EFFECTS OF MUSIC ON PSYCHOPHYSIOLOGICAL RESPONSES TO A STRESSFUL FILM

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In this experiment musical scores were added to the soundtrack of an industrial safety film that has often been used as a stressful stimulus in psychophysiological research. Two musical scores were composed in accordance with contemporary film scoring techniques in an attempt to increase and decrease the stressfulness of the film. Subjects viewed one of three versions of the film: (a) the film with no music (control condition), (b) the film with "horror" music (increase condition), and (c) the film with "documentary" music (decrease condition). Physiological responses (cardiovascular, electrodermal, and somatic) were monitored continuously while subjects viewed the film; a report of subjects' perceived anxiety level was also obtained. Results indicated that the film scores were successful in both increasing and decreasing electrodermal responses to the film, compared to the control condition. These results are seen as providing preliminary experimental support for the efficacy of musical scores for manipulating the stressfulness of films.

The presence of music in our environment has increased dramatically in recent years. Its uses now extend far beyond the domain of the arts, reaching into the business and work place, where it is ostensibly used to influence shopping behavior, worker productivity, responses to waiting room tedium, and the like. Music has also established a foothold in the treatment of mental and physical illness, with music therapy used in many institutions not only to aid in rehabilitation, but also to cause changes in emotional state. The use of music to effect changes in emotional state is most strikingly evident in film and television where a new profession has emerged with several colleges offering degrees in film music composition. All of these uses rest on the still questionable assumption that the effects of music on listeners are rulebound and thus predictable. Hunter (1973) soberly notes:

> "Little is yet known about the effects of listening to music; persons responsible for subjecting the whole population of a specific environment to the effects of listening therefore act in ignorance of the nature of these effects" (page 54).

The effects of music on listeners have been extensively studied. A recent volume edited by Hodges (1980) provides a valuable overview of what is known and what remains to be determined in this area. In this volume Haack (1980)

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provides a comprehensive review of the use of music in a wide range of contexts in terms of its influences on the behavior, mood, and physiology of music listeners. Of direct relevance to our research, in the appendix to the volume Hodges (1980) provides a brief, comprehensive review of studies of the effects of music on listeners' physiology. He concludes:

> "The data presented in the foregoing studies quite clearly support the hypothesis that listening to music does influence a person's physiological responses. However, the data do not show clear support for the nature of this influence" (page 396.).

One technique for studying the effects of music that has been used is to have people listen to various kinds of music and then subjectively report their perceived emotional states (e.g., Bonny & Savary, 1973; Hevner, 1937). Studies in this area often use Gaston's (1951) distinction between stimulative and sedative music to classify stimulus passages. In a study noteworthy for empirically-based classification of musical selections as stimulative or sedative, Rohner and Miller (1980) found no differences in self-reported anxiety when listening to these selections was compared with a no-music control condition. Differences within the two music types were in the expected direction (i.e., sedative music associated with lower anxiety) but were statistically nonsignificant.

In addition to these direct effects of music on physiology and affect, music may serve to alter persons' responses to another stimulus. Peretti and Swenson (1974) had subjects perform a difficult pencil-maze task while blindfolded, adding to the stressfulness of the procedure by telling subjects that their performance was faulty and by making them repeat the task. A decrease in *GSR response* was found when subjects performed the task in the presence of restful music, compared to task performance without music. Unfortunately the non-music condition always came first in this within-subject design, thus the reduced GSR response in the following music condition was potentially confounded by habituation to the task.

Jellison (1975) reported another study of music's capacity to modulate stress using improved methodology. In this study electric shock (30 per subject) served as the stressful stimulus; subjects received these shocks in the presence of "exciting" music, "calming" music, white noise, or silence in a between-subjects design in which three physiological measures were obtained as well as a self-report of anxiety. The results were not encouraging; essentially music had *no* significant effect on the magnitude of physiological responses to stress experienced in its presence. Self-reported anxiety was lower in the two music conditions than in the white noise condition, but, contrary to expectation, the "exciting" and "calming" music conditions did not differ.

Our research also studied the modulating effects of music on responses to a stressful stimulus, in this case an industrial safety film. One advantage of using this film stimulus is that it fits nicely into an existing literature concerned with cognitive mediators of emotional state. In a series of laboratory studies using stressful films as stimuli, subjects' cognitive appraisals of the film have been manipulated in several different ways to determine the effects these manipula-

tions have on the viewer's physiological and affective responses to the film. Speisman, Lazarus, Mordkoff, and Davison (1964) were able to both increase and decrease electrodermal responses to a stressful silent film depicting "subincision" rites by adding dialogue soundtracks that either emphasized the traumatic nature of the film, encouraged the viewer to remain detached, or emphasized the positive aspects of the depicted acts. Koriat, Melkman, Averill, and Lazarus (1972) had subjects view an industrial safety film that already had a dialogue soundtrack. Prior to the film, subjects heard one of three different instructional sets that were designed to either be neutral, increase involvement, or increase detachment. The instructions intended to increase involvement were most successful; subjects had greater cardiovascular and electrodermal responses to the film in this condition. The detachment instructions reduced self-reported "arousal." Using the same industrial accident film, Folkins, Lawson, Opton, and Lazarus (1968) found that having subjects engage in a desensitization procedure (or in its component processes of relaxation or cognitive rehearsal) reduced electrodermal and self-reported distress responses to the film.

Outside the laboratory, the most common tool used to manipulate viewers' responses to films is the musical soundtrack. The efficacy of this approach, however, has not been studied in controlled experiments. The present experiment is an attempt to both *increase* and *decrease* persons' physiological and affective responses to a stressful film by adding musical soundtracks, composed in accordance with contemporary film scoring techniques (e.g., Skiles, 1976; Wilkins, 1978), to the existing dialogue track. In addition to providing an experimental test of the efficacy of musical scores used in this manner, this research provides a test of the usefulness of this kind of methodology for studying music's capacity to modulate stimulus stressfulness.

Method

Subjects

Sixty male college students participated in the experiment to fulfill a requirement in an introductory psychology course. Twenty subjects were randomly assigned to each of the three experimental conditions. The conditions were: (a) the film with no music (*control* condition), (b) the film with "documentary" music (*decrease* condition), and (c) the film with "horror" music (*increase* condition).

Apparatus

Stimulus film and musical scores. The stressor film was a 12 minute black and white industrial safety film entitled "It Didn't Have to Happen." The film portrays three accidents in which: (a) a worker lacerates a finger in a jointer machine, (b) another worker amputates part of a finger on a sanding machine, and (c) a table saw propels a board through the abdomen of a passing worker. This film has been used frequently in psychophysiological research since its introduction by Lazarus, Speisman, Mordkoff, and Davison (1962).

The documentary (decrease condition) music was composed of a mildly active chord progression based on major seventh chords. It was composed in such a way as not to draw attention toward or away from any one part or parts of

the stimulus film. Thus, the accident scenes were viewed under essentially the same conditions as the nonstressful parts of the film. The music preceded the start of the film by 30 seconds, continued throughout the film, and ended simultaneously with the film.

The horror (increase condition) music was composed of a repetitive figure based on diminished seventh chords and harsh timbres. It was placed in such a way as to draw attention to the accident scenes. The music preceded the first accident by 20 seconds, the second accident by 10 seconds, and the third accident by 30 seconds. The music continued after each accident for approximately 10 seconds but was designed to end in a natural fashion (i.e., at changes in scene or camera angle). No music accompanied the remaining parts of the film.

The film stimuli were created by first transferring the 16mm accident film to a master video tape using a film chain. The two musical scores (described above) were performed by local musicians and recorded on audio tape. The master video tape was copied on to a second video tape with the taped music score added to the film's soundtrack using an audio mixer. This procedure was used to create the three versions of the stimulus film used in the study (in the control condition the master tape was copied without additional soundtrack material to insure that the video quality was comparable in the three conditions).

The videotapes were played back for subjects on a 15 inch video monitor. Synchronization between the videotapes and physiological recordings obtained in the experiment was accomplished by using a foil marker affixed at the start of the tape. A photosensor detected the presence of the foil marker and provided a signal to the computer at the starting point of the tape.

Physiological and affective response measures. Data were obtained for a number of response variables using a system designed for on-line analysis consisting of a Grass Model 7 polygraph and a PDP 11/10 minicomputer. The system enabled continuous detection and averaging of the data during the experiment. Using this system, the following dependent measures were obtained: (a) Heart rate interbeat interval (IBI)—the electrocardiogram was detected using two electrodes attached to opposite sides of the subject's chest; the computer timed the interval between successive heart beats at a resolution of one msec. (b) General somatic activity (ACT)—an electromagnetic sensor placed under the subject's chair detected movement in all planes. (c) Skin conductance level (SCL)—a constant voltage device was used to pass a small current through surface electrodes attached to the medial phalanges of the first and third fingers. (d) Pulse transmission times to the finger (FPTT) and ear (EPTT)—photoplethysmographic devices attached to the pinna of the ear and to the middle finger were used to determine the interval between the R-wave of the electrocardiogram and the arrival of the pulse at the ear and the finger. These measures reflect changes in cardiac contractility and mean arterial blood pressure. (e) Finger pulse amplitude (FPA)—using the same device used to detect the arrival of the pulse wave at the finger, the trough-to-peak amplitude of the wave was determined. The amplitude of this pulse wave is a measure of vasoconstriction in the peripheral blood vessels. (f) Continuous self-report of anxiety

(ANX)—subjects manipulated a dial in reference to a 10-point scale anchored by the legends *extremely calm* and *extremely tense.* The dial was attached to a potentiometer. Using a simple calibration formula, the computer was able to monitor the exact position of the dial.

Procedure

When subjects arrived for the experiment they were randomly assigned to one of three experimental conditions. Electrodes and other recording devices were then attached with the experimenter explaining the function of each. Subjects were given a set of written instructions explaining that they would be viewing an "industrial safety film." The operation of the "anxiety dial" was then explained; subjects were told to adjust it as often as necessary in order that it always reflected their current level of tension. The experimenter left the room to adjust the polygraph settings and to allow the subject to adapt to the experimental chamber. After 10 minutes, the experiment began.

The experiment consisted of 86 measurement periods. During the first seven one-minute periods the video screen was blank. Then the accident film started, continuing for 72 10-second periods. This was followed by seven additional one-minute periods with the video screen blank. Following completion of the procedure the electrodes and recording devices were removed and the subject was fully debriefed.

Results

The data had been averaged into 86 measurement periods by our laboratory computer (see above.) The physiological dependent measures and ANX were analyzed in a series of 3 x 86 (Score condition x Period) analyses of variance (ANOVAs) with Period analyzed as a repeated measure. An unweighted means solution was utilized to handle missing data. SCL data were lost for 15 subjects (five in each score condition) due to equipment malfunction, four subjects failed to use the "anxiety dial," and two subjects' EPTT data were unusable. These subjects were only dropped from the analysis of the dependent measure they were missing. Unless stated otherwise, $p = .05$ was adopted as the rejection level in all analyses.

Pre-Film Differences

Planned comparisons using *t*-tests were carried out on the averages of the seven minute pre-film period for each dependent measure. The three experimental groups did not significantly differ in any of their pre-film levels.

Overall Stressfulness of Accident Film

The accident film produced significant responses in all dependent measures. This was reflected in significant Period effects for: IBI ($F = 17.94, p < .001$); ACT ($F = 6.11, p < .001$); SCL ($F = 17.24, p < .001$); ANX ($F = 24.74, p < .001$); FPTT ($F = 2.91, p < .001$); EPTT ($F = 4.22, p < .001$); and FPA ($F = 13.60, p < .001$).

The pattern of responses in these variables was dominated by response peaks during each of the three accidents, with a lower magnitude response peak to the start of the film. Our analyses of the three film score conditions focused on the response peaks associated with the accidents.

Film Score Effects

Using the appropriate error terms from the ANOVAs, we performed a series of planned comparisons by *t*-test on the response peaks associated with the three accidents for each dependent measure. Two 10-second measurement periods were averaged to compute each of the three response peaks. We then compared these peak averages between the three film score conditions, first comparing the conditions on each peak separately, and then on the average of all three peaks.

Of all the dependent measures, only SCL differentiated the three film score conditions; Figure 1 depicts the SCL data. The overall pattern of these data matched our hypothesis, with the highest SCL occurring in the increase condition, followed by the control condition, and then by the decrease condition. The results of our analyses indicated that the SCL average for the three accidents was higher in the increase condition than the control condition (11.28 vs 9.18 micromhos, $t = 2.52, p < .01$), and lower in the decrease condition than the control condition (7.43 vs 9.18 micromhos, $t = -2.10, p < .025$). Comparison of individual accident peaks revealed that SCL in the increase condition was higher than the control condition for the first and third accidents, and higher than the decrease condition for all three accidents. A complete set of means and *t* values for these analyses is presented in Table 1.

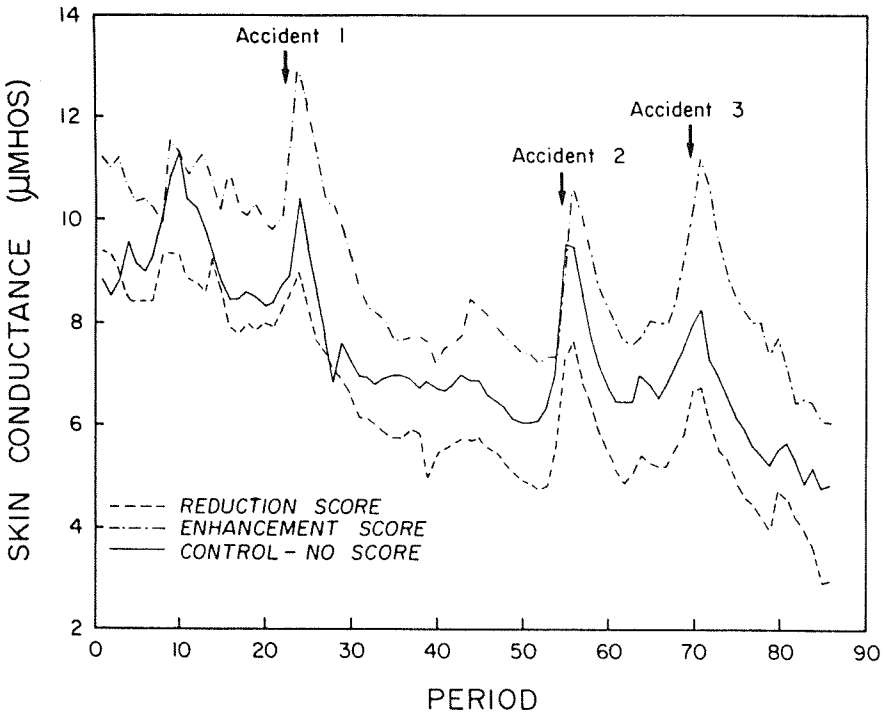

Figure 1. Skin conductance level (SCL) data for three film score conditions.

Table 1

Skin Conductance Levels During Accident Scenes

	SCL in Micromhos			*t* values		
Accident	Decrease Film Score	Control Film Score	Increase Film Score	Decrease vs. Control	Increase vs. Control	Increase vs. Decrease
1	8.7	9.9	12.6	-0.87	1.83*	2.72**
2	7.2	9.5	10.3	-1.57	0.57	2.15*
3	6.4	8.1	10.9	-1.18	1.94*	3.12**
Average of 3	7.4	9.2	11.3	-2.10*	2.52**	4.62**

*$p < .05$
**$p < .01$

Discussion

Our results indicate that musical scores can alter electrodermal responses to a stressful film, thus providing preliminary experimental validation for the efficacy of using music in this manner. Despite inclusion of a number of cardiovascular measures and ACT, physiological effects were limited to our single electrodermal measure (i.e., SCL). Further, there were no effects on our self-report measure of distress (i.e., ANX). Interestingly, findings that manipulations thought to affect cognitive appraisals of film stressors alter electrodermal, but not heart rate, responses are fairly common in the literature (e.g., Speisman et al., 1964; Folkins et al., 1968), although changes in heart rate have also been reported (e.g., Koriat et al., 1972). Lazarus, Speisman, Mordkoff, and Davison (1962), in an extensive study of the use of film stressors, concluded that electrodermal measures were the most likely to show effects. It is of course possible that there is something inherent in film stressors that makes electrodermal measures more useful, however our data clearly indicate that the industrial accident film produces strong cardiovascular responding (in a much broader range of measures than has previously been used in this area). Thus, we are inclined to believe that the basis for the predominance of electrodermal effects (if this continues to be a common finding), must be involved with the techniques used to manipulate cognitive appraisal. In this regard, Fowles (1980) has recently presented a theoretical model that suggests a division of "arousal" into processes of behavioral activation, behavioral inhibition, and a third nonspecific system. In this model, heart rate is associated more with the behavioral activation system, and electrding is associated more with the behavioral inhibition system. Most importantly for our data, it is the behavioral inhibition/electrodermal system that is associated with "anxiety." Thus if the model holds, in passive situations (such as viewing films), manipulations that alter anxiety (such as music scores), would be more likely to affect skin conductance than heart rate. Needless to say, this formulation is tantalizing but far from definitive.

The mechanism by which music effects these changes can not be determined with certainty from the present experiment, but mediation via alteration of cognitive appraisal seems likely. Several hypotheses concerning the nature of this mediation can be advanced. One possibility is that certain types of music have become associated with certain cognitive emotion states, thus representing a type of conditioned response. However feasible this explanation may appear, another explanation seems more likely in the present study; this involves the role of anticipation cues in stress response. Nomikos, Opton, Averill, and Lazarus (1968) found that most of the buildup of stress reaction occurred during the anticipation (or threat) period immediately preceding the point of impact in the accidents depicted in "It Didn't Have to Happen." Nomikos et al. (1968) cut and spliced the film to produce two versions. One version cut out visual anticipation cues and was termed the *surprise* or short anticipation (SA) treatment. The other version spliced in visual anticipation cues from the film in a nonobtrusive fashion and was termed the *suspense* or long anticipation treatment. This latter treatment significantly increased measures of stress response in the subjects, and particularly skin conductance response. In the present experiment, auditory anticipation cues were employed with similar results. In the increase condition, ominous music preceded each accident by 10 to 30 seconds. This served to increase the anticipation or threat period and thus we would expect it to increase the magnitude of the associated response (the longer the anticipation period, the greater the evidence of stress response). The pattern of means for SCL in the present experiment tends to support the importance of anticipation. Accident three had the longest anticipation period (30 seconds) and the largest increase in SCL; accident one was next, with a 20-second anticipation period, followed by accident two with a 10-second anticipation period (refer to Table 1 for mean SCL data). In the decrease condition, no such cues were present and a correspondingly lower level of stress response was detected.

Other researchers have helped to illuminate the process by which music can produce changes in physiological state. Winold (1963) performed an experiment in which skin conductance responses to consonant (major), mildly dissonant (major seventh), and strongly dissonant (diminished seventh) chords were measured. Winold found that the largest skin conductance responses were obtained to the strongly dissonant/diminished seventh chords, and the smallest skin conductance responses to the mildly dissonant/major seventh chords. The music used in the present experiment supports Winold's findings. In the increase condition, diminished seventh chords were used almost exclusively; in the decrease condition, major seventh chords dominated. It is clear that future research on the effects of music will need to adopt a more precise nomenclature than the stimulative/sedative distinction to classify the music being tested. Without such a classification system, it will be nearly impossible to discover the underlying dimensions responsible for producing the effects observed in different laboratories. As an example of such a system, Hunter (1973) has suggested a 10-dimensional clasification system for music that might serve as a useful starting point for research in this area.

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