Effects of Successive Simple Sounds Having Listener's Psychological Tempo on Calculation Task

Makoto FUKUMOTO*, Takafumi INOUE*, Yuusuke KANDA

** Fukuoka Institute of Technology, fukumoto@fit.ac.jp*

Abstract: As K. Hevner indicated, tempo of music and sounds is important factor that effects on listener's impression. Results of previous studies suggested that there were special tempi suited to each listener. This study paid attention on psychological tempo, which is a tempo predominant in human behaviors including walking and talking. To investigate the efficacy of the psychological tempo, listening experiment was conducted. First, six subjects were measured their own psychological tempo by tapping. Then, the psychological tempo was attached to successive simple tones. The listening experiment included five experimental conditions. Four of them were conditions having successive simple tones. Their tempi were psychological tempi, slower and faster tempi (80% and 120 % of psychological tempo) and fixed tempo (100 beats per minute), respectively. Moreover, as control conditions, no-sound condition was employed. To investigate the effect of tempo, calculation task was employed. In the calculation task, the subjects continuously calculated two single digits. Number of calculation times and number of accurate answers were measured. The results showed that the largest number of calculation times was observed in the condition with psychological tempo.

Key words: Tempo, Sound, Psychological Tempo, Tapping, Calculation Task, Work Efficiency

1. Introduction

Music and sound are part of most important media types which have psycho-physiological effects on human. Effects of music and sound contents have been investigated long periods, however, the effects were not clarified completely. One of the reasons why the effect was difficult to clarify is that sound contents were composed of many factors, e.g., melody, harmony, rhythm.

As Hevner indicated, tempo is the most important factor that effects on listener's impression. There were several previous studies investigating the effects of tempo [1]. Iwanaga et al. investigated the preferred tempo and suggested that medium tempo is preferred [2]. The result of their study also suggested that form of preference for tempo is inverted U shape [3]. The same tendency of the inverted U shape was also observed in another previous study [4]. Based on these previous studies, Fukumoto et al. investigated the effects of tempo on multiple impressions [5]. The results shows that inverted U shapes were different between impressions. Furthermore, in “Relax” impression, the tempo near to listener’s own heart rate well elicited relaxation feeling. Iwanaga indicated that preferred tempo was related to heart rate based on experimental results [6, 7].

These results suggested that there were special tempo suited to each listener. Medium tempo and heart rate must be good tempo. Here, we pay our attention on psychological tempo. Psychological tempo is a tempo that is predominant in human behaviors including walking, thinking, and talking.

In this study, first, the subjects were measured his/her own psychological tempo by tapping. Then, the tempo was attached to successive simple tones. In the listening experiment, we have five experimental conditions. Four of them were conditions having simple tones. Their tempi were psychological tempi (80%, 100%, 120%) and 100 beats per minute. Moreover, as control condition, no-sound condition was employed. To investigate the effect of tempo, calculation task was employed as index. In the calculation task, the subjects continuously calculate two single digits. Number of calculation times and number of accurate answers were measured.

2. Psychological Tempo

2.1 What is Psychological Tempo?

This section describes what the psychological tempo is and how the psychological tempo we measure. The psychological tempo is generally known as a tempo which is naturally preferred by each person. Moreover, another article defined the psychological tempo as a tempo that is naturally represented in actions such as walking and talking [8].

2.2 Measurement of Psychological Tempo

In the tapping test, the subjects were asked to make tapping by their own forefinger. By referring to a previous study [9], the psychological tempo was obtained with three steps. First, the subjects tapped with the fastest tempo of themselves during 30 sec. Next, they tapped with the slowest tempo of themselves during 30 s. Finally, they made tapping with their preferred tempo. The obtained tempo in the final tapping process was dealt as the psychological tempo of each of them.

Fig. 1 shows outline of the system which was built for obtaining the psychological tempo and composing music data. The system converts the psychological tempo to tempo of MIDI data. By doubling the number of taps during 30 s, the psychological tempo was converted to beats per minute (bpm).

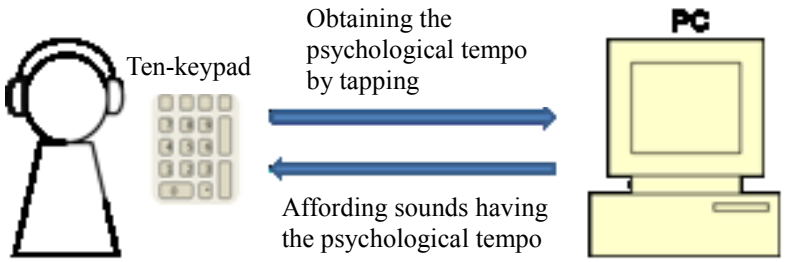

Figure.1 Schema of the system using psychological tempo

3. Experiment

To investigate the efficacy of using the psychological tempo as tempo of simple tones, listening experiment was conducted. Six males participated in the experiment as subjects. The experiment was composed of two steps: measurement of psychological tempo, listening experiment. The psychological tempo was measured with the system explained in the subsection 2.2.

Fig. 2 shows procedure of one set in the experiment. Each of the subjects individually participated in the experiment in a quiet room. The subject had a rest during 2 min first, then the subject listened to sound stimulus through a headphone during 7 min. Referring to a previous study investigating the efficacy of the psychological tempo with music piece [10], the experiment was composed of five experimental conditions that had different sound stimuli. Four of them were with successive simple sounds having different tempo. The simple sound was piano sound of MIDI format, and tempo was adjusted with MIDI sequence software. One of the conditions was with successive simple sounds having psychological tempo. Other two conditions were conditions with slower and faster tempi. Their tempo was 80% and 120% of the psychological tempo, respectively. The last one of the condition with sound stimulus was with original tempo (100 bpm) defined in the music score. No-sound condition was also employed as control condition. The order of the five conditions was randomized and counter-balanced. The subjects participated in all of the five experimental conditions in one day, and the subjects had rest 10 min at shortest between the experimental conditions.

During the listening to these sound stimuli, the subjects had calculation task simultaneously. The calculation task was Uchida-Kraepelin test, which was continuous 1-digit adds. To avoid the learning effect of the subjects during the experiment, the subjects were asked to train the calculation task about one month prior to the experiment. Number of answers, number of correct answers, and accuracy rate were used as indices to investigate the work efficiency of each sound stimulus.

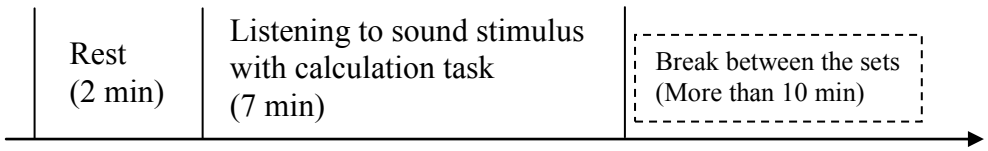

Figure.2 Procedure of one set in the experiment

4. Experimental Result

Mean of the psychological tempo between all subjects was 173.3 bpm, and standard deviation was 65.1. Maximum and minimum were 290.0 and 90.0 bpm, respectively.

Fig. 3 shows result of calculation tasks in all of the five conditions. Mean of number of answers, number of correct answers, and accuracy rate were shown in the figure. The highest number of answers was observed in the condition with the psychological tempo. The lowest number of answers and correct answers were observed in the fixed tempo condition (100 bpm). The accuracy rate was almost same between the conditions.

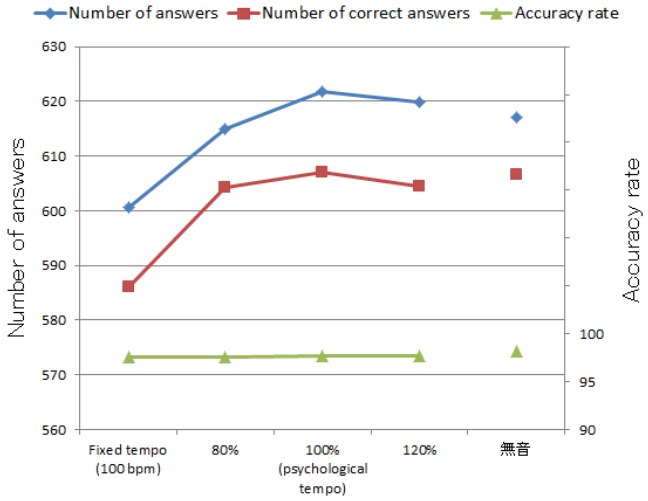

Figure.3 Result of the experiment with five conditions (100% means the psychological tempo)

5. Discussion

In the three conditions having sequential tempi (80%, 100%, 120%), the tendency of the number of calculation answers was shaped inverted U shape. As same as the result of the previous study with music stimuli having different tempi [10], middle tempo was elicited higher calculation result. Part of the reason why the psychological tempo elicited higher performance is considered as that the subjects easy to use their finger because the psychological tempo was appropriate internal tempo. This is also considered as a kind of entrainment of physiological movement by external stimulus.

Although the psychological tempo elicited the highest calculation performance between the three conditions, the number of correct answer with the psychological tempo was less than that of no-sound condition. As described above, the psychological tempo is expected to entrain the tempo of calculation task. However, the calculation task in this study was not only with movement of finger, but also with calculation. The calculation cost the subjects longer time than just moving the finger. Therefore, if the entrainment of the sound existed, a little slower tempo might elicit better calculation performance.

6. Conclusion

This study investigated the efficacy of the psychological tempo. The psychological tempo was obtained by tapping by each subject and was attached to MIDI sound file. In the experiment, five experimental conditions were employed. The condition with the psychological tempo elicited the highest mean answers between the conditions with simple sounds. However, the number of correct answer was less than the condition with no-sound. To elicit higher performance using the sound having the psychological tempo, adjustment of the tempo must be needed.

This study had no investigation with statistical analysis. As nest step of this study, we will have further investigations with larger number of subjects and statistical analysis.

7. Acknowledgement

This study was supported in part by Grant from Computer Science Laboratory, Fukuoka Institute of Technology.

7. References

[1] Hevner, K. (1937) *An experimental study of the affective value of sounds in poetry*, The American Journal of Psychology, Vol. 49, No. 4, pp.419-434.

[2] Iwanaga, M. and Tsukamoto, M. (1998) *Preference for musical tempo involving systematic variations of presented tempi for known and unknown musical excerpts*, Perceptual and Motor Skills, Vol. 86, pp.31-41.

[3] Berlyne, D. E. (1971) *Aesthetics and Psychobiology*, Appleton-Century-Crofts, NY, USA.

[4] Holbrook, M. B. and Anand, P. (1990) *Effects of Tempo and Situational Arousal on the Listener's Perceptual and Affective Responses to Music*, Psychology of Music, Vol. 18, No. 2, pp.150-162.

[5] Fukumoto, M. and Matsuo, K. (2010) *Effects of musical tempo on multiple subjective impressions*, International Journal of Biometrics, Vol. 2, No. 2, pp.124-133.

[6] Iwanaga, M. (1995) *Harmonic relationship between preferred tempi and heart rate*, Perceptual and Motor Skills, Vol. 81, pp.67-71.

[7] Iwanaga, M. (1995) *Relationship between heart rate and preference for tempo of music*, Perceptual and Motor Skills, Vol. 81, pp.435-440.

[8] Matsuda, F., Koumura, K., Yamasaki, M., Choushi, K., Jingu, H., and Taira, S. (1996) *Psychological Time*, Kitaohjisyobo, Japan (Japanese).

[9] Fujisawa, N. and Saito, M. (2007) *Relation of Musical Impression and Menal Tempo*, Proceedings of Annual Conference of Japan Society of Kansei Engineering, G32 (Japanese).

[10] Kanda, Y. and Fukumoto, M. (2012) *Investigations of Work Efficiency of Music Piece with Psychological Tempo in Calculation Task by*, Proceedings of Life Oriented Software Symposium 2012, G3-4 (Japanese).