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Relationship of Skin Temperature Changes to the Emotions Accompanying Music[1]

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One hundred introductory psychology students were given tasks that caused their skin temperatures to either fall or rise. Then they listened to two musical selections, one of which they rated as evoking arousing, negative emotions while the other was rated as evoking calm, positive emotions. During the first musical selection that was presented, the arousing, negative emotion music terminated skin temperature increases and perpetuated skin temperature decreases, whereas the calm, positive emotion selection terminated skin temperature decreases and perpetuated skin temperature increases. During the second musical selection, skin temperature tended to increase whichever music was played; however, the increases were significant only during the calm, positive emotion music. It was concluded that music initially affects skin temperature in ways that can be predicted from affective rating scales, although the effect of some selections may depend upon what, if any, music had been previously heard.

Descriptor Key Words: emotions; music; skin temperature.

In most skin temperature (ST) biofeedback studies, a pretraining stabilization period is used after which biofeedback training is begun. Taub and School (1978) emphasized the necessity of determining how long it takes for ST to stabilize in any particular laboratory setting. Only then can one be sure that ST changes during training are due to learning and not, for example, to continued habituation to the conditions of the experiment or treatment session.

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By contrast, the goal of the present study was to investigate the effects of an external stimulus, music, upon STs that were changing significantly when the music began. Therefore, during the period usually allowed for stabilization, procedures were employed to intentionally cause increases or decreases in ST. During these changes, either music that caused arousing, unpleasant emotions or music that caused calm, pleasant emotions was presented. Temperature changes during the music were analyzed in terms of type of music and direction of ST change prior to music.

It was hoped that the results would increase understanding of how suitable different types of music might be for starting or perpetuating desired ST changes such as ST increases during relaxation, and how useful the different types of music might be as agents for stopping or reversing unwanted ST changes such as ST decreases during increasing anxiety. Another reason that the results might be of interest is that although ST changes are often assumed to be an indication of success in relaxation therapy, and although music has been employed as an agent for aiding relaxation in music therapy, there is virtually no literature concerning the effects of music on ST. The closest approximation was the work of Weld (1912), who found that forearm volume decreased (blood was diverted from the forearm) when subjects' attention was held by the music. The present study was an attempt to make a more direct measurement of the relationship between music and ST.

METHOD

Subjects

One hundred introductory psychology students (42 males and 58 females) with no known hearing deficits volunteered to be subjects to fulfill a course requirement.

Apparatus

All music was presented by a Kenwood tape deck (KX920) using a Kenwood DC Stereo Integrated Amplifier and Monarch ES-125 stereophonic earphones. This sound system was built into a larger piece of apparatus (NOR X1-11) constructed and donated by Brian and Marla Scott.

All physiological recording was done using a Biolab recording system (Cyborg Corporation) in conjunction with an Apple II microcomputer. Skin temperature was measured using a Cyborg Thermal Probe taped to the volar surface of the most distal phalanx of the middle finger on the left hand.

Signals from the probe were received by the Biolab Input Module (Cyborg M120). The module was calibrated at the beginning of each experimental day, and the calibration accuracy was periodically checked using independent devices. Analogue signals from the input module were converted to digital signals by the computer, and, at the end of each trial, the mean ST as well as the first and last ST values were displayed in degrees Fahrenheit on the monitor screen. During the trials, the skin temperature changes were monitored by the experimenter as they occurred since both a graph and a digital readout were displayed on line on the monitor screen (not seen by the subject). Some analyses as well as all retrieval and displayes of data were controlled by a Cyborg program (Biotext Plus, version 2.5.1).

The experimental room was air-conditioned; however, the ambient temperature varied from a low of 68 degrees F at 9:00 a.m. to a high of about 75 degrees at about 1:30 p.m. The effects, if any, of these temperature variations will be described in the Results section.

The music selections employed as stimuli were two excerpts, each 3 min 40 sec long, from a suite by Gustav Holst entitled *The Planets. Mars: the Bringer of War* was a militaristic, sometimes shrill piece containing sections in which the pitch and volume rose gradually from low to a high explosion of sound. *Venus: the Bringer of Peace* was a soft, floating, melodious selection. The recording used was the New York Philharmonic Orchestra performance on the CBS Inc. label, Leonard Bernstein conducting.

Procedure

Subjects were seated at a table. During the first 10 minutes, the experimenter attached the thermal probe, checked the apparatus, and read a statement explaining the basic purpose and procedure of the experiment.

The subjects were each assigned either to one of four experimental groups or to a control group ($n = 20$ in each group). The procedure for the experimental groups was designed to allow ST changes during *Mars* to be compared with ST changes during *Venus* under conditions in which the subjects hearing Mars would initially be in the same psychological and physiological state as would those hearing Venus. For half the subjects, the procedure was designed to present the music at a time when ST was decreasing. For the other subjects, ST was increasing at the time the music began. Among the subjects whose temperatures were decreasing when the music began, one group heard Mars and another group heard Venus. The ST changes of these two groups were then compared. Among the subjects whose STs were increasing at the onset of the music, half heard Mars and half heard Venus. The ST changes of these two groups were then compared. The two comparisons just described allowed the determination of whether the two musical selections were accompanied by different ST changes and whether the direction of any ST differences due to the music depended upon the direction that ST was changing at the start of the music. In this way it was hoped that the musical selections could be differentiated in terms of their relative abilities to sustain ST changes in one direction and to terminate or even reverse ST changes in the opposite direction.

Following the initial music period, subjects who had heard one music selection were presented with the other selection. Again, the same groups' STs were compared. Unlike the comparisons for the first music period, the second music period comparisons involved some confounding since the prior experiences of the subjects were no longer exactly matched. However, the results of the second music period were analyzed to determine if any order effects would be observed.

The procedures for the experimental groups were as follows: Group 1 rested with eyes closed for 3:40 minutes, during which ST increased. Next, they filled out a questionnaire (described later) for 2 minutes, during which ST decreased. While ST was still decreasing, the first music period began, during which Mars was played while the subjects listened with their eyes closed. (Eyes were closed for all groups during all music periods.) During the next 2 minutes, the questionnaire was again completed. Then Venus was presented for the next 3:40-minute period (second music period), followed again by the questionnaire for 2 minutes. For Group 2, the treatments and times for each treatment were Rest (3:40), questionnaire (2:00), Venus (3:40), questionnaire (2:00), Mars (3:40), questionnaire (2:00). The ST changes during Mars for Group 1 were compared with the ST changes during Venus for Group 2, with both selections starting during ST decreases. The procedure for Group 3 was as follows: First, the subjects attempted a digits backwards memory task for 3:40 minutes. This task got progressively harder and was extremely difficult toward the end. Subjects' STs decreased. Next, the Group 3 subjects completed the questionnaire for 2 minutes, during which STs increased. During this ST increase, the first music period began with the presentation of Mars, which lasted 3:40 minutes, followed by 2 minutes of filling out the questionnaire. Then Venus was presented for 3:40 minutes, followed by the questionnaire for 2 minutes. For Group 4, the treatments and corresponding times were digits backwards task (3:40), questionnaire (2:00), Venus (3:40), questionnaire (2:00). The ST changes during Mars for Group 3 were compared with the ST changes during Venus for Group 4, with both selections starting during ST increases.

Second music period comparisons (Mars of Group 2 with Venus of Group 1, and Mars of Group 4 with Venus of Group 3) were also analyzed in the same way.

The questionnaire (hereafter referred to as the ALQ for Affective Level Questionnaire) was a semantic differential type instrument by which subjects rated the emotional feelings they had experienced during the previous rest, digits backwards, or music period. Filling out the ALQ was apparently more arousing than the rest period but less arousing than the digits backwards task, so subjects' STs decreased if the ALQ followed a rest period but increased following a digits backwards period. In addition to producing ST changes in the desired directions at the start of the first music period, the ALQ also permitted a comparison of ST changes during Venus or Mars with the affects the subjects experienced during the music periods. It was hoped that such comparisons might allow some predictions to be made about the sources of any between-music differences in ST that might be found. The ALQ ratings of emotions were done by placing marks on 12 6-inch lines anchored by the descriptors: Calmness–Tension, Unpleasantness–Pleasantness, Meekness–Boldness, Sadness–Happiness, Tenderness–Anger, Seriousness–Silliness, Hope–Despair, Acceptance–Rejection, Security–Anxiety, Low Sensuality–Sensuality (sexual feeling), Contentedness–Frustration, and Indifference–Reverence (awe).

The subjects in the control group (Group C) simply rested, first with their eyes closed for 3:40 minutes, then with their eyes open for 2 minutes, then with eyes closed for 3:40 minutes, then with eyes open for 2 minutes, and finally with eyes closed for 3:40 minutes. Thus, they had their eyes open or closed in the same pattern as the subjects in Groups 1 and 2 but without filling out any questionnaires or hearing any music. This group was not a control group in the strictest sense. The conditions prior to the start of music periods for the experimental groups were not the same as the conditions at the start of the second or third eyes-closed periods for Group C. Group C's purpose was to determine if any significant temperature changes occurred after the initial eyes-closed rest period simply as a result of extraneous factors such as habituation to the experimental setting, room temperature changes within sessions, or opening or closing of eyes.

RESULTS

ALQ

The 12 6-inch lines on the ALQ were each divided into six 1-inch segments so that subjects' scores on each emotion ranged from 1 to 6. A "neutral" overall average score across subjects on any one scale would thus be 3.5.

The left columns of Table I show the mean scores for the 12 ALQ scales on which the emotions experienced during the premusic treatments (rest and digits backwards) were rated. The ALQ scores were analyzed using a 2(premusic conditions) × 12(emotions) mixed ANOVA. The $F(1, 78)$ for

Table I. Comparisons of Affective Level Questionnaire (ALQ) Means for Each Experimental Condition: Rest (R), Digits (D), Venus (V), Mars (M)

	Premusic period			1st music period			2nd music period		
	ALQ means			ALQ means			ALQ means		
ALQ[b]	R	D	F^a	V	M	F	V	M	F
C-T	2.00	4.02	26.62[e]	1.60	4.65	53.15[e]	1.85	4.60	50.42[e]
U-P	4.65	3.50	8.69[e]	5.35	3.35	22.85[e]	5.05	2.70	36.82[e]
M-B	2.80	3.52	4.26[c]	2.50	4.40	20.63[e]	2.40	4.70	35.27[e]
S-H	4.45	3.30	10.00[e]	4.00	3.40	2.06	3.35	3.00	.82
T-A	2.35	3.58	12.52[e]	1.80	4.60	44.80[e]	1.65	4.80	66.15[e]
S-S	2.60	2.10	.78	2.15	2.00	.13	2.50	1.85	2.82
H-D	2.80	3.15	.79	2.70	3.20	1.43	2.40	4.45	28.02[e]
A-R	2.45	3.08	3.68	1.95	3.25	9.66[e]	2.40	4.05	18.15[e]
S-A	2.75	4.12	15.85[e]	2.30	4.40	25.20[e]	2.30	5.05	50.28[e]
L-S	2.70	2.05	3.68	3.90	2.65	8.93[e]	3.65	2.75	5.40[d]
C-F	1.90	4.05	38.34[e]	1.75	3.75	22.85[e]	2.25	4.25	26.67[e]
I-A	2.70	2.98	.09	4.30	4.45	.14	3.60	3.90	.60

[a]All Fs have $df = (1, 78)$.
[b]C-T = Calmness–Tension, U-P = Unpleasantness–Pleasantness, M-B = Meekness–Boldness, S-H = Sadness–Happiness, T-A = Tenderness–Anger, S-S = Seriousness–Silliness, H-D = Hope–Despair, A-R = Acceptance–Rejection, S-A = Security–Anxiety, L-S = Low Sensuality–Sensuality, C-F = Contentedness–Frustration, I-A = Indifference–Awe.
[c]$p < .05$.
[d]$p < .025$.
[e]$p < .005$.

premusic conditions = 14.16, $p < .001$. The $F(11, 858)$ for emotion = 9.68, $p < .001$, and $F(11, 858)$ for the premusic × emotion interaction = 10.10, $p < .001$. The simple effects for digits backwards versus rest on each emotional scale were tested after calculation of the proper MS_e (MS within cell) and error degrees of freedom in the way suggested by Howell (1982) for testing multiple simple effects, except that a more conservative number of degrees of freedom for error was used. As indicated in Table I, subjects reported experiencing greater tension, unpleasantness, boldness, sadness, anger, anxiety, and frustration during the digits backwards task than during rest.

The middle columns of Table I show the mean ALQ scores for emotions experienced during the first music period. The first music period scores were analyzed using a 2(music) × 12(emotions) mixed ANOVA. The $F(1, 78)$ for music = 54.13, $p < .001$. The $F(11, 858)$ for emotion = 10.01, $p < .001$, and the $F(11, 858)$ for the interaction = 14.89, $p < .001$. The simple effects for Mars versus Venus on each emotional scale were tested, again using Howell's (1982) method. As shown in Table I, subjects reported experiencing greater tension, unhappiness, boldness, anger, rejection, anxiety, lack of sensuality, and frustration when listening to Mars than when listening to Venus.

Finally, Table I shows the mean ALQ scores for emotions experienced during the second music period. These ALQ data were analyzed in the same way as the first music period ALQ scores. The $F(1, 78)$ for music = 62.12, $p < .001$. The $F(11, 858)$ for emotions = 5.15, $p < .001$, and $F(11, 858)$ for the interaction = 21.74, $p < .001$. As shown in Table I, subjects reported experiencing more tension, unpleasantness, boldness, anger, despair, rejection, anxiety, lack of sensuality, and frustration when listeining to Mars than when listening to Venus.

The ALQ results consistently indicate that being tested on the digits backwards memory task and listening to Mars both were accompanied by arousing and negative emotions, whereas resting and listening to Venus were both accompanied by calm and positive emotions.

Skin Temperature

Table II and Figure 1 illustrate the ST changes that occurred for each experimental group throughout the various periods of the experiment.

As shown in Table II and Figure 1, STs increased during rest (Groups 1 and 2) and decreased during the digits backwards memory task (Groups 3 and 4). A 2(rest and digits backwards premusic treatments) × 2(music order groups 1 and 2 versus 3 and 4) ANOVA revealed an $F(1, 76)$ for premusic treatment = 81.05, $p < .001$. A similar analysis revealed that while the ALQ questionnaire was completed after the rest or digits backwards periods, STs

Table II. Skin Temperature Changes (°F) for Each of the Groups During Each Period

	Experimental period							
	Premusic			Music (1)			Music (2)	
Group	Rest	Digits	ALQ	Mars	Venus	ALQ	Mars	Venus
1	2.28		−.21	−.46[c]		.02		.95[d]
2	3.10		−.43		.25	−.70	.20	
3		−1.05	1.46	.03		.33		.93[d]
4		−1.33	.93		.98[c]	.07	1.13 (.65)[a]	
C[b]	1.96		.11	.24		−.10	.03	

[a]The median is shown in parenthesis for this group and is a more representative average due to the extreme skewness of this group's distribution.
[b]Group C subjects simply rested throughout the session. They heard no music, nor did they complete any qeustionnaires. They had their eyes closed during premusic and music periods and had their eyes open during ALQ periods.
[c]Music period mean is significantly different from the Group C mean at $p < .025$.
[d]Music period mean is significantly different from the Group C mean at $p < .01$.

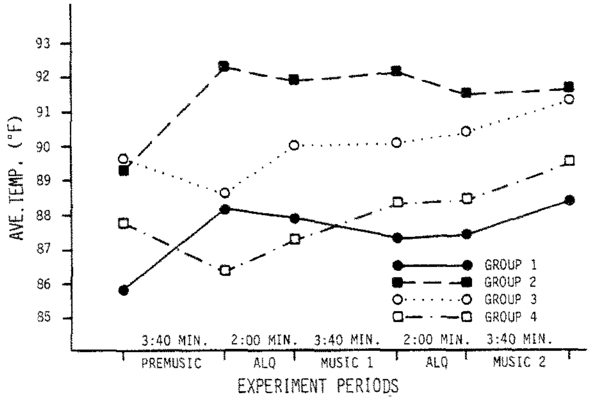

Fig. 1. Changes in skin temperature for each experimental group during each experimental period. Group 1 (Mars-Venus), Group 2 (Venus-Mars), Group 3 (Mars-Venus), Group 4 (Venus-Mars).

declined significantly towards their initial values, $F(1, 76)$ for STs following rest versus following digits backwards = 37.78, $p < .001$. Thus, the STs were undergoing the desired changes at the start of the first music period. The STs were decreasing for Groups 1 and 2 and were increasing for Groups 3 and 4.

The first music period ST changes were analyzed using a 2(premusic treatment) × 2(music) independent groups ANOVA. The $F(1, 76)$ for premusic treatments = 6.90, $p < .025$, and $F(1, 76)$ for music = 12.55, $p < .001$. The interaction did not approach significance, $F(1, 76) = .27$, $p > .05$. The critical planned comparisons (Mars of Group 1 versus Venus of Group 2, and Mars of Group 3 versus Venus of Group 4) were both significant even when alpha was reduced by half to .025 to avoid type 1 errors due to the fact that 2 comparisons were made. The difference between temperature changes during Mars (Group 1) verses during Venus (Group 2) was significant, $t(38) = -2.83$, $p < .01$. The difference between temperature changes during Mars (Group 3) versus during Venus (Group 4) was also significant, $t(38) = -2.40$, $p < .025$. Thus, no matter whether ST was increasing or decreasing at the start of the first music period, Mars was accompanied by significantly more negative or less positive ST changes than was Venus. These results are illustrated in the left half of Figure 2.

The above results cannot be attributed to group differences in baseline (initial) values for ST since there was no significant correlation ($r = .006$) between the subjects' initial STs and their ST changes during the first music period. Nor were the ST differences due to differences in room temperature. The subjects were assigned to Groups 1 to 4 in order of their appearance,

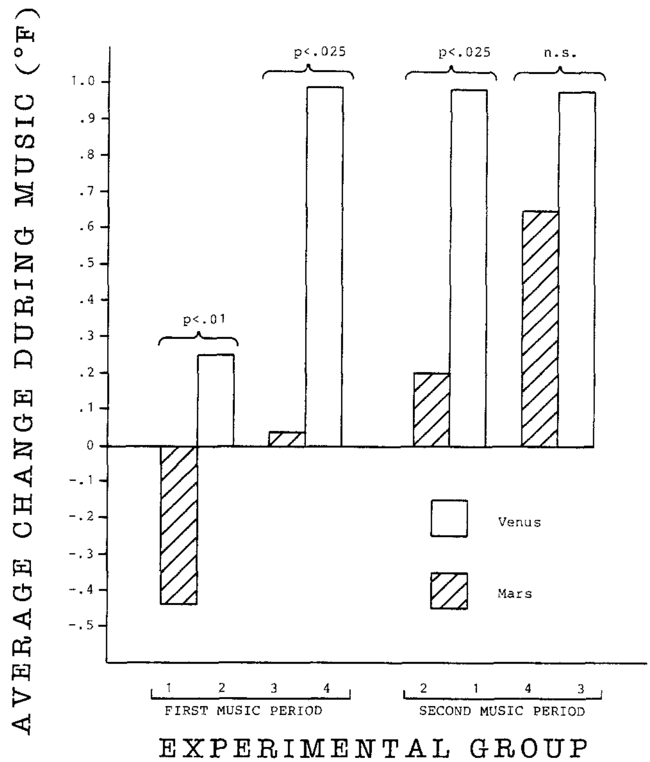

Fig. 2. Temperature changes during Mars versus temperature changes during Venus. These are the four comparisons in which the conditions prior to the music were matched (first music period) or partially matched (second music period) for the two groups being compared. The averages are means except for Group 4 (Mars) in the second music period in which the median is plotted due to the extreme skewness of that group's distribution of scores. The *p* values indicate the significance of the Mars–Venus comparisons.

and subjects from different groups were scheduled first on different days. Thus, scheduling biases such as running all subjects from Groups 1 and 2 in the early morning and subjects from Groups 3 and 4 in the late morning and early afternoon did not occur. Also, room temperature was recorded immediately prior to the sessions for a sample of 20 subjects. Although the mean first music period skin temperature changes during Mars ($\bar{X} = -.15$ °F) and Venus ($\bar{X} = .98$ °F) were even more different from each other in the subset of subjects than in the total data, there was no difference between the groups in average ambient room temperature ($\bar{X} = 73.26$ °F for subjects who heard Mars first, and 73.13 °F for those who heard Venus).

During the second ALQ period, in which the emotions experienced during the first musical selections were rated, the ST changes did not follow a regular pattern (none had been predicted). Only the decrease in Group 2 ST reached significance.

The ST changes during the second music period were analyzed in the same way as the first music period ST changes. The main effect for music was not significant, $F(1, 76) = 1.71, p > .05$. The planned comparison between STs during Mars for Group 2 and Venus for Group 1 revealed a significant difference in the same direction as that found during the first music period, $p < .025$ (as shown in the right half of Figure 2). The comparison between mean ST during Mars for Group 4 and Venus for Group 3 was not significant. However, a test for skewness indicated that Group 4 STs during Mars were not normally distributed. Three outlying scores changed the mean from .39 for the rest of the scores to 1.13 for the total distribution, and z for skewness $= 3.47, p < .001$. Therefore, unlike all other groups of scores in which skewness was not significant, the median (.65) was the measure of central tendency that best represented the average Group 4 ST change during Mars in the second music period. Thus, even in the Group 4 Mars versus Group 3 Venus comparison, the typical temperature change during Mars was less positive than during Venus, although not significantly so in this case (see Figure 2).

The fact that ST increased (though nonsignificantly) during Mars in the second music period may imply that subjects became accustomed to hearing music during the first music period and were thus not as physiologically aroused by Mars when it followed Venus as when it preceded Venus.

The bottom row of Table II lists the ST changes for Group C. After the initial ST increase during the premusic period in which subjects rested with eyes closed, no further ST changes reached significance in later periods. As mentioned in the Procedure section, Group C is not a true control group for any of the experimental groups since the conditions prior to onset of the music for Groups 1 to 4 were different from the conditions prior to the corresponding period for Group C. However, the experimental groups' mean ST changes during music periods differed from the Group C means in ways that support the results of the primary data analysis described earlier. In the first music period, as shown in Table II, Group 1 STs significantly decreased during Mars relative to the Group C mean, $t(38) = -2.35, p < .025$, whereas Group 4 STs increased significantly during Venus, $t(38) = 2.49, p < .025$. In the second music period, Group 1 STs increased significantly during Venus relative to the Group C mean, $t(38) = 3.52, p < .01$, and Group 3 STs increased significantly during Venus relative to Group C, $t(38) = 3.11, p < .01$.

DISCUSSION

The analyses of the ALQ ratings and the ST data of the first music period consistently point to the conclusion that music judged by subjects to produce arousing, negative emotions terminated temperature increases and perpetuated temperature decreases, whereas music judged to produce calm, positive emotions terminated temperature decreases and perpetuated temperature increases. In the second music period, the comparisons were harder to interpret since the groups being compared had heard different music and experienced different ST changes and emotions in the earlier periods. Also, the skewness of the Group 4 ST distribution made the Group 3 (Venus) versus Group 4 (Mars) comparison difficult to evaluate. Even so, the second music period ST results also indicated that ST charges were typically less positive during Mars than during Venus.

There were several differences between the musical selections used in this study. As previously mentioned, listening to Mars was accompanied by increased arousal (as indicated by greater reports of tension, e.g.) and also by increased negative affects (e.g., greater unpleasantness), whereas Venus was associated with reduced arousal and increases of emotions having positive valences. Nielzen and Cesarec (1981) found that Tension–Relaxation and Gaiety–Gloom were the two orthogonal factors that accounted for the most variance in emotional response to music. Since these two factors were confounded in the present study, it remains for future experiments to determine how much of the ST variance can be explained by each emotional factor.

The affective differences between Mars and Venus may have been produced by structural differences between the musical selections. Pearce (1981) and Rieber (1965) showed that faster tempos produced greater arousal. Loudness differences also led to differences in general arousal. Clynes and Nettheim (1982) and Sundberg (1982) demonstrated that music having certain patterns of physical characteristics is associated by the listeners with certain emotions. Finally, Nielzen and Cesarec (1982) factor-analyzed the structural characteristics of music and related the resulting factors to the affective factors uncovered in their earlier study (Nielzen & Cesarec, 1981). Such correlations between music structure and the resulting emotions plus the relationship demonstrated in the present study between the emotions associated with music and ST changes during the music suggest that classification of a musical selection according to its musical structure may allow one to accurately predict the effect that that musical selection would have on ST. Broader tests of this hypothesis are called for.

In conclusion, music is a powerful emotional stimulus, and the present study suggests that affect rating scales like the ALQ might be used to predict whether a particular piece of music is most likely to produce ST increases or decreases. If music is to be used in conjunction with treatments designed to stop unwanted ST changes and promote changes in a desirable direction, there is now evidence that the effect will be achieved more quickly if the initial musical selection is highly compatible with the desired ST changes. One should of course be cautious in generalizing from the results of the present study to any therapeutic situations. Subjects who are chronically anxious may (or may not) react to music quite differently than college psychology students. For now, however, one can say that some music would be more supportive of ST changes in a specific direction than would other music, and that what music would cause what ST changes is in part predictable from responses on affective rating scales as well as from a knowledge of the physical characteristics of the music.

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