



Ergonomics Analysis in the Industrial Design of Medical Instrument Products

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Abstract

With the continuous development of economy and science, medical instrument entered the digital and informational age. Conflicts between the urgent requirement and severe lack for ergonomics in the industrial design of medical instrument products became increasingly fierce. In the present paper, we attempted to use the research achievements in the area such as product form design theory, ergonomics design theory and so on, with reference to the studies of other industrial products, brought forward relative design principle and design method for ergonomics design of medical instrument product, and aimed to accomplish the design work of medical instrument product perfectly.

Keywords: Medical instrument, Industrial design, Ergonomics, Humanization, User

1. Introduction

With the progress of society and rapid development of economics, human being has entered an age with considerably advanced science and technology. Rapid development of high-tech had brought human being big progress in medical field, and their average life increased greatly, to which invention and application of medical instrument product contributed considerably. Progress of science and technology brought people not only new function, but also new issues, namely the convenience of medical instrument products. The inconvenience of product application could decentralize people's energy for accomplishing assignment, and brought an uncontrollable sense imposed by machines. The convenience of product application was related to not only product function, but also the interface of all man-machine conversation, which was the right object that ergonomics research required. However, modern medical instrument design was quite short of consideration on ergonomics. In the design and production of some medical instrument production enterprises, no further investigation on ergonomics was undertaken, which hampered the development of China medical instrument. Accordingly, ergonomics consideration in industrial design of medical instrument was of great significance, and also the issues that many product designers of medical instrument should pay attention to.

2. Ergonomics and industrial design of medical instrument product

Ergonomics origin could trace back to the early 20th century. Modern ergonomics has been developed ever since 1960s and has been an independent systematic subject. Ergonomics was a subject to investigate the interaction among people, machine and work environment (Ding, 2005). First, it was an idea where users "people" were used as the starting point of product design, coordinative relations among people, machine and environment were investigated by all means, and some design methods were outlined. It required that the shape, color, performance and so on of products should be designed centering on the physiological and psychological characteristic of human being, in order to make those products more comfortable, safe and efficient for users' work and life.

Medical instruments were products serviced for life quality and health of people, and its ergonomic quality and application safety was related to people's life security. With the progress and development of science and technology, internal structure and operating control of medical instrument tended to be more and more accurate, which required

more and more harmony between people and machines during application, and thus ergonomics design should be undertaken in the production of medical instrument.

Due to various reasons, medical instrument design has long been accomplished by medical scientific and technical workers or mechanical electronic research department according to the requirement of certain medical application area, which made lots of medical instruments lack modern design idea in the design factors such as form, color, performance interface and so on, especially in ergonomics and humanization. All these led to their only purpose for treatment, however, very important factors that all such medical instruments should consider for users' humanization concern were severely ignored.

Users of the medical equipment were people who performed. It had two implications as seen from literal explanations (Wang, 2007):

1) Users were part of human being. User possessed the common characteristics of human being, and could reflect those characteristics when using any products. People behavior was not only affected by perception ability such as vision, hearing and so on, but also the ability of analyzing and solving problems, basic ability such as reaction ability from stimulation as well. Meanwhile, it was restricted by factors such as psychological and character orientation, physical and cultural environment, education level, experiences and so on.

2) Users were people who made use of medical instrument. Its usable design focused on the special public related to product application. They could be the present users of product, and might also be the future users, or even potential users. Their behavior during the period of using products was closely associated with some characteristics related to products, such as knowledge for target product, expectant function of target product, and basic skill for using target product, time and frequency of using target product aftertime and so on. Medical instrument, as a special product, was obviously different from general consumable. A majority of medical instruments possessed double users, viz. doctor and patient. Doctors were positive users, while patients were passive users. Both belonged to "human being" category of ergonomics relationship.

Central idea of product design was "human being", "human-oriented". Design for people was one of the keys of product design. Medical instrument, as a product, was far different from general products, because it was associated with human health and life security. Therefore, properties of such product, such as usage, comfort, stability, amenity, security and so on, were paramount, among which ergonomics issues were very crucial, and humanization design was also a focus of medical instrument design.

3. Ergonomics analysis in medical instrument industrial design-a case of infrared breast scanner

Infrared breast scanner, according to the principle that different tissues had different infrared absorption, scanned breast tissue by infrared transillumination, obtained images by special infrared CCD camera, displayed all lesions of breast tissue on the screen after PC processing, and according to grayscale of image, and relation between vascular change and grayscale, diagnosed various breast diseases. In the present paper, analysis object referred was infrared breast scanner (SW-3003 common type) produced by Xuzhou Sanwei Medical equipment Co., Ltd in Jiangsu province (Figure 1). When using it, users were divided into two sorts. One was who detected, other was who was detected. Usually, people who were detected lay on the left side of the instrument for detection, and people who detected sat in the front of the instrument to detect patients; after data acquisition of the service conditions, we analyzed the product.

3.1 Dimension data analysis

Human body data collection was principal work for ergonomics analysis, and through consulting China human body dimension data, useful data was obtained, among which GB/T 10000-1988 was China important technological ergonomics standard. Data of this standard was frequently applied. Application task belonged to vision information working position. According to the design principle of vision information position, terminal position man-machine interface was depicted in Figure 2. Such task position design had the following points: A, human-chair interface; B, eye-visual screen interface; C, hand-keyboard interface; D, foot-floor interface.

When designers did their product design, human body dimension was one of the important references to determine his product size, and each percentage of human body dimensions was cardinal content of application (GB/T 12985-1991). Through data acquisition, consultation and analysis, external basic size, suitable for infrared breast scanner was ascertained which was depicted in Figure 3 in detail, namely human body dimension figure of normal sitting during work state. After data analysis, suitable height from typing operation area of infrared breast scanner to ground ranged from 66.0cm to 71.1cm; The least leg space was 63.5cm; The most reading distance from human body axis to screen ranged from 71.0cm to 76.0cm, in addition, if screen was rotatable and floating, adjustable height of screen was about 180mm, and adjustable angle was $-5^{\circ}\sim+15^{\circ}$; Optimum angle between the upper and front arm of hand control keyboard ranged from $70^{\circ}\sim90^{\circ}$, and 100mm wrist rest space should remained between wrist joint and keyboard. The infrared breast scanner used in the present study basically accord with man-machine size requirement, and man-machine issues occurred in leg space. It failed to obligate enough space for leg, which resulted in leg disamenity and easy fatigue when

people operated it. It should be redesigned and ameliorated.

3.2 Color analysis

Color played a critical role in man-machine relation, and had a great impact on user's mentality. Product color matching in industrial design was primarily taken into consideration that color should assort with function and environment of equipment. It should not only meet the requirement of function, but also satisfied the requirement of human's taste. In the industrial design of medical instrument, effects of color were tremendous, and color was first applied in the medical treatment design was in 1925 in history. In surgery hospital of USA, during the operation, gleaming blood visual afterimage appeared in the white wall, which made vision in a tired state. In order to change such state, light green grey-complementary color of red was applied in the white wall, and thus vision fatigue of operative doctors was alleviated efficaciously.

As for infrared breast scanner, for objects were all female, some very simple but elegant and clean female color should be considered as subject color, such as quite light pink, pure blue and pure green. The infrared breast scanner applied in the present analysis used white as its subject color. Though it met the basic requirement, namely very simple but elegant and clean, it was short of sweet sense, and couldn't give the patients a sense of solicitude, but a sense of rather cold, which could not meet the requirement of caring for patients. Besides, medical instrument should give people a sense of tranquility and safety, and it was not suitable for the presence of vivid ornamental color; if there was no ornamental color at all, it would give people kind of calmness, cold and even lifeless sense, and no life vigor was recognized. The infrared breast scanner applied in the present analysis only had subject color-white, with no ornamental color, and it gave us an excessively rational and lifeless sense, which could imposed an passive psychological impact on users. It should be redesigned and ameliorated. Besides, in different countries and regions, due to the difference in historical tradition, national habits and custom, people had different and even contrary color preference and taboo. For instance, people advocated red, and usually used red to represent happiness and luck. But in some other country, such as Benin, red was considered as passive color... In Argentina, purple was avoided to use. While in Peru, it was one of the most popular colors (Wang, 1996).

3.3 Visual illusion in man-machine relation

When observing objects, for retina was stimulated by light, light not only promoted nerve system to react, but also result in increasing impact in transverse direction, which made the visual impression differ from the full size and shape of objects. This phenomenon was called visual illusion. Familiar shape illusions had length illusion, direction illusion, contrast illusion, size illusion, distance illusion, perspective illusion and so on; Color illusion had contrast illusion, size illusion, temperature illusion, distance illusion, fatigue illusion and so on. Some quite typical visual illusions were illustrated in Figure 4 in detail. In the industrial design of medical instrument, visual illusion could gain better utilization, for instance, as for very huge medical instrument, according to size visual illusion principle of visual illusion, medical instrument was designed using shape or color visual illusion, with attempts to reduce bulk in vision, reduce the sense volume of medical instrument, and psychological oppression imposed by huge medical instrument, and thus accomplish humanization design. The infrared breast scanner applied in the present analysis didn't apply visual illusion principle at all, which resulted in huge, stiffness and insipidity in appearance shape and brought passive emotion during operation. Therefore, it should be redesigned and ameliorated.

3.4 Barrier-free design analysis

"Design purpose is to meet the requirement of majority, not to service for minority. Especially for the oblivious majority, they should be paid more attention by designers" (Yin, 2003, P. 11). With the popularity of humanization design, more and more attention was paid to barrier-free design. As for "paths" to perceiving external information-vision, hearing and feeling, a majority of the disabled lacked one or some certain "paths" among them, but other "paths" were useable. For people with sensory disturbance, selection for the paths of information acceptance, namely selection of perception means, was the key to determine whether the product could realize the barrier-free design for information communication. Aimed at special cases and body limitation of specific population, selective application of various perception means to convey information could solve such problem.

4. Conclusions

In the present paper, we discussed the developmental deficiency of modern medical instrument products in ergonomics, and the deficiency seriously hampered the development and progress of medical instrument. With the development of social economy and scientific technology, further research on this area was necessary. Accordingly, as a producer and designer of medical instrument, issues of this aspect should be taken into great consideration, and in this way, product quality could be greatly ameliorated, which also played a critical role in the subsequent survival and development of medical instrument produce enterprises. Good and easy usage products, as well as humanization products certainly appealed to more consumers. This embodied "human-oriented" idea, accorded with the tide of social development, and was worthwhile for us to consider profoundly.

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Figure 1. Infrared breast scanner (SW-3003 common type)

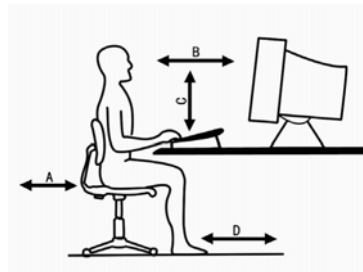


Figure 2. Human-machine interface of vision displayer station

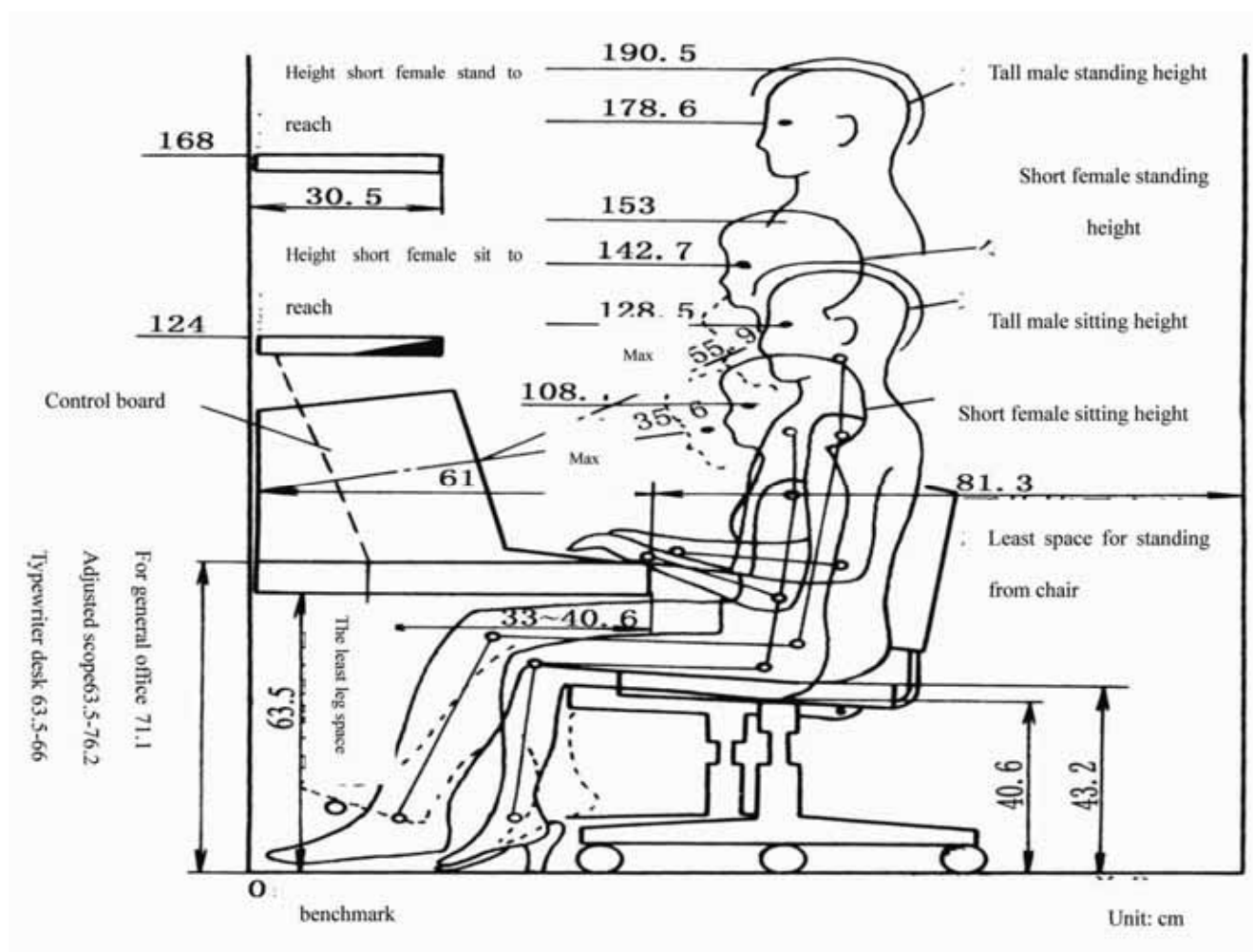


Figure 3. Human body dimension figure of normal sitting during work state

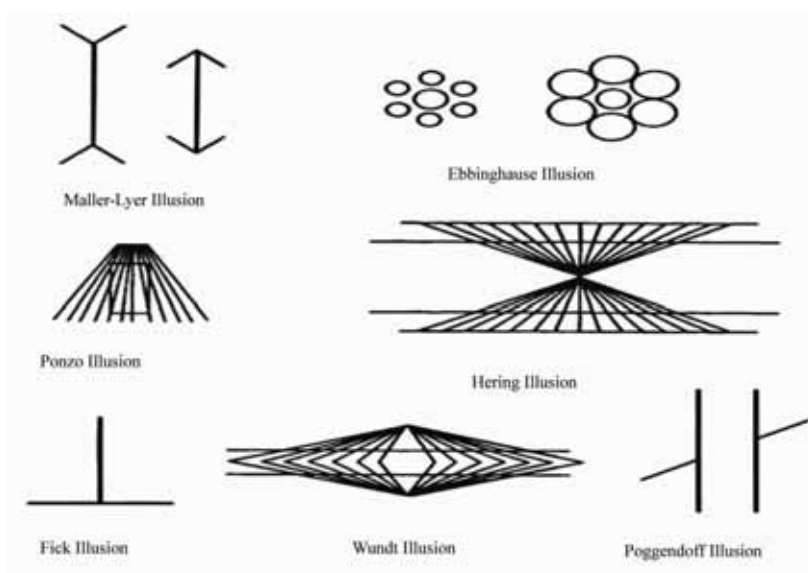


Figure 4. Typical visual illusions