DESIGN CONSIDERATIONS FOR THERAPEUTIC DEVICES - AN INVESTIGATION OF PRE-SCHOOLERS' PREFERENCES FOR AN ARTEFACT'S BASIC CHARACTERISTICS

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ABSTRACT

Toys are children's first consumer products and while playing they acquire numerous skills, learn about their environment and socialise with other children and adults. Toys are adapted and used by clinicians as therapeutic devices because they allow them to create bonds and communicate with children. Aesthetical aspects should be considered early in the design process, especially since pre-schoolers' views are still dominated by the appearance of artefacts, also known as, the perceptual salient characteristics. The study of emotions mediates the understanding of the relationships between a product, user and the process with which consumers set up preferences over products. Decisions taken in each design stage will influence whether therapeutic devices will be enjoyed by children. An experiment was carried out to test out pre-schoolers' preferences on individual attributes: form, dimension, material (hardness and weight) and surface (appearance and texture). This study exposed dominant characteristic preferences and the fact that some are influenced by gender and age. Employing these findings in therapeutic devices will enable clinicians to better engage the children during therapy.

Keywords: Emotional design, User centred design, Early design phases, Perceptual salient characteristics

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1 INTRODUCTION

When developing new products, designers are required to take several decisions, some of which influence the desirability. Toys are children's first consumer products and they set up preferences depending on how toys relate to them. Children's preferences to toys have been attributed to age, gender and culture (Bathiche, 1993), society (Calvert, 2008) and advertisement (Moses and Baldwin, 2005). Recently, Balzan *et al*. (2018) provided a high-level insight on toy preferences based on their design affordances, that is, their perceived utility. However, studies which investigate toys preference based on the artefact characteristics, such as the material used, are limited.

Toys are also used in clinical situations that involve therapy with children, since toys manage to extend the attention span in young children while reducing the effect of monotonousness (Nwokah, Hsu and Gulker, 2013). This study is part of an ongoing research which focuses on how designers can be guided on developing therapeutic devices for speech and language assessment and intervention of pre-school children, aged between 3 to 5-years old. The child sees such products as toys but from a clinician perspective, these products serve as therapeutic devices. This implies that when creating multi-user products, designers need to consider the requirements of both children and clinicians. Studies show that the creativity and cognitive abilities of children increase when they are in a positive mood (Chien *et al*., 2015). The study of emotions mediates the understanding of the relationships between a product, user and the process with which consumers set up preferences over products. Decisions taken in each design stage will influence the level of engagement by children with therapeutic devices. In view of this context, the aim of this study is to understand which low-level characteristics drive typically developing pre-schoolers' preferences. This shall provide insights for a framework that will assist designers in developing therapeutic devices and/or other products for children.

2 EMOTIONAL DESIGN IN CHILDREN'S PRODUCTS

2.1 The basic characteristics of products

A technical system is characterised by a number of components or assemblies, put together in such a way that allows the product to have a function. Tjalve (1979) defines five basic properties of products or sub-assemblies, which are structure, form, dimension, material and surface. Structure, or layout as defined in (Pahl and Beitz, 2007), is about how each sub-element of a system is positioned with respect to another, and the number of configurations for these elements is endless. In reality, toys are meant to be "childhood tools" in terms of objects of play by which children learn about the world around them (Klemenović, 2014). It is therefore argued that a therapeutic device should take the form of real life objects or living organisms such as vehicles and animals respectively. This means that the overall structure is pre-defined. For instance, a toy car will comprise of at least a body and four wheels. In (Andreasen, Hansen and Cash, 2015), the term attributes is used to combine properties and characteristics, where the latter are defined as a "class of structural attributes… determined by the synthesis of design", and properties are described as a class of behavioural attributes by which they "create their relation to the surroundings". For example, characteristics of a toy include its dimensions or compressive strength, while properties could be durable or waterproof. These two definitions reveal that properties in products are consequences of products' characteristics. Thus, form, material, dimension and surface should be referred to as the basic characteristics.

2.2 Design driven by emotions

"Good designs work; excellent designs also give pleasure" (Ashby, 1999). The design is what distinguishes two products that offer the same functionality. Emotions change the way one sees products, and thus guide decision-making when given different options. Apart from pragmatic qualities, products have hedonic qualities which are not task-oriented but satisfy psychological needs, such as satisfaction and pleasure (Hassenzahl, 2010). Desmet and Hekkert (2002), state that emotions are elicited when a product affects one's concerns. By viewing therapeutic devices as objects, agents and events (stimuli) one can gain insights into how children are attracted towards them. It is easier to understand children's preferences when therapeutic devices represent toys. For instance, toys as

objects, have various appealing features aimed at stimulating different cognitive and social play behaviours. Depending on how a toy is perceived by the senses, children will either be attracted, bored or repelled. Therefore, the basic characteristics should be considered early in the design process. Figure 1 depicts the interactions between design factors that influence both the functional and emotional aspects of products. The two-way arrows represent the interactions between the design factors. This implies that a decision for one design factor will affect another design factor. If the focus of the design is aesthetics, then, the design of the elements has to provide an aesthetically pleasing overall solution by first focusing on the interactions between form, material, surface and dimension. If one is designing for reliability, then the design of the elements is more important and should focus on the interactions of function, form, material and process. Ultimately, during design, all interactions are considered but depending on the approach some factors take secondary importance.

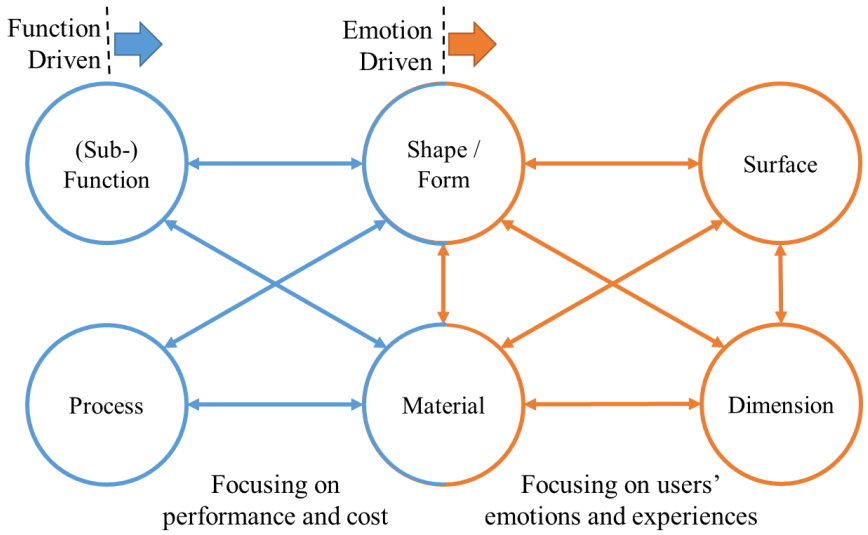

Figure 1: Interaction of design factors at embodiment stage - adapted from (Ashby, 1999)

Due to their vulnerability, children often fall victims to misleading advertisements and may quickly lose interest in toys either because they fail to deliver the expected experiences, break, are outgrown, or stop providing positive feelings (Yeh, Jewell and Zamudio, 2018). Understanding what products' attributes influence children's preferences can therefore extend the use life phase of products. Children assess whether a piece of information is relevant depending on their level of cognitive development. Research in the study of emotions of children utilise Piaget's theory which explains children's cognitive development (Correia *et al.*, 2012; Šramová, 2017; Yeh, Jewell and Zamudio, 2018). Piaget's theory states that children go through four increasingly adaptive stages and depending on the level they are, information is treated and categorised differently. At the pre-school age, children are at the *preoperational* stage (age 2-7) where their views are dominated by the appearance of artefacts which are referred to as the perceptual salient characteristics. At this age, children are not yet able to distinguish between what is perceptually and cognitively salient (Yeh, Jewell and Zamudio, 2018).

2.3 Factors influencing children's preferences

Age is a ruling factor in determining how children's preferences vary. For instance, children's inclination towards particular brands starts only to be noticed at the age of 10-11 years (Šramová, 2017). At the preschool age, when early intervention takes place, children's cognitive skills are still developing, and they may not understand a toy's function by just looking at it. Children are attracted to a toy depending on how the product's aesthetical attributes are perceived through the senses. On the other hand, preferences are also affected by gender due to societal influences depending on the cognitive type of play that a toy offers (Yeh, Jewell and Zamudio, 2018). Sensory perception in children is studied either for research purposes or for consumer testing. Children's attribute preference is very scarce in terms of published work and children consumer analyses remains proprietary of the organisation that commissions the studies (Guinard, 2001).
Studies in which young children with autism or developmental disabilities participated, suggested that sensory attributes of materials invite children to explore (VanDerHeyden *et al.*, 2002) and acted as

reinforcements for self-stimulatory and new play behaviour. Furthermore, toys having a preferred sensory attribute increased the number of times they were selected (Dicarlo, 2004). In the field of consumer products, by the age of 2, children were able to express their preference on colour (red, blue, yellow), form (geometric, organic) and texture (glossy, rough, soft) characteristics in order to establish their predominant preferences (Correia *et al*., 2012). However, these results did not explore how gender and age differences influenced their preferences and the number of attributes was limited to just three. Kierkels and van den Hoven (2008), focused on understanding tactile experiences for four objects varying only in hardness, for which 10- to 13-year-old children were requested to assign pairs of adjectives that best describe the material (hardness). Dinaky (2013) evaluated that the most influencing factors in the packaging of toys for various age groups, is the artwork, rather the colour or material of the actual packaging. Recently, Yeh, Jewell and Zamudio (2018) used trading card games to show that when pre-schoolers are required to choose between multi-attribute options they base their choices on perceptually salient factors whereas older children, like adults, are aware of cognitively salient aspects such as the power level of the card.

The above studies show that research on pre-schoolers' product basic characteristic preference is very limited. This literature leaves open the consideration of differences among differently-aged and gendered pre-schoolers. As children's brain and physical development progresses, at preschool age they begin to interact with peers, carers and objects surrounding them, while living new experiences. Therefore, it is interesting to understand whether characteristics preferences vary with age among pre-schoolers. Manufacturers developing goods that are emotionally attractive need to know in advance children's preferences in order to reduce the number of design iterations and hence, the time to market. Vision and haptics are both salient for encoding form, dimension, material and surface characteristics. To achieve this objective, the following hypothesis is postulated: Pre-schoolers' visual and haptic experiences with respect to product characteristics will vary with gender rather than age.

3 PRE-SCHOOLERS' PRODUCT BASIC CHARACTERISTICS PREFERENCES

A study was designed to investigate pre-schoolers' product basic characteristics preferences. The overall appearance of a product is achieved when all the characteristics are considered together (Muller, 2001). However, at this age, children exhibit preoperational reasoning which causes common errors such as centration, that is, "the tendency to focus on one part of a stimulus, or situation and exclude all others" (Kuther, 2019). Assessing pre-schoolers' multiple characteristic preferences in market research can be misleading and difficult as they may not be able to articulate their preferences effectively (Moses and Baldwin, 2005). There exists no suitable technique to obtain precise verbal feedback from children as young as 3-years-old. Most methods such as the Fun toolkit (Markopoulos *et al.*, 2008) can be used with children from the age of 6-years. An in-depth literature review on evaluation methods for children can be found in (Khanum and Trivedi, 2012). For this reason, our study was simplified to facilitate children's responses and avoid errors of centration. Rather than assessing multiple characteristics simultaneously, the design of experiment was simply based on a one-factor-at-a-time approach where a child was presented with different options for each individual characteristic, as described next.

3.1 The characteristics

Abeele, Zaman and De Grooff (2012) explained that it is important to start the activity by showing an actual toy to children rather than abstract parts of the toy such as a sample of the material or colour, because when a child encounters the product it will help him/her to overcome possible cognitive constraints. Correia *et al*.'s study (2012) revealed that children prefer organic shapes rather than geometrical shapes. For these reasons, each characteristic was represented in a format that they could relate to. Moreover, since this research is funded from a project where a therapeutic device in the form of a penguin is being developed, penguin models, as shown in Figure 2, were created and assigned the following characteristics:

- (Overall) **Form**: Natural vs Artificial. Two different forms of penguins were chosen because the structure/layout of internal sub-elements could be set in a way that the overall form is either representative to reality or not. For instance, a built-in screen could be positioned either in portrait or landscape orientation.

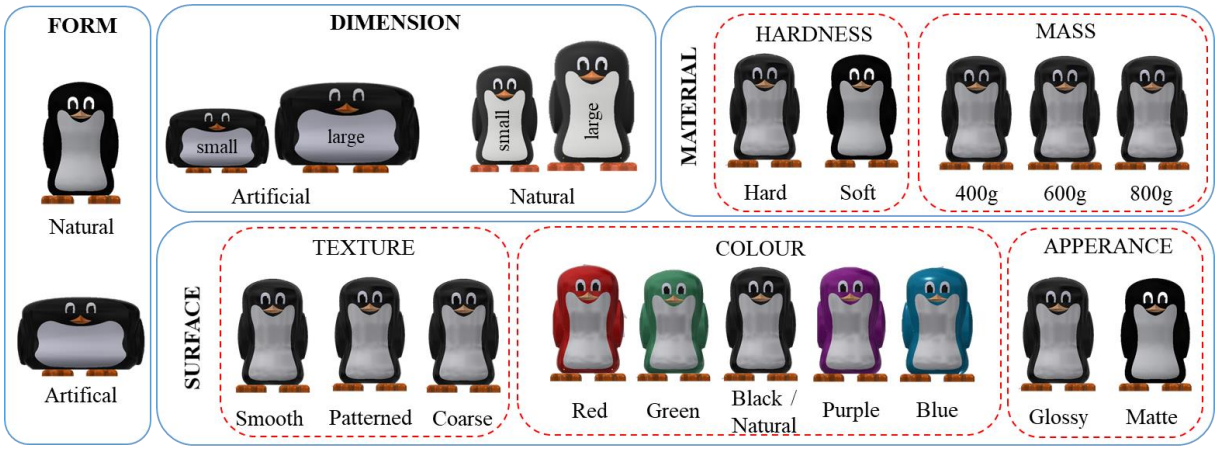

Figure 2: Penguin models used in the study

- **Dimension**: Small vs Large – Artefacts of different dimensions tend to have different specifications. For instance, a large device can accommodate a large touchscreen. Two sets of small and large illustrations were printed on paper: one set for the natural form and the other set for the artificial form. Note that only for this characteristic, children were provided a printout. For the other characteristics, children were provided physical models.
- Material – Different materials may exhibit more than one characteristic. Two material sub-characteristics which children can conceptualise are, hardness and mass.

  Hardness: Soft vs. Hard – Two distinct hardness models were provided to children in order to understand their tactile preference. The soft model was created by covering a hard model with 2mm neoprene.

  Mass: Light vs Medium vs Heavy – Mass is mainly influenced by the material and size of the toy, but it also provides an insight to the maximum allowable number of components and their weight (e.g. the maximum battery size). Based on differently sized toys, three models with a different mass (400g, 600g and 800g) were created.
- Surface – Surface characteristics can be differentiated visually or through touch. Three different surface sub-characteristics were considered.

  Appearance: Glossy vs Matte – Nowadays, most toys are plastic, and appearance can be determined by the type of paint or material used. For the purpose of the study, different black paint was used to create the two models.

  Texture: Smooth vs Patterned vs Coarse – Surface texture is a haptic perception that can influence children's preference.

  Colour: Black/natural vs Red vs Blue vs Green vs Purple – Colour plays a major role in children's selection, especially if they already formed gender-schemas. Correia *et al.* (2012) reported that bright colours stimulate positive characteristics. Instead of choosing the primary colours, it was decided to replace the yellow variant with the green one due to the low contrast with the beak and feet. In order to cater for any colour stereotyping due to the blue variant, a purple model was included.

3.2 Participants

The participants were 69 children whose age varied between 3 and 5-years (M = 4.9 years, SD = 0.87; 18 3-year-olds, 31 4-year-olds, 20 5-year-olds), including 29 boys (M = 61.28 months, SD = 11.14) and 40 girls (M = 57.85 months, SD = 9.9). Children were recruited from a primary state school in Malta and children were drawn from eleven different classrooms. Although most of the participants were Maltese, 24 children had a foreign descent. The research was approved by the ethics committee of the University of Malta and parents consented their children's participation. No history of visual, auditory, or behavioural problems were reported prior the study.

3.3 Procedure

The study was conducted on a one-to-one basis at the back of the classrooms in order to minimise disturbances. Before starting the study, each child had the experimental procedure explained. The

characteristics were tested in the following order: form, dimension, hardness, appearance, texture, mass and colour. The models were kept hidden until it was time to assess a characteristic, where the different models associated with a characteristic were shown to the child simultaneously. For instance, when evaluating the form, both the natural and artificial forms were presented together. Each child could observe and feel the models for 10 seconds before being asked to indicate which model is preferred. In case children were presented with more than two choices, as in the case of the colour, mass, texture characteristics, they were asked to rank their preference. The study was first piloted with three 3-year-old children to try out the procedure. During this trial, the Laddering method (Abeele, Zaman and De Grooff, 2012) was tried, but it did not work as children did not provide reasons for their preference. Necessary improvements, such as experiment layout and wording, were implemented in the actual study.

3.4 Measure

For the form, material hardness, surface appearance and dimension characteristics, the participants were asked to select their preferred choice from the two options. For the other characteristics, children were asked to rank their preferences. Subsequently, the Borda count method (Dym, Wood and Scott, 2016) was used to assign rating scores. The mean rating scores of texture and mass, range from 1 to 3, where 1 corresponds to the least preferred and 3 to the most preferred. Similarly, the mean rating score of colour ranges from 1 to 5, where 1 corresponds to the least preferred and 5 to the most preferred.

3.5 Results and discussion

Since the number of test variables varied between the different characteristics, different statistical methods were used to establish trends in the children's preferences. For characteristics involving two categorical variables (one test variable vs one group variable), the Chi-Square test was used. The group variable provides demographic information about the participants, that is, gender or age, while the test variable describes the participants' preference for a design characteristic e.g. the natural form vs. artificial form. The null hypothesis (H0) specifies that there is no association between the two categorical variables and is accepted if the p-value is greater than 0.05 level of significance. For rating scores, non-parametric statistical tests were used. The Friedman test was used to compare the mean rating scores between different penguin models for the same characteristic, and the Kruskal Wallis test was used to compare the mean rating scores of a characteristic between groups clustered either by gender or by age. For the Friedman test, the null hypothesis (H0) specifies that the mean ranking scores vary marginally between the different characteristic categories and is accepted if the p-value exceeds the 0.05 level of significance. For the Kruskal Wallis test, the null hypothesis (H0) specifies that the mean rating scores vary marginally between the groups and is accepted if the p-value exceeds the 0.05 level of significance.

The Chi-square test reveals no association between the form characteristic and gender ($\chi 2(1) = 0.734$, $p = 0.391$) and between the form characteristic and age ($\chi\ 2(2) = 1.642$, $p = 0.440$). This implies that irrespective of age and gender, the natural form is the most preferred. Figure 3 (a) displays the percentage of pre-schoolers preferring artificial and natural forms, clustered by age and gender. Moreover, it shows that the preference for the natural form increases marginally with age. Although studies such as (Klemenović, 2014) suggest that the fantasy elements in toys are important for children, in this case, the artificial form of the penguin was less attractive, as children frequently highlighted that it looked like a box. The dimension characteristic was analysed both for the natural and artificial forms to understand whether there is an association between the form and dimension characteristics. Even though children were provided with illustrations rather than tangible models, in both cases, a larger toy would be preferred more than a large toy as shown in Figure 3 (b) and 3 (c). The Chi-square test show that for both forms, there is no association between gender and the dimension characteristic ($\chi 2(1) = 0.025$, $p = 0.874$ and $\chi 2(1) = 1.729$, $p = 0.189$). For the natural form, there is a significant association between the dimension characteristic and age ($\chi 2(2) = 9.962$, $p = 0.007$). Figure 3 (b) shows that this significant association results from the fact that the preference for large toys varies considerably from 55.6% for 3-year-olds, to 93.5% for 4-year-olds to 70% for 5-year-olds. Although a similar trend is noticed for the artificial form, this effect is less pronounced and not significant ($\chi 2(2) = 4.548$, $p = 0.103$).

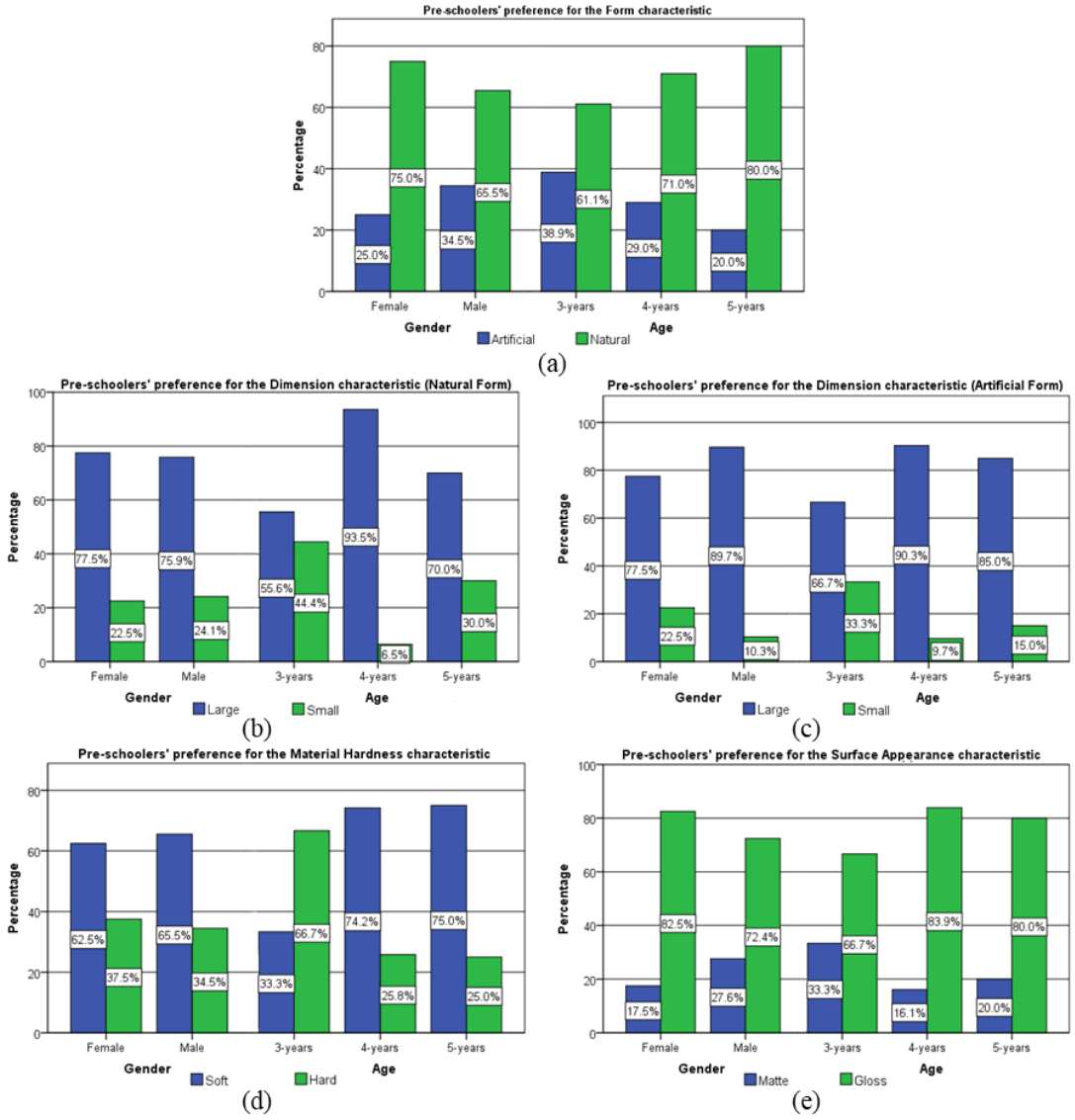

Figure 3: Pre-schoolers' form, dimension, hardness and surface appearance preferences

Figure 3 (d), shows that irrespective of gender there is a higher preference for soft toys compared to hard toys. In fact, there is no association between material hardness characteristic and gender ($\chi 2(1) = 0.066$, $p = 0.797$). However, there is a significant association between the hardness characteristic and age ($\chi\ 2(2) = 9.767$, $p = 0.008$) since most of the 3-year-olds preferred a hard material while the majority of 4- and 5-year-old children preferred a soft material. This result possibly indicates that 3-year-old children were familiar to softer material and hence found it less appealing. Figure 3 (e) illustrates pre-schoolers' preference for the surface appearance characteristic. On average there is a larger percentage (78.3%) of the participants preferring a toy with a shiny surface than a matte surface (21.7%). Moreover, the Chi square test reveals no significant association between surface appearance preference and gender ($\chi 2(1) = 1.005$, $p = 0.316$) and between surface appearance preference and age ($\chi 2(2) = 2.031$, $p = 0.362$).

Figure 4 shows error bar graphs comparing the mean rating scores of the test characteristic. Error bar graphs display the 95% confidence interval for the actual mean rating score provided to a characteristic, if the whole Maltese preschool child population had to be included in the study. When the confidence intervals are disjointed, it indicates that the mean rating scores differ significantly. Figure 4 (a) shows the overall mean rating scores for the surface texture characteristic, where the highest preference is the smooth surface texture (2.48), followed by the patterned (2.00) and coarse (1.52) surface textures. The Friedman test shows that the mean rating scores differ significantly ($\chi 2(2) = 31.565$, $p < 0.001$). Pairwise comparison revealed that the smooth surfaces are significantly preferred over the rough surfaces, which in turn are significantly preferred over patterned textures.

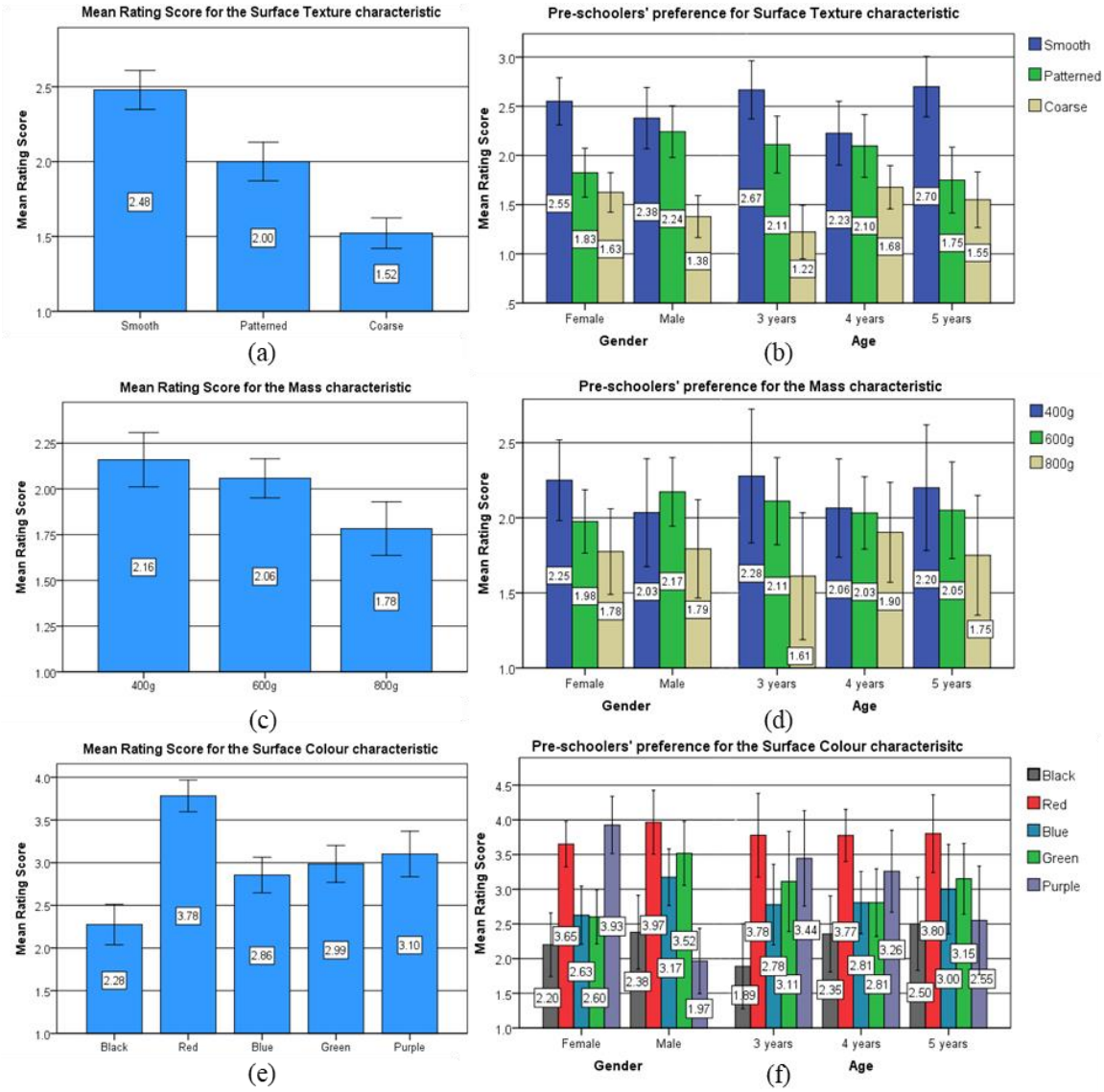

Figure 4: Pre-schoolers' surface texture, mass and colour preferences

The Kruskal Wallis test shows that the mean rating scores vary marginally between male and female children for smooth (p-value = 0.342) and coarse (p-value = 0.09) surface textures; however mean rating scores vary significantly between male and female children for the patterned surface texture (p-value = 0.026) as can be seen from Figure 4 (b). Differences in mean rating scores varied marginally between the age groups for the smooth (p-value = 0.062) and patterned (p-value = 0.224) surfaces but varied significantly between the age groups for the rough surface (p-value = 0.019). This difference resulted from the fact that 4-year-old boys' preference for the smooth and patterned surfaces were not very discerning whereas 4-year-old girls' preference for patterned and rough surfaces was very different. This shows that girls have strong preference for smooth surface and boys are mostly indifferent towards rough surfaces. Figure 4 (c) shows the mean rating scores for the mass characteristic, where the 400g model was the most preferred (2.16), followed by the 600g model (2.06) and 800g model (1.78). The Friedman test shows that these mean ranking scores do not differ significantly since $\chi 2(2) = 5.246$, $p = 0.073$. Figure 4 (d) shows that the mean rating scores provided for preference of mass characteristics vary marginally between the different gender and age-groups. Moreover, the Kruskal Wallis test confirms these results since all p-values exceed the 0.05 level of significance. While carrying out the study it was noted that children were surprised and excited when lifting the heavier model as if they were given a challenge and they wanted to show that they are strong and can lift a heavy object.

Figure 4 (e), shows that red was the mostly preferred colour (3.78), followed by purple (3.10), green (2.99), blue (2.86) and black (2.28). The Friedman test shows that these mean rating scores vary significantly since $\chi 2(5) = 32.267$, $p < 0.001$. Pairwise comparison and the error bar graph show that red is significantly more preferred, and black is significantly less preferred than the other colours. The

Kruskal Wallis test reveals no significant difference in mean rating scores for surface colour between the age groups since all p-values were greater than the 0.05 level of significance. However, the Kruskal Wallis test identifies significant difference in the mean rating scores for colour between male and female children as can be displayed in Figure 4 (f). Differences were found when analysing the results according to gender. Boys tend to prefer green and blue coloured objects, while girls tend to prefer purple coloured objects; however, there was no significant preference difference between male and female children for black and red coloured objects. These results show that by the preschool age, children have acquired gender-based schemas. Designers who want to design gender-neutral goods should use the red colour as it was prevalently preferred by both boys and girls. It was also noticed that despite black being the natural colour of penguins, children favoured the coloured penguin models most. In fact, children were very happy to see coloured penguins and eight participants commented that they are funny.
Although the hypothesis was not always true for all the characteristics, a pattern of preferences is visible when considering large sample sizes. The models utilised in this study did not have any cognitive salient characteristics and so the results obtained are due to the perceptual salient characteristics. This indicates that aesthetical attributes are not trivial even if the end users are going to be children. This suggests that design functional decisions should be considered along with aesthetical decisions. The choice of material is central because most aesthetical characteristics (form, dimension, and surface) are dependent on it. These findings provide insights about the perceptual salient characteristics that elicit positive emotions in preschool children, which manufacturers of therapeutic toys and other children's products could exploit in order to motivate and engage children in any activity.

4 FURTHER WORK

A major limitation of this study is the approach adopted in order to extract the pre-schoolers' preferences for the characteristics. The one-factor-at-a-time approach does not consider interactions between different factors whereas a multi-attribute study could have provided deeper insight for designers. As a next step, this study will be repeated with children with Developmental Language Disorder (DLD) and results will be compared to ones discussed in this paper. Furthermore, since therapeutic devices are used by adults to provide the intervention, their aesthetical preferences should also be assessed for designers to be able to compromise between users. The obtained results are valid for pre-schoolers and possibly to children up to the age of 6 since children are still in the preoperational stage. According to the Piaget's theory and (Yeh, Jewell and Zamudio, 2018) from the age of 7, children's cognitive development is more advanced and they start to look beyond the aesthetical factors.

5 CONCLUSION

Both pragmatic and hedonic qualities in products play important roles for end-users where the affective system of human beings works mostly on the sensorial perception of products. At the preschool age, children's cognitive development is still maturing and most of their decisions are based on perceptual salient characteristics. Therefore, in order to attract and engage children, an understanding for their preferred aesthetical features is crucial when designing the overall look of products. This study showed that pre-schoolers have dominant preferences over different forms, dimensions, materials (hardness and weight) and surfaces (appearance, texture and colour) but preferences may vary according to gender and age. The main contribution of this paper lies in the knowledge generated which will allow designers to design attractive products while at the same time stimulating positive emotions in children. Employing these findings in therapeutic toys will enable clinicians to better engage the children.

REFERENCES

Abeele, V. Vanden, Zaman, B. and De Grooff, D. (2012), "User eXperience Laddering with preschoolers: Unveiling attributes and benefits of cuddly toy interfaces", *Personal and Ubiquitous Computing*, Vol. 16 No. 4, pp. 451–465. http://doi.org/10.1007/s00779-011-0408-y.

Andreasen, M. M., Hansen, C. T. and Cash, P. (2015), *Conceptual Design*. http://doi.org/10.1007/978-3-319-19839-2.

Ashby, M. F. (1999), *Materials Selection in Mechanical Design*. 2nd edn., Butterworth Heinemann, Oxford.

Balzan, E., Farrugia, P., Casha, O. and Wodehouse, A. (2018), "Evaluating the impact of design affordances in preschool children's toy preferences", pp. 2165–2176. http://doi.org/10.21278/idc.2018.0155.

Bathiche, M. E. (1993), *Children's game and toy preferences: A contemporary analysis*. McGill University.

Calvert, S. L. (2008), "Children as consumers: Advertising and marketing", *Future of Children*, Vol. 18 No. 1, pp. 205–234. http://doi.org/10.1353/foc.0.0001.
Chien, M.-E., Jheng, C.-M., Lin, N.-M., Tang, H.-H., Taele, P., Tseng, W.-S. and Chen, M. Y. (2015), "iCAN: A tablet-based pedagogical system for improving communication skills of children with autism", *International Journal of Human-Computer Studies*. Elsevier, Vol. 73, pp. 79–90. http://doi.org/10.1016/j.ijhcs.2014.06.001.
Correia, W., Rodrigues, L., Campos, F., Soares, M. and Barros, M. (2012), "The methodological involvement of the emotional design and cognitive ergonomics as a tool in the development of children products", *Work*, Vol. 41 Suppl. 1, pp. 1066–1071. http://doi.org/10.3233/WOR-2012-0643-1066.
Desmet, P. M. A. and Hekkert, P. (2002), "The basis of product emotions", *Pleasure with Products: Beyond Usability*, pp. 60–68. http://doi.org/10.1201/9780203302279.ch4.
Dicarlo, C. F. (2004), "Embedding sensory preference into toys to enhance toy play in toddlers with disabilities, infants and young children". *University of New Orleans Theses and Dissertations*. Available at: https://scholarworks.uno.edu/td/148.
Dinaky, G. A. (2013), "A study on the visual effect of toy in children life", *Journal of Arts and Humanities (JAH)*, Vol. 2 No. 5, pp. 35–45. http://doi.org/10.18533/journal.v2i5.107.
Dym, C. L., Wood, W. H. and Scott, M. J. (2016), "Rank ordering engineering designs: pairwise comparison charts and Borda counts", *Research in Engineering Design*. http://doi.org/10.1007/s00163-002-0019-8.
Guinard, J.-X. (2001), "Sensory and consumer testing with children", *Trends in Food Science & Technology*, Vol. 11, pp. 273–283. http://doi.org/10.1021/acs.langmuir.5b04557.
Hassenzahl, M. (2010), "Experience design: Technology for all the right reasons". *Morgan and Claypool Publishers*. http://doi.org/10.2200/s00261ed1v01y201003hci008.
Khanum, M. A. and Trivedi, M. C. (2012), "Take care: {A} study on usability evaluation methods for children", *CoRR*, abs/1212.0. Available at: http://arxiv.org/abs/1212.0647.
Kierkels, J. and van den Hoven, E. (2008), "Children's haptic experiences of tangible artifacts varying in hardness", *Proceedings of the 5th Nordic conference on Human-computer interaction building bridges - NordiCHI '08*, p. 221. http://doi.org/10.1145/1463160.1463184.
Klemenović, J. (2014), "How do today's children play and with which toys?", *Croatian Journal of Education*, Vol. 16 No. 1, pp. 181–200.
Kuther, T. L. (2019), "Physical and cognitive development in early childhood", in *Lifespan Development: Lives in Context*, p. 816.
Markopoulos, P., Read, J., MacFarlane, S. and Hoysniemi, J. (2008), "Evaluating children's interactive roducts", *Principles and Practices for Interaction Designers*, Morgan Kaufmann Publishers Inc., Morgan Kaufmann. http://doi.org/10.1016/B978-0-12-374111-0.00020-7.
Moses, L. J. and Baldwin, D. A. (2005), "Criteria for Assessing Children's Ability to Understand and Cope with Advertising", Vol. 24 No. 2, pp. 186–201. Available at: https://cpb-us-e1.wpmucdn.com/blogs.uoregon.edu/dist/f/8769/files/2014/07/MosesBaldwin2005-2fm82vr.pdf.
Muller, W. (2001), *Order and meaning in design*. Lemma Publishers (Series in industrial design).
Nwokah, E., Hsu, H.-C. and Gulker, H. (2013), "The use of play materials in early intervention: The dilemma of poverty", *American Journal of Play*, Vol. 5 No. 2, pp. 187–218.
Pahl, G. and Beitz, W. (2007), "Engineering design: a systematic approach", PhD Proposal. http://doi.org/10.1017/CBO9781107415324.004.
Šramová, B. (2017), "Children's consumer behavior", *Intech Open*, Vol. 2, pp. 91–109. http://dx.doi.org/10.5772/intechopen.69190.
Tjalve, E. (1979), *A short course in industrial design. Newnes-Butterworths*.
VanDerHeyden, A. M., Snyder, P., DiCarlo, C. F., Stricklin, S. B. and Vagianos, L. A. (2002), "Comparison of within-stimulus and extra-stimulus prompts to increase targeted play behaviors in an inclusive early intervention program", *The Behavior Analyst Today*, Vol. 3 No. 2, pp. 188–197. http://dx.doi.org/10.1037/h0099967.
Yeh, M. A., Jewell, R. D. and Zamudio, C. (2018), "An investigation of age and gender differences in children's preferences underlying choice", *Young Consumers*, p. YC-02-2018-00781. http://doi.org/10.1108/YC-02-2018-00781.

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