were assigned based on eight Kansei emotion parameters. Results revealed that the children's responses were favorable and they felt comfortable interacting with both robots. However, the children were more drawn to interact with My Keepon due to its toy-like design and cute appearance compared to RoboBuilder. Outcome through Kansei engineering approach shows that HRI involving a robot with adorable features is more appealing to children in the kindergarten setting.

KEYWORDS: *Human-Robot Interaction (HRI); Kansei Engineering; My Keepon*

1.0 INTRODUCTION

Robots are generally machines or devices that can perform tasks according to human commands [1]. Its re-programmability feature helps distinguish robots from other automated machines. Robots are increasingly being used in a variety of real-world applications, such as rehabilitation and customer service. Human-robot interaction (HRI) is a field that focuses on enhancing human-robot interactions across a variety of activities by using robots. With its increasing availability and affordability, robots are now used as assistants and even companions, reflecting their growing presence in society [2]. Various forms of robots are used in HRI research. It is important for humans to be comfortable when interacting with robots. Honda's ASIMO, humanoid robot NAO and RoboBuilder (Figure 1(a)) are based on the human form while My Keepon (Figure 1(b)) and Furby have toy-like structures to interact with typical children and children with autism [3].

For HRI research, different robot structures suitable for different applications have been developed. This will help to build trust and will lead to more successful human-robot interactions [4]. HRI faces the challenge of expensive robot platforms due to their complexity and intelligence. Modifying cheap and commercial robots such as My Keepon (Figure 1) for HRI interaction can be the key to developing low-cost programmable robots for HRI studies [5]. Hacking these robots was initiated by the Nonpolynomial Lab through reverse engineering method on My Keepon Arduino controller [6].

Figure 1: Robots used in this study: (a) RoboBuilder 5720T and (b) My Keepon

This study aims to explore the emotional responses of children when they interact with two different types of simple robots: RoboBuilder and My Keepon in a kindergarten setting. Initially, the children were exposed to a RoboBuilder dancing to a musical tune. Then, the children interacted with My Keepon by touching it and responding to its sounds. Video records of both interactions were analyzed by giving scores on eight Kansei emotions parameters. Findings from this study may reveal valuable insights regarding the suitability of using simple, interactive robots and which type of robot is more attractive to children in the kindergarten setting.

2.0 METHODOLOGY

2.1 Kansei Engineering Approach in HRI

Previous research has revealed that understanding each entity's capabilities was necessary for effective and good communication between humans and robots [7]. HRI is an interdisciplinary endeavor since studies of HRI are connected to concepts from psychology, communication, anthropology, philosophy, and ethics [8]. The phrase "Kansei" is derived from a Japanese word that is used to describe how one feels about a certain item, circumstance, or setting [9]. Kansei refers to the human mental state in which awareness of, and sentiment for, a subject is associated. People who are rich with Kansei are those who are very emotional, adaptable, kind, and responsive [10].

Kansei is often described as an unspoken mental function [11]. The Kansei process starts when a person's impression is presented through their five senses of hearing, seeing, smelling, tasting, and skin sensation. Kansei cannot be directly quantified because it is implicit.

The Kansei process itself is not what the observations from the method are, but rather its causes and effects [11]. As a result, only the Kansei process output may be measured [12]. In Kansei Engineering, a surveying technique is employed in which participants verbalize their feelings. Participants may also be requested to complete a survey that poses straightforward questions after a person sees or uses a product. 'Kansei Words' are used to explain the feelings [10].

2.2 Robots' Specifications

2.2.1 Specifications of RoboBuilder 5720T Robot

RoboBuilder is assembled by joining block-type robotic modules to form a robot shape based on one's creativity. In this study, RoboBuilder has been constructed like a human or also known as a humanoid robot. The robot possesses 16 degrees of freedom (DOF). Its motors are known as wCK modules that need to be assembled manually. The robot is controlled using a remote. The basic programming of RoboBuilder is accomplished through the MotionBuilder software (Figure 2). Through MotionBuilder, the movements of the robot can be controlled by adjusting the angle of each wCK modules which made up the whole robot. It allows beginners to control the robot to do basic movements such as kicking, waving hands, and simple dance moves.

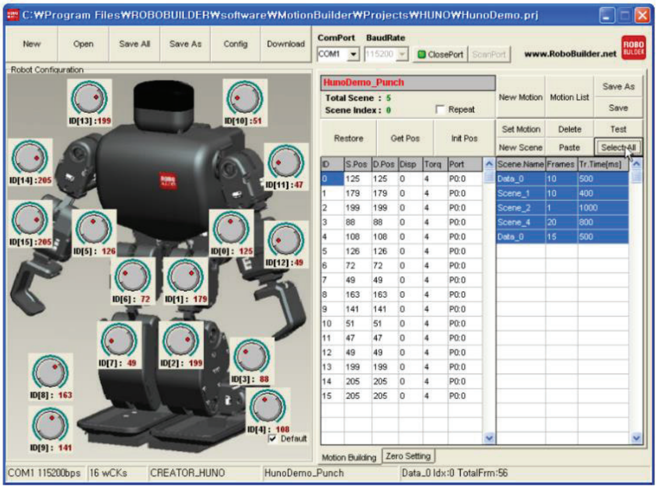


Figure 2: MotionBuilder Software to program the RoboBuilder robot

2.2.2 Specifications of My Keepon Robot

Each Keepon Pro robot costs roughly $30,000 and was initially created for HRI research activities for kids with autism [12]. My Keepon is a toy version of the robot with less complexity and circuitry that is intended as a solo interactive toy for children [13]. It is practically identical to Keepon Pro. My Keepon is a cheap option for low-cost HRI research, costing only $40.

My Keepon is a diminutive robot that measures 8 cm in diameter and 12 cm in height. It is yellow in colour and has a snowman-like form to ensure that youngsters can touch it in a secure and comfortable manner. Since the inside part is hollow and made up of soft silicon rubber, the body will deform whenever it moves or touched by humans. It has four degrees of freedom (DOFs): turning (±180), nodding (±40), rocking side-to-side (±25), and bouncing [12]. Keepon is an exciting robot platform and has been widely used by researchers in HRI studies on social development and behaviors [14]. My Keepon has two microprocessors to control its movements and sounds [13]. Arduino Uno is used in this project together with Arduino shield to establish connection between the I2C bus and the USB port of the computer. The simple hacking of My Keepon in this study is accomplished using open-source software named ViKeepon (Figure 3). Hacking the robot allows control of basic movements via a computer [13].

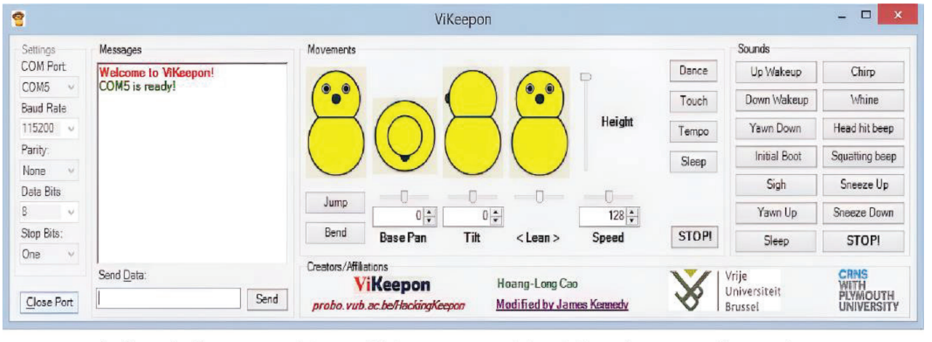


Figure 3: User interface of ViKeepon

2.3 The Interaction Protocol

The interaction content that are suitable for the child-robot session are identified using inputs from previous studies related to HRI and views from the teachers at Tadika Aulad Imtiyaz kindergarten, which is located in the university compound in Durian Tunggal, Melaka. The parents of children who participated in the experiment were informed thoroughly about the study to obtain their permission. The experiment is subjected to ethical approval from Universiti Teknikal Malaysia Melaka (UTeM) Ethics Committee before the study can commence.

2.3.1 Hardware and Software Set-up

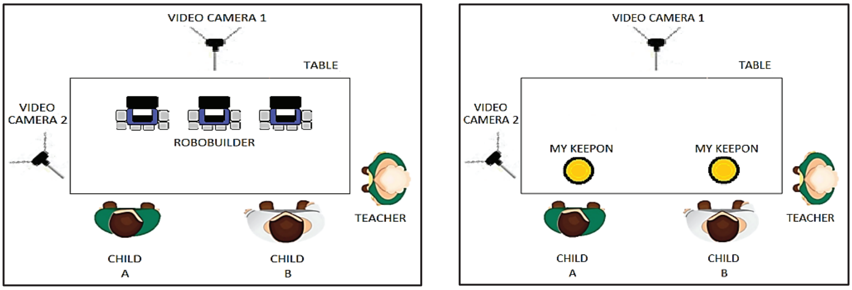
The setup for both robots were divided into four parts: hardware and software preparation, programming, commissioning and lastly testing and debugging. Testing and debugging is the stage where the robot will be tested and the behavior of the robot is analyzed. If the behavior is different than the actual plan, the debugging process will identify what the errors are, programming will be corrected until the correct behavior from each robot is achieved. This is important to ensure that the robots have the reliability to carry out the interaction with the children.

Due to the limitation of the RoboBuilder robot where it cannot detect its surrounding sound to guide its movements, the program must be executed in synchronized motion with the song. Since there was no simulation software for RoboBuilder, the debugging process was done through “trial and error” method where the program was executed and the RoboBuilder danced repeatedly until the correct synchronization was found between RoboBuilder and the song.

My Keepon is capable of both attentive and emotional gestures. My Keepon will point its head in one of two directions—up, down, or left—to line its face and body with a target. My Keepon will focus on the target attempt to make eye contact and a cooperative effort to pay attention. My Keepon is programmed to show its emotions throughout emotive activity by continually bobbling or swaying its body up and down. The programming incorporated both types of movements.

2.3.2 Experimental Layout

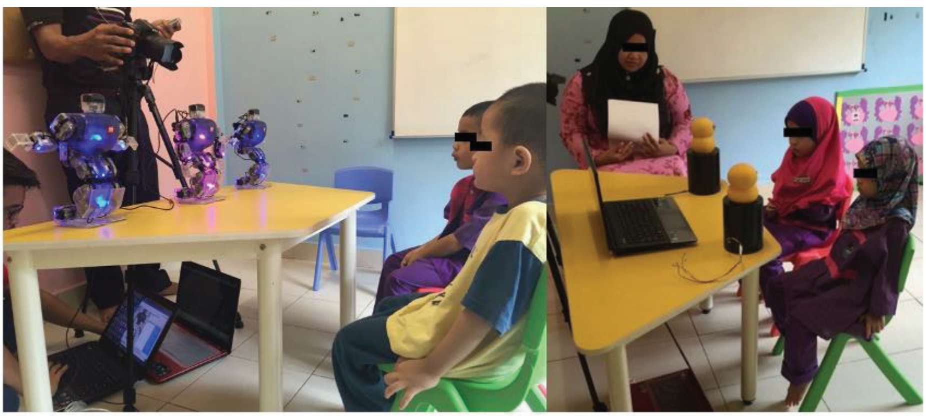
Children between the ages of four and five took part in the HRI experiment. For each child to take part, parental approval was required. The kindergarten was located on the campus. The setup's top view arrangement is depicted in Figure 4. For the purposes of the post-interaction interview, the children taking part in this study must be able to comprehend and react in simple English. Throughout the engagement, two video cameras captured the children's face expressions and movements. In this experiment, one kindergarten teacher observed the entire interaction between the two children who were seated side by side and the robots. Figure 4 illustrates this.



(a) (b)

Figure 4: Experimental layout for (a) RoboBuilder and (b) My Keepon

For RoboBuilder session, three robot units were used as shown in Figure 5. Robots were placed on a table and the children were seated in front of the robot. The robots started the engagement by welcoming the children in English and introducing themselves to the children. The robots then asked the children to dance along with them. After finishing dancing, RoboBuilder asked the children to dance together for one more time. The children spent 10 minutes playing and dancing with the robots.



(a) (b)

Figure 5: Actual pictures during the setting-up for HRI session with (a) RoboBuilder robot and (b) My Keepon. A kindergarten teacher is always present in the room to accompany the children

Two robot units were used during the session with My Keepon, when the kids encountered the robot for the first time as seen in Figure 5. My Keepon was placed in a static posture for the opening warm-up exercise. The robots then began to move, waving and making gestures to the kids in their own language. The robot will begin performing basic movements to get the kids' interest before producing noises and moving its yellow body at the same time. After then, the teacher encouraged the kids to play with and interact with the robots. The total duration is 10 minutes.

To learn more about how the kids felt about each robot, the instructor conducted a brief interview-style of eight-question survey after each engagement. The questions covered on whether each child knows that RoboBuilder and My Keepon are robots, can he/she follow the dance movements and do they want to meet the robot again in the future. Besides that, another important aspect that has been taken into consideration in the protocol is the “Conditions to Abort Procedures”. If either one of these conditions is met, the study will be aborted immediately. The conditions are: is any of the children become restless and uncooperative, the children are quarreling with each other or if the child’s teacher of parents requested to abort the interaction.

3.0 RESULTS AND DISCUSSION

Since this is a qualitative form of study on human response, observation and interview methods will be used to collect analytical data. The responses of the kids to RoboBuilder and My Keepon, along with the findings of the interviews, will show what feelings are shared by the kids and the robots when they engage. Eight Kansei emotions—"tempting," "excited," "cute," "happy," "like," "surprised," "confused," and "scared"—have been chosen for the study. The highest score is 5, and the lowest is 1. These eight Kansei emotions were chosen based on how well they represent the robot's attributes that would draw children's interest during HRI.

	5	4	3	2	1	
1. Tempting	☐	☐	☐	☐	☐	Not Tempting
2. Excited	☐	☐	☐	☐	☐	Not Excited
3. Cute	☐	☐	☐	☐	☐	Not Cute
4. Happy	☐	☐	☐	☐	☐	Not Happy
5. Like	☐	☐	☐	☐	☐	Not Like
6. Surprised	☐	☐	☐	☐	☐	Not Surprised
7. Confused	☐	☐	☐	☐	☐	Not Confused
8. Scared	☐	☐	☐	☐	☐	Not Scared

Figure 6: Evaluation sheet with eight Kansei Emotions

Four evaluators took part in the video evaluation session. The evaluators consist of one medical doctor who has prior experience interacting with children at the kindergarten and three other researchers who are familiar with HRI evaluation. Score results from the video evaluation were then averaged for each emotion and presented in positive and negative emotion graphs. For positive emotions, higher scores indicate encouraging outcomes. For negative emotions, lower scores mean better interaction outcomes. After interacting with each robot, the teacher asked a set of eight general questions directly to the children. The responses obtained were categorized into three: Understanding, Experience, and Enjoyment.

3.1 Kansei Engineering Analysis for RoboBuilder

Each interaction session between the child and the robot lasted for 10 minutes. From the results, it can be said that interaction with RoboBuilder brought out positive Kansei reactions among the children based on the Kansei emotion scores. The average rating scores fall above 3.5 as shown in Figure 7. This is mainly influenced by the feeling of excitement when the children danced with the robot, its interactive movements with the music, and its humanoid-robot shape.

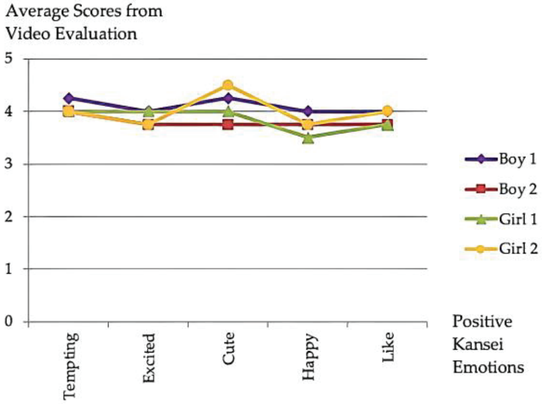


Figure 7: Scores of positive Kansei emotions for RoboBuilder

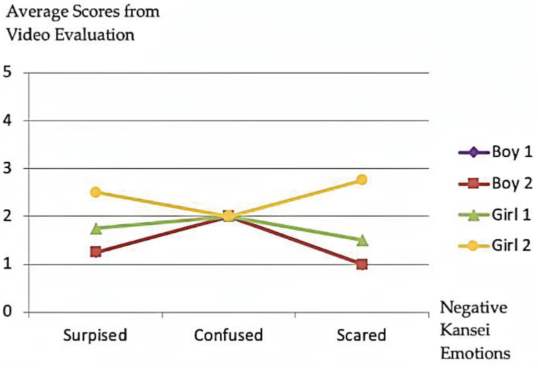


Figure 8: Scores of negative Kansei emotions for RoboBuilder

Figure 8 shows the scores for Kansei emotions of "surprised", "confused" and "scared". Most children showed mild feelings in relation to the three negative Kansei emotions when interacting together with RoboBuilder as the scores were all below 3. This is with exception for Girl 2 who showed a slightly higher score of negative reaction for "scared" emotion. However, the overall scores can be summarized as positive emotional outcomes. This discovery is comparable to the one described in [4], in which a humanoid was able to elicit emotional responses from children during one-on-one engagement sessions; however, in this prior study, the interaction lasted approximately 30 minutes.

3.2 Kansei Engineering Analysis for My Keepon

Based on past literature, it was postulated that children will give positive emotional responses to My Keepon due to its shape and attractive color. Overall, results show that all four children showed encouraging responses. Their scores on the five positive Kansei emotions were at a minimum of 3.75 as shown in Figure 9.

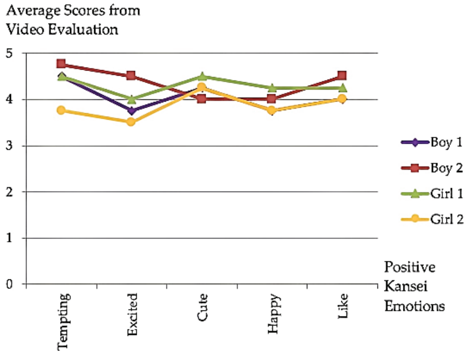


Figure 9: Scores of positive Kansei emotions for My Keepon

Kansei analysis of negative emotions shows none of the children felt the need to leave the experimental area during the interaction. Qualitatively, this means more positive emotions are shown compared to negative ones. In fact, the bright yellow color of My Keepon appears to grab the children's attention the most.

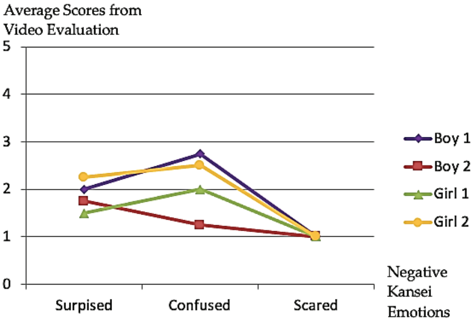


Figure 10: Scores of negative Kansei emotions for My Keepon

Based on the presented data, it can be concluded that a cute, simple robot elicited pleasant feelings in the children since they were delighted about playing with My Keepon. Their scores on the three negative Kansei emotions were at a maximum of 2.75 (for Boy 1 on the "confused" emotion). Other scores were 2.5 and below as shown in Figure 10. Overall, these observations are similar to the outcome reported in [4] where the presence of My Keepon elicited positive social responses. However, this previous finding was limited to a group of two-year-olds accompanied by their mothers.

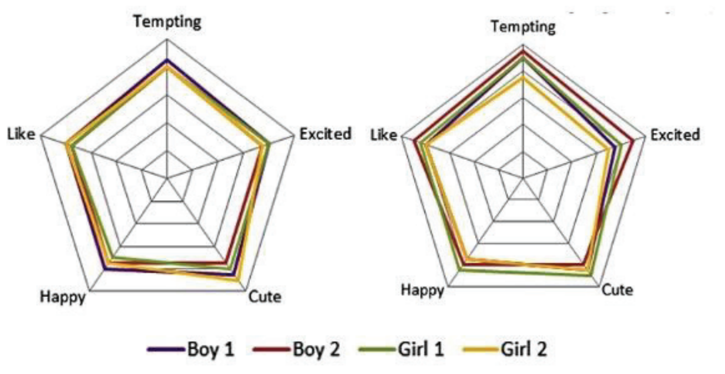
3.3 Interview Results for Both Robots

For the interview results, the eight questions were clustered into three groups: "understanding", "experience" and "enjoyment". For the "understanding" group, the children expressed that they are aware that My Keepon and RoboBuilder are actually robots. Even though My Keepon does look like a toy, the children did not get confused by its appearance. On "experience", half of the children indicated that they have had prior experience in meeting or playing with a robot. With regards to enjoyment, all four children indicated that they liked spending time and dancing with the robots.

Children's opinions towards robots and their interactions were encouraging according to the interview. Despite being aware that they were interacting with robots rather than toys, the children seemed to find RoboBuilder and My Keepon amusing due to their humanoid appearances. They also expressed the opinion that robots could be used as their play companions. In the future, robots may play an important role in children's lives.

3.4 Comparison of Kansei Emotions for Both Robots

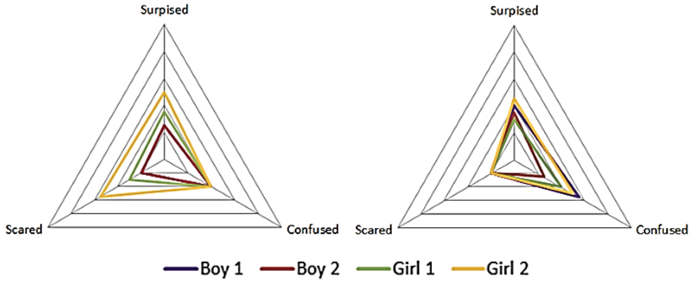
Figure 11 shows the radar graphs for positive emotions for both robots in order to compare the results of Kansei emotions between them. The larger the size of the graph, the better the response from the children. Graphs for My Keepon and RoboBuilder are almost identical. Generally, positive emotions of the children towards both robots show a favorable trend. Both graphs show that the children felt very comfortable engaging with the robots. Due to its toy-like features, the children's reactions towards My Keepon were better. This explains why the graph for My Keepon has a larger size compared to RoboBuilder.



(a) (b)

Figure 11: Radar graphs for positive Kansei emotions for (a) RoboBuilder and (b) My Keepon

Figure 12 shows the radar graphs for Kansei negative emotions where the smaller the size of the graphs means better response from the children. Based on the graphs, except for Girl 2 which shows medium size graph when interacting with RoboBuilder, most of the children's reactions towards both robots are very encouraging. It can be deduced that perhaps this child was not familiar with playing with a robot thus resulting in a bigger size graph compared to others. Another interesting observation is that for My Keepon, most children were confused by its appearance. This is because My Keepon's physical shape and color do not resemble human or any animal shape.



(a) (b)

Figure 12: Radar graphs for negative Kansei emotions for (a) RoboBuilder (left) and (b) My Keepon

The comparison of outcomes between RoboBuilder and My Keepon provides insights into how different robot attributes and appearances can influence children's responses. The distinct reactions to the two robots, despite having similar positive outcomes, align with the idea that different robots and multiple robot interactions can provide unique emotional responses between humans [4-5]. This study is also consistent with previous research findings highlighting the importance of emotional attachment in human-robot interactions. The children's positive emotional responses towards RoboBuilder and My Keepon support the idea that simple robots can effectively capture children's attention and stimulate positive emotions [7, 13].

4.0 CONCLUSION

In summary, the study successfully achieved its goal of assessing children's attraction to low-cost robots using Kansei engineering method. The children were generally attracted to simple and interactive robots i.e. RoboBuilder and My Keepon. The low-cost robots can be an attractive addition during play and learning time. The positive responses, consistent regardless of gender, emphasized the potential of these robots at the kindergarten. However, a thorough analysis of the interview data and Kansei outcomes is required to completely grasp the children's feelings. A longer interaction time will also need to be explored in future studies to observe how children respond emotionally to prolonged robot interaction based on Kansei emotions. Additionally, these investigations will provide insight into how typically developing children react in comparison to those with special needs, such as autism, and how different kinds of robots might assist in developing their communication and social skills [4, 15].

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AUTHOR CONTRIBUTIONS

A.F. Azmin: Methodology, Software, Writing- Original Draft Preparation; S. Shamsuddin: Conceptualization, Validation, Supervision; S.R. Kamat: Methodology and Editing; M. Mat Ali: Experimental Set-up and Data Collection; M. Maharof: Writing-Reviewing; H. Yussof: Validation.

CONFLICTS OF INTEREST

The article has not been published elsewhere and is not under consideration by other journals. All authors have approved the review, agree with its submission, and declare no conflict of interest on the article.

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