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Subjective and Physiological Responses to Music Stimuli Controlled Over Activity and Preference

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Results of physiological responses to music are inconclusive considering results of several studies, probably due to the insufficient control of the musical stimuli. The present study aimed to examine the effects of music type and preference on subjective and physiological responses using controlled stimuli by subjects' evaluations for music activity and preference. Subjects were 47 undergraduate students selected from a pool of 145 undergraduates. Results of evaluations of music activity and music preference for musical stimuli in preliminary research determined participation in the study. The music used in this study included the 4th movement of Tchaikovsky's Symphony No. 4 *as an excitative piece and the 3rd movement of Mahler's* Symphony No. 6 *as a sedative one. The excitative music aroused feelings of vigor and tension more than did the sedative one, while sedative music eased tension. Favorite music, regardless of music type, lowered subjective tension. Physiological responses (heart rate, respiration, and blood pressure) were greater during excitative music than during sedative music. Music preference did not, however, affect physiological responses. These results indicate that the dominant factor affecting emotional response was music type but not preference.*

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Music is used in various medical areas to control emotions and reduce anxiety and stress (see Standley, 1986). Miluk-Kolasa, Matejek, and Stupnicki (1996) examined the reduction of presurgical anxiety using an individually designed music program (IDMP). Since patients who heard music showed lower systolic blood pressure, heart rate, cardiac volume, and blood glucose and high skin temperature, it was concluded that music had the effect of reducing presurgical anxiety. Liebman and MacLaren (1991) reported that sedative music reduced subjective anxiety during the third trimester in adolescent pregnancy. Rohner and Miller (1980), however, reported that highly anxious individuals showed little reduction of state anxiety while listening to sedative music. Logan and Roberts (1984) compared sedative music to a no-music condition and reported that subjective tension decreased in the no-music condition but increased in the sedative music condition.

As stated above, the effect of sedative music has not been sufficiently confirmed. Effects of sedative music were found to be inconsistent in studies using heart rate as a measure. Hodges (1980) summarized the contradictory results of research related to heart rate: (a) heart rate increased during excitative music and decreased during sedative music, (b) both excitative and sedative music increased heart rate, (c) both excitative and sedative music influenced heart rate but changes were unpredictable, and (d) music had no effect on heart rate. One reason behind these inconsistent results is the dissonance between impressions of music activity within a piece of music as judged by experimenters and subjects. Taylor (1973) reported that percentages of agreements with the experimenters' preclassification were 56.7% for subjects' impressions of music and 49.0% for subjects' GSR[1]. Hadsell (1989) also examined the agreements between experimenters' and subjects' categorizations of sedative and excitative music. Overall agreements with experimenters' preclassifications were 79.4% for music therapists and 76.5% for nonmusicians. These two studies showed low agreements between precategorized music types by experimenters and

[1] On page 90 of Taylor's paper, he noted that "The GSR data were evaluated by scoring each upward deflection of four units or less as a sedative response, and an upward deflection of more than four units as a stimulative response." According to this scoring, as Taylor showed in Table 1 on page 91, number of agrees was 147 and disagrees were 153. Therefore, the percentage of agreements is 49.0%.

evaluations by subjects. Therefore, the control reliability of music type by the experimenter was insufficient to examine the effect of music type.

Stratton and Zalonowski (1984) explored properties of music with relation to relaxation using various types of music, such as sedative music, excitative music, atonal music, and so on. They found that subjective relaxation was related to subjects' music preference rather than music type. Davis and Thaut (1989) examined the effect of music preference on anxiety, relaxed feelings, and physiological responses using music selected by subjects from a pool of 32 pieces. Results showed an increase in relaxation and a decrease in anxiety as subjects listened to their selection. Vascular blood flow decreased significantly during music but other physiological measures did not change. Thaut and Davis (1993) compared the relaxing effect of experimenter-selected music, subject-selected music, and a no-music condition. Results demonstrated that music decreased anxiety level but that there was no difference in decrease between music selected by either the subject or the experimenter. It therefore remains unclear whether preferred music leads to a state of relaxation.

In reports by Davis and Thaut (1989) and Thaut and Davis (1993), musical pieces selected by subjects were mostly of the rock and popular type, with over half being vocal. In other words, music pieces selected by subjects were rather excitative music from the point of music types, and were also influenced by the contents of vocal texts. Music selected by the experimenter in Thaut and Davis (1993) was a sedative piece, which had not been selected as preferred music by subjects. Moreover, since patients selected music used in Miluk-Kolasa et al. (1996), preference was controlled for but activity and type were not.

From the point of stimulus control in the previous studies, preferred music was not sufficiently controlled for by type or activity. The present study aimed to control both music activity and preference in order to examine the effect of music on relaxation. In order to control music stimuli, subjects (Hadsell, 1989; Taylor, 1973) must classify two types of music, excitative and sedative, in terms of musical activity. Secondly, subjects must be selected by the differences of subjects' preference to the same piece. In the present study, we selected the music and subjects based on results of preliminary research where subjects evaluated excitative and sedative music.

Method

Selection of Subjects and Music

Initial subjects were 145 undergraduate students (male = 65, female = 80; 18–21 years in age). Music was selected from a pool of five excitative and five sedative pieces selected from symphonies composed during the Romantic period. Taylor's 1973 standards of classification were used; quiet and slow pieces are considered sedative in nature while rhythmic and dynamic pieces are considered excitative. After listening to a piece, subjects were asked to rate their preference and impressions of activity (sedative vs. excitative) on a 5-point scale. Subjects were selected to continue with the study based on their evaluations about preference and activity. Likewise, stimulus music was selected on the basis of subject evaluations. The excitative music was an excerpt from the 4th movement of Tchaikovsky's *Symphony No. 4,* performed by A. Leaper, Polish National Radio Symphony Orchestra, Katowice (NAXOS 8.550488). The sedative selection was an excerpt from the 3rd movement of Mahler's *Symphony No. 6,* performed by G. Sinopoli, Philharmonia Orchestra (DG 423 082-2). Music presentations were each 5 minutes 48 seconds in duration. All selected subjects had not heard these two pieces prior to the experiment. Subjects ($N = 47$) fell into one of four categories: 14 preferred both sedative and excitative music, 11 preferred sedative music, 11 preferred excitative music, and 11 did not show a preference for either type of music.

Apparatus

Apparatus used to present the music were a Victor VX-1 CD player, a Nakamichi IA-S4 amplifier, a Pioneer D-05 digital audio tape deck, and Bose Model 121 and Bodysonic MC-350 speaker systems. Presented tone pressures were about 60–75 dB(A). An electrocardiogram (ECG) and respiration were measured using a polygraph 360 system (NEC Medical Systems) and recorded to digital data recorders (TEAC DR-M2a and DR-F1). Recording frequencies were 1 kHz for ECG and 20 Hz for respiration. Electrodes, used to measure ECG, were attached to subjects' chest and a thermistor, used to measure respiration, was attached under subjects' nostrils.

An Ohmeda Finapres 2300 measured systolic and diastolic blood pressures (SBP and DBP) through a finger cuff attached to the second joint of the left middle finger. SBP and DBP data were transmitted to a personal computer (EPSON PC-386GE) through an RS-232C interface for each pulse. Messages about the start and end of the experimental sessions were displayed by CRT (SONY KX-21HD1) controlled by a personal computer.

Procedure

After a subject entered the soundproofed experimental room and sat on the Bodysonic system, which was a reclining chair with speakers, electrodes and sensors were attached to him/her. An experimental session consisted of a premusic phase (2 min), a music presentation (5 min 48 s), and a postmusic phase (2 min). Physiological data were continuously measured during all phases. Subjects were instructed not to move their body, not to strain themselves, and to keep eyes closed while physiological data were being taken. At the end of the experimental session subjects checked subjective responses to the music. All subjects listened to both types of music (sedative and excitative). Order of music presentations was counterbalanced among subjects.

Measures

Subjective indices were impressions of music and elicited emotions. Impressions of music were measured by 9 items selected from the affective value scale of music (Taniguchi, 1995), which were 5-point scales of semantic differential (SD) type. Emotional responses were evaluated by using scales of multiple emotional states (Terasaki, Kishimoto, & Koga, 1992), which were evaluated by 7-point Likert-type scales. Items concerning relaxation, tension, and anxiety were also included and the scales were anchored by "very little" (1) to "very much" (7).

Physiological indices here heart rate (HR), blood pressure (SBP and DBP), and respiration rate. For HR, R-R intervals were translated to beats per minute (bpm). SBP and DBP were recorded per each pulse. Respiration and HR were translated from peak-to-peak intervals to cycles per minute (cpm). All physiological responses were continuously recorded throughout the music, and every one (1) minute through a music phase. Changes of scores from an average response during a premusic phase were used in statistical procedures.

Impressions of music and emotions elicited by music were analyzed by factor analysis and two-way ANOVAs (music type × prefer-

TABLE 1

Extracted Factors and Loadings of Impressions to Music

Items	Activity	Evaluation
Soft–hard	–.913	
Quiet–annoyance	–.884	
Sober–pronounced	–.874	
Fast–slow	.872	
Easy–uneasy	.859	
Passive–active	–.795	
Like–dislike		.886
Familiar–unfamiliar		.802
Interesting–uninteresting		.695
Contributions	4.800	2.094
Cronbach alpha	.945	.834

Note. High factor loadings show high tendencies in the properties of the left end adjectives. Loadings over 0.4 are displayed.

ence). Physiological responses were analyzed by three-way ANOVAs (music type × preference × phase). Since the phase was a repeated measure, degrees of freedom in the ANOVAs were adjusted using the Greenhouse-Geisser method.

Results

Impressions of Music

Impressions of music were analyzed by the principle component analysis and rotated by the varimax method. Table 1 shows loadings of two extracted factor: activity and evaluation. Since Cronbach alphas for activity and evaluation factors were .945 and .834 respectively, two factors had sufficient internal consistencies. For both factors, factor scores were calculated by averaging item scores after reverse items were modified.

Impressions of music were measured by the operation checking used in this study. Activity was determined by checked items for sedative/excitative dimensions of the music. Evaluation was determined by checked items for music preference. Table 2 shows means and standard deviations for each music type and preference condition.

Since there was a significant effect for music type, F (1, 90) = 690.07, $p < .001$, subjects recognized that excitative music was more

TABLE 2

Averages and Standard Deviations of Impressions to Music

	Sedative Music		Excitative Music	
	Favorite	Unfavorite	Favorite	Unfavorite
Activity	1.87 (0.43)	1.91 (0.49)	4.19 (0.47)	4.38 (0.36)
Evaluation	3.58 (0.56)	2.97 (0.64)	3.53 (0.90)	3.05 (0.86)

Note. Standard deviations in parentheses.

active than sedative music. There were, however, no significant effects for preference, $F(1, 90) = 1.70$, *ns*, and music type by preference interaction, $F(1, 90) = .07$, *ns*. Since there was significant effect for preference, $F(1, 90) = 12.54$, $p < .0001$, favorite music was confirmed to be preferred. However, there were no significant effects for music type, $F(1, 90) = .00$, *ns*, and music type by preference interaction, $F(1, 90) = .17$, *ns*.

In summary, the effect of music type was observed in the activity factor and the preference effect was observed in the evaluation fac-

TABLE 3

Extracted Factors and Loadings of Emotional Responses

Items	Relaxation	Vigor	Tension
Relieved	.808		
Relaxed	.748		
Aggressive	–.581		
Absorbedly	.560		
Vigorous		.750	
Merry		.668	
Refreshing		.534	
Bad temper			.808
Depressed			.728
Angry			.704
Boring			.651
Unsettled	.450		.586
Tensive	.444		.501
Fatigued			.434
Contributions	2.642	1.659	3.168
Cronbach alpha	.796	.718	.861

Note. Loadings over 0.4 are displayed.

TABLE 4

Averages and Standard Deviations of Emotional Responses to Music

	Sedative Music		Excitative Music	
	Favorite	Unfavorite	Favorite	Unfavorite
Relaxation	5.51 (0.97)	5.24 (0.82)	3.72 (1.30)	3.27 (0.91)
Vigor	3.59 (0.76)	3.76 (0.56)	4.07 (0.78)	4.11 (1.05)
Tension	2.49 (0.81)	3.07 (0.64)	3.19 (0.98)	3.46 (1.09)

Note. Standard deviations in parentheses.

tor. These results indicate that operations of music type and preference are valid and that these two factors were independent.

Emotional Responses to Music

Emotional responses were analyzed by the principle component analysis and rotated by the varimax method. As shown in Table 3, three major factors were extracted; relaxation, vigor, and tension. Cronbach alphas were .796 for relaxation, .718 for vigor, and .861 for tension. These high alphas demonstrate that these three factors had sufficient internal consistencies. The three factors were scored by averaging item scores after reverse items were modified.

Table 4 shows mean scores and standard deviations for each condition. For relaxation, there was a significant effect for music type, $F(1, 90) = 78.38$, $p < .001$, which means that subjects felt relaxation during sedative music more than during excitative music. There were, however, no significant effects for preference, $F(1, 90) = 2.87$, *ns*, and music type by preference interaction, $F(1, 90) = 0.17$, *ns*. For vigor, since effect for music type was significant, $F(1, 90) = 6.22$, $p < .05$, subjects felt vigor in excitative music more than in sedative music. Effects for preference and music type by preference interaction were not, however, significant, $F(1, 90) = 0.40$, *ns*, and $F(1, 90) = 0.16$, *ns*, respectively. For tension, there were significant effects for music type, $F(1, 90) = 8.59$, $p < .01$, and preference, $F(1, 90) = 5.29$, $p < .05$. Subjects felt more tension in excitative music than in sedative music and more tension while listening to music that was not preferred. There was, however, no significant effect for music type by preference interaction, $F(1, 90) = 0.70$, *ns*.

In summary, sedative music arouses feelings of relaxation while excitative music arouses feelings of vigor and tension. According to subjective indices, music type has a dominant effectiveness to affection.

Physiological Responses to Music

Figure 1 shows changes of physiological responses (HR, SBP, DIP, and respiration) during music listening from the premusic phase. Increments of heart rate during music showed a significant effect for music type, $F(1, 90) = 5.43$, $p < .05$, where heart rate was higher during excitative music than during sedative music. They also showed an effect for phase, $F(4.8, 630) = 11.18$, $p < .001$, $\varepsilon = .678$. Music type by phase interaction was significant, $F(4.8, 630) = 4.98$, $p < .01$, $\varepsilon = .678$, differences of heart rate in music type were gradually greater during the last half of the music presentation. For respiration, since main effect for music type was significant, $F(1, 90) = 9.70$, $p < .01$, excitative music triggered a higher respiration rate than did sedative music. Effect for phase and music type by phase interaction were significant, $F(4.8, 630) = 17.66$, $p < .001$, $\varepsilon = .674$; $F(4.8, 630) = 7.00$, $p < .01$, $\varepsilon = .674$, respectively.

For SBP, significant effect for music type, $F(1, 90) = 15.82$, $p < .001$, showed a greater increment of SBP during excitative music than during sedative music. Effect for phase and music type by phase interaction were significant, $F(3.1, 630) = 6.10$, $p < .01$, $\varepsilon = .435$; $F(3.1, 630) = 5.09$, $p < .05$, $\varepsilon = .435$; respectively. SBP for excitative music was high during music and dropped slightly at the midpoint of the music presentation. During sedative music, SBP remained unstable. DBP, which showed the same patterns as did SBP, showed a significant effect for music type, $F(1, 90) = 16.63$, $p < .001$. Effect for phase and music type by phase interaction were significant, $F(3.7, 630) = 8.01$, $p < .01$, $\varepsilon = .528$; $F(3.7, 630) = 5.62$, $p < .01$, $\varepsilon = .528$; respectively. DBP immediately increased as soon as the excitative music started, while during sedative music, it remained low.

As mentioned above, music type dominantly influences physiological responses. On the other hand, effects of preference for music were mostly not observed.

Discussion

The aim of the present study was to examine the effect of music type and preference on responses to music. Effect of music type

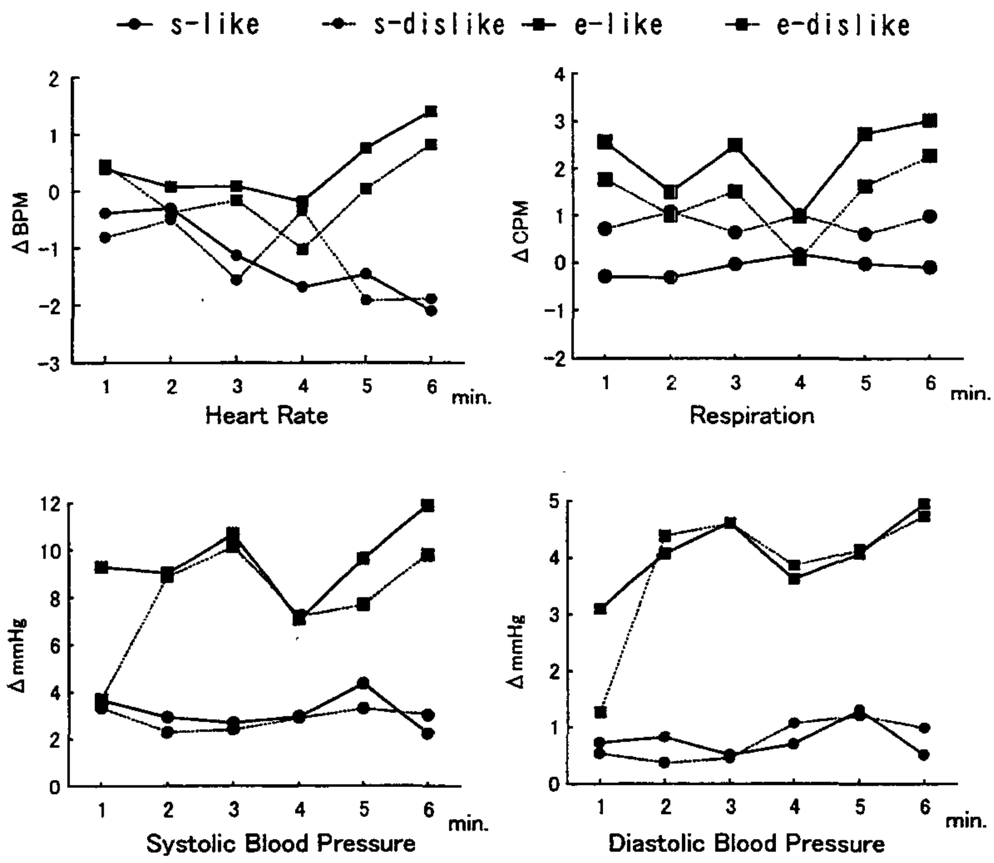

FIGURE 1.
Changes of physiological responses during music.

was observed in all subjective indices, so sedative music leads to high relaxation and low tension. Effect of preference was only observed, however, in tension. Preferred music, therefore, leads to lowered tension. Sedative music did lead to lower physiological arousal than did excitative music. These results demonstrated that music type was an important factor to induce responses. Specifically, the sedative property of music was related to anxiety reduction more than was preference.

Through previous studies suggested that physiological responses to music showed inconsistent results (Dainow, 1977; Hodges, 1980), the present study showed a clear effect of music type (activity). This might be due to the strict control of music type. In the previous studies, since control availability for music types (sedative/excitative) were about 50% to 80% (Hadsell, 1989; Taylor, 1973), experimenter-selected music is not sufficient stimulus control. Therefore, in order to investigate the effect of music on relaxation, subjects' control of musical stimuli is needed. We observed preference effects for subjective tension only. Insignificant effects of preference on all other subjective and physiological responses mean that music preference might not affect stress reduction sufficiently. It is important to state, therefore, that preference does not have any anxiety reduction effects. Iwanaga, Ikeda, and Iwaki (1996) examined the effect of repetitive exposure to music and noted that even excitative music showed a decrement of tension and an increment of relaxation with repetition. As repetitive exposure increased music preference (Bartlett, 1973), Iwanaga et al. (1996) considered that preference increment might cause anxiety reduction by repetitive exposure. Subjects, however, heard the excerpts only once in the present study. It is possible that listening to preferred music repeatedly might have had a relaxing effect.

The reasons for insufficient preference effect could be explained from two points of view. First, selection procedure of music might affect this finding. In order to control the properties of the musical stimuli, subjects listened to music that they had not previously heard and, it was selected according to subject evaluations. The procedure enabled us to control for preference but could not compare with music that subjects usually prefer to listen to (i.e., music that they would listen to on a daily basis), therefore causing a disparity in anxiety reduction. Secondly, sensitivities to response eliciting were widely varied by types of responses. Because there were difference in threshold and latency time to express their responses (Lang, 1971), all responses were not expressed similarly. Preference effect, which we observed in only subjective tension in the present study, means that subjective tension is more sensitive that other responses. Iwanaga et al. (1996) reported that subjective measures were more sensitive than were physiological ones. We can therefore observe that preference might affect various responses if subjects were exposed to the music repetitively and if the music was subject-selected preferred music.

In previous studies (Davis & Thaut, 1989; Miluk-Kolasa et al., 1996; Thaut & Davis, 1993), music selected by subjects or patients reduced anxiety and tension before surgery and during tasks. Considering the deviation between these findings and results of the present study, one might conclude that the process of music selection itself had the effect of reducing stress. Selective control (Averill, 1973) and self-administration (Miller, 1979), which was one of the repertories of coping strategies in stress situations, reduces stress responses but, could not change objective situations. Participation in music selection raises subjective control and reduces stress responses. Active coping, in which subjects self-select music, might lead to the reduction of stress.

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