Brief Report

Effects of Music on Cardiovascular Reactivity Among Surgeons

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Objective.—To determine the effects of surgeon-selected and experimenter-selected music on performance and autonomic responses of surgeons during a standard laboratory psychological stressor.

Design.—Within-subjects laboratory experiment.

Setting.—Hospital psychophysiology laboratory.

Participants.—A total of 50 male surgeons aged 31 to 61 years, who reported that they typically listen to music during surgery, volunteered for the study.

Main Outcome Measurements.—Cardiac responses, hemodynamic measures, electrodermal autonomic responses, task speed, and accuracy.

Results.—Autonomic reactivity for all physiological measures was significantly less in the surgeon-selected music condition than in the experimenter-selected music condition, which in turn was significantly less than in the no-music control condition. Likewise, speed and accuracy of task performance were significantly better in the surgeon-selected music condition than in the experimenter-selected music condition, which was also significantly better than the no-music control condition.

Conclusion.—Surgeon-selected music was associated with reduced autonomic reactivity and improved performance of a stressful nonsurgical laboratory task in study participants.

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ALTHOUGH no current data exist regarding the prevalence of music in operating rooms, music is thought to be fairly common during surgery. The effects of music on patients during various medical procedures including surgery have been investigated from a variety of perspectives. Recent studies have explored the anxiolytic effects of music before, during, and after surgery.[1-4] Other studies have demonstrated the positive role of music in pain control during and after both medical and dental procedures.[5-9] A third type of research has produced a wide range of findings regarding the therapeutic benefits of music based on physiological responses to music before, during, and after medical procedures.[10-13] It has even been reported that anesthetized patients who undergo surgery during music require less medication for pain.[14] Conspicuously absent in the empirical literature regarding the therapeutic effects of music is any mention of the effect that music may have on surgeons.

Although we do not know about surgeons specifically, we do know something about the effects of music on psychophysiological responses in general. Peretti[15,16] measured galvanic skin response and reported that music had a calming effect during a stressful task. Stoudenmire[17] demonstrated the role of music in reducing state and trait anxiety comparable to muscle relaxation training. In some cases, certain types of music have been associated with decreased physiological responses during stress,[18-20] although others have failed to demonstrate this relationship.[21-24] Music has also been associated positively with performance on stressful tasks. Recently, Rauscher et al[25] reported that subjects' spatial task performance was enhanced when preceded by a Mozart sonata compared with silent or relaxation audiotape control conditions.

Ethical and practical concerns limit the use of a true field experiment to test the hypothesis that music reduces surgeon stress and enhances surgical performance. Consequently, we decided to examine this assumption by modifying a standard psychophysiological laboratory paradigm[26-29] to include music as an independent variable and surgeons as participants. To determine whether music effects are specific to subjects' music preferences or simply the presence of music, we included three music conditions. Our specific predictions were that music would reduce autonomic reactivity (ie, skin conductance, blood pressure, and pulse rate) and enhance performance while physicians experienced a standard psychophysiological stressor (serial subtraction).

Methods

Subjects and Setting.—Participants were 50 male surgeons ranging in age from 31 to 61 years (mean, 52 years) who volunteered for the study because of their interest in learning about physiological responses to music. All were self-reported music enthusiasts who regularly listened to music during surgery. All were free of cardioactive medications. The experiment was performed in a soundproof hospital research laboratory.

Design.—Music was varied in three conditions within each subject. Each participant performed two serial subtraction tasks in music-free, self-selected, and investigator-selected (ie, Pachelbel's Canon in D) music conditions. The latter is an orchestral piece often used in commercially available "stress-reduction" tapes. Order of music conditions was counterbalanced across subjects.

Stressor.—A serial subtraction task was used as the stressor in this study. The task required subjects to perform aloud rapid serial subtractions of a specified value from a large number. This type of mental arithmetic task has been used in numerous laboratories.[26,30-32] These studies have demonstrated that task performance typically induces substantial increases in autonomic responses from baseline resting values.

Physiological Recording Apparatus.—Skin conductance responses were recorded using laboratory equipment (Grass model 7D polygraph with a skin conductance coupler). Fluctuations in skin conductance exceeding 0.05 micromho during each 20-second period were later tallied by experimenters blind to the music condition. Blood pressure was measured from the index finger of the subject's left hand using a blood pressure monitor (Health Check CX-1). Pulse rate was measured and recorded using a photoplethysmographic pulse meter (Panasonic model NKM 017).

Procedures.—Surgeons were scheduled individually by telephone to participate in this experiment and were re-

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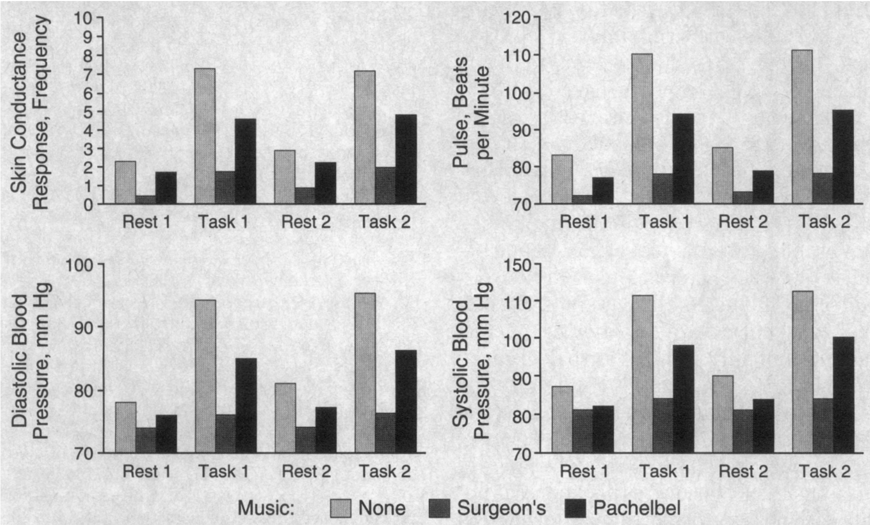

Figure 1.—Physiological responses of participants based on three different music conditions.

quested to mail audiotapes of their preferred operating room music to the experimenter. All complied. On arrival at the hospital laboratory, surgeons were greeted by the same experimenter who subsequently explained the general nature of the experiment and obtained informed consent.

Participants were brought into a soundproof room (approximately 3×4 m) and seated in a comfortable upholstered chair prior to attachment of electrodes and sensors. After the physiological recording equipment was calibrated and adjusted, subjects were asked to sit quietly.

Instructions were provided to subjects throughout the experiment via audiotape. Immediately after the beginning of the experiment was announced, the first experimental music condition commenced via headphones. Participants were instructed to sit quietly, and a 5-minute baseline physiological recording period then began. This was followed by an instruction period during which surgeons listened to instructions about performing the upcoming mental arithmetic task. They were instructed to count backward rapidly out loud by 13s from a five-digit number at a start signal. At the end of 2 minutes of counting, the surgeons were instructed to sit quietly and to continue listening to the music. After another 5-minute baseline rest period during which the music continued, the participants were instructed to repeat the subtraction task by counting backward by 17s. After the second subtraction task, the music, if any, was turned off, and the sensors were removed. Subjects left the room for approximately 15 minutes during which they washed their hands, and the experimenter set up the audio equipment for the second phase of the experiment.

When surgeons returned, the same procedures were followed except that the music condition was changed, and the values to be subtracted during the mental arithmetic tasks were changed to 23s and 27s. After the second phase, the participants were dismissed while the third phase was set up. On the surgeons' return, the procedures were repeated a third time except that the music condition changed and the values to be subtracted changed to 43s and 47s.

Results

Physiological Responses.—Four data analyses were performed using a 3×2×2 randomized factorial analysis of variance (ANOVA) design, one for each dependent physiological measure (ie, skin conduction response, pulse rate, diastolic blood pressure, and systolic blood pressure). The within-subject factors were music condition with three levels (no-music control, surgeon-selected music, and experimenter-selected music control), task with two levels (first vs second serial subtraction), and period within task with two levels (rest vs task). Figure 1 depicts the cell means of the physiological responses according to the 3×2×2 design.

The overall ANOVAs (Table) revealed the same pattern of effects for all physiological measures, including main effects for all within-subject variables (music condition, task, and period) as well as music condition by task and task by period interactions. The difference between music conditions was greater during task performance than at rest for all physiological responses. Further, a posteriori tests revealed reliable differences during both baseline and task period, such that all autonomic responses were highest during the no-music control condition, next highest during the experimenter-selected music control condition, and lowest during the surgeon-selected music condition (P<.02; see Table).

Analysis of Variance Summary

Effect*	F	P
Skin Conductance Response Frequency		
Music condition	641.42	<.0001
Task	15.88	<.004
Period	1010.34	<.001
Task × period	9.43	<.004
Pulse Rate		
Music condition	491.38	<.0001
Task	18.26	<.0003
Period	3542.06	<.0001
Music condition × task	7.22	<.002
Task × period	10.00	<.003
Diastolic Blood Pressure		
Music condition	152.19	<.0001
Task	53.68	<.0001
Period	2297.93	<.0001
Music condition × task	7.99	<.0007
Systolic Blood Pressure		
Music condition	125.12	<.0001
Task	17.64	<.0002
Period	1026.48	<.0001
Music condition × task	4.32	<.02
Speed		
Music condition	17.76	<.0001
Task	42.43	<.0001
Music condition × task	13.92	<.0001
Accuracy		
Music condition	314.31	<.0001
Task	37.81	<.0001
Music condition × task	20.91	<.0001

*Task refers to first or second serial subtraction; period refers to rest or task intervals.

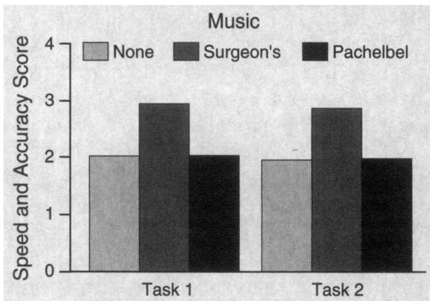

Figure 2.—Speed and accuracy of task performance with three music conditions. The values are derived from the following equation: 4–(speed × accuracy), with speed=1 (fast) or 2 (slow), and accuracy=1 (accurate) or 2 (inaccurate).

Performance Data.—The surgeons' performance on each task was categorized by speed (fast vs slow) and accuracy (accurate vs inaccurate). A laboratory assistant, who was blind to the experimental conditions, listened to all the subjects' serial subtractions and rated their task performance.

Separate analyses were performed using a 3×2 randomized factorial ANOVA design for music condition and minutes within each subtraction task. These within-subject factors were analyzed by looking at music condition with three levels (no-music control, surgeon-selected music, and experimenter-selected music control) and minutes within task by minute 1 and minute 2. The overall ANOVAs revealed identical patterns of effects for speed and accuracy, including main effects for both within-subject variables (music condition and minutes) and a music condition by task interaction (Figure 2). Further, a posteriori t tests revealed that both speed and accuracy were significantly better in the surgeon-selected music condition than the other two music conditions (all $P<.0001$).

Comment

This study examined the effects of music on surgeons' psychophysiological responses and performance during a standard psychological stressor, mental arithmetic. We believe surgeons have never been studied in this context. The results provide evidence that for this group music can have beneficial effects both autonomically and behaviorally.

The beneficial autonomic effects of music demonstrated herein were derived largely from the reduced cardiovascular reactivity during task performance. Considerable evidence exists in support of the relationship between cardiovascular reactivity and cardiovascular disease, particularly coronary heart disease and hypertension.[33-35] The beneficial behavioral effects of music demonstrated herein were derived largely from improved task performance. To the extent that surgeons' performance and cardiovascular responses during a standard laboratory psychological stress task generalize to the surgical suite, one would expect beneficial effects of the same music on both cardiovascular reactivity and performance during surgery.

The participants in our study endorsed this view. They gave many examples of the frequent and enduring stress they experience during surgery. It is important to note that all participants believed in the beneficial effect of music and were eager to participate in our study. We cannot speculate whether music would have beneficial effects for surgeons who customarily choose not to listen to it during surgery or for surgeons who might listen to music but are not devoted music enthusiasts.

No specific category of surgeon-selected music was associated with favorable physiological responses and improved task performance. Individuals were most positively affected by the music they chose, regardless of its tempo, timbre, or instrumentation. Study participants chose 50 different pieces, all instrumental (46 classical, two jazz, and two Irish folk). This experiment lends credible support to the importance of individual taste and selection of music. An example of this is the more positive influence James Galway and the Chieftans playing traditional Irish music, complete with drums and tin whistles, had on one surgeon as compared with Pachelbel (the control music condition).

These findings raise interesting issues regarding possible mediators of the relationship between music and performance. We contend that preference and not just familiarity contributed to the favorable performance responses and benign physiological responses in the self-selected music condition, since Pachelbel was not related to better performance and only somewhat to decreased physiological reactivity. Accordingly, the self-selected music may have caused the surgeons to feel better able to perform the experimental stress task because of the past association of this specific music with positive performance during surgery. Our position depends, of course, on the assumption that there was nothing particularly distracting or otherwise negative about the experimenter-selected music, Pachelbel, and that any other selection from the same genre would have produced similar results.

In this study, we demonstrated evidence that, for some surgeons, music is related to improved autonomic responses and performance during stressful tasks. Also, support was found for our surgeon subjects' intuitive beliefs that music is beneficial during stressful tasks. In 1889 Nietzsche wrote, "Without music life would be a mistake."[36] Over a century later, our data prompt us to ponder if, without music, surgery would be a mistake.

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