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A REVIEW OF HEALTHCARE DEVICES: MOVING DESIGN FROM OBJECT TO USER

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ABSTRACT:

This paper examines on the design evolution of a selection of healthcare devices and identifies some characterizations in their design which could not be isolated at each point. Beginning from a problem to solution (functional); to the need for safety and comfort with an ergonomic approach; to include technology that replaces many mechanically-operated functional aspects; enabling design to integrate new materials or forms to be aesthetically appealing, understandable and user-friendly; then trying to solve the 'failure' of design through universal design. Sensory and symbolic attributes which are successful in enhancing interaction, experience, and emotions can be understood as a decisive factor shaping the future of healthcare devices. It concludes with implications that encourage designers to broaden their perspectives towards healthcare.

Keywords: Evolution of Design, Healthcare, Design Attributes

1. INTRODUCTION

A few centuries ago, barbers were also surgeons; probably the local blacksmith made the tools. As the practice of medicine and surgery became more controlled and complex, and as people increased their insight into how the human body functions, design became more important. In the nineteenth century, engineers were usually the ones who determined what the requirements were for functionality, and in many occasions, medical products look like afterthoughts. After World War II, ergonomists emphasized on measurable and causal connections that are manifest in the push and pull of controlled physical forces. Technology came along as another driving force behind most medical equipment, while 'design' remains as crude metal boxes decorated with a confusing array of controls and displays. Today, medical equipment manufacturers begin to understand the value of good design. They are hiring in-house designers or outside firms whose design teams are conducting critical user research. To balance the different needs of the doctor and the patient, functionality would need to be addressed first as it relate to what the device does; then the patient's perspective needs to be considered.

For healthcare devices, especially those meant for home-use, there is tremendous fear on most user's part that something could potentially go wrong. Hence, designers have added icons, graphics, and pictures along with minimal steps for user-friendly, interactive design. Consumers would be interviewed to specify what aspects they desire of a medical device. It is important to give users more confidence through the design, building it through intuitive or fail-safe design principles, so it could be better used even in an emergency situation. Usually the technologies and functionality of a healthcare device is pre-determined by so many other factors rather the opinion of the designer. However, besides performing what it needs to do, aspects like the form and colour could be softened so it looks less threatening. Certainly, in the near future, medical devices are trying to move away from the cold and sterile image it had for decades.

2. MATERIALS AND METHODS

The study is based on a review of existing literature published during 1960 -2006. Major electronic research databases (Medline through PubMed, scientific journals via their own sites or Science Direct) as well as a web search engines (Google predominantly) were used to identify research published in the area of medical devices (and related fields) and health care. The selection approach explicitly focused on patient-centred care and home healthcare domain, comprising the development of hardware technology to be used explicitly for patient care and/or education at home; and evaluation of hard-and-software technology that is used for patient care and/or education at home.

Categories to be considered in this context (with the focus being the home) include (1) tools and services for patients and relatives; (2) monitoring equipment; (3) smart home technologies when applied for healthcare or prevention and (4) evaluation from different viewpoints: usability, quality of care, etc…Those that were not included comes in the following adjacent areas: (1) medical equipment sales on the web, i.e. general equipment related web sites about; (2) manufacturing and sales, unless they include history or support for personalized healthcare or advice for self care; (3) research that is not explicitly referring to home care as an application area. To identify future trends, even review articles, future vision papers, and a variety of publications from healthcare organizations and research groups have been included in the literature study.

The objectives of this paper are to:

- ☐ Understand the 'big picture' of the industry in which how and why healthcare devices were first designed, developed, regulated, and used and how these trends evolved.
- ☐ Examine the influential characterizations in healthcare device design and the driving factors behind some of these phases.
- ☐ Understand the future challenges to product developers in designing and developing such devices, alongside with external factors.

3. DESIGN CHARACTERISTICS IN HEALTHCARE DEVICES

Some characteristics in healthcare device design can be identified through time and they come about through the influence of design movements as well as other influencing societal progression. Each of them is briefly described below to allow a better and more apt understanding of their definition in relation to this study.

- ☐ *Functionalism* refers to the belief that the intended function of something should determine its design, construction, and choice of materials. It is also seen as a philosophy which emphasizes on practical and utilitarian concerns.

☐ *Ergonomics* is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data, and methods to design in order to optimize human well-being and overall system performance (IEA 2000). In medical design, the domain of ergonomics mainly refers to physical ergonomics, which deals with the human body's responses to physical and physiological loads. Relevant topics include manual materials handling, workstation layout, job demands, and risk factors such as repetition, vibration, force and awkward/static posture as they relate to musculoskeletal disorders. It is the application of scientific knowledge of human capabilities and limitations to the design of systems and equipment to produce products with the most efficient, effective, and safe operation.

☐ *Technology* can refer to (1) the development and application of techniques for manufacturing and productive processes; (2) a method of applying technical knowledge, and (3) a sum of practical knowledge with regards to material culture. Technology can be understood in several aspects such as material advancement, new inventions, or improving on existing developments; be it present in whichever aspect mentioned before, it has been a fundamental requirement in medical devices for giving accurate measurements (O'Brien et al. 2001).

☐ *Appearance and Aesthetics* refers to product qualities such as smoothness, shininess/reflectivity, texture, pattern, curviness, color, simplicity, usability, velocity, symmetry, naturalness, and modernism. They focus on the exterior enhancement and is interested in the way people perceive products. However, its meaning can differ due to social and cultural factors, but the distinctive focus of them is reaching out to the sensory modalities in relation to product design.

☐ *Universal Design* is related to "inclusive design" and "design for all," is an approach to the design of products, services and environments to be usable by as many people as possible regardless of age, ability or situation. It is a relatively new paradigm that emerged from "accessible design" and "assistive technology". While assistive technology provide a level of accessibility for people with disabilities, they also often result in separate and stigmatizing solutions, for example, a ramp that leads to a different entry to a building than a main stairway. Universal design strives to be a broad-spectrum solution that helps everyone, not just people with disabilities, and it also recognizes the importance of how things look.

☐ *User experience and Emotional Design* is about improving people psychologically to feel that they are recuperating better overtime. Mitchell (1993) argued in favour of a 'redefinition of design in terms of user experience, not physical form', writes: "… design itself needs to be redefined in terms of people's experiences, instead of in terms of object… in favour of a focus on the dynamic, multi-sensory experiences of design users" (p.131). A good starting point for the healthcare model of product emotions could be referred to Ortony, Clore and Collins (1988) because it focuses particularly on the relationship between different types of concerns and the eliciting conditions.

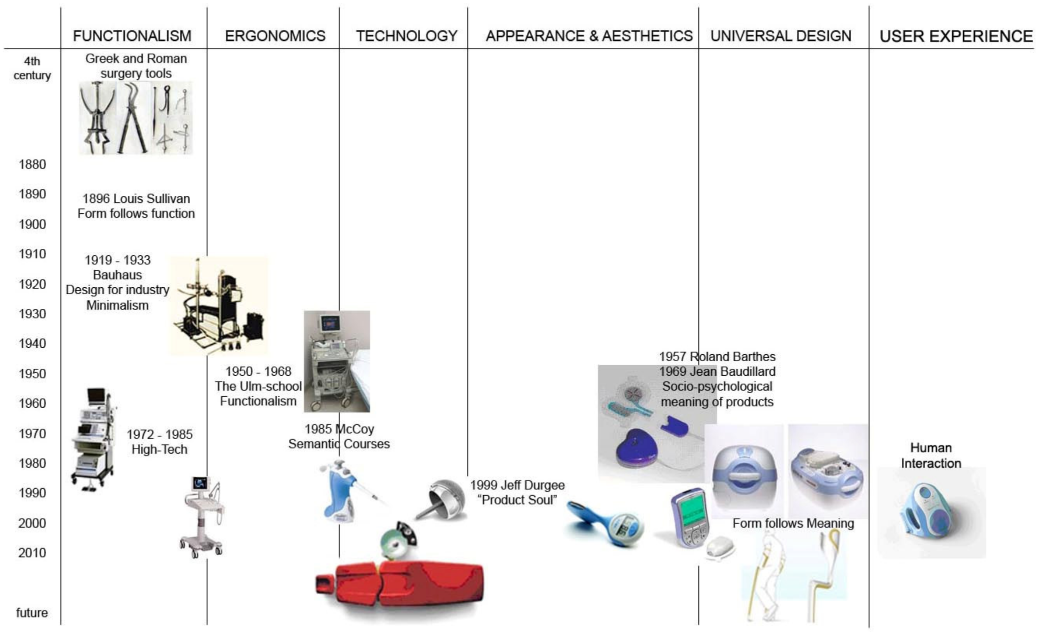

Figure 1: Brief Evolution of Medical Design from Early Records to Near Future.

Through the review, there has been a selection of some innovative and unsuccessful products for discussion. Some of them are representative or influential in any of the six characterizations along with the time movement have been schematically presented in the Fig. 1. Some rely on a winning combination of technology and design to fill a medical need, while others work on improving an existing medical tool and are focused because they may show either distinct characteristics of design, engineering or ergonomic concerns, improving on an existing solution or addressing a previously unsolved problem. More in-depth understanding into the varied reasons for their performance in the market with their design characteristics explained would be brought into the discussion.

3. 1. FUNCTIONALISM

Functionality is often linked to usability. It alone in the design of medical devices should be carefully monitored because of the likelihood of them being rejected by social desirability. When the X-ray machine was invented in 1895, it took thirty-seven years to be commercially produced by companies such as Toshiba and made available on the market (refer to Fig. 2). It was a break-through of the technology of its time but its purpose was purely functional, ignoring the physical and psychological comfort of the patient definitely. During the 1930s, the design style was most associated with modernism, known as the Bauhaus style of design, and it translated some key characteristics such as rejection of ornamentation in favour of functionality and upholding asymmetry and regularity versus symmetry. The style almost matched the institutional and clinical image of the medicine practice perfectly, rejecting any unnecessary decoration.

1930s was a very special era as a small number of medical equipment revealed a high quality of workmanship - it was a time when artists and craftspeople got together with scientists to merge their usual detailing concepts for furniture with medical equipment. The instruments demonstrated an air of loving craftsmanship not found in modern stainless steel and plastic. Common materials used were like metal, wood, and fabric. No matter how much of this craftwork might have appeared, they were strictly limited to technical and engineering constraints. The first impressions of medical equipment from old photographs and movies were unpleasant, cold, and intimidating.

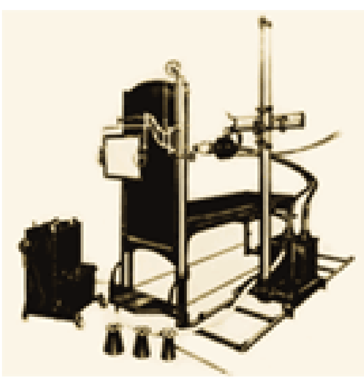

Figure 2: X-ray machine in 1932 by Toshiba (Source: Toshiba 2006).

It is not surprising to find equipment designed in the 70s to 90s also bearing the image of functionalism (see Fig. 3). It was probably due to the idea of the high-tech notion and the accompanying design movement that drove the outcome to be such. Materials such as new metals and plastics were chosen in favour of traditional materials such as wood. The idea was not to hide the construction but to make significant design elements out of constructional necessities.

Doctors often complained that the workstation equipment though functional is frequently a miscellaneous collection of devices that lacks physical integration and the initial positive responses of usability can sometimes turn to a negative sense of comfort after a period of use with examples.

Figure 3: Toshiba's 1982 diagnostic ultrasound equipment.

3. 2. ERGONOMICS

Ergonomics started from a long way back, probably since the Egyptians because of their inventions such as the scissors and walking crutch. After World War II, the concept of ergonomics flourished and diversified and found its way in the operating theatres, surgical tools for doctors, assistive devices for patients, and so on. It came to its peak in the 1950s where the objective of manufacturers was to produce a product with an effective, efficient, and safe user/product interface. In truth, the more complex a device or the more critical its functions, the more important ergonomic engineering becomes in its design (Sawyer and Lowery 1994). Today, more and more people are familiar with ergonomics because of its positive impact towards usability in consumer software applications or electronic devices. In medical devices, the essential application of ergonomics is to consider people's mental and physical capabilities as well as their perceived needs or preferences, and tries to accommodate these in the development of good designs that will be safe, usable, efficient, and satisfying.

Especially when the device serves a life-critical function, there is an inherent justification for a very strong focus on ergonomics to help achieve important design objectives, especially safety. Given the proper attention to ergonomics, one would expect that a medical device could be improved in myriad ways. For example, it means it is better suited to the physical interactions of those exposed to it. If it is something one can pick up, the handle will be properly shaped so it's comfortable, so that one would not accidentally drop it. When a display is designed according to good ergonomics principles, the display is readable from the intended viewing distance and the information is organized in a fashion that is complementary to the task at hand. Controls will be laid out, shaped, and labeled in a manner that is as intuitive as possible, so that the threshold for learning how to use the device is lower and long-term usability is assured. In recent times, the Information Age has spawned the area of human-computer interaction (HCI) and it is included in much in medical device design. The domain of ergonomics for this field has extended to cognitive ergonomics, which is also known as engineering psychology, concerns mental processes such as perception, attention, cognition, motor control, and memory storage and retrieval as they affect interactions among humans and other elements of a system.

3. 3. TECHNOLOGY

Technology in medical design can be understood in several aspects such as material advancement, adaptations, new inventions, or improving on existing developments. Different types of innovation can be understood as technology for medical applications. The Birmingham hip and the digital thermometer are clear examples to show the adaptation and usefulness of technological advancement. It is interesting to note how people consider what makes a good medical product and what is approaching in the industry: the question about the advancement of technology and greater heights in the medical practice. No doubt, much technology gave rise to medical cures and enhanced treatment for decades, and since, few consumers would actually question on the accuracy, adaptability and success of these technologies that are made available. However, there was a "medical" product which was 'illusion' with having medical technology and prolonging beauty but eventually was posing as a danger to people's health.

The quest for beauty and good health is closely linked to boundless technical research and hence, quack products are ever so successful because of this over-trusting appeal of technology. People have always desire to look youthful, enjoy beauty, and prolong life, and yet there appeared on the market a series of questionable medical device, promising strengthened health and longevity. However, some of which sadly compromised on safety and true effectiveness, all with the aim of targeting sales, tapping on people's inner desire to look fit and almost perfect. In 1976, four million women in the United States each spent USD$9.95 on this device which caused bruising and nothing more. It was supposed to enlarge the breast apparently where user could create a vacuum by pumping the pedal with the foot. The device consists of a pump, clear plastic tubing and three cups which were all in large sizes (refer to Fig. 4). In the same year, there was also a 'therapeutic' disaster in which thousands of women were injured by the Dalkon Shield intrauterine device. All these so-called 'medical devices' did alert the market to acquire a different level of regulatory scrutiny—standards that were up to pre-market approval. It is products like such that once again reminds people from time to time about their reliance on technologies.

Figure 4: Foot Operated Breast Enlarger Pump (Source: Museum of Questionable Medical Devices 2006).

The appealing side of technology is its advancement in material innovations; resulting in materials that are strong, lightweight and bio-compatible, and true enough; titanium and certain plastics are the materials that meet all of these needs. Such have been used extensively in applications from joint replacement, spine and trauma systems, to instrumentation and dental implants. An example is the Birmingham Hip, which offers an alternative to part of the conventional procedure for patients who had a hip replacement (refer to Fig. 5). Previously, patients must spend several days in the hospital followed by monthly and annual check-ups, and not infrequently, the artificial hip wears out and needs a replacement. However, the Birmingham Hip not only conserves the patient's natural bone, it also has been shown to offer 98% more wear resistance than the metal-on-plastic-joint of traditional replacements.

Figure 5: Birmingham Hip Resurfacing System (Source: BusinessWeek 2006)

Material innovations also enables the design of applications such as the thermometer, which has undergone changes from the mercury-type to digital-operated version (refer to Fig. 6). It is much safer for children, and besides the adoption of new technologies, ergonomic considerations can still be identified in some of the recent designs such as by Vicks. Characteristics of medical device design can be seen to be overlapping.

Figure 6: Thermometer for Children by Vicks (Source: BusinessWeek 2006)

3. 4. APPEARANCE AND AESTHETICS

One of the primary concerns in medical design is to first address function (coupled with technology) then ergonomics. Typically, manufacturers of medical equipment have not been exactly interested with appearance. Subsequently as ergonomics became a regulated factor in design and “unbeatable” technological breakthroughs were considered the next level was to develop a strategy to resist against competition. Designs with strong technological character are less literal but rather, appearance and aesthetics were addressed alongside. Appearances have grown increasingly important and nowadays, designers have the opportunities to walk into the operating theatre and try to think for the surgeons by understanding their feelings and sensibilities. This proposes the way to design medical devices that are really aesthetically and tactilely oriented.

Figure 7: The Symphony™ Graft Delivery System (Source: DePuy Acromed, Inc. 2001).

The Symphony™ Graft Delivery System is a new product for reconstructive spinal surgery (refer to Fig. 7). This device is designed to deliver an osteoconductive or osteoinductive growth factor, a mixture of blood and bone, as an implantable graft log. It is designed based on observing extensive spinal surgery and lower spine and fusion surgery. It is obvious that the device encompasses characteristics such as functionality, ergonomics, technology, new materials and sensibility in style. However there tends to be less design impact on high volume disposable commodities that are commonly used as stand-alone items, such as syringes.

In healthcare device design, it is not surprising that designers are expanding the physical and psychological possibilities for exuberant and expressive forms. Designs were typified by a heightened sense of proportion, increased use of colour, and emphasis on conceptual and technological possibilities. Organic design is one such example, which first influenced consumer products greatly, and later translated its impact to healthcare devices. Through the use of computer-aided design (CAD) which varies across design disciplines and industries such as in the automotive, the architectural, and the interior product design industry, it is also not lacking in use for healthcare device design. Over the years, the key characteristics in product design remains as bearing holistically conceived designs that relate to their surrounding environment, such that designs are very much inspired by nature and human forms. With the advancements in CAD, organic designs were possible by new manufacturing processes, new materials. Since then, even in healthcare design, products are energized by new possibilities in computer-based design. It caught up with the ideas for curvaceous and organic forms that designers wanted to explore.

Form creation and modeling have become organic rather than orthogonal, facilitating the composition of unusual and asymmetrical forms. The typical beige or white box was slowly being transformed by colours, personalized details, and clever peripherals. Designs were warm and poetic, with no loss of functionality, but rather strengthen with an enhanced humanistic character. In 2001, the frog design team generated an injection-molded, component-based, almost toy-like solution that exhibited self-evident product semantics: one looks and one would know how to pick it up and use it. The pipette shifted the existing paradigm with its undulating body that conforms to the hand, expressing grip dynamics and ease of operation, and most importantly, inspiring the user to gain essential confidence for handling precision healthcare devices. The Ovation BioNatural Ergonomic Pipette has truly wonderfully combined ergonomic, technologies; appearance and aesthetics factors together (refer to Fig. 8).

Figure 8: The Ovation BioNatural Ergonomic Pipette (Source: Ovation BioNatural Pipette 2001).

Another example to illustrate the focus on appearances and aesthetics drifting from small handheld devices to larger scale ones is the Orthora 200 (refer to Fig. 9). It is a cool re-design of an orthodontic surgeon's chair which won a 2002 red dot award in product design. The fully reclining chair has height adjustability and fine level adjustments to provide comfortable working positions for the surgeon and optimal access to the patient's head. The backrest provides good support for the patient's shoulders and the headrest is retractable and angle adjustable.

Figure 9: The Orthora 200 – an orthodontic surgeon's chair (Source: Keller-Hoehl 2006).

Figure 10: Pearl Finish washbasin (Source: Keller-Hoehl 2006).

The sink has a special coating which allows water to run off smoothly (refer to Fig. 10). It does show some resemblance to the Bauhaus aesthetic, designed in accordance with the formal, technical, and principles of modernism, which avoided any superfluous decoration, yet remaining as a beautiful functional object.

Emphasis on appearances for large scale medical equipment came about probably due to the theory and research into the concepts like that of 'Patient-Centred Care[1]'. Figure 11 shows a CT machine by Siemens, clearly designed innovative technology and clinical considerations but also with product specifications and added-on requirements such as "appearance to be friendly and non-threatening to the patient" written into the specs. Visual appeal is often part of the function. The refined look and feel of consumer products has raised user expectations in all product categories. It would be a nicely styled device, with function being first priority, technologies considered, and other environmental factors in view. Since the 1990s, more people in the medical field now recognize the value that design can bring to a medical product, and, as a result, there are more people engaging to help drive innovation and get a competitive edge. As companies recognize the need for industrial design, they began to invest in design research and addressed not only the needs of the doctor but also the physical and emotional needs of the patients.

Figure 11: The Somatom Sensation (Source: Siemens AG 2006).

3. 5. UNIVERSAL DESIGN

As self-healthcare devices are increasingly entering the home, it meant more people are expected to deal with their own medical needs and be more involved in using healthcare devices. Universal

[1] The theory of Patient-Centred Care (PCC) focuses on several aspects, such as exploring both the disease and the illness experience; understanding the whole person; incorporating prevention and health promotion; and enhancing the patient-doctor relationship.

design attempts to help not only people with disabilities, but also recognises the importance of good appearances. For example, the crutch has been in existence for a very long time, but it is only after concepts like universal design and material advancement that their designs have been vastly improved. Now, people may take a crutch to the shopping centre and it packs away in a small bag when they do not need it and it flips into vertical shape when they do. It is quite amusing and interesting when it extends itself through gravity. Although the crutch used to have this sterile and institutional image, reinforcing the fact that one is incapacitated rather than fostering a positive mentality about healing - thoughtful features now such as a forearm cuff style that reduces the risk of secondary injuries often caused by underarm crutches; a hook at the front of the handle for carrying items such as shopping bags, water bottle, keys, etc. considering height adjustment quick release feature are added on (refer to Fig. 12). Both functional and psychological issues are considered.

Figure 12: Advanced Rehabilitation Monitoring Technology by frog design (Source: BusinessWeek 2006).

Designs are thoughtful to enable user to know what to do with these crutches when they are not actively in use, the problem of portability - foldable unit that can collapses into a compact pod to fit discreetly into a car trunk or airplane luggage rack, or under a restaurant chair or a office desk. They use to require twice the effort and energy than normal walking - how to relieve the repetitive stress on the hands, wrists, and arms, or damage the brachial plexus, the network of nerves that controls the muscles of the shoulder and arm that underarm crutches causes - the parts of the crutch that come in contact with the body were added with neoprene pads to these surfaces (refer to Fig. 13). It is not difficult to see that designs that win the day have the magical combination of universal design principles as well as material and technology advancement.

Figure 13: The Human Crutch by One & Co's Sprout (Source: BusinessWeek 2006).

3. 6. USER EXPERIENCE AND EMOTIONAL DESIGN

The future of designing a healthcare device to be as trendy for a fashion accessory is still impossible as yet. However, manufacturers are taking great effort to break away from designing devices that bear the cold feeling of medical stigma, but rather they would be happy enough that their consumers would no longer feel shy when revealing their use at gatherings. This aim to improve people's psychological well-being can be regarded as part of user experience. Designers do envisage people using different components of a device in different scenarios; multi-functional to some extent. For instance, the new diabetes insulin management system device has this sleek look to enable the user (though he has a persistent medical condition) to have an enjoyable user experience (refer to Fig. 14). The pod contains a small cannula that painlessly enters the skin and delivers the drug on command, making insulin injections wireless. Instead of using needles, patients can treat themselves with the click of a button.

Figure 14: OmniPod Insulin Management System (Source: BusinessWeek 2006).

Good user experience does not allow people to struggle when they are using the devices, especially if they do not have the luxury to get on their knees and make it work. It is extremely difficult to satisfy young children while trying at best to give them the appropriate treatment. However, through careful re-design that appeals to be friendly to them by color and shape, designers try to tell them how it works, avoid reminding these young patients that they have an ailment, are sick, and different from everyone else. For example, by making the design friendlier and more 'universal', the optimal configuration of the iontophoretic lidocaine device shown in Figure 15, could still deliver powdered lidocaine into the epidermis for the rapid production of local anesthesia among children undergoing venipuncture. In such cases of medical re-designing, considerations that demanded the coupling of advanced technology with an analytical and imaginative approach to problem solving is needed.

Figure 15: Iontophoretic Lidocaine System for Children (Source: Becton Dickinson 2001).

However, not all known 'user experiences' approaches designed for everyday products can be applicable to healthcare devices. The question of what 'user experience' truly means needs to be re-examined in the product's intended context. Currently, the description of experience design by the American Institute of Graphic Design (AIGA): 'A different approach to design that has wider boundaries than traditional design and that strives for creating experiences beyond just products or services' (AIGA 2005). According to Margolin (1997), there is no theory of social action that incorporates a relation to products, nor many studies of how people acquire and organize the aggregates of products with which they live their lives.[2] The issues of what information and content the healthcare device would perform and consist of; who its users are; what environment it would be justified for should help in understanding this discourse of what is meant by user experience in relation to healthcare device design.

[2] This study focuses on the symbolic use of products for the construction of identity rather than on their role in the user's realm of action.

4. DISCUSSION

The type of users often differs between daily consumer products and healthcare devices. Except market research done by large companies such as Philips or Siemens, there has not been any public community that shares a holistic understanding of what a user is, or how he or she related to healthcare devices. End users have a set of different psychological attitudes and probably physical upkeep from others. The concept of the user is based on an object-centric perspective, the person defined in relation to the healthcare device concerned (Grudin 1990). There is a need to encapsulate the possible background reasons why this user will access to the device, for example, she is diabetic and pregnant and she requires much e-health information and records of her contractions at her finger tips throughout her term. Eventually by integrating all of the accumulated insights that fit the users' mind and body, a good device design or system, generated based from viable design solutions, should work effectively under all potential circumstances, including unusual or unlikely possibilities.

The use of healthcare devices differs from the use of equipment in other industries in the variety of contexts of use, the range of characteristics of the users, and the extremely dynamic quality of factors in providing care. Distractions, such as children or other family members, variations in lighting and noise levels, and the demands of using the device exceeding the user's capabilities, all can contribute (Norman 1988). Other problems, such as not following procedures precisely or relying on the device too heavily, also are concerns. These risky behaviors can involve lifestyle changes, such as changes in diet or physical activity, or less attention to self-monitoring their health condition due to over-reliance on the health information stated by the device (Lewis 2001). Probably in no other domain are there as many conditions that affect task performance or that varies so precipitously. Although the performance of the device may be effective during trial-test sessions, if the user becomes accustomed it and starts taking shortcuts when a specific technique is critical, or failing to communicate with healthcare professionals as advised, these could also lead to trouble.

4. 1. ENHANCING EMOTIONAL DESIGN

To enhance emotional design for healthcare devices, it is composed of many different perspectives and values, such as deriving the design from an object from its natural functions and relationship, to include customizable features that address safety in utility or usability, but also with regards to interpretation, empathy, and experience. Emotional design for healthcare-related products should be intuitive, giving users more confidence through the design, and ensuring a safe experience even in emergency situations. Figure 16 illustrates a concept of a rescue can with integrated oxygen equipment. It takes on an emotional design approach, semi-radically changing the typical outlook to improve the efficiency of the lifeguard while trying to open the respiratory passages of the drowning person and help him ventilate while still in water.

Figure 16: O'CN – Rescue Can With Integrated Oxygen Equipment (Source: iF concept award product 2006).

Sonny is another example to illustrate the notion of emotional design in medical concepts nowadays. It is designed with the essence of kindness and care and aims to act as a little award for sick children, reminding them of fun and consolation instead of any medical condition (refer to Fig. 17).

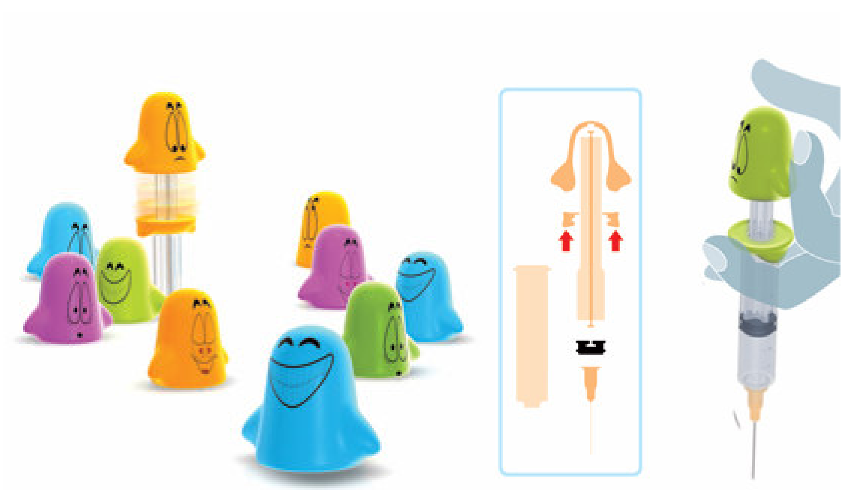

Figure 17: Life Science Category - Sonny (Source: red dot award design concept 2006).

Emotional design can also be linked to both cognitive and physical issues and very often connected to sensory and symbolic attributes. Sensory attributes would refer to shapes, texture and feel of materials while symbolic attributes refer to analogies or representations that carry with the subtle concept of a social norm. According to Dewey (1963), he emphasized the contribution of material things (sensory attribute) to the construction of experiences. By providing the right pre-conditions such as these attributes in pleasurable product design, it could motivate users to be more willing to participate in their healthcare, etc, through the device (refer to Fig.18).

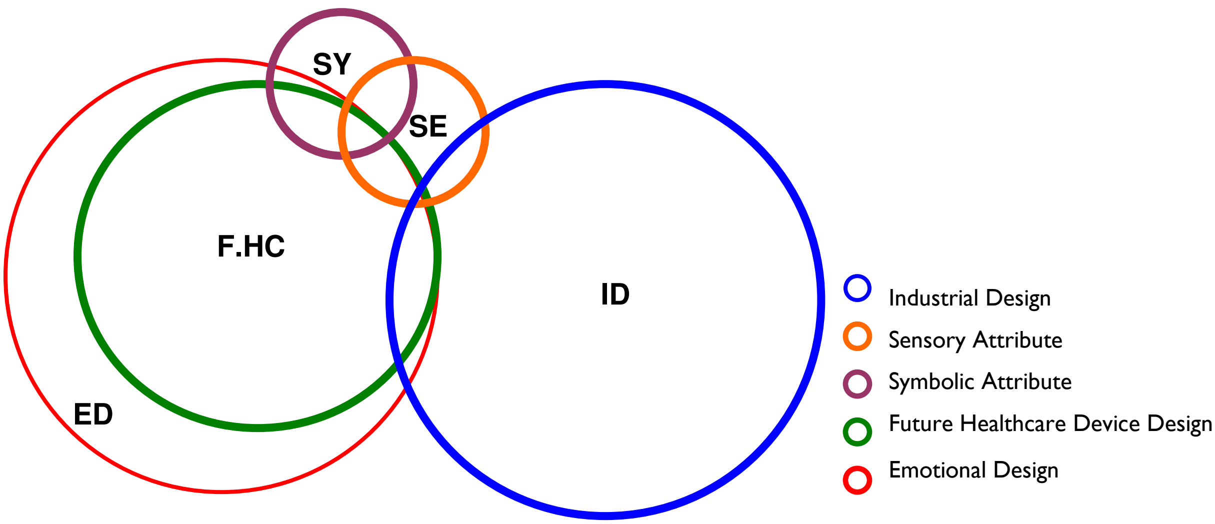

Figure 18: Possible Issues Characterizing Healthcare Design in Near Future.

Designers should take effort to comprehend possible user scenarios – unintended or not. For home consumers, where they are untrained in medical knowledge, it is highly important to start examining what users experience with the healthcare devices they buy home. Existing social protocols and use practices no longer apply as they are based on rather different conditions. Despite the advancement of technology and introduction of intuitive features, it can still cause users to commit errors, often times resulting in adverse effects, especially when users are lay-man consumers, untrained and laden with health set-backs.

4. 2. A COMPARISON OF CHARACTERISTICS OVER TIME

There is no doubt a linear relationship between time and the six characteristics which belong to the build-up of the phases in healthcare device design. The characteristics can be identified through time as they move through the influence of design movements as well as other influencing societal progression (refer to Table 1). The size of the dot is determined by an iterative approach to literature review, with analysis to allow themes to emerge when saturation was achieved. Characteristics such as functionalism, ergonomics, and technology are still very crucial in healthcare device design in today's times although some the examples shown previously expounded on the strong influence apparent in the 1930s, 1950s and 1980s. As mankind progresses in innovations and appreciation of design and consumerism, it can also be seen that the merging of the six characterizations is unavoidable and each are no longer isolated in the design process. They have been repeatedly illustrated in the examples shown earlier such as the Vicks Thermometer, the Ovation BioNatural Ergonomic Pipette, and the Orthora 200 orthodontic surgeon's chair.

	1900	→	*1920*	→	*1940*	→	*1960*	→	*1980*	→	*2000*	→	*2020*
Function	•		•		•		●		●		●		●
Ergonomics					•		•		●		●		●
Technology									•		●		●
Aesthetics & appearances											●		●
Universal design											•		•
User experience & Emotional design											●		●

Table 1: A Comparison of Characteristics over Time.

5. CONCLUSION

The core of this paper has shown that the characteristics in healthcare device design could not be isolated at any point. At the lowest level of physiological basic needs industrial design helps to fulfill the functional aspects of the healthcare device. At the second level, design can improve the need for safety and comfort with an ergonomic approach that improves the use of the product. When healthcare devices are designed with ergonomics addressed, it should be able to efficiently and effectively fit into the clinical environment, with similar user interfaces and fully connected to the department, hospital, and outside world. As technology replaces many mechanically-operated functional aspects of the product, it may very often involved new messages being integrated into the product to make the product aesthetically appealing, understandable and user-friendly. It became important to focus on the communicative aspects of product design, which refers to the messages that make the product and its system more approachable, contributing to the ease of use of the product and therefore correspond to the need for comfort. User-centred principals are being applied, thus enhancing the aspect of universal design. Sensory and symbolic attributes are successful in enhancing experience and emotional needs in the use of healthcare devices, and they are definitely here to stay for more research and development. New forms of medical devices are thus designated to convey the concept of assurance, well-being, comfort, modernity and youth. More research is necessary to examine on different patient reactions towards emotional design in such devices, and emerging trends can be identified according to cultural differences as well.

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