

Research on Interactive Interface of Intelligent Electronic Medical Testing Equipment

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Abstract—Purposes: Integrated emotional concept into the innovative design of the human-machine interface of medical monitoring equipment to enhance its ease of use and availability. **Methods:** Use Donald Norman's three levels of product emotional experience model, Maslow's hierarchy of needs theory and Kansei engineering theory, combined with variety of research methods to tap user's emotional needs. **Results:** Construct a user emotion needs model for human-machine interface of medical monitoring equipment.

Keywords-component; medical monitoring equipment; human-machine interface; emotional design

I. THREE-LEVEL MODEL OF EMOTIONAL DESIGN FOR HUMAN-MACHINE INTERFACE OF MEDICAL MONITORING EQUIPMENT

People have different levels of emotional experiences in product. Donald A. Norman, a cognitive psychologist, divides people's emotional experiences into three categories: instinctive emotions, behavioral emotions, and reflective emotions[1]. The changes in user emotions are divided as follows: evocation, association and identification. Evocation aims to stimulate the user's emotional response via some ways, and this emotional reaction can be projected inside the products; association refers to connection with products as a result of chemical-reaction-like wonderful changes in projection after use of products. Ultimately this association will gain user's identification and acceptance on the products. Similarly, the emotionalized design of the human-machine interface (HMI) hereunder can be divided into three levels: design of sensory level, design of efficiency level and design of cognitive level, as shown in Fig 1.

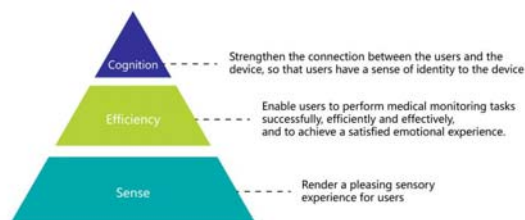


FIGURE I. THE THREE LAYERS DESIGN MODEL OF THE EMOTIONAL DESIGN OF HMI IN MEDICAL MONITORING EQUIPMENT

A. Design of Sensory Level

Sensory level emotion refers to the immediate response of human being against any stimulation, for example, instantly

tightened muscles in dangerous situations, or; relaxed muscles in favorite situations.

B. Design of Efficiency Level

Efficiency level emotion is defined as the feelings of people using products, such as their anxious mood while watching suddenly suspended video; and relaxed and happy mood while the video becomes smooth. The purpose of designing the efficiency level is to enable users to perform medical monitoring tasks successfully, efficiently and effectively, and to achieve a satisfied emotional experience.

C. Design of Cognitive Level

Cognitive level emotion refers to users' impression, memory to products, as well as their usage meaning, such as unique and self-satisfied experience from DIY products; memory and reflection evoked by retro-type modern products. Cognitive level emotion reflects people's spiritual demand, as the highest level of consciousness, emotion and cognition.

II. ANALYSIS OF EMOTIONAL FACTORS IN HUMAN-MACHINE INTERFACE OF MEDICAL MONITORING EQUIPMENT

A. Emotional Factors in Sensory Level

Sensory level emotionalized design focuses on intuitionistic visual experience that a product brings to users. Regarding HMI of medical monitoring equipment, it means users' emotional experience from visual elements of HMI. The visual elements of the human-machine interface mainly include color, graphic, text and icon, which complement each other and directly affect the user's sensory level emotion visually.

B. Emotional Factors in Efficiency Level

Efficiency-level emotionalized design is aimed to ensure users to complete the medical monitoring task smoothly via the HMI. Thereby a good efficiency level design solution shall contain the interface readability and interface usability.

1) *Interface readability*: HMI aims to stimulate user's visual experience to transmit functional information, which requires good readability of the visual elements in interface: interface graphics, text, pictures and other information, within the limited range of the interface, can be reasonably arranged [2]. It is regarded as an important channel for establishing emotional connection between users and products. Because of the specific nature of medical monitoring equipment, users

require higher readability of interface: in medical monitoring equipment HMI.

2) *Interface usability*: In the HMI of medical monitoring equipment, the interface usability can be subdivided into easy to understand, easy to learn and easy to operate. Easy to understand is the degree of effort made by users to understand the logic concept and function of interface. Easy to learn is the degree of effort made by users to learn the interface. Easy to operate is the degree of effort made by users to run and operate the control interface.

C. Emotional Factors in Cognitive Level

Good cognitive level emotionalized design solution should be capable to stimulate user's resonance, trigger user's identification and dependence on the interface. Therefore the efficiency level emotionalized factors can be summarized as the interface pleasure and interface resonance.

1) *Interface pleasure*: Martin EP Seligman, a social psychologist, has pointed out that human control on the outer world can lead to a pleasant and positive emotional experience. On this basis, people are more willing to try new things and accept new challenge[3]. The pleasure of HIM may also be understood as the controllability of the interface. Stable and continuous controllability sense allows users to discover, identify, and expect current operating behavior, and to reduce the confusion and mis-operation, thereby to obtain a good emotional experience.

2) *Interface resonance*: The HMI resonance is a strong sense of identity and emotional experience arising from effective and positive communication with the interface by users during the operation process, and such the communication is related to the feedback of interface. The feedback information is divided into positive feedback and negative feedback. Positive feedback refers to certain and encouraging feedback of information during interaction process hereto. Negative feedback is defined as reminding and informing behavior arising from user mis-operation or interface alarm triggering.

III. EMOTIONAL DESIGN ANALYSIS OF HUMAN-MACHINE INTERFACE OF MEDICAL MONITORING EQUIPMENT

A. Analysis on Users Characteristics



The medical monitoring equipment has a relatively complex and mixed customer group, and is characteristic of multiplicity. According to the user relationship in medical service, the users of medical monitoring equipment can be generally divided into two major categories, respectively the subjective users and the objective users. The subjective users refer to the professional medical treatment staff and play a dominant and behavioral subject role; the objective users include the patients and the non-professional caregivers who are responsible for caring for the patients, and play a subordinate and behavioral follower role.

B. Analysis on Users Emotional Demands

1) *Emotional demands of sensory level*: Considering that the emotions on sensory level are related to the initial responses of people, we mainly adopt questionnaire investigation method to study the emotional demands on sensory level and dig out the equipment preferences of users on sensory level. In addition, in-depth interview method is combined to dig out the reasons behind the preferences. The colors, image styles and text arrangement method of mainstream product interface in medical monitoring equipment are categorized, concluded and collected into investigation questionnaires. 50 questionnaires in total are issued to the subjective users and the objective users respectively in the Department of Surgery and Department of Internal Medicine in Guangdong Huizhou Center People's Hospital and 48 questionnaires are recycled (25 from the subjective users and 23 from the objective users). Thus, there are 48 effective questionnaires and the efficiency rate is 96%. The specific investigation results are as follows.

a) *Interface color*: In the questionnaire, we select the two most representative color samples in mainstream brand products to carry out user emotional preference investigation (refer to Table 1). And Fig.2 shows the results.

TABLE I. COLOR CLASSIFICATION OF HUMAN-MACHINE INTERFACE

| | |
|--|---|
| A.Single main color+auxiliary Achromatic-color |  |
| B.Single main color+auxiliary multi-color |  |

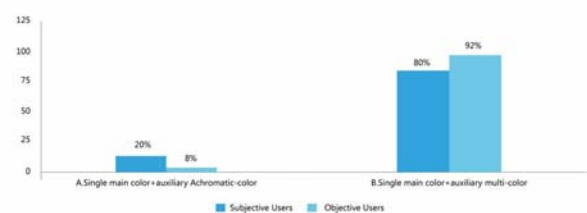


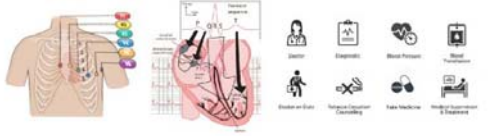
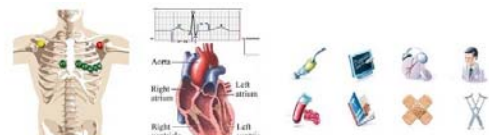
FIGURE II. THE RESULTS ABOUT USER'S EMOTIONAL NEEDS IN INTERFACE COLOR

80% subjective users and 92% objective users are more inclined to choosing B. Deletion: Delete the author and affiliation lines for the second affiliation. It is found through the sampled in-depth interviews on this part of users that the subjective users choose this sample because of their work nature. They are under a serious and nervous environment for a long term and suffer from great psychological pressure. As the auxiliary interface color, the multi-color system can activate the dull atmosphere and contribute to proper

relaxation; the reason why the objective users choose this sample is that the multi-color system can break the coldness and gravity of medical monitoring equipment and help to alleviate the anxiety and tension brought by diseases and environments.

b) Interface graphic: The graphic can be generally concluded into two major categories Selection: Highlight all author and affiliation lines(as show in Table 2). And Fig.3 shows the results.

TABLE II. PATTERN CLASSIFICATION OF HUMAN-MACHINE INTERFACE

| | |
|--------------------------|---|
| A. Abstract style |  |
| B. Realistic Style |  |

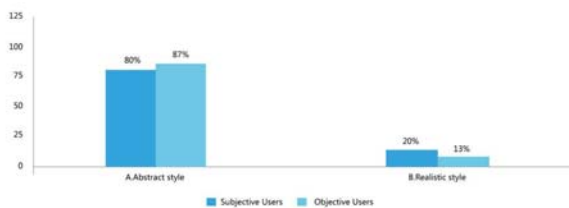






FIGURE III. THE RESULTS ABOUT USER'S EMOTIONAL NEEDS IN INTERFACE GRAPHIC

The users who choose A. abstract style are in the majority, respectively 80% subjective users and 87% objective users. It is found through in-depth interview that the subjective users choose image design of abstract style because its style is clearer, comfortable and neat as well as possesses higher recognition compared to the realistic style; the reason why objective users choose A. abstract style is that the realistic style imposes people with greater psychological pressure, and makes people feel safer compared to the abstract style as well as is easier to be recognized.

c) Interface text: The interface text factors influencing user emotional experience on sensory level include colors with texts, font, word size and arrangement method. Specifically, due to properties of medical monitoring equipment, the fonts and arrangement methods adopted by different brands are relatively standard. Therefore, we only analyze two variables(refer to Table 3). And Fig.4 shows the results.

TABLE III. TEXT CLASSIFICATION OF HUMAN-MACHINE INTERFACE

| | | | |
|------------------------------------|--|--|---|
| A. the same color and word size |  | B. the same color but different word sizes |  |
| C. different colors and word sizes |  | D. different colors but the same word size |  |

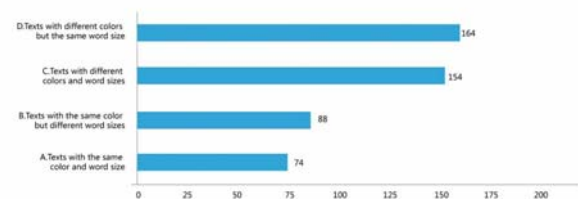


FIGURE IV. THE RESULTS ABOUT USER'S EMOTIONAL NEEDS IN INTERFACE GRAPHIC

The users who choose C and D are in the majority, which indicates that users are inclined to arrangement of texts with different colors. In the meanwhile, there is a tiny difference in the proportion of users which choose C or D and A or B, which indicates that the users are not very sensitive to the variable, word size. It is found through in-depth interview that the subjective and objective users express that the primary demand for interface texts is clarity. Therefore, they are inclined to texts with different colors. Specifically, the subjective users indicate that texts with different colors can effectively lower the agitated feeling due to long-time data observation; the objective users indicate that different colors are more active and are easy to be distinguished and recognized, thus avoiding mis-operations.

2) *Emotional demands of efficiency level:* the user demands are satisfied through user behaviors and the user behaviors embody the user demands[4]. As a result, mainly use observation method to investigate user's emotional demands in this level.

a) Emotional demands of subjective users: In the case of Department of Cardiothoracic Surgery in Huizhou Center People's Hospital, there are 35 beds and 22 medical workers in total. Each work shift requires 4-6 workers. The daily operation of nursing staff on ECG monitoring equipment needs to go through 7-8 steps. In addition, the patrol check is carried out every 1-2 hours and the monitoring part needs to be changed every 6-8 hours. It can be seen that there are many patients in Department of Cardiothoracic Surgery and the work load of the medical staff is massive. Therefore, the usability of human-machine interface in monitoring equipment is the most fundamental emotional demand of medical staff on efficiency level. Including interaction effectiveness and interaction comfort.

b) Emotional demands of objective users: As for the objective users, the utilization of medical monitoring equipment is to control or cure the diseases. Therefore, they are most concerned about how the disease state is, what the recent development trend and how to control or treat the disease. Likewise, in the case of ECG monitoring equipment, as for medical ECG monitoring equipment, it is widely used because obstacles on reading and understating the interface information if no professional medical knowledge is acquired. Therefore, they are at a loss for a long term; as for civil ECG monitoring equipment, with the economic development and medical technological improvement, the equipment medical professionalism is gradually improving. While the equipment satisfies the increasingly diverse user demands, how to use the equipment has become more difficult. So, the learnability of HMI in medical monitoring equipment is the most fundamental emotional demand for objective users. Including understandable interface information and learnable functional operation.

3) Emotional demands of cognitive level: The emotions on cognitive level refer to the product memory after the users use the product and the meaning the product utilization and are established on the basis of emotions on both sensory level and efficiency level. Products with good emotional design on cognitive level should be moving and unforgettable. Therefore, the emotional demand of users on cognitive level of human-machine interface in medical monitoring equipment is mainly centered on whether the interface can satisfy user psychological appeals.

a) Emotional demands of subjective users: As knowledge-based workers with high professionalism, the medical staff needs to invest a very long time and efforts into education and training, which generally take 5-8 years. After employed, they need to receive regular education and training to make sure that they are qualified for their jobs. The work nature causes widespread psychological health issues in them. A survey from the Ministry of Health in 2007 indicates that 90% medical staff feel great work pressure, 70% medical staff feel that their legitimate rights cannot be protected and 50% medical staff sometimes suffer from passive emotions. This phenomenon is increasing year by year[5]. The hierarchy theory of needs from Maslow assumes that each individual has the need to be respected and to realize themselves. This goes more for the medical staff in special work posts. Therefore the controllability of the human-machine interface is the most fundamental emotional demand for the subjective users on cognitive level, including interface which can provide continuous and controllable operations as well as offer inheritance. In this way, the training cost for medical staff can be lowered, and the operation mistakes can be reduced to improve the confidence of medical staff.

b) Emotional demands of objective users: An investigation report on the physical and psychological appeals of 142 patients and their families of Zhejiang Huzhou No.1 Hospital that 94.37% patients hope to gain the support and care from families and work units and 71.83% patients hope to gain the

active care and respect from medical staff. It can be seen that the care and respect from external care are their demand peaks. Therefore, the friendliness of human-machine interface is the most fundamental emotional demand for objective users on cognitive, including positive feedback and service-based interaction.

4) User's emotional demands model: Use Category Classification to carry out multi-level recursive deduction on user's emotional demands. Finally construct the emotional demands model as shown in Fig.5.

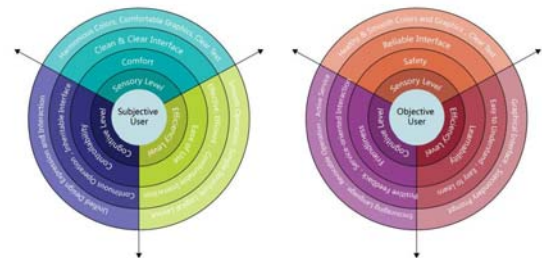


FIGURE V. EMOTIONAL DEMANDS MODEL OF SUBJECTIVE AND OBJECTIVE USERS

IV. CONCLUSIONS

Medical monitoring equipment oriented towards special groups should guarantee the operational safety and high efficiency of medical staff and alleviate the psychological pressure of patients to guarantee their life safety. Integrating emotionalized concept into design of human-machine interface of medical monitoring equipment contributes to improving the usability and availability, thus further promoting the market competence of medical monitoring equipment. Based on this, a three-level design model for emotionalized design of human-machine interface in medical monitoring equipment is proposed. Then, based on the user investigation prospective, an emotional demand model for subjective and objective users of medical monitoring equipment is constructed and the principles for the emotionalized design are concluded, which provides certain theoretical reference for the design of human-machine interface in medical monitoring equipment.

ACKNOWLEDGMENT

A Funded Project: by the Culture Creativity Fund under Shanghai Municipal Commission of Industry and Information Technology (15q10701).

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