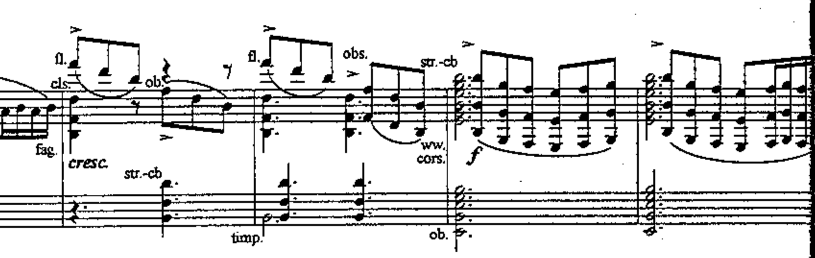

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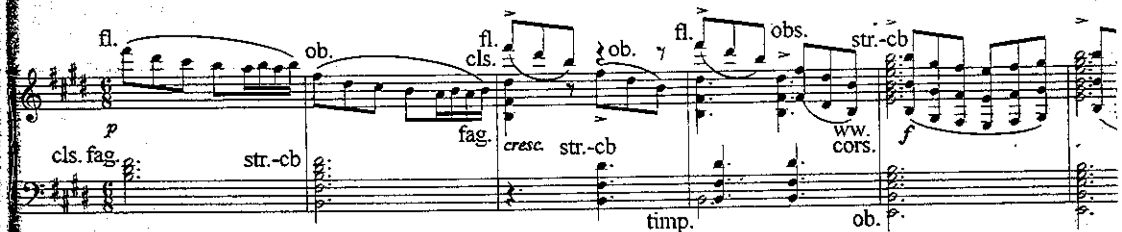

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To the memory of
Edward Calvin Carterette(1921-1999)
A great scholar, teacher, and friend

XX. Inner Hearing among Symphony Orchestra Musicians: Intersectional Differences of String-Players versus Wind-Players

Warren Brodsky, Avishai Henik, Bat-sheva Rubinstein, & Moshe Zorman

1. Introduction

Intersectional group-differences

Musicians can already be viewed as a highly specialized occupational group by the time they take up their first appointment in a symphony orchestra. Kemp (1996) based this notion on six criteria which contribute to the unique overriding characteristics which make up this group. These are: (1) orchestra-players have received instrument tuition from early childhood; (2) orchestra-players were perceived as *special* by parents, and *somewhat different* by peers throughout school; (3) orchestra-players have endured long hours spent in solitary practice during adolescence — the long-term effects of which concern both the saturation by music itself, as well as the acquisition of instrument proficiency and competence on the developing personality; (4) orchestra-players have applied themselves assiduously to their studies at college; (5) orchestra-players demonstrate a unique combination of personality traits and temperaments (including high levels of introversion, anxiety, imagination, and sensitivity); and (6) orchestra-players demonstrate remarkable confidence at giving expression to their internal life in public. While these features seem to unite orchestra musicians in the universal sense of the word, Kemp clearly recognized the fact that there are fundamental variations among the many music performers which make up a symphony orchestra. To some extent, the variance

among orchestra musicians might be related to the particular instrument they play (for example violin, flute, trombone, harp), or perhaps to the instrument section to which they ascribe membership (such as strings, brass, woodwinds, percussion). Researchers have often questioned if specific group-differences based on musical instrument are at play when investigating personological issues among professional musicians. According to Kemp these studies usually yield to one of two fundamental theories. The first suggests that specific needs are operative on some deep psychological level when a person feels drawn to a particular instrument. The second suggests that specific psychological orientations and/or styles develop over a long period of time (from early childhood) as a result of the demand characteristics inherent to each specific and unique musical instrument.

Many descriptive studies about symphony orchestra musicians have focused on issues surrounding the musical instruments they play, and the nature of the relationship that develops between musicians and their instrument. For example, Ostwald (1992) points out that this relationship frequently "begins at an early age, continues through out various stages of psychological development, and may endure for a lifetime" (p.110). He outlines six aspects which determine the relationship of a performer to their instrument. These are: (1) the sheer physical contact or impact of the instrument on the player's body; (2) the co-ordination of movements with and around the instrument; (3) producing sounds on the instrument, and experiencing the feelings associated with musical ideas; (4) giving concerts and appearing in public with the instrument; (5) providing care, protection, and repair for the instrument; and (6) appreciating the cultural and historical significance of the instrument. Ostwald concluded that "the attachments of performers to their musical instrument can be a source of pleasure and satisfaction but may also be fraught with worry and discomfort" (p.113). In a clinical-trial intervention study[1] Brodsky (1995) reported findings suggesting that the relationship that develops between musicians and their instruments may not only take on an obsessive character whereby players find it difficult to be separated from their instrument for any great length of time, but that they often relate to their instruments *as* *if* endowed with a personality of their own. This phenomenon has been previous reported by Sloboda and Howe (1991). It should be pointed out that the most widespread trait projected on musical instruments (by musicians of all types and music *genres*) is 'gender stereotyping.' Gender sentiments about particular musical instruments have as much to do with the way a performer handles the instrument, as it does with the actual *qualia* of sounds produced (i.e., the tone quality, loudness, and pitch connotations). For example, soft subtle and high-pitched instruments have been classified as feminine, while large powerful and lower-pitched instruments have been classified as masculine. Evidence supporting these attitudes indicates that 'predominately viewed as feminine instruments' include cello, clarinet, flute, French horn, glockenspiel, harp, piano, piccolo, and violin; whereby 'predominately viewed as masculine instruments' include bass drum, bassoon, cymbals, guitar, oboe, saxophone, string bass, trumpet, trombone, and tuba (Ables & Porter, 1978; Griswald & Chroback, 1981; O'Neill & Boulton, 1996). There appears to be evidence which suggests that both children and adults have clear consistent attitudes about which instruments are appropriate for boys to play, as well as which instruments are more suitable for girls. For example, O'Neill (1997) and O'Neill, North and Hargreaves (1998) report to have found indicators of *fitting* between young children and some instruments; one of the strongest determinants seems to be the child's gender.

As a result of these biases (or perhaps in-spite of them) distinctive characteristic intersectional perceptions about orchestra musicians are often reported by musicians themselves. Appearing to take on a certain adversary nature, Davies (1978) reported that the two groups of musicians who most adhere to stereotyped patterns of intersectional perceptions are the string-players *versus* the brass-players. Accordingly, string-players related to brass-players as musicians who are lacking in refinement - they are heavy drinkers, of lower intelligence, that play loud, and exhibit noisy behaviors in general. On the other hand, string-players described themselves as precious, oversensitive, a bit touchy, delicate, serious and high-minded. Other studies (Builione & Lipton, 1983) report that string-players often described brass-players as loud, extroverted, macho, and

masculine (as opposed to the brass-players who often see themselves as gregarious, loud, confident, and jovial). On the other hand, brass-players often described string-players as over-confident, frustrated, quiet, and feminine (as opposed to the string-players who often see themselves as sensitive, competitive, and insecure). It is interesting to point out that woodwinds are usually described by both string and brass players as quiet, sensitive, intelligent, and meticulous. A wealth of insights about the lives and temperaments of symphony orchestra musicians has been published by Danziger (1995) which resulted from his celebrated interview study of the London Philharmonic Orchestra. While there may only be limited truth in generalizations about orchestra musicians, personality profiles of players according to their instrument types have been found and presented by many researchers; these have been reviewed at length by Kemp (1996) in his landmark book *The Musical Temperament*.

While widespread perceptions and beliefs about orchestra players have lead to cynicism and brutal ridicule of particular instruments or instrument sections, they have also given rise to a *mythology* concerning the developed skills of certain orchestra musician types. Some of these are:

- Violin-players are particularly more intelligent and musically sensitive than other instrument players. This myth is perhaps perpetuated by the fact that the *concertmaster* is the leader of the first violin section.
- Second violinists have under-developed aural skills and abilities compared to first violinists. This myth is perhaps perpetuated by the emphasized importance of the higher voice or part of these two string sub-groups.
- Viola players have moved down from the violin because of mediocrity or failure on the previous instrument. This myth is perhaps perpetuated by the fact that the viola requires a greater degree of strength, arm length, and hand-finger span which develops at a later age. It is interesting to note that the same myth has been adopted *vis-a-vis* bass-guitarists who tend to move-on to the instrument from the electric guitar.
- Woodwind instruments are considerably easier to learn than stringed instruments which require a more long-term

application. This myth is perhaps perpetuated by the fact that woodwind instruments provide immediate aural-oral feedback and thus learners can play recognized tunes sooner than their counterparts on stringed instruments.

- Bassoon players are the "slow learners" of the woodwind section. This myth is perhaps perpetuated by the fact that bassoon music is comparatively easy to read.
- Brass instruments are fairly easy to master. This myth is perhaps perpetuated by the fact that large group settings are usually utilized to teach these instruments.
- Both string and woodwind instruments require long hours of solitary practice which is not a necessity for brass instruments. This myth is perhaps perpetuated by the excessive amount of attention string and reed-players put into their instrument.
- Wind players (woodwinds and brass) make considerably more mistakes than string players. This myth is perhaps perpetuated by statistical artifacts which most likely result from masking effects of large string sections.
- Percussion-players are not real musicians. This myth is perhaps perpetuated by the facts that percussionists usually begin their formal training at an older age after not having had early conservatory-based ear-training and theory experiences. In addition, they perform on a battery of instruments often viewed as "percussive toys," offer the orchestra a host of un-fixed pitched sounds which boarder on noise, and move easily back and forth between the more "serious" and "pop" musical idioms.

While the above myths will most likely continue well into the next millennium (as they serve to compensate mortal musicians for their own personal lacking of supernatural skills akin to those of the *Muses*), in an attempt to rise above hearsay beliefs, annotated texts of a descriptive nature, and personality typologies, the current research explored inter-sectional group-differences of symphony orchestra musicians based on empirically demonstrated musical skills. Kemp (1996) points out that on the face of it, string-playing skills seem to be far more complicated than those required of other music instruments. The aural skills required, and the degree of sensitivity to

pitch and tonal nuances, appear to far exceed the training necessary to master instruments of other types (for example, wind instruments). Therefore, string players may have developed specific aural skills to a higher degree than other players (especially as these seem to be a much more important feature of their general musicianship and do not simply serve them to manage intonation). On the other hand, since brass-players do not have the visual cues offered by keys, they may have developed an intensive dependency on their lips and ears (in addition to the three valves) which together are used to determine a whole range of pitches. While most other instruments offer a fair degree of visual and tactile cues about where to play the initial note of entry, brass-players are merely left to imagine the note aurally, adjust the tension in the lips accordingly, and to hope for the best (Davies, 1978). Moreover, the sounds produced by wind instruments (especially woodwinds) are far more exposed and transparent than sounds of the stringed instruments (which are grouped together in such a way so that inaccuracies and oversights by a particular player go unnoticed). Wind-players often play on an individuals basis (as soloists) or in small ensembles (i.e., voiced parts as choirs) which have been penned or orchestrated for the purposes of coloration and contrast to the larger orchestra. As a result, wind-players may have developed specific aural skills, well in excess above and beyond those skills necessitated by string-players, as a result of the demand characteristics of their particular instruments. The purpose of the current research endeavor, then, was to explore intersectional group-differences (between string-players *versus* wind-players) related to the development of a particular aural skill — *Inner Hearing*.

Inner Hearing

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). The ability of musicians to experience musical images was first deliberated by Seashore in 1938 who believed that musicians create music by "hearing-it-out" as opposed to "picking-it-out" on an instrument. Referred to as *Audiation* by Gordon in 1976, Walters (1989) describes this process as "hearing music that is not before the ear at the moment through recall, prediction, or conception" (p.5). This is recognized as musical imagery. Music audiated during a given experience may have been triggered (i.e., brought into consciousness) by either external or internal sources. However, it is interesting to note that musical imagery can also be triggered by reading the graphic representation of music (i.e., musical notation). This phenomenon — referred to as Acoustic Picture, Mental Score (Raffman; 1993), Notational Audiation (Gordon, 1993), Silent Singing (Walters, 1989), or *Inner Hearing* — has been described as a "skill" that is learned. Campbell (1989) states that "whether the term 'inner hearing' or the term 'audiation' is applied, the result is that one using notation 'hears what he sees, and sees what he hears' once the skill has been developed" (p.304). While only a few authors have described this phenomenon to begin with, the existence of Inner Hearing has been challenged by some researchers. For example, during his study of music-reading, Sloboda (1984) reckoned that "there is no obvious way of assessing the claim" to begin with, and that "among the population of fluent music readers those who can read silently are statistically rare." Therefore, his conclusion is simply "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" (p.224). Yet, there are others who not only give credence to the presence of Inner Hearing, but conceptualize operational models with which the mechanics of this skill can be explained. For example, Gordon (1993) links this skill to phonological origins — a process of moving back and forth from aural to oral channels and modes of activity while sight-reading music notation.

In a recently published experiment, Walters, Townsend, and Underwood (1998) devised a task designed to measure the ability to convert visual representations into auditory representations. Subjects viewed a 'bar' of music for 10 seconds, immediately thereafter, were presented with an auditory musical stimulus which was either identical to the visual pattern or different. Subjects were then required to report whether these patterns were the same or different, as well as the locus of difference (i.e., differences of pitch, rhythm, etc.) The results indicated that expert sight-reading pianists were able to complete this task with 76% accuracy, while intermediate-skilled sight-reading

pianists completed the task with 63% accuracy, and the under-skilled sight-reading pianists completed the task with 62% accuracy. Accordingly, these findings not only demonstrate a significant main effect of *expertise*, but "provide evidence that skilled sight reading is associated with an ability to convert a visual representation of musical structure into auditory representation" (pp.142-143). Yet, the methodology used within this study is slightly problematic, and thus one might question the validity of these conclusions. Foremost, the sample used were university music majors who "had taken part in music training for at least five years" (p.128) — much less than even entry level for professional musicians. Therefore, the term "expert" can hardly be used in this context. The place of training and expertise in musical perception and imagery experiments has generated much debate within the research literature in the past few years. For example, Sergent (1993) openly attacked previous studies of this sort stating that the lack of musical training implies under-developed cognitive structures for the processing of music, and may result in perceptions, processes, and interpretations that may not exploit full music potentialities. Second, the experimental task utilized by Walters *et al.* can not be considered a valid measure of musical imagery. Halpern (1992) has called attention to the problem of presenting truly perceptual musical tasks in studies on musical imagery, as almost always some memory component will enter into auditory comparisons. In this regard, Deutsch and Pierce (1992) recommend caution in interpreting the results of experiments and demonstrations made with simplified, quasi-musical sound stimuli that are presented in a non-musical or barely musical environment or context. A single "bar" of music *frozen-in-time* for 10 seconds hardly seems to constitute a challenge, nor reflects the type of temporal stimuli that musicians deal with on a day-to-day basis which might indicate their real-world musical skills involving Inner Hearing. Moreover, Walters *et al.* fail to touch upon the core problem of the issue at hand — separating the visual surface cues evoked when sight-reading musical notation, from the aural representations or Inner Hearing.

The issue raised by Walter *et al.* (1998) is, nevertheless, a very important one. Therefore, we utilized a different design to study this question. With an experimental approach developed by Brodsky

(Brodsky & Henik, 1997a; 1997b; 1998a; 1998b; Brodsky, Henik, Rubinstein & Zorman, 1998) the existence of Inner Hearing was not only confirmed through a tightly controlled empirical demonstration, but the findings provide initial conceptual data about the very nature of this skill itself. Recruiting samples of highly-trained expert musicians, Brodsky *et al.* were able to tease-out the aural skills (required to mentally hear a score) from the visual skills (involved in sight-reading). By exploiting music-compositional techniques, melodies were arranged and presented such, that subject iden- tification of the original musical theme relied solely on their aural skills. This manipulation has been referred to as an *Embedded Melody*. The unique contribution of Embedded Melodies to the demonstration of Inner Hearing, and their interface within an articulatory suppression concurrent interference paradigm, have been accounted for elsewhere (Brodsky, Henik, Rubinstein, & Zorman, submitted). To demonstrate the developed skill of Inner Hearing, subjects were presented melodic variations and asked to judge if a theme (presented aurally) matched the melodic source embedded in the text (previously read silently). As we have defined Inner Hearing a process involving articulatory kinesthetic-like cues linked to the phonological system, it follows that concurrent phonological interference (i.e., articulatory suppression) would greatly reduce successful completion of the experimental task. We hypothesized that under normal conditions (non-distracted sight-reading) highly-trained expert musician subjects would be able to successfully complete tasks requiring them to match a musical theme (heard aloud) to a score of an Embedded Melody (read silently). Further, we hypothesized that combined rhythmic distraction (tapping the pulse beat and hearing an extraneous task-irrelevant rhythmic pattern during sight-reading) would hamper, but not significantly interfere with successful task completion. In contrast, we hypothesized that articulatory suppression (singing a song aloud during sight-reading) would cause notable interference with task completion, and result in significantly increased reaction times and error rate. The study found that while the general effects of interference hampered Inner Hearing, articulatory suppression specifically impaired Inner Hearing (more significantly than did rhythmic distraction).

Studies highlighting individual differences among musicians, specifically in regard to their aural skills related to musical notation, have already been carried out. For example, Banton (1995) studied sight-reading under three feedback conditions. Her findings indicate that the way in which auditory feedback is used by the performer correlates with their level of expertise. That is, because less skilled sight-readers are unable to formulate a clear mental representation of the performance prior to attempting to play the music, they utilize auditory feedback more to confirm the correctness of their playing. Hallam (1995) outlined analytic/holistic strategies which are used in acquiring an overall conception of the work before detailed practice begins. She demonstrated that adoption of this approach depends entirely on whether or not musicians are able to formulate an internal aural representation of the music without actually hearing it. Finally, Brodsky and Henik (1997a; 1997b; 1998a; 1998b) and Brodsky *et al.* (1998) found vast differences of Inner Hearing affiliated with mode of activity within the music profession. Accordingly, under-developed Inner Hearing skills may be the price paid when straying off the performance-track. Music Teachers and Musicologists undertake numerous hours of class-room learning, develop extra-musical skills involving pedagogy, methodology, and research, as well as invest a substantial amount of time in practicum and fieldwork experiences. This regimen leaves little room for daily performance practice, ear training, sight-singing, and dictation — all of which contribute to the general development of aural skills including Inner Hearing. Yet, none of these studies investigated differences of Inner Hearing among samples of equal expertise; all were based on *between-groups* comparisons of different musicians-samples according to their established level of skill. Therefore, the current research mandated the recruitment of seasoned professional symphony orchestra players as a homogeneous population, with equal levels of expertise, in order to explore the effects of instrument type as a *with-in group* variable.

2. The study

Subjects

Thirty-two (N = 32) contract players from two symphony orchestras in Israel participated in the experiment. The subjects were recruited via on-site visits to the rehearsal halls of both orchestras by the first author. Three cases were dropped from the sample because they were not members of either string or wind sections. Therefore the final sample of the current study (including all subsequent discussion and analyses) reflect a cohort of twenty-nine (n = 29) musician-subjects. Of the twenty-nine subjects, seventeen (58.6%) were string-players [1stVln = 7; 2ndVln = 3; Vla = 3; Vcl = 2; CtBs = 2], and twelve (41.4%) were wind-players [FrHr = 3; Trpt = 1; Ob = 2; fl = 2; Bssn = 2; Trom = 2]. The average age of the sample was 46 years old (sd = 10.6; range = 25-65), and there were twice as many men than women (m = 20; f = 9). Only 17% of the players were native-born Israelis, while the rest immigrated from a host of countries including Russia (40%), Romania (21%), USA/UK (28%), and Eastern Europe (7%). However, it should be pointed out that these players had already resided in Israel for an average 19 years (sd = 9.44; range 3-33 years). Thus, we expected that the sample had previous exposure to Israeli culture including folk-pop song repertoire. In general, the sample reported 16 years of formal instrumental study (sd = 4.75), and 11 years of formal ear-training (sd = 4.32) which took place between age 12 (sd = 4.99) and age 22 (sd = 3.75). No statistically significant differences were found between the two subgroups participating in the study with the exception of their reported years of formal instrumental training (strings = 17.76, winds = 12.58; $t = 3.57$, $df = 26.87$, $p < .001$ 2-tailed). Finally, half of the sample (48%) reported to have completed their formal education with an undergraduate degree, while the another half was split between Artists/Teachers Diplomas (17%), graduate degrees (31%), and post-graduate degrees (4%).

Stimuli

Fifty melodies were selected at random by the fourth author (an Israeli composer). The themes were either popular symphonic or operatic sources (from Barlow & Morgenstern, 1975), or contemporary Israeli folk/pop songs (from Klausner & Zur, 1988). The melodies chosen were rewritten as variations-on-a-theme (referred to amongst music theorists as Musical Theme and Variation Form) using compositional and arrangement techniques, including: embellishment through quasi-contrapuntal treatment of the original text; displacement of registers; melodic ornamentation; and rhythmic augmentation/diminuation. In all cases, the original melodic theme, phrase structure, and harmonic plan remained intact as scaffolding. Both versions (original theme and arranged variation) were recorded with a 4-octave touch-sensitive MIDI keyboard controller (*Fatar Studio 49*) and MIDI Sequencer (*Power Traks Pro, V3*). These were edited for audio glitches and graphic presentation with a music composing and publishing package (*Encore, V4*). The arrangements were recorded and transcribed in the tonality, key signature, meter, and tempo as found in the original sources. All texts were presented as G-clef single line melody, with stems in an upwards direction, placed in standardized measure widths, with an average melody length extending to twelve bars (range 8-16 bars). No other markings or graphic features were present in the texts. See Figure1.

The final scores of both versions were evaluated by the third author (an instructor of Ear Training and Music Theory) who was originally blind to the objectives and goals of the study. The evaluation was made with respect to: (1) level of difficulty pertaining to goodness of fit (as a set of items); and (2) deficiencies within initial measures (i.e., inclusion of a pick-up note). Four melodies were judged unsuitable according to the first criteria, while eighteen melodies were judges unsuitable according to the second criteria. As a result, twenty-two melodies were dropped from the final item pool. The remaining twenty-six melodic pairs were matched to a *Melodic Lure*. A melodic lure is a theme which is similar in local surface cues to the original theme (such as direction, texture, opening interval, rhythmic pattern, meter, tonality, and key signature), but is clearly different than the former melody. Melodic lures were also recorded and edited in a similar fashion as the original themes and arranged variations. Each set of three melodies (i.e., original theme, arranged variation, and matched melodic lure) were randomly placed in an ascending presentation order; the first twenty four sets were selected for presentation within the experiment, while the final two sets were designated as items for practice trials.

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

Design and Test Presentation

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). In total, there were twenty-four trials. Each of the twenty-four arranged variations was presented as a pair, with either the original theme or with its matched melodic lure — referred to as *rendition*. Rendition type (i.e., A = arranged variation + original theme; B = arranged variation + melodic lure) was also assigned at random. Presentation of the experimental stimuli utilized a *split-half* design whereby half of the subjects received Test-Version I consisting of twelve arranged variations paired with the original theme and twelve arranged variations paired with a matched melodic lure, while the other half received Test-Version II (which was a mirrored-rendition version). In addition, item sequence order was rotated to balance all biases linked to presentation order; every other subject received either ascending or descending order.

Apparatus

Stimuli were presented on a 17" *IBM* color monitor. Stimuli

presentation and data collection were controlled by an *IBM* Pentium 166 Hz personal computer, with a 16-bit *SoundBlaster* sound card (*Creative Labs Inc.*) and two stereo speakers. All experiments were designed and executed with *MEDS 97-16* (Music Experiment Development System) developed and supplied by Roger A. Kendall of UCLA (Kendall, 1997; Kendall & Carterette, 1992).

Procedure

Each experiment ran for approximately forty-minutes consisting of four segments, including: a short briefing, completion of a one-page questionnaire, two practice trials, and twenty-four trials of a music cognition task. On a typical trial, a subject was exposed to a sequence of events. First the notation of the arranged variation appeared on the computer monitor screen and stayed in view for as long as needed (but not more than one minute). Previously the subjects had been directed to read the arranged variation in its entirety and not to focus exclusively on the first few measures. When the subject finished reading, he or she verbally acknowledged completion to the experimenter (the first author) who closed the notation text file. 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. The subject indicated his or her answer by keypress; depressing the allocated "O" key for the Original Theme, or "N" key for Not Original Theme (in the event that a matched melodic lure was presented). Each subject was asked to press the appropriate key as fast as possible and not make errors. Reaction Times (RTs) were measured from the onset of the heard melody to the subject's keypress in milliseconds. Throughout the experiment, the experimenter observed and documented each subject's demonstrated *on-task* behavior specifically targeting vocal and motor responses during the silent reading.

Results

For each subject we computed the Success Rate and Median Reaction Time (RTs) of the correct responses. In general, the wind-players demonstrated successful task completion within a shorter period of time (RTs) than did the string-players. That is, they were faster at correctly

Table. 1. Intersectional differences of inner hearing task among orchestra players

	Number of correct items*						Reaction times			
	Mn	Sd	Range	%	Range	P	Mn	Sd	Range	P
Strings	15.5	2.26	12-19	64	50-79		11,130	5,307	4,074-21,541	
Winds	17.0	3.65	12-22	70	50-87	NS	6,540	1,123	5,111-7,626	.003

Total number of subjects N = 29 (Strings = 17; Winds = 12)
*Maximum number of correct items = 24

matching between melodies heard aloud and music-notation previously read silently. See Table 1. Moreover, the results indicate that differences of mean reaction times between these two sub-groups were statistically significant ($t = 3.46$, $df = 17.99$, $p < .01$ 2-tailed).

In order to rule-out that the above differences may simply be an artifact of superior expertise by one of the two wind instrument types participating in our generic "winds" subgroup, we subjected the data to post-hoc analyses. The results of analyses between the brass (n = 6) and woodwind (n = 6) players indicated non-significant differences in neither their mean reaction times (brass: mn = 6,976 sd = 561; woodwinds: mn = 6,105 sd = 1,417) nor their mean number of correctly matched melodies (brass: mn=16.6 sd = 3.6 [69% success rate]; woodwinds: mn = 17.3 sd = 3.9 [72% success rate]).

Data from the self-report assessments of the musicians seems to point at interesting though non-significant trends. Using a 4-point Likert-scale (1 = not at all; 2 = below average; 3 = average; 4 = above average), the musician-subjects ranked the perceived confidence they had in their music skills, including: sight-reading, inner hearing, short-term musical memory, on-line music theory analysis, and principal approach to learning new repertoire. In general, we found that those musicians who ranked their sight-reading, inner hearing, and music memory skills "above average" did in-fact demonstrate greater success in task completion than musicians who lacked confidence in these skills. See Table 2. Moreover, self-assessments of sight-reading abilities were highly significantly correlated with self-

Table 2. Self-assessed musical of skills: relation to success rates

Area of self-assessment	Rank	Number of correct items* Mn	Sd	# Cases
Sight-reading	Below average	12.0	0.00	1
	Average	15.6	2.33	11
	Above average	16.7	3.71	17
Inner-hearing	Below average	14.0	0.00	1
	Average	15.3	2.69	9
	Above average	16.6	3.05	19
Musical memory	Below average	13.0	1.41	2
	Average	15.8	2.45	16
	Above average	17.2	3.37	11
Learning strategy	Listens to piece on CDs	13.0	0.00	1
	Plays through whole piece	15.0	2.40	4
	Silently-reads aarts of piece	15.8	3.90	9
	Silently-reads whole piece	16.8	2.29	15

*Maximum number of correct items = 24

assessments of inner hearing abilities (*Spearman* $R = .67$, $p < .000$); self-assessments of sight-reading abilities were significantly correlated to self-assessments of short-term music memory abilities (*Spearman* $R = .42$, $p < .025$); and self-assessments of short-term music memory abilities were almost significantly correlated to self-assessments of inner hearing abilities (*Spearman* $R = .35$, $p = .059$). Further, it is interesting to note that those musicians demonstrating higher success rates of task-completion reported that their primary learning strategy when learning a new piece involves silent score-reading (rather then learning strategies involving playing through the entire piece at first-seating). Perhaps, those musicians who do not easily cue the aural representations from the notated text find themselves to be disadvantaged. Hence, by creating an initial performance or listening to pre-recorded CDs — both externalized auditory presentations — the musicians are able familiarize themselves with the piece prior to

Table 3. On-task exhibited vocal behaviors: relation to RTs

Area of observed behavior	Type	Reaction times Mn	Sd	# Cases
Vocal output	Vocal (external voice)	19,504	0,000	1
	Sub-vocal (barely audible)	12,181	5,617	9
	None (internal voice only)	7,293	2,416	19
Vocalization type	Combination of external sounds	19,769	0,000	1
	Whistling (external voice)	16,891	4,828	4
	Lahling (sub-vocal sounds)	8,543	2,319	4
	Humming (sub-vocal sounds)	7,626	0,000	1
	None (internal voice only)	7,293	2,416	19

the onset of formal practice. This trend supports Hallam's (1995) findings presented above.

However, perhaps the most interesting additional data collected in the current study regards the documented observed behavior of the musician-subjects as exhibited during the experimental task itself. In general, the musician-subjects who read the presented notation in absolute silence were able to complete the experimental matching task more quickly (i.e., lower RTs) than those musicians who externalized the sound via vocal output (Spearman $R = .55$, $p < .01$); and these differences were statistically significant [$F(2, 26) = 9.2779$, $p < .001$].[2] Further, among the musicians who required some form of vocalization to enhance their ability to convert visual representations to auditory representations, those who utilized sub-vocal vocalization types (mouthing patterns which were barely audible) were able to complete the experimental matching task more quickly than those musicians who utilized audibly vocalization types (Spearman $R = .48$, $p < .01$); and these difference were also statistically significant [$F(4, 24) = 13.23$, $p < .000$]. See Table 3.

3. Discussion

The current research endeavor highlights differences of developed

aural skills (Inner Hearing) among symphony orchestra musicians differentiated by the instrument section with which they perform. Most specifically, the intersectional group differences highlighted in the study focus on string-players compared to wind-players. Unlike previous studies which have highlighted such differences among these two sub-groups based on personological investigation or comparisons, the current study uses an empirically-based and tested music cognition matching task specifically designed to tap the aural skills utilized in silent sight-reading. It is interesting to note that in spite of the facts that our string-players reported to have had statistically significantly more years of formal instrument lessons (strings = 17.76, winds = 12.58; $t = 3.57$, $df = 26.87$, $p < .001$ 2-tailed), as well as having had several more years of formal ear-training (strings = 12.23, winds = 9.66) which began at a earlier age (strings = 10.6; winds = 14.5), the wind-players still appear to have developed Inner Hearing to a higher degree than string-players. It should be pointed out, however, that while wind-players begin their ear-training at a later age, they remain in formal ear-training classes till they are older (strings = 21.8; winds = 23.2). When attempting to interpret these findings, we sought to find biases based on levels of expertise and developed musicality (reported by the musicians themselves). However, non-significant differences surfaced from the analyzes — both musician subgroups reported near identical self-assessments of their developed musical skills and abilities, including: sight-reading, inner hearing, short-term musical memory, on-line music theory analysis, and principal approach to learning new repertoire. Therefore we have ruled out differences of instrumental expertise or musical development as biases in favor of the wind-players as an explanation of our major finding.

We have noted that in a previous study Kemp (1996) found idiosyncratic differences among brass-players. Accordingly, unlike all other instrumentalists who demonstrate higher levels of *pathemia* (described as tending to live at the level of feelings and affect), brass-players demonstrated *cortia* (described as indicating quick activation times and an alert and energetic disposition). Kemp concluded that these findings indicate fundamental differences in cognitive styles between brass-players and all other instrumentalists (including woodwind players). However, our comparisons between between brass-players and woodwind-players suggests that no such difference exists (certainly not regarding their on-task reaction times). Therefore, we have ruled out cognitive or motor activation advantages or biases in favor of the brass-players as an explanation of our major finding.

Our major finding confirms, that as a group, wind-players are not only successful in matching heard melodies to texts read silently, but that they complete the this task in a more timely fashion than string-players. This is an indicator of the level to which their Inner Hearing has been developed. We can only surmise that this development might occur either as a result of inherent demand characteristics of the instruments themselves, or as a result of specific strategies and operations utilized over a long-term practice and training regimes (encompassing approximately 10,000 hours from an early age).

Two overriding measures were utilized throughout the study — success rate and reaction times. We can not but note that in all cases, differences between the sub-groups (and the total sample) based on success rates were found to be non-significant. We feel that highly-trained and expert samples will eventually arrive at the correct answer on any task within their domain of expertise. After all, they are expert! This has not been the case, however, in research studies that have recruited samples of naive musicians (for example, Walters *et al*, 1998). Nonetheless, it appears to us that a more robust and perhaps sensitive measure for *with-in group* differences among musicians is reaction time (RTs) — especially as these tap cognitive processes. Therefore, we feel certain that music perception and cognition studies that do not utilize paradigms and methodologies involving reaction times may come up short-handed.

Previously we alluded to the interesting data surrounding vocal output and involvement during sight-reading. Brodsky, Henik, Rubinstein, and Zorman (submitted) have hypothesized that Inner Hearing is a process of silent singing cued by musical notation, resulting in detectable auditory perception and loading of the "inner ear," generated by kinesthetic-like cues linked to the phonological system. In order to confirm this theory, we have conducted several studies using an articulatory suppression concurrent interference

paradigm. Brodsky and Henik (1997a; 1997b; 1998a; 1998b) and Brodsky, Henik, Rubinstein, and Zorman (1998) presented findings that clearly demonstrate how the skills of Inner Hearing become impotent under conditions involving vocal output (singing during sight-reading). Thus, finding that those symphony orchestra musicians who whistled or vocalized more audibly did in-fact elevate the amount of time (and cognitive processing) required to complete the matching task, supports our previous findings. Moreover, we find that the majority of musicians (across both sub-groups) seem not to exhibit vocal output during sight-reading at all. As clearly this is a more advantageous requisite for Inner Hearing skills, it just may be that this is something musicians have had experience with and already know about — at least intuitively.

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Notes

1. This study has been presented previously. For more details see: Brodsky, W. & Sloboda, J. A. (1997). Clinical trial of a music generated vibrotactile therapeutic environment for musicians: main effects and outcome differences between therapy subgroups. *Journal of Music Therapy*, *34*, 2-32.
2. These results were statistically significant also when we took out the subject groups with only one participant [vocal output: F (1, 26) = 10.6083, $p < .01$; vocalization type: F (2, 24) = 19.1430, $p < .000$].

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XXI. Memory for Japanese Pop Songs with Different Styles: Role of Combination of Text with Melody

Hiromichi Mito & Tadahiro Murao

1. Introduction

Recent studies have shown that the different experiences to music results in developing particular cognitive skills needed to memorize different styles of music. Oura and Hatano (1988) pointed out that the same subjects showed different results in music recall tests according to the style of music. In the experiment, although the subjects with abundant experience of western music showed high performance in memorizing western music, they were not able to memorized Japanese music. Mito and Oura (1996) found that easily memorized songs were dependent on the degree of familiarity of melodies to the subject. The subjects who often sing or listen to the current pop songs could memorize the pop song with the current style accurately. On the other hand, the subjects whose main musical activity was limited to classical music were not able to memorize the pop song with the current style. These results show that music knowledge seems to be organized by each style of music.

Although the studies on the memory of various styles of music indicated that the music knowledge accumulated by persons differed according to their habitual experience and training in music, the kind of difference in structure of the piece that affects the memory has not been made clear. Moreover, in the memory for song, the effects of the combination of the text with melody have not been solved as well. There is empirical evidence that melody and text appear inseparable