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EMF: Humanoid Robots Design Scheme for Child with Autism

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Abstract
This research explores the humanoid facial design through Eyes-Mouth Features (EMF) as an indication of human embodied consciousness design. The study will be focused on portraying the practical model based on the syntax context focusing on Autism Spectrum Disorder (ASD) based design development. This design integrates the value of appealing sensations that can trigger the feelings and impressions of the child with ASD. It is critical to developing an effective decision support system for designers to deal with challenges relating to consumers' psychological preferences towards a humanoid facial character that appeals to human emotion.

Keywords: Humanoid; Design; Autistic; Facial Appealing

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1.0 Introduction

Autism spectrum disorder (ASD) refers to a range of conditions characterised by challenges with social skills, repetitive behaviours, speech and nonverbal communication, and unique strengths and differences. ASDs are characterised by social-interaction difficulties, communication challenges and a tendency to engage in repetitive behaviours. A complex developmental disability typically appears during the first three years of life, is Four times more prevalent in boys than girls, has No racial, ethnic or social boundaries, and cuts across family income, lifestyle and educational levels. Autism and its associated behaviours have been estimated to occur in as many as 1 in 68 newborns. This means that approximately 9,000 children in Malaysia are born with autism yearly. Rational reasons are they can work in the human environment without needing to adapt themselves or change the environment. Our environment and our tools are adapted for us. Why adapt all to robots?! It is easier for a human being to interact with a human-like being.

Impaired communication involves delayed or loss of responsive language as one primary determinant of autism. Addressing their cognitive capabilities helps to assist in improving their quality of life and helps to ease their lives as they perceive the world differently due to their sensory issues. The literature shows that many researchers have chosen robots as a tool in the intervention for children with ASD. As in Malaysia, there are several relevant studies related to robot-based intervention programmes (RBIP) in managing ASD. However, there is rarely the involvement of ASD children in the design development process to create a humanoid robot. The lack of literature in this topic calls for the dire need for this study. The method of the New Product Development process and the designer's knowledge of ASD issues and humanoid might be inappropriate and need clarification. Gardiner and Rothwell (1985) stated that the customer's role involves more than simple consultation but includes using the customer as a partner in the design and development process. New emergent

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research domain here in Malaysia. Hence, it requires further study to establish its incremental validity and research justification that goes beyond the scientific emergent research domain here in Malaysia.

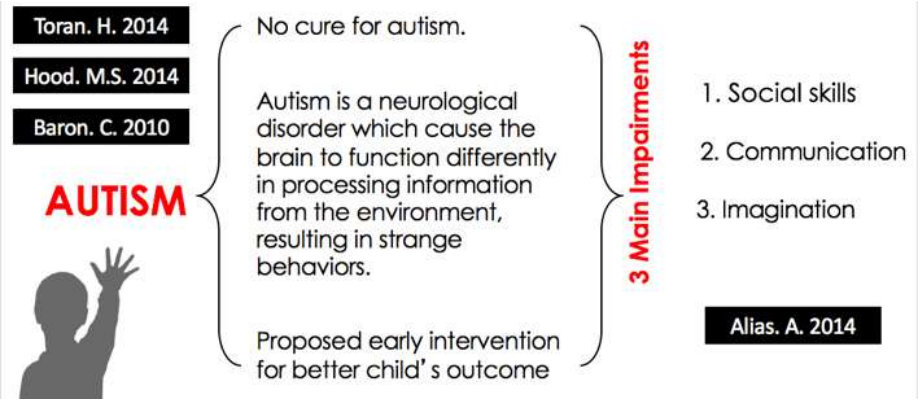


Fig. 1: EMF sketch experimentation

2.0 Humanoid Robot Design for Autism

In the process of new product development (NPD), the method of personalisation character approach is commonly used in automotive design and product design. The approach meant to emphasise the product's physical form, such as aesthetics, ergonomics, and user interfaces. Despite this, the approach will create more positive attitudes towards product design. It is possible to adapt the design by changing colour, covers or casing and of users' choices (Weiss et al., 2008). Personalisation is now more important than anything else in the market. People want to be able to personalise exclusively to their needs. There comes to the point where it has to be moved forward very quickly. For instance, a product with a particular colour, for example, blue for a man or pink for a woman. It shows that people want things that they can call their own where they can be associated with their character. Personalisation also refers to matching one object's nature with one subject's needs (Riemer & Totz, 2003). For example, the new Beetle Car models from Volkswagen have an identical iconic character of beetle insect beside the strong personality of young, fun and cuteness. The new model of Beetle was managed to carry the old identity by reaming the original structure and form with more dynamic, masculine, and sporty characteristics. In these contexts, the approach of personalisation characters on design can cater to a specific group or individual's interest, intention and demand.

Robots were utilised extensively as assistive technology in many areas of ASD research (Cabibihan et al., 2013). Cabibihan added that robots help children with autism become more socially engaged and train complex social behaviour such as recognising personal space, communication, turn-taking, gross motor skills, and skill in specific tasks. Robots for autism therapy was made in 1976 by paediatrician Sylvia Weir and psychotherapist Ricky Emanuel with a mobile turtle-like robot LOGO at the University of Edinburgh (Shamsuddin et al., 2012). According to Kaur et al. (2015), eight relevant studies related to robot-based intervention programs (RBIP) in managing ASD in Malaysia. It studies the interaction between humanoid robot NAO and ASD children. The finding from that study of eye contact and emotions using its body poses and gestures result that this robot can reduce the autistic traits of the children with ASD. NAO robots perform verbal and non-verbal interaction during the Robot-based Intervention Program (RBIP). According to Idzhar et al. (2012), Humanoid Robot NAO is an autonomous humanoid robot developed by a French Company named Aldebaran-Robotics. It is a small toy-like size of a two-year-old child with 58 cm high and 4.5kg weight, 25 degrees of freedom from his head to his feet and each joint is equipped with a position sensor. It also can detect faces, mimic eye contact, and moving the head accordingly. There are LEDs in the eyes' contour to simulate emotions and equip with two cameras, voice synthesis, voice recognition. It can read text with a child-like voice. Other than that, there are more humanoid robots for ASD: Robota, Pabi, Iromec, Kaspar, Ryan, Aurora, Bubblebot, Troy, FACE, Pleo Labo-1, Infanoid, Milo, Hoop-3, M3-Synchy, Smile Supplement Robot, Actroid-F, Probo. Some types are Biped, wheel, upper-torso, anthropomorphic, and zoomorphic. The categories of robot design are appearance, functionality, safety requirements, autonomy, modularity, and adaptability (Cabibihan et al., 2013; Yokoi et al., 2003). The appearance consists of visual appeal, realism, size, anthropomorphic, non-anthropomorphic or non-biomimetic. After all, the current design approach is not solely based on autism preferences or co-created with them (Anwar et al., 2020).

Robot is a machine designed to execute one or more tasks automatically with speed and precision. There are as many different types of robots as there are tasks for them to perform. Robots that resemble humans are known as androids. Humanoid refers to any being whose body structure resembles that of a human: head, torso, legs, arms, hands. But it is also a robot that resembles a human in appearance and behavior. The difference between a robot and an android is only skin-deep, looks exactly like humans on the outside, but with the internal mechanics of a humanoid robot. Is a robot whose appearance is based on the human body. Humanoid robots have a torso, a head, two arms and two legs. Some may only be from the waist up. Some may have a 'face' with 'eyes', 'ears', a 'nose' a 'mouth', Androids are humanoid robots built to resemble a male human Gynoids are humanoid robots made to resemble a human female. Based on literature, there is a lot of experiment including clinical research investigating the engagement of humanoid robot and child with autism. Recent research has found that these children are more comfortable interacting with robots. Robots are suitable for teaching autistic children as they are capable of frequent repetition.

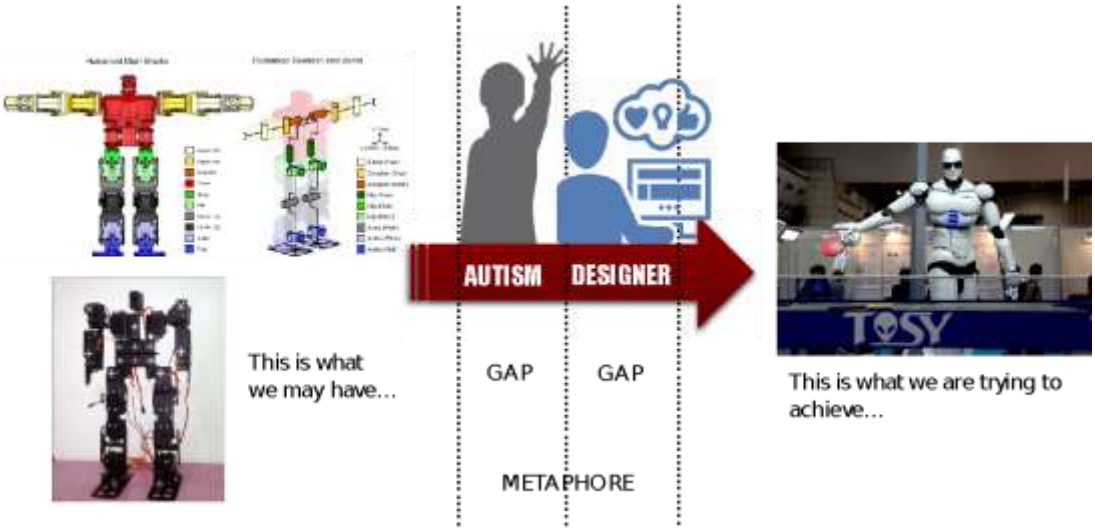


Fig. 2: EMF sketch experimentation

3.0 Eyes-Mouth Features (EMF) as Design Element

This study explores the notion that humanoid design is fundamentally a sign of human embodied mind in product design. Based on contextual of syntactic that can be generalised as an ASD-based product design, the study will be directed to represent the practicability of this proposed model. In addition, this model can be connected to related design fields and product design to product form design. For industry, an imaginative procedure that includes complex visual discernments is a product form design (Siran et al., 2020; Anwar et al., 2015). To manage issues concerning the consumers' psychological preferences toward product forms, it is vital to build up an effective decision support system for designers. It is suitable to apply these standards in assessing the design analysis of product development as product recognition based on religion and culture.

Our mission on this research is to practically plan procedural design activities in promoting autism interaction to humanoid robot design and development: - Our objectives: Carry out an investigation (multiple case study) of 'design-form-anatomy' by revealing the underlying invisible factors of form influences within autism through metaphorical form description. To further examine the Metaphorical form element that influencing the activity in assisting designer's creativity to form development of humanoid 'skin deep'. A design research methodology is defined as an approach and a set of supporting methods and guidelines to be used as a framework for doing design research. Defining and interpreting product design in visual appearance by design methodologies as a reference point for product design. Traditional design methodology recommends was stated below.

Table 1. Design Strategy

Existing Problem description	Abstract solution model
The problem described depends on an individual perspective of a person.	Abstract functional representation and concrete form representation – to open up new solution space

Based on Table 1, a design methodology was applied in this design research based on a model by Blessing and Chakrabarti (2009). Where moving from the existing problem descriptions to an abstract solution model. The existing problem depends on an individual's perspective, and the abstract solution model is an abstract functional representation and concrete form representation, which opens up new solution space. Abstract models are designed for concrete solutions through functional principles and principle structures. In product design, it seems to be a solution for the interpretation of visual appearance concepts such as form and shape to describe the form of the object (Chakrabarti, 2009; Hatchuel & Weil, 2009; Razzouk, 2012; Abidin, 2012: Anwar,2016).

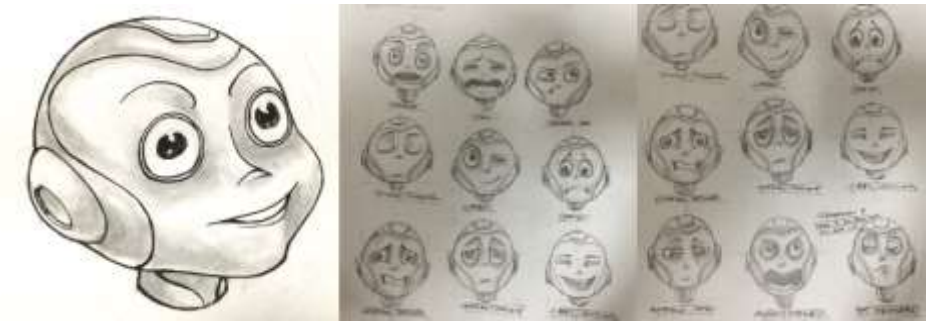


Fig.3: EMF facial expression sketch attributes

This approach was widely used for studies in a related area of investigation and was most far-reaching in configuration inquire about design research methodology. Although the model framework represented in the Blessing and Chakrabati consisted of four stages, the methodology developed to survey the constantly practised by designers in the product industry, including the academy, is the main factor about product development which examines the design protocol analysis.
The approach towards response was established by research enhancement through the analysis of any empirical research methodology and design research. The descriptive analysis was generated from literature-distinguished mitigating processes, while the prescriptive study used the situation identified in practice and replicated the same laboratory study.

4.0 EMF Facial Appealing Factors

Facial character, especially for the humanoid design, plays a big role in the appealing factors affecting the viewer's connection. 'Appeal' factors are rather a vague subject, unstructured and indeterminate. Yet, it is so important to create that character to suit the needs for autistic patients understanding on this particular research. The possibility to measure it directly remains vague. A study by Lokman (2010), stated that "we need to devise indirect measurement methods by considering an alternative form of expression." Kansei Engineering methods also appear to support this study as it is rather ambiguous and may not directly quantify Kansei in animation character design. Arshad et al. (2018) found that 'appeal' in designs contributes to a sense of emotional involvement and is thought to affect the visuals and their intended objective to the viewers. The characteristics that contribute to 'appeal' in EMF model development characters must be recognised to develop a loose concept that can help researchers and designers further investigate character in the future.

To further understand how the EMF progress, the research will be overviewed through qualitative and quantitative research based on the research framework. Two (2) phase of concentrates in data collection will be partitioned as beneath:

4.1 Phase 1: A design literature studies

A review of configuration research will be directed to characterise and recognise the information knowledge gap regarding the design issue. It can make it practicable to empirical significant methodological issues in current design practice and experimental investigations. Another source must confirm the activity system strategy for capturing the experimental information.

4.2 Phase 2: Data Processing and Analyses (Experiment – video observations)

For the experiment part, the observational studies will base on design activities. The importance of this observation due to the lack of study have been conducted especially on video interviewing where, a process of capturing applicant reaction (Bauer et al., 2006), and many scholars have noted about the needs (Guchaita et al., 2014). Toldi (2010) depict, any conventional and video interview is still in its early stages. There is a requirement for qualitative and exploratory investigations alongside quantitative studies to completely comprehend the impact of utilising video technology. Therefore, video observation will be done on the designers. In mapping and analysing design activities, they will record as recorded like the In-Vitro Design Protocol setup by Anwar et al., (2016). The individual task and group undertaking disconnected workstation format

Fig.4: character development

5.0 EMF Design Concept

The concept of personalisation in design approaches is currently in a broad category of product and user, such as leisure products categories like car and accessories. Even so, personalisation designs for children with ASD are rarely available in the market, especially in the robotic sector. The physical appearances of humanoid robots commonly used in treatment for ASD are widely and varied, and

several robots have been suggested as potential therapeutic tools for their treatment. Accordingly, robot engineers and therapists are also concerned with finding the best appearance of robots used in interventions. They have recently attempted to examine preference for robot appearance in individuals with ASD. However, given that most of the experiments are still in the pilot study and the lack of participants, less research has been done to analyse the specific characteristics and features to design a humanoid robot's facial appearance that caters specifically to ASD children. Some main components to be based on include the study of proportions, facial expressions, typology and material used. Moreover, a survey on what characters the ASD children are familiarly attracted to have to be considered because Autism Spectrum Disorder affects the normal functioning of the brain and the way they see and interact with the world are different from other people.

To manage issues concerning the consumers' psychological preferences toward product forms, it is vital to build up an effective decision support system for designers. It is suitable to apply these standards in assessing the design analysis of product development as product recognition based on religion and culture to the practitioner in industries and education fields. This study explores conceptual design, narrowed down into automotive design as less study have been made for this topic. The significance behind this study is to explore the conceptual stage of new product development (NPD) process to the final design stage and the factors that influenced the pattern of design characteristics. Moreover, this can be used as a design guideline in product optimisation specifically from concept stage to final design stage.

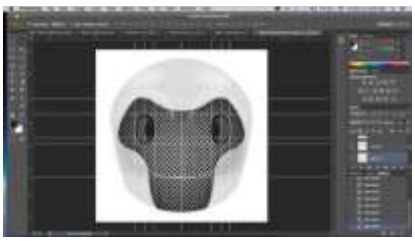
Furthermore, the analysis of the pattern of characteristic changes in these stages could minimise design changes in later stages of development. Through the process, visual aesthetic can be accommodated through Designer Sketch Design Ideation (DSDI) model adapted from Vermont, 2017. The significant from this approach of model; it provides researcher the most prominent sketch line ideation through over layered continues ideation sketching by the designer.

5.1 EMF Digital Characterization

Through digital visual concept development, EMF characterisation enables designer to re-think EYE and MOUTH allocation through the aspect of design formalistic. This process integrates the value of appealing sensation and requires an effective design observation that can trigger the feelings and impressions of the viewer. Firstly, creating an appealing facial outlook on EMF investigation needed a thorough understanding of how the allocation evokes feelings and impressions to the viewer. Most of these EMF digital characterisation are created with the understanding of appealing narratively and human emotions. Facial appealing is a product just like any other tangible product that requires feelings and impressions before making decisions to purchase it. Processing within the Factor Analysis, as suggested by Kansei Engineering, five (5) appealing factors within EMF facial characterisation were pre-determined (TM Soikun, 2015). These five factors which are Charismatic, Aesthetic, Mysterious, Significance and Expressive are presented in the table below.

Table 2. Design Proposed

HUMANOID ROBOT	DESCRIPTION
	**Factor 1** Charismatic Appealing value: Pleasing, Attractive; Simplicity, Round, Bold
	**Factor 2** Aesthetic Appealing value: Stimulating; Charming; Distinctive; Elegant
	**Factor 3** Mysterious Appealing value: Charismatic; Personality; Strong Lines; Bold

	**Factor 4** Significance Appealing value: Warm; Balance; Charming; Culture-related
	**Factor 4** Expressive Appealing value: Feminine, Emotive; Cheerful, Less-aggressive

There were at least 30-factor aspects recorded that can be selected to determine how the 'appeal' factors worked through the new character design. From the calculation using the multivariate analysis; five (5) EMF loose design principles are presented. Before the factors, designers may also mix the 'appeal' components (variables) based on their interpretations, choosing from one or all at once. Furthermore, this may assist designer and product developer in designing their character design to represent appealing in human emotion. Furthermore, this can be the platform to bridge the designers' exploration in calibrating appealing influence within facial expression especially to the autistic patients.

The results' generalizability is constrained because they are based on a small sample of randomly selected autistic individuals resulted from several studies. The face design analysis is also unable to determine what these facial movements genuinely indicate to a human observer. This intuitive-learning approach just considers the presence of specific movements and ignores the quality of the expressions. The rest of the EMF design is interconnected with the eyebrows, so if the chin changes, the lips, nose, ears, eyes, skin, and even the beard implicitly characterised. Thinking of the face as a whole construct a convincing composition because even if any child with autism can't see some portions of the face, their positioning will still have an impact on what is visible. The act of intuitive-learning design along a line is one approach to harmonise design layout. The power of forms is best demonstrated by EMF, whose neutral face is drawn along a straight vertical axis, shocked expression curves outward, integrating eyes and mouth with it, and the angry face curves inward, scrunching EMF features together.

6.0 Conclusions and Future Works

The EMF provides a platform in dealing with facial characterisation through the aspect of formalistic and visual semiotics that focus on 'appeal' factors in helping designers work within their creativity and experience. This statement supported Nagamachi (1999) that explained; the most vital stage in Kansei Engineering is the collaboration within designers depending on the project. After the data was acquired, designers' collaboration feedback helps explain and analyse the data and interpretation. Several ideas might be attained from the data analysis. Hence, designers should comprehend the final data interpretations with their creative ideas and study the character through design reference that can be found in art books and on the internet. The principles of art and design can be found in many drawing guide books, and they can help designers understand and organise all of the aspects in a design work by applying the principles of art and design. In order to achieve a visual tempo, these concepts function by carefully positioning pieces in a design. The majority of this project's discussion applies to the application of design principles in creative design that can make it easier and provide additional ideas to achieve the appealing factors through EMF concept. The use of essential geometrical shapes to substitute the formalistic form of a real human, such as the eyes and mouth characteristics, is common in design concepts. Future research could integrate data from human observations with automated facial analysis to aid in the interpretation of facial expressions. Additionally, it could be interesting to assess the participants' levels of arousal during dialogues using physiological indicators like heart rate, dilation, and perspiration production of EMF.

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References

Abidin, S. Z. (2012). Practice-based design thinking for form development and detailing. PhD Thesis. NTNU-trykk

Anwar, R. (2016). Characterising a syntactic pattern of formgiving in design thinking process. PhD Thesis. Universiti Teknologi MARA

Anwar R., Abidin S.Z., Hassan O.H. (2015) A Pattern in Formgiving Design: Giving Priority to a Principle Solution in Industrial Design Situation. In: Gen M., Kim K., Huang X., Hiroshi Y. (eds) Industrial Engineering, Management Science and Applications 2015. Lecture Notes in Electrical Engineering, vol 349. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-662-47200-2_35

Anwar R., Abidin S.Z., Hassan O.H. (2016). In-vitro design protocol: Artificial situation strategy uses to comprehend designers' thought. MATEC Web of Conferences Vol. 52, pp.03002 EDP Sciences.

Anwar, R., Vermol, V. V. and Kamaruzaman, M. F. (2020). Conceptual Design of COD-E Humanoid Robots. Journal Environment-Behaviour Proceedings Journal. Vol. 5, Special Issue CSSR2018.

Arshad, M. R., Kim, H. Y., & Manaf, A. A. (2018). Character pleasantness in Malaysian animated cartoon characters. SHS Web of Conferences, 53. Retrieved from https://www.shs

Cabibihan et al., 2013 J.-J. Cabibihan, H. Javed, M. Ang, S.M. Aljunied Why robots? A survey on the roles and benefits of social robots in the therapy of children with autism Int. J. Soc. Robot., 5 (2013), pp. 593-618

Hatchuel A, Weil B (2003) A new approach of innovative design: an introduction to C-K theory. In: Proceedings of the international conference on engineering design (ICED'03), Stockholm, Sweden, pp 109–124

Lokman, A. M. (2010b). Kansei/Affective Engineering and Web Design. In Industrial Innovation. Kansei/Affective Engineering (Vols. 1–2, pp. 227–251). Retrieved from http://dx.doi.org/10.1201/EBK1439821336-9

Nagamachi, M. (1999). Kansei engineering: The implication and applications to product development. 6, 273–278. Retrieved from https://doi.org/10.1109/ICSMC.1999.816563

Yokoi, E.S. Neo, Kajita, S. K. and Tanie K., (2003) "Whole Body Teleoperation of a Humanoid Robot Integrating Operator's Intention and Robot's Autonomy: An Experimental Verification," Japan, pp1652

Razzouk, R. & Shute, V. (2012). What Is Design Thinking and Why Is It Important? Review of Educational Research. https://doi.org/10.3102/0034654312457429

Riemer K., Totz C. (2003) The Many Faces of Personalisation. In: Tseng M.M., Piller F.T. (eds) The Customer Centric Enterprise. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-55460-5_3

Soikun T.M., Vermol V.V. (2015) Adaptation of Kansei Engineering Concept in Designing Appealing Computer Animation on Sabah Oral Tradition. In: Hassan O., Abidin S., Anwar R., Kamaruzaman M. (eds) Proceedings of the International Symposium on Research of Arts, Design and Humanities (ISRADH 2014). Springer, Singapore. https://doi.org/10.1007/978-981-287-530-3_35

Shamsuddina, S., Yussof, H., Ismail, L. I., Mohamed, S. Hanapiah, F. A. and Zaharid, N. I.. (2012). Humanoid Robot NAO Interacting with Autistic Children of Moderately Impaired Intelligence to Augment Communication Skills Procedia Engineering 41 (2012) International Symposium on Robotics and Intelligent Sensors 2012 (IRIS 2012).

Siran, Z., Abidin, S. Z. and Anwar, R. (2020). The Influence of Reference Material for Sketching Strategies and Form Establishment at the Embodiment Design Level. Journal Environment-Behaviour Proceedings Journal. Vol.5, Special Issue CSSR 2018.

Vermol V.V., Anwar R., Hassan O.H. & Abidin S.Z. (2017) Designer Activity Experience: Blind UserDesigner Activity Model In Knowing Product Influence Through Blind User Perspective. Adv. Sci. Lett. 23, Pg. 10815-10821 (2017)

Weiss, L. A., Shen, Y., Korn, J. M., Arking, D. E., Miller, D. T., Fossdal, R., et al. (2008). Association between microdeletion and microduplication at 16p11.2 and autism. *N. Engl. J. Med.* 358, 667–675. doi: 10.1056/NEJMoa075974