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Interpretation of Humanoid Design towards ASD Learning Abilities: Theoretical framework

Fatin Amirrah Zainal Abidin [1], Rusmadiah Anwar [2], Zainudin Siran [3]

[1,2] Nation Design Center, College of Creative Arts, Universiti Teknologi MARA Shah Alam, 40450 Shah Alam, Selangor, Malaysia
[3] Centres for Immersive Digital Applications and Content (CISDAC), Faculty of Creative Multimedia, Multimedia University (MMU), 63100 Cyberjaya, Malaysia

rusma935@uitm.edu.my, famirrah.zabidin@gmail.com, *zainudin.siran@mmu.edu.my*
Tel +60 13 890 8298

Abstract
The humanoid robot has been used in part of the intervention programme for Autism Spectrum Disorder (ASD). Some studies address what kind of form and functionality a human-like robot should have to be socially accepted by them as Autism Spectrum Disorder (ASD) children's motivation faces complex challenges. This research aims to study the specific factor, problems and connection elements between the contexts of issues related to the interpretation of humanoid design toward ASD learning abilities. All the studied variables identified from the literature of recent theory models were summarized and arranged accordingly to form the conceptual framework.

Keywords: Humanoid Robot Design; Personalisation; New Product Development; ASD Learning Abilities

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1.0 Introduction

Human-robot social interaction plays a vital role in spreading the use of robots in daily human life. In the course of effective social interaction, robots will be able to perform many tasks in human society and improve the lives of mankind. These tasks may include but are not restricted to handling various house duties, providing medical care for elderly people, assisting people with motor or cognitive disabilities, educational entertainment, personal assistance, and many more. Artificial intelligence (AI), synthetic emotion, and programmed interactivity are three critical components of this emergent form of human communication, which is rapidly gaining importance in today's technological society (Zhao, 2006). Robotics nowadays are programmed with physical entities that interact with humans socially, often giving them human-like characteristics at this moment. In this social encounter, both parties see and interpret emotions multimodally. The main benefits of designing a robot to mimic human emotional expressions are to enable emotional empathy and make social ties by borrowing from immediately recognizable anthropomorphic features like facial expressions, gestures or speech. To communicate effectively, such appearance-constrained robots have to draw on modalities like colour, sound or vibration instead. Previous research on affective communication utilizing non-anthropomorphic channels concentrated on analyzing emotion recognition of specific unimodal and multimodal expressions. However, a precise multimodal analysis would allow deriving design recommendations that can adapt to a variety of appearance-constrained social robots to create tailored expressions that maximize emotion identification and users' confidence in emotion recognition, especially for special needs people. This research attempt to discover the most prioritized facial character element

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design preferences which can interact with ASD children. A humanoid robot is used as the subject matter to analyse the character of patterns to determine the correlation between the behaviour of children with autism spectrum disorders and the visual design appearance.

1.1 Humanoid Robot Design

The specific character and preference features of humanoid robot design are still unclear and rarely developed (Anwar et al., 2020). The recent robotic innovation insists on the basic movement and appearance to distinguish their intentions (i.e. friendly versus unfriendly), capability to understand and emotional expression (Woods, 2006). The robot engineers and therapists are concerned with finding the appearance of the appropriate robot for interventions. Several experiments were in the pilot study stage and lacked participants, less research has been done to analyze the specific characteristics and features of designing a humanoid robot's facial appearance. Some of the main components to be based on include the study of proportions, facial expressions, typology and material used. More humanoid robots are still in the research stage, such as Robota, Pabi, Iromec, Kaspar, Ryan, Aurora, Bubblebot, Troy, FACE, Pleo Labo-1 Infanoid, Hoap-3, M3-Synchy, Smile Supplement Robot, Actroid-F, and Probo. Some of the types are Biped, wheel, upper-torso, anthropomorphic and zoomorphic. The robot design requirements categories are appearance, functionality, safety requirements, autonomy, modularity, and adaptability (Cabibihan et al., 2013). The appearance consists of visual appeal, realism, size, anthropomorphic, non-anthropomorphic or non-biomimetic are things to be considered when innovating the design of the robot. Some of the humanoid robots that are currently available in the market is shown in Table 1.

Table 1. Commercialize Humanoid Robot for ASD

Robot Design	Specification, Character and Function
	Model: QTrobot (2012) Character: upper-torso, White colour body with blue colour details, monitor head-mounted, have a voice Functions: a tool for therapists and educators, It uses facial expressions, gestures, and games to teach children
	Model: NAO 6 Character: a bipedal robot, white and grey colour body part, light green eyes Function: used for social and emotional skills
	Model: BUDDY PRO Character: upper-torso with wheel robot, white body, touch screen head, light on the shoulder. Function: an emotional robot is a small robot that improves social skills by playing games, telling stories and doing small exercises with the kids.
	Model: MILO Character: with a human-like face, spiky hair and a child-like, friendly voice. It has a video screen on the chest that shows symbols. Function: to teach social behaviours and emotional identification
	Model: LEKA Character: a ball-shaped robot with a screen display Function: It helps parents, caregivers, and therapists teach motor, cognitive, and emotional skills through play
	Model: KEBBI AIR S Character: an upper-torso robot with a Head panel Function: An educational/ companion/ service robot for all scenarios
	Model: MISTY II Character: upper torso with wheel Function: A Partner in Socially Assistive Therapy

Model: IPAL

Character: biped with wheel, display in the body

Function: serve as a teacher's assistant in the education process.

1.2 Facial Expression Design

The human face plays an essential part in human-human experiences. It acts as an identification marker that makes it possible to visually differentiate one person from another and as a channel by which non-verbal social cues are conveyed. According to Sowmiya et al., (2022), robots with good aesthetic design, rich personalities and social cognitive intelligence can connect deeply and meaningfully with humans. Moreover, giving robots human form and functionality should make human-robot interaction easier and better (Prakash & Rogers, 2015). Moreover, It is at least one reason for the increased zeal in humanoid design, which are robots designed to have some human resemblance. Ekman (1993) introduced a 'Facial Action Coding System (FACS)' that led to a theory implying a definite nature for expressions, suggesting all indications are combinations of the primary expressions of happiness, sadness, anger, fear, disgust, and surprise. For many researchers, when creating a humanoid robot, the so-called "uncanny valley" is necessary to avoid. According to Mori (1970), the uncanny valley is the appearance of a too human-like robot until it comes to a point when the robot becomes "creepy". However, there is a limited understanding of the impact of the uncanny valley on children with Autism. The robots like Kaspar and FACE passed the uncanny valley, or this factor does not affect children with Autism. There has to be further research to identify the exact issues in creating the robot's face design specifically for children with an autistic spectrum disorder.

1.3 Autism Spectrum Disorder Learning Abilities

Autism Spectrum Disorder (ASD) is a neural development characterized by impaired social interaction, verbal and non-verbal communication and restricted and repetitive behaviour (Kaur et al., 2015). The neurological disorder affects the brain's biological activity and communication. The criteria consist of severe developmental disorder, delayed development, limited ability to social interaction and loss of understanding. Improvement requires a systematic approach and early intervention to enhance communication and social through the assistive system such as turn-taking and eye contact. Robot Based Intervention Program (RBIP) is a scientific interactive learning method for teaching children with Autism. Cabibihan et al., (2013) mentioned, that robots help to engage complex social behaviour to recognize personal space, communication, turn-taking, gross motor skills and skilled in specific tasks. According to Quiroga et al., (2022) in robot-assisted therapy scenarios, it is important to have robots that can be easily adapted to the needs of the therapy. In Malaysia, the studies on robot-based intervention programs (RBIP) cooperating the interaction between humanoid robot NAO and ASD children. Developing eye contact and emotion through body poses and gestures to reduce autistic traits. However, less research to analyze the specific characteristics and features to design a humanoid robot's facial appearance that caters specifically to ASD children. despite this, the physical appearances of humanoid robots designed for ASD treatment are vast and vary. the engineers and therapists looking for appropriate robot appearance for interventions. Most of the research is still at the pilot study level and lacks participants.

2.0 The Development of Conceptual Framework

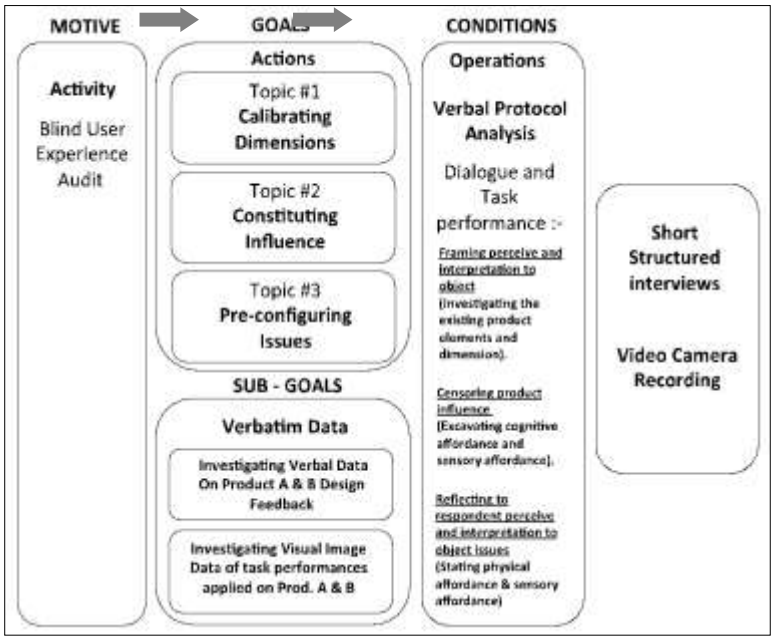

Fig. 1: Theory models of Tactile Iconography Array Configuration for a Blind People
(Source: Vermont, et al. 2016)

In order to establish a solid research base, this study is adapting the theory models of Tactile Iconography Array Configuration for blind people explored by Vermol, et al. (2016). The theory was inspired by the concept of Hierarchical Structure by Kaptelinin (2005), which explores the design activity in research, and involved three major stages: the motives, goal and conditions. The motive stage insists on specific design activity for particular research samples (respondents) as the fundamental criteria for the research. At the goal stage the specific activity will be extracted to expand into some detailed activity, involving two elements 1) verbatim data (visual and verbal) and 2) the design action (influence factor, problems and context). While for the conditions stage constitutes a specific research operation which is Verbal Protocol Analysis (VPA) that through dialogue and design experiment. The importance of the connection between activity, action and operation determines the credibility of the data finding in design research (Vermol, et al., 2016) and the critical factor to the success of research in design (Anwar, 2015).

The literature review will clarify relevant definitions and terms related to the title and field of study during the early research stage. The volume of data to be collected from previous studies would then influence a research guideline (Siran & Anwar, 2020); (Anwar, 2016). The comparative variable will determine the influence of lack of information through the analysis of observational data and will explain the challenges later. The empirical test in design activity is essential to understand how designers think during the form-giving process (Siran, 2018; Anwar, 2016; Abidin et al., 2008; Warell, 2006). This research study will focus on three main factors; 1) To discover the most prioritized facial character preference, which interacts with ASD children 2) To profile the character of personalization design into humanoid robots in the NPD process 3) To analyse the character of patterns for the correlation of ASD children behaviour and the visual appearance of humanoid robots.

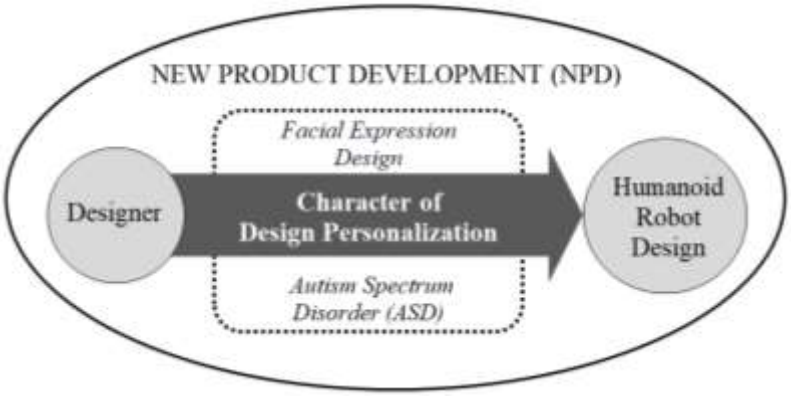

Fig. 2: Humanoid Character Design Personalization Conceptual Research Framework

The fundamental issue of this research is new product development (NPD), which insists on the design process (Anwar et al., 2015). The specific concern of the design process is how the designer approaches the design of the humanoid product concept. For this reason, an in-depth understanding of the designer's thinking is critically needed. It's required for strategic investigation method through design experiment with the task: designing a humanoid robotic to assist Autism Spectrum Disorder (ASD) children for enhancing their social abilities. Through the scientific method of a design experiment, *the specific* character of design personalization elements of humanoid robotic design for ASD children is able to clarify. As for design guidelines and inspiration for personalization character, therefore the task brief states some criteria of *Facial Expression subject to be implemented into the design*. Through this conceptual framework, therefore further exploration can proceed toward clarifying the criteria of related variables.

3.0 Discussion

There are many studies related to the importance of the facial design of robots as it is the main area where are attracted by the children. According to Ha et al., (2022), studies have been made intending to utilize eye tracking for the appearance of a robot, which is one of the trends in social robot design research. Research into the design of social robots may be broken down into three categories: surface and appearance design, functional and role-based design, and interaction design.

In order to explore the issue rigorously, a structured research method was strategised to profile the specific character of design personalization elements of humanoid robotics from the designer. The process begins with studying the related literature, acquiring feedback from ASD on Facial Expression character, profiling designers thinking through Verbal Protocol Analysis methodology (VPA) design experiment to the group of designers and validating the design outcome through testing on the ASD children. The recent theory and literature issues influence the conceptual research framework, categorizing the variables into particular arrangements processes. The survey feedback from ASD children provides a basic design guideline specification to the task brief to the designers in the design experiment (VPA). The ASD children's feedback is studied particularly on the Facial Expression of a cartoon character, often shown in TV series. the controlled environment of the VPA experiment was set to incorporate an experienced designer who has expertise in designing a character and is familiar with product design (Siran, 2020; Anwar 2016). Activity from the design experiment of VPA contributes rich data related to the design process, influence factor and the character of designers thinking of robotic products for a particular category of people.

The Design outcome from the VPA experiment will be transformed into a prototype to be tested on ASD children and in the area of expertise (teacher or counsellor). Their response and feedback will influence the effectiveness of the proposed design as the data validation.

4.0 Conclusion and Future Work

These studies significantly discovered the most prioritized factors, which clarify the character of design personalization elements of humanoid robotic design as studies have rarely been conducted on this topic. Moreover, the study to be used as a design guideline for the development studies beneficial to researchers and designers. Because of this, the study will not go into detail on the technical difficulties, such as the engineering calculation. In addition, the efficacy of using humanoid robots in any industry will not be addressed by this study in any capacity. The analysis of findings from the correlation of patterns between the designer's behaviour and the character of ASD's actual response through Facial Expression is clarifying the character of designers thinking pattern on design personalization elements of humanoid robotic design. The future work will include exploration of the character of anatomic body movement of the humanoid robotic design to recognize how it might different the behaviour that underlying the designer's way of thinking.

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