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Effect of Music on the Performance and Impression of Simple Repetitive Operation of Calculation

Ryo Yoneda and Masashi Yamada

Graduate School of Engineering, Kanazawa Institute of Technology, Kanazawa, Japan

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ABSTRACT

It is often said that music affects the impression of our environment and also our behavior. The author's group previously investigated the effect of music on the performance and impression in the virtual environmental context of video games; racing games and Pachi-slot games (slot-machine type games). The results commonly showed that the "no music" condition provided the best performances, and that a musical excerpt which provided a high degree of "unpleasant" impression to the games resulted in a high degree of negative effect on the performances. In the present study, we examined the effect of music on the performance and impression in the situation of simple repetitive operation. We provided a repetitive calculation task based on the Uchida-Kraepelin test. The experiment consisted of two sections. In Section 1, the participants performed the calculation task with one of the various types of musical excerpts or without music. In Section 2, the participants only listened to musical excerpts without the calculation task. The results showed that the number of the calculation in a 10 min was larger in the condition of "no music" than the other "with music" conditions. Moreover, a principal component analysis and multiple-regression analyses revealed that a "light" and "mixed" musical excerpt provides "bright" and "unpleasant" impression to the calculation task and, in turn, results in a serious negative impact on the performance.

INSTRUCTION

It is often said that music affects the impression of our environment and also our behaviour [1]. The interaction between the impression of visual information and music has been investigated in various contexts; music videos [2], television commercials, films [3], car audio [4], as well as computer graphics with music. However, the effect of music on our behavior has rarely been investigated with scientific experiments.

The author's group previously investigated the effect of music on the performance and impression in the virtual environmental context of video games; a racing game [5] and a Pachi-slot game (a slot-machine type game) [6]. The results commonly showed that the "no music" condition provided the best performances, and that a musical excerpt which provided a high degree of "unpleasant" impression to the games resulted in a high degree of negative effect on the performances. The results can be interpreted as follows: The musical excerpts which provided an unpleasant impression to the games decreased the players' concentration.

In the present study, we examined the effect of music on the performance and impression in the situation of simple repetitive operation.

EXPERIMENTAL METHOD

We provided a computer program for repetitive calculation task, based on the Uchida-Kraepelin test. In this task, the following trials were repeated for 10 min: Two single-figure numbers were displayed on the computer screen, then a participant added the two numbers and inputted the number of the last figure of the result as shown in Figure 1.

Eleven students from the Kanazawa Institute of Technology trained themselves to answer in this test for more than 2 weeks without music. After the training, they played nine successive trials, which had 10 minutes for each trial. The results showed that there were no significant differences in the numbers of answers among nine sessions for all eleven players. Then, they participated in the experiment.

The experiment consisted of two sections. In Section 1, the participants performed the calculation task with one of the various types of musical excerpts or without music. In Section 2, the participants only listened to musical excerpts without the calculation task. Half of the participants participated in Section 1 first, and then in Section 2. The others participated in the reverse order.

In Section 1, the participants wore Stax Lamda SR-404 headphones, through which the musical stimuli were presented, and watched a 15.4-inch PC (TOSHIBA dynabook PAAX 740LSK) from 50 centimeters away. The participants performed the calculation task while being presented with one of the ten musical stimuli listed in Table 1 or without music. The presentation level for each stimulus is shown in Table 1 also. The musical excerpts are identical to the excerpts used in our previous experiment which is conducted in the context of the Pachi-slot game [6]. In the calculation task, the following trials were repeated for 10 min: Two single-figure numbers were displayed on the computer screen, then a participant added the two numbers and inputted the number of the last figure of the result through a ten-key numerical keypad (Fig. 1). One session consisted of three trials of the 10-min calculation task while listening to a musical excerpt or under the condition of no music. Each participant played one session for each condition and the performances of the "number

of answers" and "correct percentage of answers" were measured under each condition.

After each session, the participant was requested to evaluate the impression of the calculation task under that condition, using 17 bipolar seven-step semantic differential scales (e.g., "very active", "fairly active", "slightly active", … , "very passive"). These scales were identical to those we used for the evaluation of the impression of the racing game [5] and the Pachi-slot game [6].

In Section 2, the participants listened to musical excerpts listed in Table 1 without the calculation task, and evaluated the impression of each excerpt using 18 bipolar seven-step scales. These scales were identical to those we used for the evaluation of the impression of musical excerpts in the context of the racing game [5] and the Pachi-slot game [6]. The presentation level for each stimulus was identical to the level used in Section 1.

RESULTS AND DISCUSSION

The evaluation scores obtained in Section 1 were averaged over the participants and then used in principal component analysis. The analysis showed that the impression of the task with music is spanned by three factors of "Brightness", "Dynamics" and "Pleasantness". Similarly, the impression of the music in Sections 2 was analyzed and revealed that the impression space is spanned by three factors of "Neatness", "Lightness" and "Impression",

The correct percentage of answers did not vary with the conditions, significantly. However the number of answers was quite different among different conditions. The numbers of answers for each condition is normalized in the same participant, and averaged over participants (Fig. 2). We call this performance score for each condition, in the present study. Figure 2 shows that the performance score for the no-music condition of (NS) is higher than those for all the other conditions where music was presented. These results are consistent with the results for the racing game and Pchi-slot game situations [5,6].

The impression of the calculation task under each condition is, plotted in the three-dimensional space spanned by the three factors of "Brightness", "Dynamics" and "Pleasantness" in Fig. 3. The factor scores for the three factors are then used as explanation variables in multiple-regression analysis, with the performance score being used as the criterion variable. The resulting multi-regression line is shown as a vector in Fig. 3. The results showed that the coefficient of determination, R^2 was larger than 0.8. Moreover, each of the three factors "Neatness", "Lightness", and "Impression" for music is used as criterion variable in multiple-regression analysis with the three factors for the calculation task impression, "Brightness", "Dynamics", and "Pleasantness" as explanation variables. The results showed that the coefficient of determination, R^2 was larger than 0.7 for the factor of music impression "Neatness" and "Lightness". The resulting regression lines of "Neatness" and "Lightness" are also shown as vectors in Fig. 3.

Figure 3 indicates that a "heavy" and "neat" musical excerpt provides "dark" and "pleasant" impression to the calculation task and does not affect the performance in a negative way. Contrarily, a "light" and "mixed" musical stimulus provides "bright" and "unpleasant" impression to the calculation task and, in turn, results in a serious negative impact on the performance.

In our previous studies, where the racing and Pachi-slot games were used, it was shown that a musical excerpt which provided a high degree of "unpleasant" impression to the games resulted in a high degree of negative effect on the performances and that. However, in the present study, a musical excerpt which provided not only "unpleasant" impression but also "bright" impression resulted in a high degree of negative effect.

To illustrate the discrepancy between the results for the games and for the calculation task, we then supposed a hypothesis as follows: In the calculation task, the participants successively pushed a key in almost equal intervals. And it is suggested that the tempo or rhythm of music correlate with the impression of "heaviness" or "brightness". Therefore, we supposed that the performance correlated with the tempo of the musical excerpts.

To clarify whether our hypothesis described above is correct or not, we counted the tempo of each excerpt in BPM (beats per minute), and the coefficient of correlation between the performance score and the tempo shown in BPM was calculated. The results showed that the coefficient, R was lower than 0.5. This suggests that the hypothesis is not fully correct, i.e., the discrepancy between the results for games and the calculation task, is not illustrated by the effect of musical tempo. Rather, it may reasonable to interpret simply that the differences between the games and the calculation test led the discrepancy.

CONCLUSSION

It has not been clarified the numerical correlation between the success rate and physical factors in music, yet. In the next stage, we will try to clarify the numerical correlation between the performance score and several perceptual factors of music; roughness, sharpness, loudness, *etc*.

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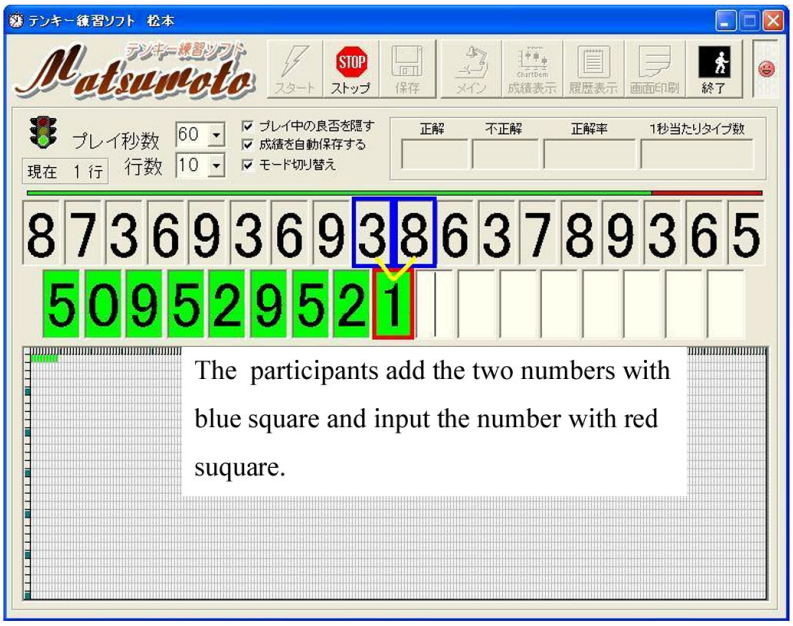

Figure 1. The computer screen for the calculation task.

Table 1. The musical excerpts used in the experiment

Title [Abbrev.]	LAeq [dB]	Genre
DUB-I-DUB [DUB]	79.6	Pop-Music
Rydeen [Ryd]	76.8	Techno-Music
Livin' La Vida Loca [Livin]	82.1	Pop-Music
1st movement, 5th Symphony [L.v.B]	83.3	Western Classical Music
So-ran [So-ran]	84.1	Japanese Traditional Folk-Song
Energy Flow [Energy]	76.0	New-Age Music
Kawa-no Nagare-no Yoni [Kawa-no]	83.6	Enka (Japanese-Style Popular-Song)
T2 Main Title [T2]	80.2	Movie Sound Track
Fogbound [Fog]	79.0	Preset Excerpt for a Racing Game
AONANA Big-bonus [AONANA]	81.1	Preset Excerpt for a Pachi-slot game

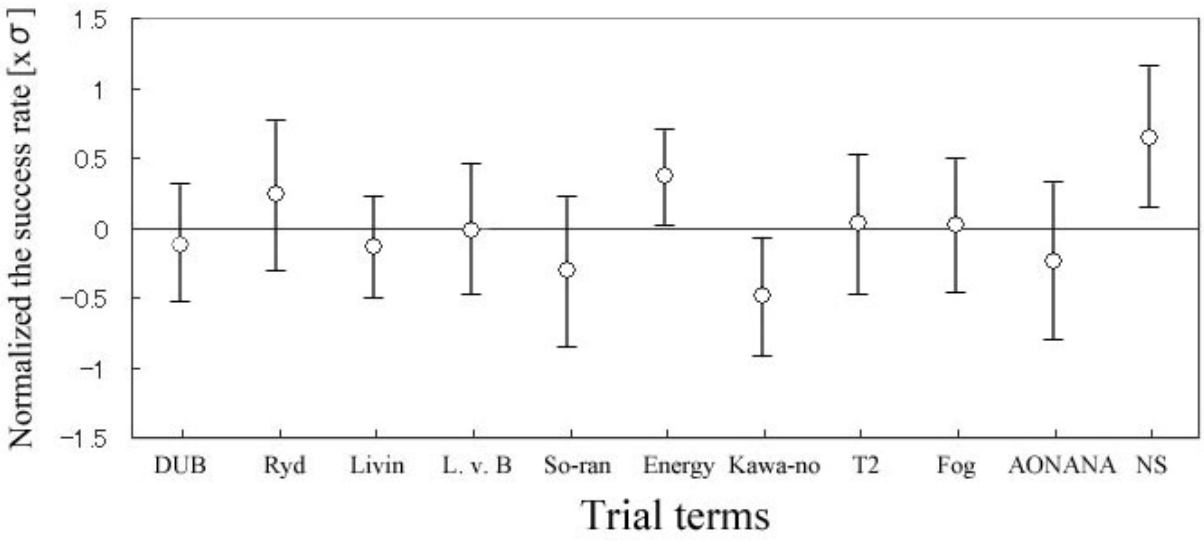

Figure 2. The performance score for each musical excerpts

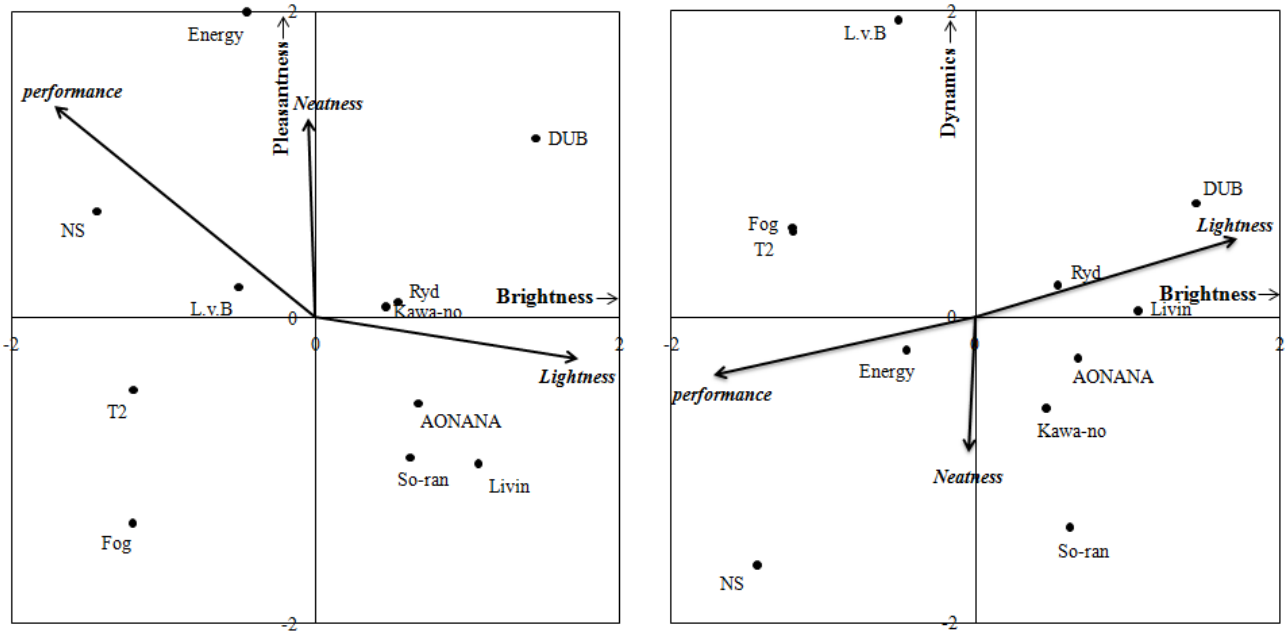

Figure 3. The results of the experiment. The vectors show the performance score and two factor of musical impression.