An Investigation on Vibrotactile Emotional Patterns for the Blindfolded People

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Abstract
The purpose of this study was to investigate the association of emotional linking and patterns. The results could explore that the vibrotactile was raised on tactile sensations, and then construct a tactile emotional interaction model. Total of forty volunteer subjects were participated in this experiment, and these subjects were blindfolded sight. The subject's physical activity is normal, and without wearing any decorative items on the finger. In the experiment, the independent variables were six types of vibrotactile and their corresponding types of basic emotions, including happiness, anger, sadness, surprise, disgust, fear. The dependent variables were the optimum combination of vibrotactile emotion and intensity scores of vibrotactile. The results illustrated that the vibrotactile characteristics of each emotion linking and the diversification of amplitude for the tactile emotions. Furthermore, six types of vibrotactile emotional pattern were different ($p < 0.01$), but the subject's genders were no significant ($p > 0.05$). The results of this study could be used as a reference for the visually impaired's assistive devices design, as well as to enhance the use of the product justice.

Keywords: visually impaired, vibrotactile, emotional linking, product justice

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Introduction

In recent years, people have many innovative interactions are different from the traditional model of human-computer interaction, such as 3D interactive, somatosensory, brain wave control, operation and even other senses interactive experience, because of the advances in digital technology. Basdogan et al (2000) also pointed out the tactile sense of the body, makes it possible for us to feel the reality of the outside world, and many researchers began to add a tactile element to the interface or the tool for input and output providing more possibility of innovation in digital interactive media.

In addition, many studies also emphasize tactile interfaces can provide another mode for information input, especially when Visual or auditory system overload (Schrope, 2001; Sears et al., 2003; Brewster & Brown, 2004; Rodriguez et al., 2014). Therefore, tactile sense is the method to reduce the load of other feeling channels, and to enhance the accuracy of the information determining (Pascoe et al., 2000). A brilliant design of tactile interactive interface not only increase the success of receiving information but also provide another choice of information determining channel for users when the condition of information transmission is too complicated. In addition, the study also noted that the tactile concept has also been used in wearable product design (Hoggan and Brewster, 2007). These wearable concept products provide not only vision transmission channel, but tactile transmission channel that is a design point for more intuition and less interference by other channels.

Brewster and Brown (2004) have used the vibration of mobile phones to test people identified on the meaning of different messages. Experimental phones presented different types of meeting with the vibration level, such as lecture, group meetings, individual meetings. The experimental results show that if you use a different frequency of vibration and vibration of body positions for identifying the type of meetings to maintain a very high recognition rate, and recognition rate of vibration can increase 30%. The study suggests that reducing the amount of tactile information improves users' rate of recognition. Qian et al. (2011) applied the vibration sense concepts of tactile icons (Tactons) on a mobile device. This research attempts to provide a better performance in tactile vibrating feedback in order to reduce the load on the visual channel. Rodriguez-Sanchez et al. (2014) designed the wayfinding system with the concept of tactile markers on a smartphone, through the design of tactile vibration and frequency let users find their destination. However, relevant researches seldom focused on the investigation and discussion of emotional responses in touch interactions. Therefore, this study aims to the investigation of emotion link based on tactile sense, discuss deeply the emotional link of tactile interaction process and convert issues. The result would the research foundation of relevant tactile display for products design in further research.

Furthermore, different feeling and cognition is often triggered by the tactile exploration process, such as the reaction of tactile emotional linking. These reactions may occur in different patterns of Human-Computer interaction. According to the compilation of relevant literature, the previous works lack this important issue that deeply investigate the cognition of vibrotactile emotion. Therefore, it is worth exploring a new field of research for the non-visual interaction and visual disturbances aids.

Methods

The purpose of this experiment was to investigate people's emotional linking with the vibrotactile information. In this study, a within-subjects experimental design was performed. The features of vibrotactile emotion were presented in the experimental results.

Subjects

A total of thirty volunteer subjects were participated in this experiment, and these subjects were blindfolded sight. The subject's physical activity is normal, and without wearing any decorative items on the finger.

Stimulates

The independent variables in the experiment were the vibrotactile intensity and the basic emotions. The dependent variables were the frequency of vibrotactile intensity and optimum combination of vibrotactile emotion. A combination was composed by a row of six cells. The vibrotactile intensity contains the two kinds of vibration level (strong: 90Hz and weak: 30Hz). The duration of each vibration was two seconds. The basic emotions were of happiness, anger, sadness, surprise, fear, and disgust. All of the vibration stimulation by a computer control.

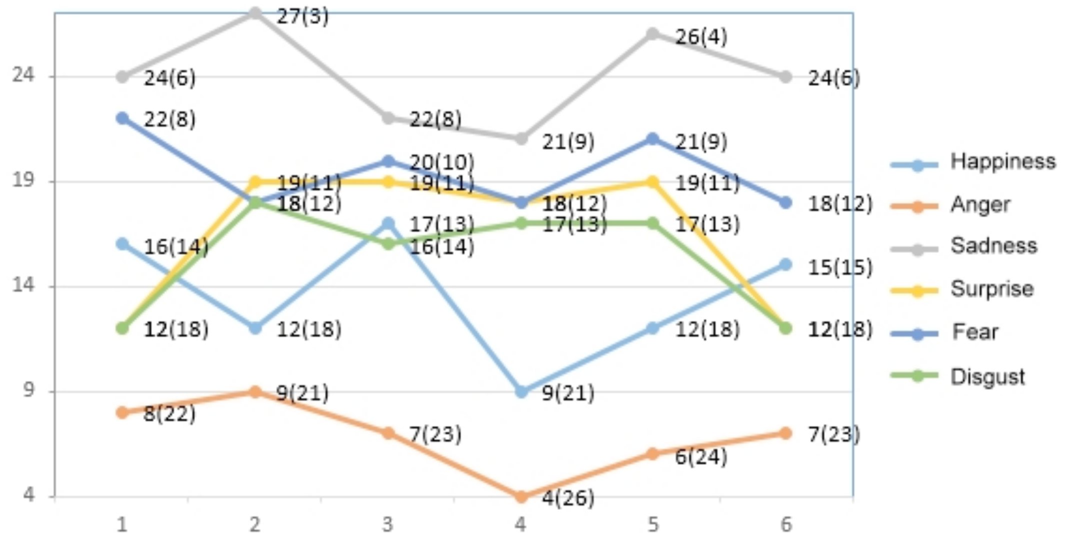
Procedures

Before the experiment, the subjects were briefed on the rules and purpose of the experiment. Subjects can be adjusted to the most comfortable sitting height. Subjects were able to understand the differences between the independent variable by the experimental training program. When the official start of the experiment, subjects have to match the basic emotion with the vibrotactile combination. The paired combination of tactile vibration level and basic emotion type would be recorded. This paired experiment allows the subjects to feel repeatedly, until they considered the combination was an optimum result. The subject's left index finger as a test point in the experiment. A complete combination of vibrotactile emotion was about 18 seconds. The experimental data would be recorded by the computer automatically. An experimental procedure for about 15 minutes to complete. The experimental situation was shown in Fig. 1.


Fig.1 Paired experiment of vibrotactile emotion

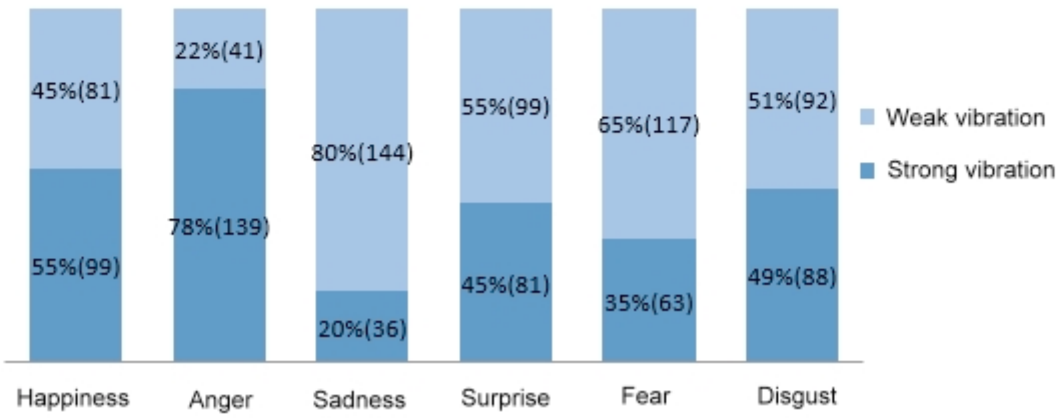
Results

The characteristics of emotional oscillation could be observed by the cumulative frequency of the vibration level. The cumulative frequency of weak vibration was shown in Fig. 2. The number in parentheses was the cumulative frequency of strong vibration on the polyline. Obviously, the subjects accustomed to using weak - vibration means "sadness" emotion, and the frequency of weak vibration was the highest in every cells. Relatively the frequency of weak vibration was the lowest for the "angry" emotion. The strong vibration often appeared in the "angry" emotion. The frequency of ranking about strong vibration was as follows: angry> happiness> disgust> surprise> fear> sadness.
The proportion of different vibration intensity in the six basic emotions was presented in figure 3. Among them, the proportion of strong vibration was higher than weak vibration in the happiness emotion. the proportion of weak vibration was higher than strong vibration in the surprise emotion. And, the proportion of strong and weak vibration nearly half in the disgust emotion. Fear emotion was more inclined to weak vibration presentation. Obviously, the results presented that anger mostly showed strong vibration (78%), while sadness was mostly rendered weak vibration (80%).



* (Value) was the cumulative frequency of strong vibration

Fig. 2 Each basic emotional ups and downs of the situation with weak vibration.



* (Value) was the cumulative total of the number of times for the different vibration intensity

Fig. 3 Comparison of the proportion of vibrotactile intensity for each basic emotion

In this study, the intensity of the tactile vibration was given a weighted score (the score of weak vibration was 1 point, and strong vibration was 2 points). The descriptive statistics of two kinds of vibration level for different gender was shown in Table1. From the average, the subjects were women preferred to use the weak vibration (3.23> 3.15), and the male subjects who are using more strong vibration (5.69> 5.57). However, the result of t test showed gender does not affect the use of vibration type ($p > 0.05$).

Table 1 Descriptive statistics of vibration level on different gender

	Gender	N	Mean	SD
Weak vibration	Male	96	3.15	1.596
	Female	84	3.23	1.347
Strong vibration	Male	96	5.69	3.223
	Female	84	5.57	2.690
Total	Male	96	8.83	1.633
	Female	84	8.80	1.351

Further, a one-way ANAVA analysis was used in emotion factors on different vibration level. The results showed that emotion factors on two kinds of vibration level were presented significant differences, which were weak vibration ($F = 36.41$, $p < 0.01$) and strong vibration ($F = 36.50$, $p < 0.01$). From the result of Duncan grouping for the weak vibration, we found that the sadness and fear emotion were more frequently appear (Mean = 4.80). In contrast, anger emotion was the least (Mean = 1.37). The average score of vibrotactile intensity in the weak vibration was similar during the happiness, disgust, and fear emotions. On the other hand, three kind of emotional presentations were similar in the strong vibration. These emotions included surprise, disgust, and happiness. Overall, subjects often used strong- vibration to express anger emotion (Mean = 9.27), but strong vibration rarely appeared in the sadness and fear.

Discussion and conclusion

In fact, the tactile applications could be observed in the related non-vision research works, especially in Tactions (Brown and Kaaresoja, 2006 Qian et al., 2011). These applications of Tactions included simple vibrating alert, wayfinding, direction of guideline (Rochlis & Newman, 2000; Brown & Kaaresoja, 2006; Rodriguez-Sanchez et al., 2014). From the study of results, we can find the relevance of the vibrotactile to emotions, and they have connectivity. Therefore, the results provide another valid coding dimension in the tactile perception channel. The coding dimension of tactile emotion can enhance the combination of information, i.e. multidimensional codes. Many studies noted the effective work of the multi-dimension codes can reduce people's information uncertainty (Sanders & McCormick, 1993).

In this study, people use the vibrotactile to describe some basic emotions would not be hindered. For example, subjects who have an intuitive and immediately response to write the coding of vibrotactile emotions. From the style of vibrotactile emotions, people use the ups and downs of a continuous vibration to describe happiness, such as a small bird hopping. For the emotion of anger, people are accustomed to using continuous vibration and high strength, just as the furious feelings. Conversely, sadness is a continual and low intensity vibration, as low melancholy feeling. Similarly, people describe the emotion of fear that like hold their breath, low vibration intensity occupy most of the coding space. For the surprise, high vibration intensity appears at the beginning and end, such as the procedure of opening presents. Furthermore, most of the study participants could not immediately describe the emotion of disgust by observing the experiment. They need to spend more time on the feelings of disgust. They tend to use a continuous weak vibration with vibrational oscillation to represent this negative emotion. Therefore, the six basic emotions corresponding vibrotactile style are similar with our emotional feelings and response. The results of study can be used to vibration information design, and assist the product development of vibrotactile emotional function. For example, more diversity and abundance of vibration settings on the smartphone. Currently, the six basic emotions of vibrotactile style were investigated in this study. And more emotions could be explored about vibrotactile in the future works. Besides, the vibrotactile emotion index (VEI) will be constructed in our further study.

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