ICMPC SEOUL 1998

Proceedings of the Fifth International Conference on MUSIC PERCEPTION AND COGNITION

August 26-30, 1998 Seoul, Korea

Demonstrating Inner Hearing Among Highly-Trained Expert Musicians

WARREN BRODSKY[1], AVISHAI HENIK[1], BAT-SHEVA RUBINSTEIN[2] & MOSHE ZORMAN[3]

[1]*Department of Behavioral Sciences, Ben-Gurion University of the Negev*
Beer-Sheva, Israel

[2]*Rubin Academy of Music, Tel Aviv University*
Tel Aviv, Israel

[3]*Music Teachers Seminar, Levinsky College of Education*
Tel Aviv, Israel

e-mail: wbrodsky@bgumail.bgu.ac.il

Introduction

When learning new music, composing pieces, or performing in concert, musicians rely on imagery as much, if not more, than the actual external sounds themselves (Hubbard & Stoeckig, 1992). Hearing music "that is not before the ear at the moment through recall, prediction, or conception" (Walters, 1989, pg. 5) is recognized as musical imagery. However, musical imagery also occurs while reading notation. Referred to as *Inner Hearing*, this imagery is considered an expertise. That is, "one hears what he sees, and sees what he hears, once the skill has been developed" (Campbell, 1989, pg. 304). Gordon (1993) conceptualized this skill as a process of moving back and forth from aural to oral channels and modes of activity while sight-reading music notation. Yet, Inner Hearing has been challenged by Sloboda (1984) who reckoned "not to make anything of the case of people who claim to be able to read a score in complete silence, without mediation of instrument or voice " (pg. 224). Todate, musical imagery as a cued response to musical notation remains essentially speculative in nature. Hence, the main purpose of the current study was an attempt at resolving these speculations through demonstration of Inner Hearing via skill mastery.

The Study

<u>Operational Concepts.</u>

To tease-out the aural skills (required to mentally hear a score) from the visual skills (involved in sight-reading), we exploited music-compositional techniques that allow a melody to be arranged and presented such, that identification of the original musical theme relies solely on aural skills. We refer to this manipulation as an "embedded melody." Demonstrating that musicians can correctly identify the original theme of an embedded melody (read silently) might not, however, be evidence in itself of Inner Hearing. Thus, if normal sight-reading tasks could be hampered by conditions which interfere with Inner Hearing, then, we would assume that musician-subjects used Inner Hearing under non-distracted sight-reading tasks.

<u>Pilot Trials.</u> In an early trial (N=10) we demonstrated interference effects by having subjects sing a standard folk-song as an articulatory suppression task. Further, we found that combined finger-tapping and attending to a task-irrelevant rhythmic pattern was a more appropriate distractor than either single task. In our second trial (N=18) we demonstrated longer reaction times and greater errors among subjects sight-reading under articulatory suppression conditions compared to subjects sight-reading under normal or rhythmic distraction conditions. While these differences were not significant, streamlining the sample according to their performance of experimental tasks under normal sight-reading (i.e., estimated error rate) resulted in a stronger group effect. We concluded that further experimentation required a sample demonstrating higher aural abilities and expertise (Experiment 1), and that the nature of the experimental task (i.e., identifying embedded melodies) needed further exploration (Experiment 2).

<u>Hypotheses.</u> (1) under normal non-distracted sight-reading musicians will be successful at task completion (matching a musical theme heard aloud to a score of an embedded melody previously read silently); (2) sight-reading under rhythmic distraction conditions (hearing an extraneous task-irreverent rhythmic pattern while tapping the pulse beat) will hamper, but not significantly interfere with, successful task completion; and (3) sight-reading under conditions involving articulatory suppression (singing a song aloud) will cause notable interference with task completion, and result in significantly increased reaction times and error rate.

EXPERIMENT 1:

<u>Subjects.</u> Eighteen musicians were solicited on the basis of demonstrable accomplishments involving aural analytic abilities, sight-singing, and dictation. Subjects were 10 males and 8 females, between the ages of 17-55 (*mn*=22; *sd*=10.64), reporting 5-18 years of instrument tuition (*mn*=11; *sd*=4.25).

<u>Stimuli.</u> Fifty popular symphonic/operatic or Israeli folk melodies were selected at random, and arranged as variations-on-a-theme (leaving the original melodic theme, phrase structure, and harmonic plan intact). Melody length ranged from 8-16 bars. Texts were presented as G-clef single line melody, with note stems in an upwards direction, in standardized measure widths. See Figure 1. Thirty-six melodic sets (including an original theme, arranged variation, and a

matched melodic lure) were selected at random. Each item was paired at random with either the original theme or with its matched melodic lure; the study used a split-half design.

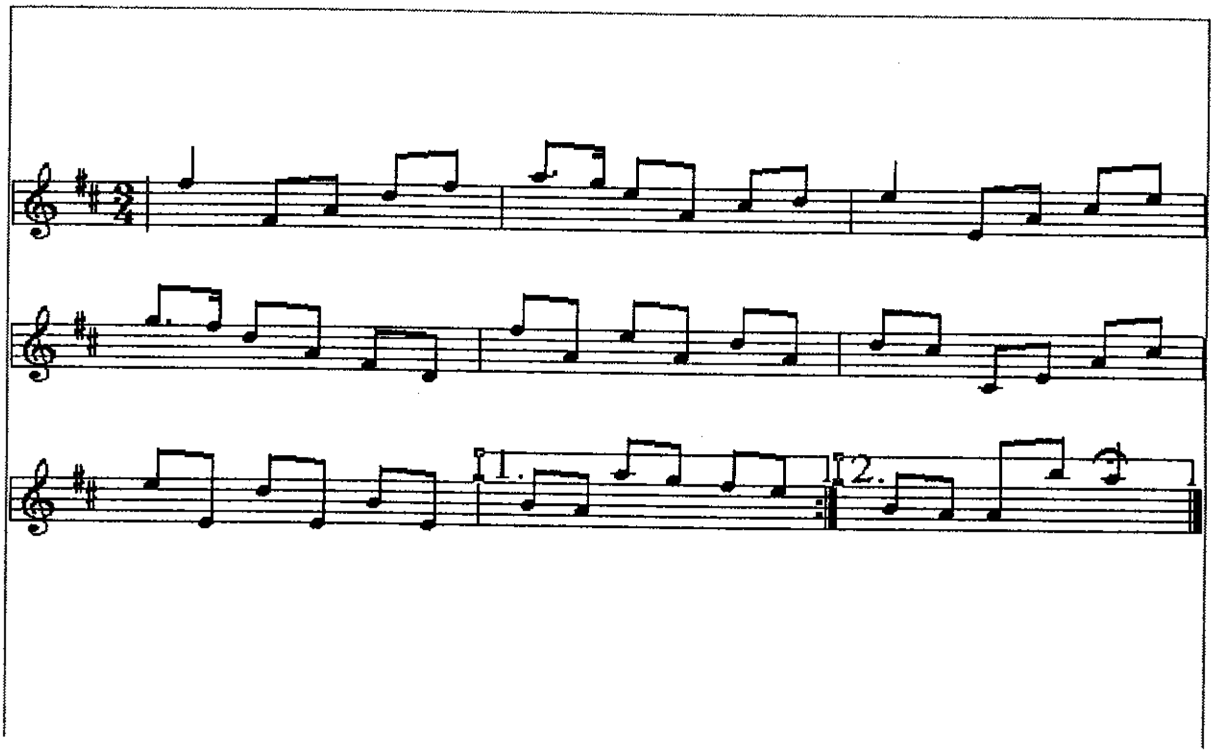

Figure 1: Arranged variation of a melodic theme [Arrangement © M. Zorman]. Source of the Embedded Melody is "La Donna Emobile" from the Opera Rigoletto by G. Verdi.

Apparatus. Hardware: *IBM* Pentium 166 PC, 16-bit *Creative Labs Inc.* SoundBlaster sound card, two stereo speakers, and 17" *IBM* color monitor. Software: *Music Experiment Development System - MEDS 97-16* (Kendall, 1997; Kendall & Carterette, 1992).

Design and Test Presentation. Using a single factor within-subjects design, the experimental task required subjects to match the music notation read (the arranged variation) to melodies heard thereafter (either the original theme or the matched melodic lure) under three sight-reading conditions: (1) NR/normal un-interfered sight-reading; (2) RD/sight-reading under rhythmic distraction; and (3) AS/sight-reading under articulatory suppression. Each three blocks of twelve items, paired with either the original theme or matched melodic lure, comprised a sight-reading condition. Sight-reading condition and item rendition were rotated to balance all biases linked to presentation order - full rotation required eighteen subjects.

Procedure. The notation of the arranged variation appeared on the computer monitor screen and stayed in view for as long as needed. Previously the subjects had been directed to read the arranged variation in its entirety. When finished reading, the subject verbally acknowledged that the notation text file could be closed. A melody was immediately heard over the stereo speakers, and the subject was required to indicate whether or not the heard melody was the original theme of the embedded melody by pressing keys "O" (original theme) or "N" (not original theme) of the computer keyboard. Subjects were asked to key-press as fast as possible and not make errors. Experimental sequences of interference conditions were identical to the normal condition withstanding the secondary task (i.e., either hearing an extraneous task-irrelevant rhythmic pattern and tapping the pulse beat, or singing a standard popular Israeli folk song - both while sight-reading).

Results and Discussion. Median reaction times (RTs) for each subject in each condition were entered into a repeated measures analysis of variance (ANOVA). There was a significant condition effect ($F_{(2,34)}=5.37$, MSe=9,856,176, $p<.01$). Planned comparisons indicated significantly longer RTs for subjects sight-reading under the articulatory suppression condition than under the other two conditions ($t=-2.75$, df=17, $p<.01$; $t=-2.44$, df=17, $p<.025$ for the NR and RD sight-reading conditions respectively). A similar ANOVA was conducted for the rate of correct responses, and there was a significant condition effect ($F_{(2,34)}=11.5$, MSe=1.45, $p<.0001$). Planned comparisons indicated significantly less correct answers for subjects sight reading under either interference condition when compared to normal un-interfered sight-reading ($t=3.47$, df=17, $p<.001$; $t=5.52$, df=17, $p<.0001$ for the RD and AS sight-reading conditions respectfully). These results demonstrate the debilitating effects that interference conditions cause to Inner Hearing. Most specifically, highly-trained expert musicians took a significantly longer time to process material when reading musical texts under conditions involving Articulatory Suppression. See Table 1.

Table 1: Number of Correct Items/Mean Reaction Times Per Condition in Experiment 1

# Correct Items				Mean Reaction Times (in MS)		
Condition	M	SD	Range	M	SD	Range
NR - Normal	10.11	.90	9-11	9,054	3,940	4,162-16,668
RD - Rhythmic Distraction	8.83	1.47	5-12	8,587	5,083	3,596-23,300
AS - Articulatory Suppression	8.22	1.17	7-11	11,762	6,349	5,434-27,769

EXPERIMENT 2:

Subjects. Twenty-three musicians (advanced Music Performance, Music Education, and Musicology majors) participated in the experiment. Subjects were 5 males and 18 females, between the ages of 25-55 (*mn*=30; *sd*=9.94), reporting 3-18 years of instrument tuition (*mn*=9; *sd*=4.25).

Design and Procedure. The stimuli, apparatus, design, and test procedure of Experiment 2 were the same as in Experiment 1, with the following exceptions: a block of twelve variations were first presented visually as musical notation (i.e., the normal un-interfered sight-reading condition), followed by a block of twelve variations presented aurally as melodic variations heard aloud.

Results and Discussion. In general, the musician-subjects who demonstrated poor (and at times random) performances when embedded melodies were presented as silent notation (requiring Inner Hearing), greatly improved to statistically significant performance levels when the same were presented aloud. Median RTs for each subject in each condition were entered into a repeated measures analysis of variance (ANOVA). There was a significant condition effect ($F_{(1,22)}$=11.21, MSe=14,506,202, $p<.01$). A similar ANOVA was conducted for the rate of correct responses, and found a significant condition effect ($F_{(1,22)}$=47.33, MSe=2.31, $p<.0001$). These results confirmed that poor task-performance under normal sight-reading conditions resulted because of impoverished skills of Inner Hearing, and not because of the task itself. That is, when presented aurally, musician-subjects had little difficulty identifying the embedded melody and therefore demonstrated significantly greater success in judging if a melody was the original theme or a melodic lure. See Table 2.

Table 2: Number of Correct Items/Mean Reaction Times Per Condition in Experiment 2

# Correct Items				Mean Reaction Times (in MS)		
Condition	M	SD	Range	M	SD	Range
Visual Presentation	6.70	1.26	4-8	12,555	3,940	6,166-25,857
Aural Presentation	9.78	1.76	7-12	8,795	5,083	3,730-17,854

General Discussion

The task developed for the experiment proved not only to be a musical challenge for the subjects, but appears to have been successful in differentiating between the aural and visual skills involved with sight-reading musical notation. The study demonstrated that rhythmic distraction does not cause a similar interference effect on Inner Hearing as does articulatory suppression. We feel that this suggests that Inner Hearing is an articulatory kinesthetic-like cue linked to the phonological system. Our data illustrates that unlike the rhythmic distraction condition which appears to cause minimal simple interference to general cognitive resources, articulatory suppression specifically interferes with comprehension.

The predictive validity of academic success in Ear Training courses for the ability to demonstrate Inner Hearing must be considered. Referrals of subjects were made on the basis of demonstrable grades regarding abilities involving sight-singing and aural dictation. It is interesting to note that Gordon (1993) refers to these aforementioned skills as *Notational Audiation* - a synonym for Inner Hearing. Thus, perhaps Experiment 1 can also be seen as empirical validity of Gordon's definitive description of the component factor skills collectively referred to as Notational Audiation. Further, all of the twenty-three subjects solicited for Experiment 2 from Music Education and Musicology programs failed to demonstrate Inner

Hearing on any statistically significant level in the visual condition. One possible explanation regarding this is that those musicians who stray off the performance track into music education or musicology specialties are required to engage in numerous hours of class room learning, develop extra-musical skills involving pedagogy, methodology, and research, as well as invest their time in daily practicum and fieldwork experiences. Clearly, this regimen leaves little time for daily performance practice, ear training, sight-singing, and dictation - all of which contribute to the general development of aural skills.

Finally, we feel that the current study has shed new light on Sloboda's (1984) claim that there is no obvious way to demonstrate Inner Hearing. By utilizing a methodology incorporating interference conditions and embedded melodies, we feel the study successfully demonstrated the fact that at-least 1-out-of-10 musicians who claim to be able to hear musical notation in their 'mind's ear' are not just recounting an anecdotal legend.

References

Campbell, P. S. (1989) Dalcroze reconstructed: an application of music learning theory to the principles of Jacques-Dalcroze. *In* D. L. Walters and C. C. Taggart (eds) *Readings in Music Learning Theory*, pp. 301-315. Chicago, Ill.: GIA Publishers, Inc.

Gordon, E. E. (1993) Learning Sequences in Music: Skill, Content, and Pattern. A Music Learning Theory (4th edition). Chicago, Ill.: GIA Publishers, Inc.

Hubbard, T. L. & Stoeckig, K. (1992) The representation of pitch in musical imagery. *In* D. Reisberg (ed) *Auditory Imagery*, Chapter 9, pp. 199-236. New Jersey: Lawrence Earlbaum Associates (LEA).

Kendall, R. A. (1977) *Music Experiment Development System (MEDS) Software, Version 96-32.* Los Angeles: Music Perception and Acoustics lab (MPAL), Department of Ethnomusicology, University of California, Los Angeles.

Kendall, R. A. & Carterette, E. C. (1992) Convergent methods in psychomusical research based in integrated interactive computer control. *Behavior Research Methods, Instruments, and Computers*, 24, 116-131.

Sloboda, J. A. (1984) Experimental studies in music reading: a review. *Music Perception*, 2, 222-236.

Walters, D. L. (1989) Audiation: the term and the process. *In* D. L. Walters and C. C. Taggart (eds) *Readings in Music Learning Theory*, pp. 3-11. Chicago, Ill.: GIA Publishers, Inc.