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The Potential for Therapeutic Applications of Music on Problems Related to Memory and Attention

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The effect of music on memory and attention was explored with 16 right-handed males (age 10 to 12 years). Using a within-subjects, repeated-measures design, a verbal dichotic listening task (monosyllabic digits) was preceded by both exposure to music and exposure to quiet. Results indicated that prior exposure to the music: (a) increased memory capacity (number of digits reported) on the free-report task, and (b) reduced distractibility (intrusions from the nonattended ear) on the directed-report task. The results are interpreted within an arousal framework. It is suggested that music may increase bilateral cerebral arousal levels, possibly through the mediating role of the right hemisphere. Applications with anxious and distractible populations (i.e., attention deficit disordered) and implications for future research are discussed.

Our interest in the potential therapeutic effects of music emerged from a methodological concern we encountered in the course of an alternate experiment. While children were waiting to participate in a dichotic listening experiment (i.e., listening to two different messages presented simultaneously, with one message directed to each ear), we considered allowing them to listen to music to pass the waiting time more enjoyably. However, it was not clear whether or not this exposure to music would affect their subsequent dichotic performance. In the present study, we addressed this concern by testing a group of

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children on a dichotic listening task following both waiting conditions—music exposure and no music exposure.

On dichotic listening tasks, the right ear is normally superior for processing verbal stimuli, which leads to a right ear advantage (REA) or bias for information presented to the right ear (Kimura, 1967). This right ear advantage is logically linked to the greater involvement of the left hemisphere in verbal language tasks (Kimura, 1967), and structurally linked to the more numerous contralateral neural connections (i.e., the connections between the left hemisphere and the right ear, and between the right hemisphere and the left ear) (Rosenzweig, 1951). Changes in hemisphere activation or engagement may be indicated by alterations in left ear or right ear report (Levy, 1983) and, therefore, changes in the REA.

Concurrent situational factors such as instructions to attend to a particular ear (Obrzut, Hynd, Obrzut, & Pirozzolo, 1981), eye gaze direction (Hynd, Snow, & Willis, 1986), and requiring a written response (Kershner, Henninger, & Cooke, 1984) are known to affect verbal dichotic processing and the right ear advantage. However, the effects of preceding situational factors are less well understood. It is hypothetically possible that prior exposure to music could differentially affect the two cerebral hemispheres with consequential effects on subsequent tasks. A music-induced hemisphere activation or engagement could create a processing bias which would affect subsequent verbal processing, much like a priming effect.

In fact, there seems to be a fairly strong rationale for suspecting that music would affect subsequent processing. What is not clear is whether these effects would be due to a differential activation of the right hemisphere or an increased activation of both hemispheres. Clearly, research has accumulated to link the processing of music to the differential engagement of the right hemisphere (Gates & Bradshaw, 1977; Zatorre, 1979)—an effect which may be even more pronounced in nonmusicians (De Pascalis, Marucci, Penna, & Labrozzi, 1987; Morais, Peretz, & Gudanski, 1982). A preferentially engaged right hemisphere could influence subsequent verbal processing, perhaps by depressing or interfering with left hemisphere functioning. Such an effect would be indicated by a lowering of the right ear advantage normally found on verbal dichotic tasks.

Other research studies suggest a bilateral engagement of the hemispheres in music processing (Breitling, Guenther, & Rondot, 1987; Duffy, McAnulty, & Schachter, 1984; Gates & Bradshaw, 1977). For example, in terms of left hemisphere involvement in music processing, Gates and Bradshaw (1977) note that left hemisphere lesions may be related to problems with time sense, tapped rhythms, melody recognition, receptive amusia, and the perception of tone duration. These effects indicate that the left hemisphere also plays a role in music processing. Gates and Bradshaw (1977) argue that both hemispheres are involved in music processing and that an interactive view of hemisphere involvement is most consistent with present research. Moreover, their view is supported by EEG data—in the form of brain electrical activity mapping (BEAM)—which show arousal in both hemispheres in the perception of music (Breitling et al., 1987; Duffy et al., 1984), albeit with somewhat greater right hemisphere arousal. An increase in bilateral engagement could affect subsequent verbal dichotic processing, perhaps by increasing overall processing resources and, therefore, processing efficiency. Increases in processing efficiency would be marked by increases in capacity and improvement in the ability to attend as directed.

Considering the two hypotheses, the differential arousal hypothesis predicts that music will induce a right hemisphere bias and affect dichotic listening performance by either a relative depressing of right ear report (left hemisphere) or a relative enhancing of left ear report (right hemisphere). The bilateral arousal hypothesis predicts enhanced performance for both ears (both hemispheres).

Method

Subjects

Subjects were 16 male children (mean age = 11.5 years; *SD* = 0.78) who showed generally average achievement on standard scores on the Wide Range Achievement Test (WRAT) (Reading mean = 109.25, *SD* = 12.64; Spelling mean = 107.3, *SD* = 16.54; Math mean = 94.9, *SD* = 8.8) and were right handed as indicated by writing, drawing, throwing and cutting tasks.

Procedure

All subjects were tested on a dichotic listening task on two separate occasions. One half of the subjects were tested first following the "quiet" condition. This condition involved filling in identification data (i.e., name, age, school, date, session number, etc.) on the answer forms in a quiet room. The other half were tested first following exposure to the music condition, which was characterized as filling in identification data on the answer forms while listening to a music selection. The conditions were reversed for the second set of trials.

The dichotic digits test was composed of 24 trials of monosyllabic digits compressed into bursts of two pairs per second. The tape was prepared at the Phonetics Laboratory at the University of California at San Diego using stimuli of 307 msec. duration (digitized natural speech, adult female voice) after amplitude and duration normalization.

The first sitting was considered a familiarizing session where the students worked through the test format, including all 24 trials, and learned how to fill out the identification data on the response forms and the response forms themselves during the dichotic testing. This served to put them at ease and deal with any uncertainty and mistakes in transcription procedures. The next two sessions were considered experimental sessions, and both were administered in the afternoon on two separate occasions. For the first experimental session, one half (n = 8) of the students were required to listen to the music selection for approximately 5 minutes and fill out identification data on the answer forms prior to the dichotic task; the other group (n = 8) filled out identification data in the quiet setting, prior to the dichotic task. This condition was reversed for the second experimental session, which served to control for differences due to the order of presentation. Within each session three conditions were tested: (a) free report ("report as many digits as you remember hearing"); (b) directed left report ("report the digits you hear with the left ear"); and (c) directed right report ("report the digits you hear with the right ear"). In the directed report conditions, half of the subjects in each group were instructed to report the left ear digits first; the other half reported the right ear first. This served to counterbalance for order of report effects (Hiscock & Kinsbourne, 1980). Furthermore, in each of the directed report conditions, the ear that the subject was to report was pointed to by the experimenter and the subject was required to touch the attended ear prior to the task.

The task was administered first in a free-report condition. The subjects were presented with bursts of three pairs of numerals so that in one burst they heard six different numerals, three to each ear, with an 11-second interval between trials. After one warm-up trial, they were requested to write down all the numerals they remembered hearing. This was followed by two counterbalanced, directed-report conditions of eight trials each, presented at 14-second intervals, using four pairs of numerals per cluster. One half of the subjects were instructed to report only the right ear numbers on the first block of eight trials, and half were instructed to attend to their left ear and to report the left ear numbers. The selective listening order was reversed in each group for the second block of eight trials (using the same set of numerals). Headsets were reversed between the two directed conditions to offset any difference in the signal-to-noise ratio between channels. The subjects were again instructed, as above, by naming, pointing, and touching the target ear. The subjects wrote down their responses immediately after hearing the numbers. This test lasted approximately 10 minutes.

The dichotic tape was played on a TEAC 160 Stereo (dual channel) Cassette Deck-C47 through Realistic NOVA 40 headphones connected in series to permit group testing. The average signal amplitude for each channel was set at approximately 65dB for music and dichotic stimuli.

The music selection was the first five minutes of Pink Floyd's "The Wall."

Results

Free Report Data

A three-way ANOVA was computed for the total number of correct digits reported in the free report condition. Independent variables were Order of Music Presentation (music first, quiet first), Music Exposure (yes, no), and Ear (left, right). Order of Music Presentation was a between-subjects variable, while Music Exposure and Ear were within-subjects variables treated as repeated measures. There was a main effect for Music Exposure, $F(1, 14) = 11.51$, $p < .01$, which revealed higher report when the music preceded the dichotic task (left ear mean = 15.6; right ear mean = 15.1) compared to the quiet condition (left ear mean = 13.1; right ear mean = 14.1). In addition, there was a Music Exposure by Order of Music Presentation interaction effect, $F(1, 14) = 15.11$, $p < .01$. Tests for simple effects indicated a music effect on both ears, but only when the quiet session was first (left ear, $t(7) = 2.52$, $p < .05$; right ear, $t(7) = 2.34$, $p = .05$). The depressed performance when there was no music exposure existed only on the first session. This indicates that the music enhancement effect (due to music on the first session) is long term and continues to exist several days later during the quiet testing session. There was also evidence of a practice effect when there was no music exposure between Time 1 (mean = 12.05) and Time 2 (mean = 14.69) testings, $t(14) = 2.43$, $p < .03$. The practice effect when the music was on between Time 1 (mean = 14.44) and Time 2 (mean = 16.25) was not significant, $t(14) = 1.27$, $p > .2$. Means and standard deviations are presented in Table 1.

Directed Report Data

In the directed report conditions, a five-way ANOVA was computed on the digits reported. The independent variables were Order of Music Presentation (music first, quiet first), Ear Directed First (left, right), Music Exposure (yes, no), Direction Attending (left, right), and Channel Reported (attended, non-attended), with the last three variables being within-subjects variables treated as repeated measures. There was a main effect for Music Exposure, $F(1, 12) = 6.90$, $p = .01$, and a main effect for Channel Reported, $F(1, 12) = 72.14$, $p < .0001$. There were two-way interaction effects for Channel Reported by Order of Music Presentation, $F(1, 12) = 5.82$, $p < .04$, Channel Reported by Ear Directed First, $F(1, 12) = 10.47$, $p < .01$, and Channel Reported by Direction Attending, $F(1, 12) = 14.71$, $p < .01$. There was a three-way interaction for Channel Reported by Direction Attending by Order of Music Presentation, $F(1, 12) = 5.84$, $p < .04$, and a four-way interaction for Channel Reported by Direction Attending by Order of Music Presentation by Ear Directed First, $F(1, 12) = 7.56$, $p < .01$. Means and standard deviations for the directed report conditions are presented in Table 2.

To explicate the interaction effects, separate four-way ANOVAs were computed: (a) for digits reported on the attended

TABLE 1

Mean Number of Digits Reported on the Dichotic Listening Task for the Free Report Condition

Ear	Music First $n = 8$		Quiet First $n = 8$	
	M	*SD*	*M*	*SD*
Left Ear				
Music	15.75	3.49	15.50	4.28
No Music	15.25	2.18	11.00	5.26
Right Ear				
Music	13.13	5.30	17.00	4.60
No Music	14.13	2.80	14.13	5.13

Note. Maximum score possible on each ear would be 24 digits.

channel, defined as correct digits reported; and (b) for digits reported from the nonattended channel, defined as intrusions.

Correct digits reported. The four-way (Order of Music Presentation × Ear Directed First × Music Exposure × Direction

TABLE 2

Mean Number of Correct Digits Reported on the Dichotic Listening Task for the Directed Report Condition

Ear Directed First	Music First		Quiet First	
	M	*SD*	*M*	*SD*
Left Ear First	$n = 4$		$n = 4$	
Attending Left				
Music	21.50	5.45	25.00	4.76
No Music	20.00	2.71	24.25	5.74
Attending Right				
Music	24.45	3.70	27.50	4.51
No Music	21.50	3.70	27.25	5.19
Left Ear First	$n = 4$		$n = 4$	
Attending Left				
Music	16.00	3.46	20.50	3.41
No Music	16.00	1.41	21.25	0.96
Attending Right				
Music	19.50	3.11	19.25	4.57
No Music	19.50	2.08	21.00	2.58

Note. Maximum score possible on each ear would be 32 digits.

TABLE 3

Mean Number of Intrusion Digits Reported on the Dichotic Listening Task for the Directed Report Condition

Ear Directed First	Music First		Quiet First	
	M	*SD*	*M*	*SD*
Left Ear First	$n = 4$		$n = 4$	
Attending Left				
Music	8.00	3.27	6.75	4.27
No Music	11.00	2.94	7.25	4.79
Attending Right				
Music	4.75	3.20	4.00	3.56
No Music	9 50	1.73	4.75	5.19
Left Ear First	$n = 4$		$n = 4$	
Attending Left				
Music	15.00	3.37	7 75	1.71
No Music	15.75	1.71	9.00	1.82
Attending Right				
Music	11 75	3.86	9.75	3.10
No Music	12.50	2.08	10.75	2.22

Note. Maximum score possible on each ear would be 32 digits.

Attending) ANOVA computed for correct digits revealed no main effect or interaction effects involving Music Exposure. Thus, this analysis is not reported further at this point.

Intrusion errors reported. The four-way (Order of Music Presentation × Ear Ordered First × Music Exposure × Direction Attending) ANOVA computed for intrusions reported revealed main effects for Music Exposure, $F(1, 12) = 6.43$, $p < .03$, Order of Music Presentation, $F(1, 12) = 7.17$, $p < .03$, Ear Directed First, $F(1, 12) = 11.80$, $p < .005$, and Direction Attending, $F(1, 12) = 10.76$, $p < .007$. In addition, there was a two-way interaction for Direction Attending by Order of Music Presentation, $F(1, 12) = 6.29$, $p < .03$, and a three-way interaction for Direction Attending by Order of Music Presentation by Ear Directed First, $F(1, 12) = 7.65$, $p < .02$. The main effect for Music Exposure was due to fewer intrusions when music preceded the dichotic task (see Table 3). The main effects for Ear Directed First, Order of Music Presentation, and Direction Attending are qualified by the three-way interaction. Tests for

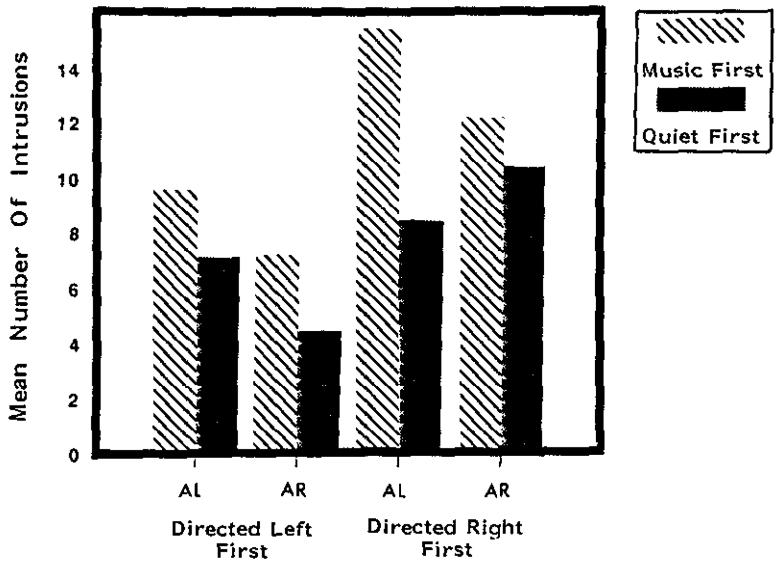

FIGURE 1.
Directed report intrusions attending left (AL) and attending right (AR). There is a music-induced right ear priming effect, which leads to higher intrusion scores when attending left as a result of receiving the music session first and being directed to attend right first.

simple effects revealed that the interaction was due to a higher rate of intrusions for subjects directed right first when attending left and exposed to the music first, $t(6) = 3.84$, $p < .01$ (see Figure 1). It seems there was a long-term, music-induced, right ear priming effect somewhat similar to the strengthened priming effect obtained when hyperactive children are treated with ritalin (Hiscock, Kinsbourne, Caplan, & Swanson, 1979). Such an effect is characterized by a preferential attending to the right ear even when instructed to attend left. The complementary effect on the correct report digits was evident in a significant three-way interaction for Direction Attending by Ear Directed First by Order of Music Presentation, $F(1, 12) = 6.81$, $p < .02$. Tests for simple effects showed a right ear priming effect that depressed subsequent left ear performance when attending left, but only for subjects who attended right first and received the music first (mean = 16.00), not the quiet first (mean

= 20.8), $t(7) = 3.30$, $p < .02$. Means and standard deviations are presented in Tables 2 and 3.

In summary, the main effects for Music Exposure reveal an increase in total digits reported (free report) and a general reduction in intrusion errors (directed report). In addition, the interaction effect on the directed report data suggests a long-term, music-induced, right ear—left hemisphere—priming effect, which leads to decreases in left ear report when attending left and increases in intrusions from the right ear when attending left.

Discussion

The differential activation hypothesis in favor of the right hemisphere was not supported. Rather, the bilateral capacity increase on the free report data and the reduced distractibility on the directed report data support the notion of a music-induced involvement of both hemispheres (Breitling et al., 1987; Duffy et al., 1984; Gates & Bradshaw, 1977).

This bilateral arousal effect may be due to the music-related processing specialties of each hemisphere (Gates & Bradshaw, 1977) and thus the need to activate both hemispheres. Or it may be that music-induced right hemisphere arousal mediates bilateral arousal. Research indicates that the right hemisphere, more so than the left hemisphere, is able to mediate bilateral arousal (Heilman & Van Den Abell, 1979; Van Den Abell & Heilman, 1979). Ensuring right hemisphere arousal through music may then facilitate concurrent left hemisphere arousal.

The arousal interpretation would support existing research on music-induced arousal. For example, using EEG measures with children (ages 8 to 9 years), Furman (1978) noted that music led to decreased alpha (indicating increased arousal) when compared with silence. Also, Wilson and Aiken (1977), using physiological indices (galvanic skin response, respiration, and heart rate) with college students, reported music-induced effects consistent with increased arousal. Similarly, Zimny and Weidenfeller (1962) reported that stimulative music increased excitement (galvanic skin response) with children.

If information processing may be enhanced by music-induced arousal, then there is clearly a potential strategic role for music in educational and therapeutic settings. The value of a music-induced memory capacity—as noted in the present study—increase is obvious. Children with short-term memory difficulties, whether due to hypoarousal, anxiety, or personality, may benefit from exposure to music *prior* to certain tasks that require short-term memory processes.

The key for facilitative music-induced effects may be *prior* exposure rather than *concurrent* exposure to music. Existing research examining the effects of music on information processing generally evaluates information processing concurrent with the presentation of musical stimuli. This research has not been viewed as facilitative of memory as measured by comprehension (Furman, 1978), paired-associate recall (Myers, 1979), or phonological short-term memory (Salame & Baddeley, 1989). However, studies with exceptional individuals are more promising. For example, Michel, Parker, Giokas, and Werner (1982) reported that music facilitated vocabulary gains in reading disabled subjects, and Shehan (1981) reported that music facilitated paired-associate learning with learning disabled subjects. Perhaps the learning impaired would show more favorable responses regardless of whether the music was prior to or concurrent with the task.

The reduced distractibility in the directed report condition following the music presentation is intriguing in that it indicates a music-induced enhanced ability to process information as instructed. Distractibility is normally defined as attending to the nonsalient elements of a task, such as digits from the non-attended channel in a dichotic task. Even if the reduced distractibility parallels the "narrowing of perception" or reduced cue utilization normally seen as a response to stress (Lindsey & Norman, 1977) or emotional arousal (Easterbrook, 1959), the response would not be interpreted as maladaptive within the parameters of this study. In light of this, the present findings may have implications for populations that are notoriously distractible. For instance, music could be investigated for its possible therapeutic effect on enhancing classroom attending behaviors for attention deficit disordered (ADD) students and the autistic, among others.

Several studies, in fact, have reported a music-induced decrease in activity level in ADD children (Cripe, 1986) and mentally retarded children (Gregoire, 1984; Reardon & Bell, 1970). Effects on attention have been less promising (Cripe, 1986), which may be related to sampling limitations (i.e., small sample size) and/or the use of very young children (ages 6 to 8) who may not be developmentally ready for mature selective attending (Ross, 1976). Nevertheless, music-induced effects would appear to be a rich source of therapeutic practices and research interests (Jellison, 1988).

The music-induced, long-term, right ear priming effect is theoretically interesting. Apparently, the interhemispheric effects of situational variables extend beyond the physical presence of the stimulus (also noted by Hiscock & Bergstrom, 1982). This would seem to implicate experiential memory factors in interhemispheric response, and may partially explain inconsistent findings and the lability of perceptual laterality effects often reported in dichotic studies. On the positive side, it seems to indicate potentially long-term therapeutic effects from brief pairings of music with behavioral tasks.

Questions about the effects of other music forms (classical, instrumental, etc.), sex differences, age differences, and stimulus properties (volume and duration) remain. However, the findings suggest further exploration would be warranted, and a number of interesting research questions exist for educators, music therapists, and social scientists.

Admittedly, the present study used a small sample. However, differences on within-subjects independent variables would be considered reliable. Also, it has been argued that one ought to place as much confidence in results from small samples as large samples because a much larger mean difference is necessary to detect significance in small samples (Neale & Liebert, 1973). A large mean difference may presage a large effect size with practical rather than miniscule implications.

Generally, then, the music has beneficial effects on (a) attentional capacity and memory (as indicated by the enhanced free report); and (b) distractibility (as indicated by the reduced intrusions from the nonattended channel). These music-induced effects would seem to hold research and therapeutic promise.

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