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Classifying Emotional Responses of Children with Autism towards Robot Movement: A Proposed Framework Based on a Preliminary Case Study

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ABSTRACT

Children with Autism Spectrum Disorder (ASD) face unique challenges in recognizing, processing, and expressing emotions. Recent technological interventions using robots provide promising avenues to support these individuals. By integrating the Kansei Engineering approach and the KJ Method, this study proposes a refined framework for classifying emotional responses elicited by various robot movement patterns such as circular, forward, forward left, forward right, reverse left, and reverse right based on previous preliminary case study. These theoretical underpinnings, describe methodological approaches, and discuss the implications for designing adaptive robot systems that enhance social communication and educational outcomes for children with ASD. While based on preliminary case study, the proposed framework provides valuable insights into interpreting emotional responses in children with ASD and can act as useful reference for incorporating robots into their daily routines.

1. Introduction

Autism Spectrum Disorder (ASD) is a complex neurodevelopmental disorder characterized by deficits in social interaction and communication, as well as repetitive and restricted behaviors [1,11]. In recent years, technological advancements, especially in robotics, have provided innovative ways to support educational and therapeutic interventions for children with ASD [3,4,17]. Robots have been shown to capture attention, facilitate social interaction, and assist in emotion regulation through controlled and predictable movement patterns [9,14].

Despite these advances, a critical challenge remains such as the robust identification and classification of emotional responses from children with autism during interactions with robots. Owing to their difficulties in expressing emotion in conventional ways, it becomes necessary to develop detailed classification systems. Building on the promising results of an exploratory case study conducted at a Malaysian care center, Pusat Jagaan Kanak-Kanak Istimewa SAYANG in Shah Alam

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[22], this proposes an enhanced framework based on Kansei Engineering and KJ Method. The goal is to create a unified taxonomy of emotional responses of children with ASD towards robot movement.

2. Literature Review

2.1 Autism and the Complexity of Emotional Expression

Research has demonstrated that children with ASD experience and process emotions differently than non-autistic children. The challenges are compounded by sensory processing anomalies and difficulties in language and communication, which can mask or alter emotional expressions [10,19]. Autism spectrum disorder encompasses a wide range of abilities and developmental variations. While some individuals with autism demonstrate strong verbal communication skills and others entirely non-verbal. The level of support required also significantly different, certain individuals need substantial assistance with daily functioning, whereas others can lead relatively independent lives with minimal support. As children with autism grow, they exhibit distinct behavioural patterns, including avoidance of eye contact or verbal interaction, intense focus on specific objects, or social withdrawal. These behaviours are often associated with what has historically been termed "infantile autism," a condition that may persist into adolescence and adulthood. Autism spectrum disorder (ASD) commonly emerges before the age of three and often endures across the lifespan, although the severity and presentation of symptoms change or improve over time. While some children show signs of autism within the first year of life, others do not exhibit noticeable symptoms until 24 months of age or later. In certain cases, children initially achieve typical developmental milestones and acquire new skills up to approximately 18 to 24 months of age, after which a regression occur, resulting in the loss of previously acquired abilities. [1]. Traditional methods of emotion recognition do not translate effectively, making non-verbal cues and behavioural observations pivotal for understanding these children’s inner experiences.

2.2 Robots in ASD Intervention

Social robots have been introduced to foster engagement and facilitate communication in children with ASD [5]. Their use in therapy leverages consistent, controlled movements, and simplified social cues, supporting the development of trust and emotional comfort. Various studies have documented that specific robot movements such as forward, circular, reverse can evoke distinct emotional responses which from delight and curiosity to confusion and mild distress [14,16]. A study investigating the interaction between children with autism and either a human arm or a robotic arm model revealed notable findings. The results indicated that children with autism demonstrated enhanced performance when exposed to robotic arm movements, as evidenced by reduced movement times and earlier peak velocities. These outcomes suggest that robotic interaction positively influence the visuomotor priming mechanisms in children with autism [14]. These findings indicate that robot movement is not more than a mechanical function but a mediator of social and emotional interaction. However, a study emphasized although the use of robot-assisted movement in rehabilitation and therapy benefit children with autism, it is essential to consider the associated ethical implications. These include evaluating the emotional bonds that form between children with ASD and robots, as well as assessing the appropriate extent to which robots should be integrated into the therapeutic process. The researchers further argued that robots should not serve as a replacement for human interaction in autism therapy but rather function as a complementary tool that supports and enhances human involvement [18].

2.2 Kansei Engineering and the KJ Method in Emotion Analysis

Kansei Engineering translates subjective impressions into design parameters offers a valuable framework for quantifying emotion [6,7]. KJ Method, an affinity diagram technique, developed by Professor Jiro Kawakita, is a well-established technique in Kansei Engineering designed to support the development of innovative and user-cantered designs that enhance the overall user experience [7]. This method was specifically developed to analyse and categorize design elements based on distinct concepts related to physical design features. It involves the collection and synthesis of Kansei Words, which are derived from a variety of sources including academic journals, product websites, and relevant literature. These Kansei Words are then grouped through expert-driven clustering to determine their affinities and subsequently classified into specific design characteristics of the product with careful consideration of user needs and preferences. In the pilot study by Zabani *et al*., [22], this method was employed to consolidate emotional response keywords into clusters such as reluctant, elated, blissful, enthusiastic, and agreeable. This categorization not only assists in understanding how children with ASD respond to robot movement but provides concrete design guidelines for future robot interventions.

3. Methodology

3.1 Integration with Preliminary Case Study

The review findings were integrated with data from the preliminary case study conducted at Pusat Jagaan Kanak-kanak Istimewa SAYANG in Shah Alam, Malaysia [22]. In that study, observations and caregiver-led interviews during robot movement sessions generated specific emotional keywords, which were then clustered using the KJ Method. These clusters served as the baseline for the proposed classification framework.

3.2 Proposed Framework Development

The development of the proposed framework is grounded in a multidisciplinary approach that integrates emotional data collection, behavioral observation, movement pattern analysis, and expert validation. The framework is designed to systematically classify the emotional responses of children with ASD in relation to specific robot movement patterns. It synthesizes four key components:

- Emotional Keywords: A comprehensive set of emotion-related terms was derived from two primary sources, semi-structured interviews with caregivers and direct behavioral observations of children with ASD during robot interaction sessions. These keywords reflect the emotional reactions exhibited by the children.
- Movement Patterns: The framework incorporates seven distinct robot movement patterns circular, forward, forward left, forward right, reverse left, reverse right. Each movement was designed to simulate common gestures and motions that obtain from different emotional responses in children. The emotional impact of each movement type was assessed to identify patterns of affective engagement.
- Clustering Analysis: KJ Method was employed to group the extracted emotional keywords into meaningful clusters. This qualitative clustering process involved organizing keywords based on semantic similarities and emotional affinities, allowing for the emergence of broader emotional categories that represent consistent patterns of response across multiple interactions.

- Expert Validation: To ensure the reliability and relevance of the emotional clusters, the framework underwent iterative review and validation by a panel of experts, including clinical psychologists specializing in autism, as well as professionals in Kansei Engineering. Their input was crucial in refining cluster definitions, ensuring that the emotional groupings aligned with both psychological theory and user-cantered design principles.

4. Result

4.1 Emotional Response Keywords and their Associations

The preliminary case study reported a diverse set of keywords for specific robot movements shown in Table 1. For instance, forward motion elicited responses such as curious, excited, and attentive, while more complex or reverse movements occasionally induced feelings of confusion, weird, and amazed.

Table 1
Summary of emotional response keywords by robot movement

Robot Movement	Emotional Keywords
Circular	Happy, Cheerful, Excited, Confused, Attracted, Weird, Blur, Attentive, Interested
Forward	Curious, Excited, Attentive, Anticipating, Interested, Confuse, Attracted, Delighted, Accepting
Forward Left	Surprised, Interested, Amazed, Amused, Anticipating, Weird, Adoring, Admiring, Happy, Amused, Excited
Forward Right	Interested, Amazed, Amused, Anticipating, Enjoy, Joyful, Excited
Reverse Left	Curious, Attentive, Enjoy, Excited, Amazed, Amused, Happy
Reverse Right	Curious, Excited, Delighted, Enjoy, joyful, Anticipating, Satisfied, Amazed, Attentive, Adoring, Admiring

4.2 Cluster Formation from KJ Method

KJ Method was employed to systematically organize and analyse the collected Kansei keywords. This qualitative technique facilitated the identification of emotional themes by grouping semantically similar words into distinct clusters. Through expert evaluation and iterative synthesis, a refined classification framework was developed, resulting in five emotional categories or macro clusters. Each cluster captures a specific affective response pattern relevant to children with ASD in the context of robot interaction:

1. Reluctant: This category encompasses negative or unclear emotional responses such as confused, weird, and blur. These terms reflect discomfort, uncertainty, or hesitation, which indicate a lack of engagement or difficulty in processing the interaction.

2. Enthusiastic: Comprising terms like anticipating, admiring, and adoring, this cluster represents positive forward-looking emotions, highlighting eagerness, appreciation, and emotional attachment during interaction with the robot.

3. Blissful: Including expressions such as joyful, happy, and cheerful, this group reflects a state of emotional contentment and pleasure, suggesting a strong positive response and comfort in the interaction.

4. Elated: This is the most diverse cluster, featuring emotions like amazed, amused, delighted, attentive, excited, curious, interested, attracted, surprised, and enjoy. These terms indicate high engagement, emotional arousal, and cognitive stimulation, the key indicators of effective interaction and learning potential.

5. Agreeable: Encompassing accepting and satisfied, this cluster captures a sense of contentment and openness to the robot, suggesting a balanced and harmonious emotional state.

This structured taxonomy not only reflects the emotional diversity observed during interaction but also integrates insights from both empirical observations and expert judgments. It provides a framework for future studies exploring affective responses in robot-assisted therapy or educational interventions among children with ASD. The classification can inform robot design considerations by aligning emotional goals with specific behavioural cues.

5. Discussion

5.1 Implication for Robot Design

The refined emotional classification framework supports the design of adaptive robotic systems that respond in real time to the child’s affective state. For example, a robot programmed to detect early signs of confusion through facial cues or body language could modify its movement parameters to reengage the child or switch to a less complex motion. Similarly, boosting features that evoke joyous reactions can enhance learning and therapeutic outcomes [9,17].

5.2 Role of Caregiver and Expert Validation

Integrating caregiver observations and expert insights include clinical psychologists and Kansei expert provides a more detailed understanding between movement and emotion. The multi-layered validation is critical to ensure that the classification scheme reflects not only laboratory conditions but also real-world interaction dynamics [22].

5.3 Limitation and Future Work

While the proposed framework presents a promising approach to understanding and designing emotion-sensitive robot interactions for children with ASD, it is important to acknowledge its current limitations. The framework is primarily based on preliminary data gathered from a small sample size, which not capture the full variability in emotional responses across the broader ASD population. As such, the generalizability of the findings remains limited.

Future research should aim to expand the participant pool to include a more diverse group of children, particularly those representing a wider spectrum of autism severity from high-functioning individuals to those with more profound support needs. This would enhance the robustness of the emotional taxonomy and ensure its applicability across different user profiles.

Additionally, incorporating sensor-based emotion recognition systems such as facial expression analysis, eye-tracking, voice analysis, and physiological monitoring such as heart rate, skin conductance could provide objective, real-time insights into the emotional states of children during robot interaction. These multimodal data sources would enrich the emotional dataset and support the development of more accurate and responsive robot behaviours.

Ultimately, addressing these limitations through broader, sensor-supported, and long-term research efforts will be essential in refining the proposed framework and ensuring its value for practical implementation in educational, clinical, and domestic settings.

6. Conclusion

The researcher has developed a refined emotional taxonomy intended to inform the design of more adaptive, personalized, and effective robot-assisted interventions for children with ASD. This taxonomy, grounded in the principles of Kansei Engineering and rigorously validated using KJ Method offers a systematic classification of emotional responses based on observed behavioural patterns and affective expressions during human-robot interaction. By translating subjective emotional experiences into structured clusters, the framework enables caregivers and therapists to better understand how children with ASD emotionally engage with robotic systems.

This approach addresses a critical gap in current technology development by emphasizing the emotional dimension of user experience, an aspect that is often overlooked in favor of functionality alone. The taxonomy can serve as a foundational reference for selecting or designing robot features such as facial expressions, movement types, or voice modulation that are more likely to evoke positive emotional responses, maintain engagement, and support therapeutic goals.

Ultimately, this framework provides a valuable tool for researchers and practitioners seeking to optimize educational and therapeutic applications involving robots and contributes to the growing body of interdisciplinary research at the intersection of robotics, affective computing, and special needs education.

References

[1] Centers for Disease Control and Prevention. (2022, March 9). Autism Spectrum Disorder (ASD). Retrieved from https://www.cdc.gov/ncbddd/autism/treatment.html

[2] Maw, Su Su, and Chiyori Haga. "Effectiveness of cognitive, developmental, and behavioural interventions for Autism Spectrum Disorder in preschool-aged children: A systematic review and meta-analysis." *Heliyon* 4, no. 9 (2018). https://doi.org/10.1016/j.heliyon.2018.e00763

[3] Saleh, Mohammed A., Habibah Hashim, Nur Nabila Mohamed, Ali Abd Almisreb, and Benjamin Durakovic. "Robots and autistic children: a review." *Periodicals of Engineering and natural Sciences* 8, no. 3 (2020): 1247-1262. https://doi.org/10.21533/pen.v8.i3.1162

[4] Bartl-Pokorny, Katrin D., Małgorzata Pykała, Pinar Uluer, Duygun Erol Barkana, Alice Baird, Hatice Kose, Tatjana Zorcec, Ben Robins, BJörn W. Schuller, and Agnieszka Landowska. "Robot-based intervention for children with autism spectrum disorder: a systematic literature review." *Ieee Access* 9 (2021): 165433-165450. https://doi.org/10.1109/ACCESS.2021.3132785

[5] Valadão, Carlos Torturella, Christiane Goulart, Hamilton Rivera, Eliete Caldeira, Teodiano Freire Bastos Filho, Anselmo Frizera-Neto, and Ricardo Carelli. "Analysis of the use of a robot to improve social skills in children with autism spectrum disorder." *Research on Biomedical Engineering* 32 (2016): 161-175. https://doi.org/10.1590/2446-4740.01316

[6] Lokman, Anitawati Mohd. "KE as affective design methodology." In *2013 International Conference on Computer, Control, Informatics and Its Applications (IC3INA)*, pp. 7-13. IEEE, 2013. https://doi.org/10.1109/IC3INA.2013.6819139

[7] Karim, Hanisah Abdul, Anitawati Mohd Lokman, and Fauziah Redzuan. "Older adults perspective and emotional respond on robot interaction." In *2016 4th international conference on user science and engineering (i-user)*, pp. 95-99. IEEE, 2016. https://doi.org/10.1109/IUSER.2016.7857941

[8] Ghorbandaei Pour, Ali, Alireza Taheri, Minoo Alemi, and Ali Meghdari. "Human–robot facial expression reciprocal interaction platform: case studies on children with autism." *International Journal of Social Robotics* 10, no. 2 (2018): 179-198. https://doi.org/10.1007/s12369-017-0461-4

[9] Ali, Emad Mohammad, Fatimah Eid Ziad Al-Adwan, and Yazan M. Al-Naimat. "Autism spectrum disorder (ASD); symptoms, causes, diagnosis, intervention, and counseling needs of the families in Jordan." (2019): 48-56. https://doi.org/10.5539/mas.v13n5p48

[10] Hyman, Susan L., Susan E. Levy, Scott M. Myers, Council on Children with Disabilities, Section on Developmental and Behavioral Pediatrics, Dennis Z. Kuo, Susan Apkon, Lynn F. Davidson et al. "Identification, evaluation, and management of children with autism spectrum disorder." *Pediatrics* 145, no. 1 (2020): e20193447. https://doi.org/10.1542/9781610024716-part01-ch002

[11] Ben-Sasson, Ayelet, Liat Hen, Ronen Fluss, Sharon A. Cermak, Batya Engel-Yeger, and Eynat Gal. "A meta-analysis of sensory modulation symptoms in individuals with autism spectrum disorders." *Journal of autism and developmental disorders* 39, no. 1 (2009): 1-11. https://doi.org/10.1007/s10803-008-0593-3

[12] Aziz, Azhar Abdul, Fateen Faiqa Mislan Moghanan, Mudiana Mokhsin, Afiza Ismail, and Anitawati Mohd Lokman. "Humanoid-robot intervention for children with autism: a conceptual model on FBM." In *International Conference on Soft Computing in Data Science*, pp. 231-241. Singapore: Springer Singapore, 2015. https://doi.org/10.1007/978-981-287-936-3_22

[13] Pierno, Andrea C., Morena Mari, Dean Lusher, and Umberto Castiello. "Robotic movement elicits visuomotor priming in children with autism." *Neuropsychologia* 46, no. 2 (2008): 448-454. https://doi.org/10.1016/j.neuropsychologia.2007.08.020

[14] Ferrari, Ester, Ben Robins, and Kerstin Dautenhahn. "Therapeutic and educational objectives in robot assisted play for children with autism." In *RO-MAN 2009-The 18th IEEE international symposium on robot and human interactive communication*, pp. 108-114. IEEE, 2009. https://doi.org/10.1109/ROMAN.2009.5326251

[15] Barakova, E. I., & Lourens, T. (2020). Expressing and interpreting emotional movements in interactive systems. Personal and Ubiquitous Computing.

[16] Miskam, Mohd Azfar, Mohd Aminullah Che Hamid, Hanafiah Yussof, Syamimi Shamsuddin, Norjasween Abdul Malik, and Siti Nora Basir. "Study on social interaction between children with autism and humanoid robot NAO." *Applied mechanics and materials* 393 (2013): 573-578. https://doi.org/10.4028/www.scientific.net/AMM.393.573

[17] Ntaountaki, Polyxeni, Georgia Lorentzou, Andriana Lykothanasi, Panagiota Anagnostopoulou, Vasiliki Alexandropoulou, and Athanasios Drigas. "Robotics in Autism Intervention." *Int. J. Recent Contributions Eng. Sci. IT* 7, no. 4 (2019): 4-17. https://doi.org/10.3991/ijes.v7i4.11448

[18] Belin, Laurine, Laurence Henry, Mélanie Destays, Martine Hausberger, and Marine Grandgeorge. "Simple shapes elicit different emotional responses in children with autism spectrum disorder and neurotypical children and adults." *Frontiers in psychology* 8 (2017): 91. https://doi.org/10.3389/fpsyg.2017.00091

[19] Redzuan, Fauziah, Anitawati Mohd. Lokman, Zulaiha Ali Othman, and Salha Abdullah. "Kansei design model for engagement in online learning: a proposed model." In *International Conference on Informatics Engineering and Information Science*, pp. 64-78. Berlin, Heidelberg: Springer Berlin Heidelberg, 2011. https://doi.org/10.1007/978-3-642-25327-0_7

[20] Boccanfuso, Laura, Erin Barney, Claire Foster, Yeojin Amy Ahn, Katarzyna Chawarska, Brian Scassellati, and Frederick Shic. "Emotional robot to examine different play patterns and affective responses of children with and without ASD." In *2016 11th ACM/IEEE international conference on human-robot interaction (HRI)*, pp. 19-26. IEEE, 2016. https://doi.org/10.1109/HRI.2016.7451729

[21] Redzuan, Fauziah, Anitawati Mohd Lokman, Zulaiha Ali Othman, and Salha Abdullah. "Kansei design model for e-learning: A preliminary finding." In *Proceeding of the 10th European Conference on e-Learning (ECEL-2011)*, pp. 685-696. 2011.

[22] Zabani, Fatin Nadhirah, Jo Anne Saw, Nur'aina Daud, Azhar Abd Aziz, and Anitawati Mohd Lokman. "Exploring Emotion Classification for Children with Autism in Response to Robot Movement: A Preliminary Case Study in Malaysia." In *International Conference on Kansei Engineering & Emotion Research*, pp. 28-40. Singapore: Springer Nature Singapore, 2024. https://doi.org/10.1007/978-981-97-9890-2_3