Rethinking ergonomics in design

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Abstract. Considering the complexity of product design, designers normally use a holistic approach to create a product based on target customers and market needs. To create products, many design tools and techniques used in most cases are qualitative. Although ergonomics design principals are widely taught in many design and engineering schools, it might be limited to anthropometry, usability testing, principals and check lists. Ergonomics research data and knowledge are not presented for easy use to designers, hence ergonomics aspects are often overlooked by designers during the ideation stage. Creative design, even though commercially successful, sometimes are looked down as it may not 'pass' the traditional ergonomics check list. Ergonomics tools need to be developed to consider the different stages in design. Ergonomics should consider developing tools and methods with designers in mind, so that ergonomics tools can be easily adapted by them. With a clear collaboration between designers and ergonomist better creative design with imbedded ergonomics can be created.

Keywords: Ergonomics design, design tools, design methods, product design

1 Design

Design is used a lot these days and words such as mechanical design, are sometime used side by side to industrial design. In addition, there are additional terms related to corporate design and career design [1], as it holds something essential and useful for the society. Industrial design, although related to science and technology to some extent [1], is closer to society like graphic design, architecture and fashion design. These design fields focus on relations and interactions with consumers. Holtzblatt and Beyer [2] discussed contextual design, as a user centered design process to drive innovative design based on depth field research. Design, in a general sense, relates to make things, that can be tangible or intangible, to enhance life. Hence, user experience can be observed, understood, interpreted to build the right thing for people. According to Taura [1], design is described using an analogy of "living things moving in a field" and to create products, designers should engage with 'things' while living and moving in the field themselves. Hence, there is no need to have a list of features to achieve a preconceived purpose structured in a way that made sense. Product design is about redesign of the users' life and work that can help them achieve their goal, touch people that matter to them and perform their activities via better products [2]. Successful design is

beyond “cognitive load”, but products that express our identities, and create surprise and sensory delights [2].

2 Ergonomics

HFES Strategic Planning Task Force noted, as have others internationally, that the technology of human factors/ergonomics is human-system interface technology [3]. “Human-system interface technology deals with the interfaces between humans and the other system components, including hardware, software, environments, jobs, and organizational structures and processes. Like the technology of other design-related disciplines, it includes specifications, guidelines, methods, and tools.” [3] In most cases ergonomics design has traditionally focused on design and redesign of product, workstation, and systems that are safe and reduces fatigue, accidents, errors, but at the same time increase productivity [4]. Work related musculoskeletal disorder is widely considered when considering ergonomics in design [3]. For products with direct human interface illnesses, injuries, comfort and fit are also considered. Recently ergonomists working in product design have started to focus on product with joy in mind.

Ergonomics in design uses various techniques and methods that guide the “ergonomics designers” to create products. Given that the focus of ergonomics is on human, many books are dedicated to anthropometry, biomechanics, digital human models, cognitive models, physical models, vision models, pain and comfort thresholds, and so on [5]. Also, research results for different age group, gender and diverse cultures for physical parameters as well as cognitive perceptions have been evaluated. Ergonomics also heavily focuses on user centered design. Ergonomics user-centeredness in design has been criticized because users are not aware of technical opportunities or trends and many times it does not provide new types of design solutions that surprise people [6]. Wahlström et al. [7] proposed three procedures for new design creation: (1) Reformulation of user-study findings; (2) Foresight of technology trends and future developments; and (3) Codesign and coevaluation with actual users and experts in the relevant field of application after creation of the initial design ideas. Evaluation methods, such as usability testing, can be used for testing concepts, prototypes and design solutions. Check list, widely used by ergonomists, can be organized, checked off and reviewed for completion – but they never lead to a holistic design [2]. According to Holtzblatt and Beyer [2], usability testing can fix 10-12% of the problems with an existing product or concept. It is not a way to invent better product or concept and it cannot reveal what will really enhance and transform people’s lives [2]. In the case of engineering, expert knowledge can be useful and hence cocreation and codesign is highly valued. On the other side, users may not know what they want. The product and the activity being supported in a product is simply not the way people think and work. For example, a writer does not think the way the word processor is configured.

3 Some limitations with ergonomics evaluation

Ill-fitted or improper designs are often criticized in ergonomics evaluation. However, there are very limited ergonomics design tools for designers. Ergonomics research results were often published as complex measurements, mathematical models etc. Designer, who are involved in designing products, may not be able to understand those mathematics and models, also they do not get a clear message on how to make a creative product design better based on ergonomics research papers. Designers reading ergonomics evaluation may feel that they are being blamed and hence they may tend to ignore ergonomics principles. For example, a designed wooden chair, which the authors' claim is primarily to attract potential customers with its unusual design, revealed many shortcomings in an ergonomics study [8]. For example: The chair does not possess a backrest and thus it may induce premature fatigue and affect proper sitting position; The sitting area dimension is not of appropriate dimension, which may result in higher pressure, and greater fatigue; and wood is used which is less suitable for long-lasting seating. An aesthetic evaluation of the chair also has been conducted using 7 subjects and the score was 7.14 out of a maximum score of 10 [8]. The chair seems to have a market value since 57.14% would buy the chair [8]. It is agreed that the chair is not well designed for prolonged period such as workplace. However, wooden chairs are widely used and considering lots of elements of design including target customers, the chair may fit well in public places, bar, restaurant or at home. Even the participants point out that the chair has very good aesthetic evaluation. The paper concluded that many designers put primary emphasis on the aesthetic characteristics of the product while completely or partially ignoring ergonomics properties [8]. The question is how designers would use these suggestions or evaluation? Designers should be considered as the target study audience too when presenting ergonomics research. Given that designers are trained to design products and services, ergonomics principals and ergonomics education should focus on creating tools and methods that can be easily adopted by designers.

4 Ergonomics education for designers

Society and market are becoming more sophisticated, and consumers are demanding products that are easy to use, aesthetically pleasing and safe. Rapid development of manufacturing technologies is also enabling the increase personalization and customization of products. Ergonomics methods and tools in design should consider individual factors such as gender, age, race, culture, personality traits and mental associations, but also the creative aspects of design. New ergonomics methods and tools should be developed to consider ergonomics during all the design stages.

There is a recognition in literature that: results of ergonomics research are a rich resource; and findings should be translated for application by designers. Ward and Wright [9] discussed how ergonomics teaching can benefit industrial design education and claimed that "ergonomics is an important part of design education" [9]. Designers routinely use anthropometric information (or human size) in the workplace, furniture and bus interior design. "The human user adds considerable complexity to the designer's task" [9] and research can be carried out to help designers in these areas in a simpler

way. Given that there is no clear method available to the designers, designers in product design consultancies and in-house design teams often build their understanding of users with qualitative methods. Design methods make extensive use of qualitative methods such as stories and anecdotes, casual observation, talking with users, interviews, role play, and games. During the initial stages of product design designers generally explore scenarios with different contexts and different users that are represented as persona or a target user profile. Initial ideas are illustrated in sketches for communication with target consumers, stake holders and for design critiques in team designs. In early design phases, ergonomics knowledge and tools are essential since many ideas are explored before a detailed version is developed in detail. Designers should have physical and cognitive ergonomics knowledge and apply these techniques when representing design ideas (sketches, mockup models and simulations) and ideas evaluation [9].

On the other hand, ergonomist should understand designers and present ergonomics data, tools and methods in a simplified manner so that it can be easily adopted by designers in their studio. Development of ergonomics tools should consider the user in mind, in this case designers.

5 Design examples

Here a design student project is introduced as an example of product design process. This example shows the need for designers and ergonomics to work together to make designed products ergonomically and esthetically. It is related to an ear associated product design. The design steps are presented, and a discussion of ergonomics need is discussed afterwards. The example mainly demonstrates their thought process.

Product: The team came with a design for earphone. They named it "AUD around You | surround sound" which means audio around the person like surround sound system. A logo was developed as a representation of the A, U and D character. The product together with the logo and name are shown in Figure 1.

Figure 1. Display of product

Society consideration: The team put down the society consideration that "Like other large cities in the world, Hong Kong has its share of noise problems. As Hong Kong's economy has grown in recent decades, so too has the noise that comes from transport, construction, commercial and industrial sources in this compact, densely populated city. If left unchecked, this sort of noise can lead to mental stress and hearing loss and can

interfere with daily activities such as doing homework, watching television, talking on the telephone and sleeping."[10]

Persona and target user: The team studied the target user. "People who enjoy being alone and people who like to go to coffee shop but want to be in a silent environment, workshop, or studio. Being alone isn't necessarily a dreadful thing, as there are a handful of benefits that emerge once you learn to embrace solitude. Once you learn to enjoy being alone, you're going to grow as a person. By using AUD|Around You, amazing things will happen in your life when you start to enjoy being alone."

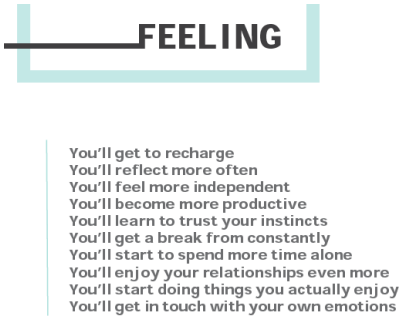

Figure 2. Mood and 'feeling' expression

Inspiration: The design was inspired by sea shell and egg shell (Figure 3). The designers wanted to take the sound transmission features to AUD headphone. "Since seashells resound with something that the roar of the ocean-a sensation whose explanation has offered a puzzle pleasurable and provocative to scientists and lay listeners alike. By designing with a shell inside the headphone, sound can travel around to our head from the speaker."

Figure 3. Inspiration and concept

Design consideration and idea generation: The conceptual and initial sketches are shown in Figure 4. "The principle is that rushing sound that one hears is in fact the noise of the surrounding environment, resonating within the cavity of the shell. The same effect can be produced with any resonant cavity, such as an empty cup or even by simply cupping one's hand over one's ear. The similarity of the noise produced by the resonator to that of the oceans is due to the resemblance between ocean movements and airflow. They become more obvious when louder external sounds are filtered out. This

occlusion effect occurs with this circumaural headphones, whose cups form a seal around the ear, raising the acoustic impedance to external sounds." [11]

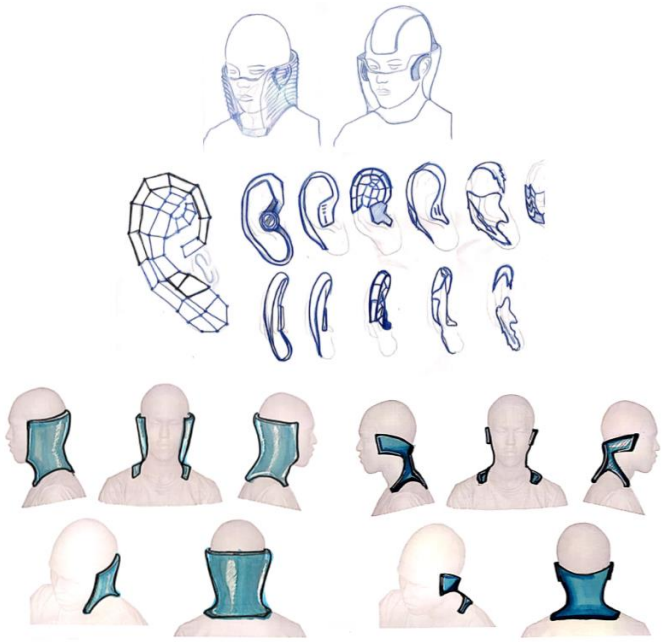

Figure 4. Sketching and visualization

While shaping the AUD|Around You by using the head size, the edge size between the head and hair, and also the ear size are used (Figure 4). The designers believed that when people hear with a normal headphone and earbuds, sounds can still affect the user from the outer world. "People will start to get painful when using the normal headphone for an extended period of time. AUD Around you could help in, by not touching our ear but only covering the edge beside the ear and bones, it may help in decrease the pressure on the ear. Also, people can enjoy a sealed world by hearing songs, nature sounds or even not playing any music."

Prototyping and final design: After the initial sketches and a concept presentation, the product was refined, and a prototype was developed. Using the concept sketches and then using a 3D model of head, the team used 3D design software to create a 3D model of the product (Figure 5). The designers then consider colour of the products based on their mood board and colour board or colour story to create a set of viable products. A sample prototype was created using 3D prototyping techniques. In other cases, the 3D modelling and 3D printing could be replaced by manual or other prototyping methods.

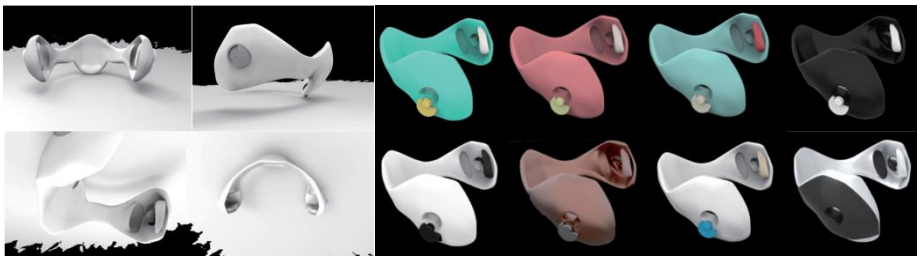

Figure 5. 3D modelling and colour consideration

The prototype product is presented as a possible scenario as used by a target consumer (Figure 6). Generally, designers also propose visual display design, and communication design for a given product.

Figure 6. Scenario and lifestyle

6 Discussion and conclusion

Design involves many different fields of knowledge and designers may not have all the knowledge during inspiration and ideation. Database and knowledge-based methods could be used during the inspiration stage to provide existing products as well as information and data about the different field. These also include ergonomics knowledge. During concept generation, image recognition and software tools using ergonomics as well as AI could be developed to calculate merit for different concepts. During the conceptual stage, the different sketches and ideas can be qualitatively and quantitatively evaluated using different ergonomics and usability methods (such as thinking aloud method) by target consumers or experts. The usability test could be done during the iteration stages when the concepts are refined. During prototyping phase, 3D human models are useful to create physical prototypes. More research can be done to create comfort threshold model, and product models for different human body parts.

This paper considered some of the limitations of ergonomics principals and methods when applied to product design from a designer point of view. The designers rely on many qualitative tools and personal experience when designing products. Ergonomist working in the fields of product design should consider the creative design process and the designer mental model to create ergonomics tools and methods that can be easily adapted to designers.

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