A Novel Clothing Design Method for Children with Autism Spectrum Disorders Based on Fun Computing Theory and Substance-field Analysis

IOP Conf. Series: Materials Science and Engineering **520** (2019) 012019 doi:10.1088/1757-899X/520/1/012019

A Novel Clothing Design Method for Children with Autism Spectrum Disorders Based on Fun Computing Theory and Substance-field Analysis

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Abstract. Autism spectrum disorders (ASD) is a natural disorder that is characterized by impaired communication, impaired interaction and also by limited and repetitive behaviour. In this paper, we present a novel method based on Fun Computing and Substance-Field (Su-field) Analysis to empower designers in conceiving effective clothing design making children with ASD more interactive. In this method, Fun Computing is used to enhance the children's enthusiasm for interaction and Su-field analysis contributes to describing the interactions and behaviours in the design process. Finally, we conduct a controlled experiment to demonstrates the effectiveness of this method by measuring idea quality and quantity.

1. Introduction

Autism spectrum disorders (ASD) is a subtype of extensive developmental disorder, which is more common in men and occurs in infants and young children [1]. It is mainly characterized by varying degrees of speech developmental disorders, interpersonal barriers, narrow interest and behavioural stereotypes. About three-quarters of patients have significant mental retardation, and some have better abilities in some aspects of general mental retardation [2]. Individuals with ASD suffer direct and indirect consequences related to social interaction deficits. Children with ASD often have a desire for more peer social interaction, and may also express poor social support and more loneliness than their typically developing peers [3]. To improve this situation, interventions based on principles of applied behaviour analysis (APA) have been presented to improve functional communication skills in children with ASD and decrease problematic behaviours such as aggression [4][5], but healing interventions targeting social deficits have not achieved the same level of attention [6]. Indeed, social deficits in this population remain a main treatment challenge [7].

Meanwhile, design activities are the refinement, processing and re-creation of society. Designers extract valuable and meaningful contents from society and apply them to design activities to enrich people's lives and bring innovation to people. However, little attention is focused on the social care for handicap children such as children with ASD in clothing design, most clothing designers pay much attention to fashion, smart technology, marketing and so on. Herein, a novel method based on Fun Computing and Su-field Analysis are presented to empower designers in conceiving effective clothing design making children with ASD more interactive.

Our method is based on the understanding of fun computing and Su-field Analysis, Su-field Analysis is a TRIZ analytical tool for modelling problems related to existing technological systems [8]. Thus, this method is also considered as a tool which abbreviates the knowledge distance between designers' own knowledge and new ones in the total technology space [9].

2. The novel clothing design method for children with ASD

In TRIZ theory, Su-field Analysis is an analytical tool for modelling problems related to existing technological systems. The desired function is the output from an object or substance (S1), caused by another object (S2) with the help of some means (types of energy, F) [9,10,11]. Figure 1 shows the basic model of Su-field Analysis.

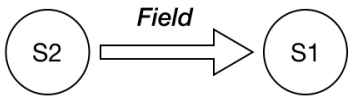

Figure 1. The basic model of Su-field Analysis

2.1. Fun computing theory

For clothing design, we define field is fun computing. 'Fun' is the easiest way to change people's behaviour for the better [12]. For example, some researchers installed giant piano keyboards covering the stairs leading out of a subway station in Stockholm. When people step on it, these keyboards play beautiful melodies. As a result, 66% more people than normal chose the stairs over the escalator, that's the famous 'Piano Staircase' project. In this paper, we generalize the 3 basic principles included in Fun Computing theory applicable to the clothing design method for children with ASD.

- Fun computing is a form of entertainment that use comprehensive technology and existing knowledge.
- Fun computing has the ability of motivating children with ASD to engage in more physical activity or perform onerous work in a fun manner.
- Fun computing can be widely used only for entertainment but also for physical training, psychotherapy and moral consciousness improvement.

2.2. Human-fun (Hu-fun) Analysis

In this paper, we combine Fun Computing theory and Su-field Analysis to present Human-fun (Hu-fun) analysis model for clothing design, S1 in Su-field Analysis is defined as human and S2 in Su-field Analysis is defined as clothing element. Figure 2 shows the basic model of Hu-fun Analysis.

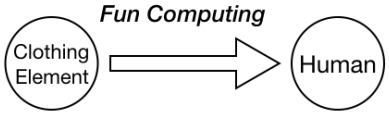

Figure 2. The basic model of Hu-fun Analysis

There are four basic principles included in Hu-fun Analysis:

1. Effective complete clothing design system for children with ASD contains children, clothing elements and fun computing.
2. Incomplete clothing design system requires completion or a new clothing design system.
3. Ineffective complete clothing design system requires improvement to create the desired clothing.
4. Negative complete clothing design system requires the elimination of the negative effect.

2.3. Making a model

The effect of clothing could be on children from the output of the fun computing. The term fun computing is used in the broadest sense, including the fields of physics and psychology. A complete clothing design model for children with ASD is a triad of human, clothing elements and fun computing.

The innovative problem is modeled to show the relationships among clothing elements, human and the fun computing. Complex systems can be modeled by multiple, connected Hu-fun Models.

There are four steps to follow in making the Hu-fun Model:

1. Identify the clothing elements. Clothing elements comprise clothing which are either acting upon human or is within substance 2 as a system.
2. Construct the model. After completing these two steps, stop to assess the completeness and effectiveness of the system. If some element is missing, try to identify what it is or find the substitute.
3. Consider design solutions from the General Solutions.
4. Develop a concept to support the solution. In following Steps 3 and 4, activity shifts to other knowledge-based tools.

2.4. Analysis nomenclature

In Hu-fun Analysis model, the human is the recipient of the system action, in this paper, human is children with ASD. Clothing element is the means by which fun can be achieved. We summarize clothing elements as:

- (St) — Style design including outer contour, inner structure and partial
- (Co) — Colour
- (Fa) — Fabric
- (Pa) — Pattern
- (Eq) —Equipment

There are six different connecting relationships between the clothing element and human expressed by different symbols and shown in Figure 3.

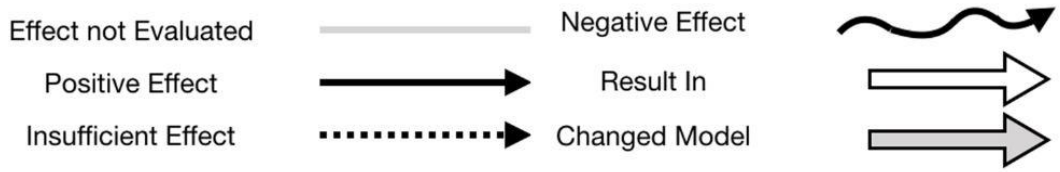

Figure 3. Six relationships between the clothing element and human

2.5. General solutions

There are three general solutions in Hu-fun Analysis based on the 7 general solutions in Su-field Analysis [11].

- General Solution 1: Complete an Incomplete Hu-fun Model

Complete a Hu-fun model if any of its three components is missing.

- General Solution 2: Modify Clothing Elements to Eliminate or Reduce Negative Impact

Designers can change internally or externally and temporarily or permanently the characteristics of clothing elements to eliminate or reduce the negative impact on the human.

- General Solution 3: Expand Existing Hu-fun Model to a Chain

Expand the existing Hu-fun model to a chain by introducing a new Sub-Hu-fun model to the system.

3. Data collection and analysis

In this study, we use a control experiment to demonstrates the effectiveness of this method by measuring idea quality and quantity.

3.1. Participants

In this experiment, participants consisted of 8 students pursuing the master degree of clothing design and engineering in the same university, they all completed the basic clothing design courses and got the credits.

3.2. Analysis of idea quality

In this study, we adopt the method presented by Shah, Smith, and Vargas-Hernandez [13]. In this method, idea quality can be sufficiently estimated even though there is not enough quantitative information to do formal analysis at the concept stage. In addition, this method adds all the quality scores for all the alternatives to achieve the total score for the set. As a result, the idea quality is defined as:

$$\boldsymbol{M = \sum_{j=1}^{m} f_j \sum_{k=1}^{2} S_{jk} p_k \Big/ n * \sum_{j=1}^{m} f_j} \tag{1}$$

In this equation, S_{jk} is the score for quality for function j at stage k; m is the total number of functions; f_j is the weight for function j; p_k is the weight for stage k. The denominator is for normalizing to a scale of 10.

3.3. Experiment process

The 8 participants were asked to design clothing for children with ASD within half an hour. After the first design process, we introduced the novel clothing design method presented in this paper to the 8 participants and asked them to design clothing for children with ASD again within the same time. We define the 8 participants in the first design process is Group A and in the second design process is Group B.

3.4. Experiment results

Finally, we got all the design ideas from the 8 participants and and evaluated them by measuring their quality and quantity. Table 1 shows the idea quality and quantity of each participant.

Table 1. Idea quality and quantity of each participant

Group A	Idea Quality	Idea Quantity	Group B	Idea Quality	Idea Quantity
A1	2.54	1	B1	4.56	2
A2	2.12	0	B2	5.58	6
A3	3.41	1	B3	3.67	2
A4	1.89	1	B4	4.52	2
A5	3.87	2	B5	4.06	3
A6	2.46	1	B6	5.79	4
A7	4.12	2	B7	4.63	3
A8	3.16	1	B8	4.58	2

Then we analyzed these data with Paired-Samples T-test, Table 2 shows the result.

Table 2. The result of the Paired Sample T-test.

Group	Idea Quality $\bar{X}$	Idea Quality SD	Sig	Idea Quantity $\bar{X}$	Idea Quantity SD	Sig
A	2.95	0.082	0.08	1.125	0.640	0.022
B	4.67	0.71	<0.05	3	1.414	<0.05

Both the result of idea quality and idea quantity are significant, it can indicate that the novel method presented in this paper is an effective tool in designing clothing for children with ASD as it has the ability to promote participants' idea quality and idea quantity.

4. Discussion

Su-field analysis is an analytical tool in TRIZ theory which aims to solve technical problems. In the design method proposed in this paper, 'fun computing', 'children with ASD' and 'clothing element' are implanted into the basic model, and 'fun computing' is selected as a targeted way. By introducing a second substance or field to the original, the field is reconstructed, destroyed and transformed to achieve the effect of clothing on the autistic children's experience in a fun atmosphere, the effect of adjuvant treatment is then achieved. Through the comparative experiment, the new design method has improved the idea quality and idea quantity of designers, thus we can conclude that the new method plays a positive role in the design process. At present, the design of clothing for children with ASD is limited to the design of functions and styles, ignoring the factors of fun emotions [14]. However, compared with technical systems, the fun emotions of children with ASD is a more complicated system, so future research should be focused on analyzing, understanding, and capturing the fun emotions of children with ASD, as well as to achieve a more effective treatment for children with ASD under the results of emotion and behavior analysis [15].

5. Conclusion

In this article, we present a novel method including Hu-fun Analysis to empower designers in conceiving effective clothing design making children with ASD more interactive. In addition, we conduct a control experiment to demonstrates the effectiveness of this method by measuring idea quality and quantity. In future research, human experiments on observing the behavior of children with ASD with clothing designed by the method are most needed to explore, as well as the contextual or process factors that condition the effective use of the method.

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