

Healthcare applications of vibrotactile stimulation developed by Tactile Score

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Abstract

We constructed a system to convert the tactile score into vibratory tactile sensation. We conduct basic biological experiments on electronic tactile stimuli and apply the results to medical and healthcare applications. We use two types of electronic tactile stimuli. One is direct vibrating tactile stimulation, and the other is airborne vibrating tactile stimulation. Verification experiments of this system have confirmed cosmetic effects such as skin collagen aggregation, improvement of hypertension and diabetes, and reduction of pain and nerve paralysis. In addition, a clinical study was conducted in which patients with dementia were exposed to vibrotactile sensation (low-frequency sound) via air vibration and an improvement in cognitive function was confirmed.

Keywords: Healthcare, vibrotactile, Tactile score

1. Introduction

Our hands have great power. There is a word in Japanese called, "Te-arte [1]". This word is the English term for "hand healing," or healing by laying one's hands on someone. In Japan, hand healing has been valued since ancient times.

It seems which is not limited in Japan. Dr. Abraham Varghese, a physician and professor at Stanford University Medical School, gave a TED Talk in 2011 titled "A doctor's touch," in which he emphasized that, the importance of healing through the doctor's touch. He addressed that:

"the most important innovation in medicine, to come in the next 10 years, that is, the power of the human hand - to touch, to comfort, to diagnose and to bring about treatment [2]".

The sense of touch is the earliest of the five senses to develop, which is developmentally and biologically fully formed at birth. A baby's sense of touch at birth, is said to be superior to that of an adult.

However, the science and technology of the sense of touch is, still in its developmental stage compared to the other senses. For example, the senses of audiovisual, smell and taste have their own "products". What about touch? Can you think of some products based solely on

the sense of touch? There is a product that people have used since time immemorial, across cultures and customs, that is based solely on the sense of touch. It is the massage. The mural paintings on the tombs of doctors from the Egypt period, depict a massage that is familiar to us today. We may have yet to develop massage techniques for more than 4000 years.

2. Methodology

We have studied massage and proposed a method for describing the sense of touch called the Tactile Score. In our previous research, we found that tactile sensation can only be expressed by the change in vertical force. So, we decided to describe only the change in vertical force over time. It is like describing music only in terms of pitch changes.

2.1. Tactile Score

Why do we feel "cheer" from the children's "Good morning"? What is the difference between them? The difference is "the way you say it. How we say it can be characterized by the pitch and volume of our voice, but let us look at the volume of our voice.

When we think back to the children's "Good Morning," their voices gradually became louder and louder. So, let us describe the change in "loudness" by using the music notation. In musical notation, the higher the note is, the lower the note is, and the higher the note is, the lower the note is. The middle line (the third line) is the "normal" volume, and the lower the volume, the higher the volume, and the higher the volume, the lower the volume. The "rhythm of speech" is represented by the notes as they are. We call this notation to describe tactile sense as the Tactile Score [3] (Fig. 1)

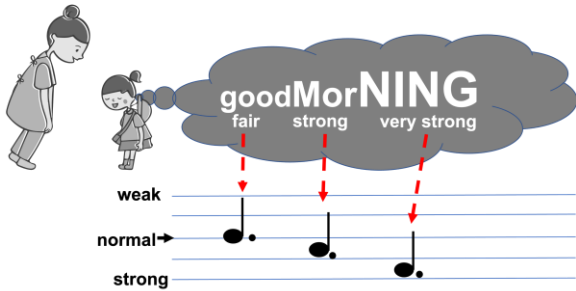


Fig. 1 Tactile Score

2.2. Transform Tactile Score into Vibrotactile

Tactile score was for mainly hand massages. Hand massage has long history, and its effectiveness has been confirmed. However, its effectiveness would be affected by skill of technician and even if well trained and experienced technician, it is impossible to give massage to more than two persons at the same time. And also, it is also very difficult to confirm that the technician gives exactly same tactile stimulations to patient.

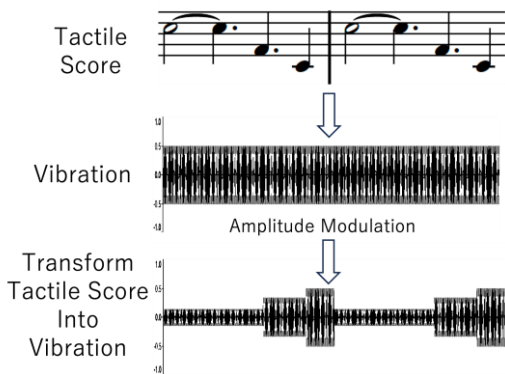


Fig. 2 Transform Tactile Score into vibrotactile

To solve the difficulties, we transform the Tactile score into vibrotactile. Since the Tactile score denotes the strength of force, we transform the force into the amplitude of vibration. Hence, we found that applying amplitude modification with the Tactile score can

transform a Tactile score into a vibrotactile. Since a vibrotactile is a very low-frequency sound, we can record it as a music file in WAV or MP3 format. Hence, we can exchange a vibrotactile translated from a Tactile score via the Internet of electrical files.

By this Tactile score - vibrotactile translation, we can transform tactile stimulation by human hands into electrical data; this technique gives us the way to the digital transformation of tactile sense, tactile DX.

We obtained a Tactile Score, which is converted to vibrations. In order to confirm that this transformation works correctly, the biological responses of the vibration transformed from a Tactile score were compared to a hand massage using the same Tactile Score. Then, we confirmed that the transformed vibration shows almost the same biological response. So, we obtained a method which allows a skilled technician's massage to be converted to a vibratory massage using the Tactile Score (Fig. 2).

We had a method to convert tactile sensations into vibrations but no general-purpose equipment to replay the vibrations. Therefore, together with electrical and audio equipment manufacturers, we developed a general-purpose, face-shaped vibration presentation device (Fig. 3). This device allows users to receive massages by distributing tactile sensations online. We are starting a pilot service of internet delivery of vibration massage around 2019, and more than 1,000 users are already using the service.

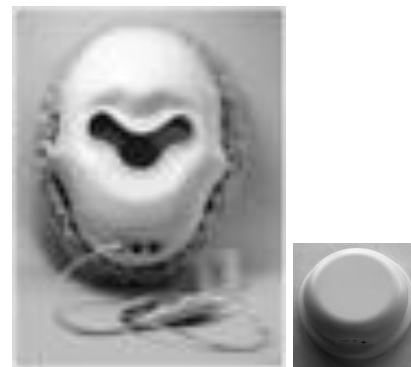


Fig. 3 General-purpose vibrotactile display players; (left) for face, (right) for body.

With using this equipment, in order to verify the effectiveness of the vibrating massage, we compared the skin condition before and after the treatment. We examined that collagen fibers had agglomerated on the skin surface. It has known that the collagen fibers sink from the surface of the skin due to ageing and other factors, but by applying transformed vibration, they rose to the surface of the skin.

3. Preliminary Results

We are now analyzing test data from users of our Internet massage delivery system who visit hospitals for hypertension and diabetes before and after receiving the vibration massage service. We have just started the analysis and are surprised at the results. One user who was taking medication for hypertension, had stopped taking the user's hypertension medication. Because the user's blood pressure became lower and felt terrible after the user started the vibration massage. Now, the user's blood pressure has stabilized in the normal range without medication. We have confirmed several such cases. Since blood pressure is subject to seasonal fluctuations, we will continue to monitor it over a long period.

In addition, users who had high blood glucose levels and were scheduled to apply insulin, have stabilized their blood glucose levels at normal levels, after starting vibration massage. We have monitored this user's blood glucose levels regularly. We have observed that when the user skips the use of vibratory massage, the blood glucose levels rise again.

4. Conclusion

Our survey of past literature shows that when wounded soldiers were transported in horse-drawn carriages for long periods during the Greek period, their wounds healed faster. Also, in the 18th century, it was confirmed that patients with Parkinson's disease improved their motor functions when transported in a carriage for long periods.

From the survey, our findings in preliminary results would be a rediscovery of the wheel. Vibrotactiles had been utilized in medicine before World War II and were once forgotten. However, in the 21st century, vibrotactile has been rediscovered and applied in medical treatments; at Tronto University, a vibration chair has been used to treat patients with dementia and Parkinson's, and also vibroacoustic therapy has been used in northern Europe or Germany.

The main difference between our method and others is the Tactile score. Other methods have focused on sound or music, while we have been interested in tactile stimulation. Hence, we have focused on how to design the tactile stimulations.

Acknowledgements

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Authors Introduction

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He received his Doctor degree in Informatics in 2001 from Graduate School of Informatics, Kyoto University, JAPAN. He is currently an associate professor of Graduate School of Informatics, Nagoya University, JAPAN
