Automatic Auditory Processing of Musical and Phonemic Sounds: Differences Between Musicians and Nonmusicians

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(ABSTRACT)

The present study examined the ability of musicians and nonmusicians to preattentively process musical and phonemic information, as assessed by mismatch negativity (MMN). Participants were musicians (N=22) and nonmusicians (N=22). Auditory stimuli (60dB) in an oddball paradigm (80% standard, 20% deviant) were presented in four conditions (500 stimuli each): chord, phoneme, chord interval, and tone interval. MMN was seen significantly more often among musicians during the presentation of chords, with no evidence of MMN distribution differences during phonemic processing and interval processing. During the tone interval condition, musicians had a greater MMN peak amplitude in the central region, and a greater MMN mean amplitude in the anterior frontal, frontal, frontocentral, and central regions. This did not emerge in the chord, phoneme, or chord interval conditions. During the phoneme condition, MMN latency was shorter for musicians than nonmusicians and differed in hemispheric dominance in the frontocentral region. No differences were found for MMN amplitude in the phoneme condition. Consistent with Koelsch, Schröger, and Tervaniemi (1999), musicians were more likely to exhibit an MMN than nonmusicians in the chord condition. Finally, there was the expected stronger preattentive processing in the right hemisphere MMN for the musical stimuli. Unexpectedly, there was a stronger right hemisphere bias for phonemic stimuli.

This thesis is dedicated to

Mom, Dad, and Michael

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Overview

Understanding differences in attentional processes in humans has been a topic of neuroscience research for many years. Of particular interest is the automatic processing of information that occurs prior to perceptual awareness. This type of processing occurs out of awareness and is often considered to be independent of attentional effort.

Differences in early sensory processing of auditory information between musicians and nonmusicians have been observed in a limited number of studies. Mismatch negativity (MMN), the difference between event-related potentials (ERPs) following two stimuli (a common standard stimulus, and a rare deviant stimulus) in an oddball paradigm provides a physiological measure of sensory information processed by the brain (Näätänen, 1992). The MMN is believed to reflect a neural code of a difference between two dissimilar stimuli. Recently, it has been found that preattentive automatic processing in musicians, as assessed by MMN, is superior to that of nonmusicians (Koelsch, Schröger, & Tervaniemi, 1999).

The purpose of the present study is to examine the automatic processes of musicians compared with nonmusicians for not only musical but also nonmusical auditory stimuli. It is proposed that musicians' automatic processing of auditory stimuli is superior to that of nonmusicians.

Automaticity and Preattentive Processing

Processing is automatic when it occurs involuntarily, without awareness and without interfering with other ongoing mental activities (Posner & Snyder, 1975). While attention does increase the presence of a response to certain stimuli (for review, see Sokolov, Spinks, Näätänen, & Lyytinen, 2002) the fact that it occurs either in the presence or the absence of attention qualifies the process as being automatic. If processing for specific stimuli is automatized, it is fast and difficult to suppress. The cocktail party effect is an excellent example of automatic processing. The sound of one's own name amid multiple complex sounds will capture an individual's attention. This is evidence for a level of sensory vigilance that will influence a person's behavior only under certain conditions. Hence, focused attention is not required.

Broadbent (1958) proposed a filter theory of attention based on a series of dichotic listening tasks. He stated that stimuli are temporarily stored and analyzed for physical properties at a preattentive level (the S-system). The preattentive level serves as a filter for which only certain relevant stimuli may pass on to a higher level processing stage (the P-system). He further stated that the information stored in this preattentive level was temporally limited and that it would escape the preattentive level when the time expired without ever influencing the behavior of the individual. While this construct of preattention is commonly evidenced in the literature, it is a misnomer. The term “preattention” implies a moment when there is an absence of attention. However, in tasks examining “preattention”, a person is not truly experiencing a lack of attention, the attention is just placed away from certain stimuli (for example, visual rather than auditory) so it is out of awareness. Therefore, there is not a truly “preattentive” level but rather a stage of sensory evaluation at which point it is determined whether attention should be drawn to that specific stimuli.

Evolutionarily, automatic processing is necessary for survival. It alerts an individual of relevant information in the environment without requiring constant vigilance. It can serve as an alerting system for potentially dangerous situations by informing the individual of a change in his/her environment by eliciting an orienting response (OR). The OR is an automatic process that is influenced by the level of attention; more attention allotted to the task facilitates a stronger OR (Sokolov et al., 2002).

Automatic processing can be influenced by a number of factors. For instance, automatic processing has been found to improve with practice (Schneider, Dumais, & Shiffrin, 1984). Tasks such as walking, talking, driving a car, typing, and playing a musical instrument each involve a progressive level of expertise. When first engaging in these tasks, a large amount of effort and focused attention must be expended in order for the task to be carried out. With practice, however, many of these tasks reach a point when very little effort and attentional resources must be allocated to perform the task. These tasks reach a level of automaticity that comes with increased exposure and practice. It is the same for processing auditory information. For instance, if a person changed her name, experience with the new name is necessary before the cocktail party effect is seen. Such is the case for musicians with musical stimuli, as is discussed in the next section.

Trained Musicians: Neuropsychophysiology Perspectives

Musicians are individuals who are trained in the creation of music through composition or performance of a musical instrument, including voice. They are trained to listen to and evaluate complex auditory stimuli. Music is an art that exists in a single moment. When a note stops resonating, when a phrase is spent, and the piece is complete, it no longer exists in the physical world. Musicians are trained to hear and understand as much as possible during the fleeting time that music is physically present. Musicians undergo ear training in which one learns to recognize the relationships between notes as well as other elements of music such as timbre, rhythm, and melody. This extensive training in the rapid evaluation of musical auditory information may have consequences on the organization and anatomy of brain structure. In fact, several differences in laterality for musical perception, brain anatomy, and brain physiology have been found between musicians and nonmusicians.

Hemispheric differences between musicians and nonmusicians.

It is a general statement and a common finding that musical processing is a function of the right auditory cortex whereas verbal processing is a function of the left auditory cortex (Tervaniemi et al., 2000). This is, for the most part, true. However, studies indicate that both hemispheres perform necessary functions in the processing of both types of stimuli. This is because musical and verbal information share similar physical properties. Sentence structure is similar to phrase structure and prosody is similar to melody, but these are only similarities. It must not be assumed that music and language are identical (Sloboda & Gregory, 1980); they are not identical and this fact is reflected in the neural processing of each. It is suggested that because studies usually define music as the presentation of pitch in isolation, embedded in chords, or structured as melodies and that few studies have considered elements other than pitch such as rhythm, timbre, or intensity, it is assumed that music is a right hemisphere structure (Liegeois-Chauvel, C., Peretz, I., Babai, M., Laguitton, V., & Chauvel, P., 1998). It may be that the processing of pitch is a right hemispheric function, but not the processing of music as a whole. Studies of brain-damaged patients (Peretz, 1990, Peretz & Kolinsky, 1993) that isolate musical elements rather than trying to assess music globally have determined that some elements are processed in the right hemisphere (for example, pitch) and others are processed in the left (for example, rhythm). This has been found to be true for musically untrained individuals, but as the level of musical expertise increases, the processing of music becomes less asymmetric due to the different strategies of music appreciation used that recruit left hemispheric functioning (Bever & Chiarello, 1974).

Qualitative differences between musicians and nonmusicians have been demonstrated using dichotic listening tasks. Dichotic listening tasks are common paradigms for addressing the topic of hemispheric differences between groups. In this paradigm, two sets of monaural auditory stimuli are presented simultaneously; the left ear receives a different set of stimuli than the right ear. This paradigm assumes that information received by one ear is predominantly projected to the contralateral hemisphere for processing (Sergent, 1993). Participants are instructed to attend to both ears and to report what information is perceived.

Using the dichotic listening paradigm, Messerli, Pegna, and Sordet (1995) found that musicians had a right ear advantage (left hemisphere) when music was played at a fast tempo whereas nonmusicians showed a left ear (right hemisphere) advantage under the same condition. They concluded that both musicians and nonmusicians use their right hemisphere in the processing of musical information, but certain conditions allow musicians to use the left hemisphere for processing musical information. This could be because musicians are trained to critically analyze musical information and nonmusicians are not; therefore, the sequential analytic processing may be more of a left hemispheric function.

In another study, Brancucci and San Martini (1999) studied nonmusicians with both a monaural and a dichotic listening test. In the dichotic test, participants matched a monaural probe tone to one of the preceding dichotic pair of tones. In the monaural test, participants matched one of the pair of dichotic tones with a target monaural tone. Their results indicated that a left ear (right hemisphere) advantage is produced by both the dichotic and monaural tests when sound discrimination is made on the basis of timbral (musical) cues. This further supports the proposal that musically untrained individuals demonstrate a right lateral preference for processing musical information (defined as tones and timbre).

Anatomical & physiological differences in the brain. Musicians and nonmusicians seem to differ not only in brain organization as indicated by laterality differences, but also in brain anatomy and physiology, as well. For instance, Pantev et al. (1998) used functional magnetic resonance imaging to measure the cortical activation in expert musicians. Dipole moments for musicians listening to piano tones were enlarged by 25% compared with nonmusicians who had never played an instrument. Results suggested that musicians have increased auditory cortical activations compared with nonmusicians. This implies a greater allocation of cortical areas for the processing of auditory information in musicians, possibly because of training.

Schlaug, Jäncke, Huang, and Steinmetz (1995) demonstrated that the planum temporale, an area of the brain containing auditory association cortex that coincides with Wernicke's area, was more left lateralized (and larger) in musicians than in nonmusicians. They posited that much of the variance could be explained by those musicians possessing absolute pitch (AP). Furthermore, morphometry also found that the left planum temporale in musicians was significantly larger than that of normal right-handed subjects (musical skill was not identified) (Zatorre, Perry, Beckett, Westbury, & Evans, 1998). The left planum temporale is generally larger in the left hemisphere compared with the right hemisphere within an individual, but these findings indicate that it is larger in the musicians' left hemisphere compared with nonmusicians' left hemisphere.

Using morphometry of in-vivo magnetic resonance images, Schlaug, Jäncke, Huang, Staiger, and Steinmetz (1995) reported that the anterior half of the corpus callosum in musicians was significantly larger than that of nonmusicians. The corpus callosum is responsible for interhemispheric transfer of information, so this may be an explanation for the greater hemispheric symmetry in musicians compared with nonmusicians.

Absolute pitch

Absolute pitch (AP) is the ability of an individual to accurately name a musical tone in the absence of any reference tones (Ward, 1999). Individuals possessing this ability comprise less than .01% of the general population, but it is found more frequently within musicians

(Takeuchi & Hulse, 1993). The source of this ability is unknown, but arguments have been made for its innateness and/ or for the possibility that one may be trained in the ability (Ward, 1999). Whether or not AP is something that can be learned or something that only certain people will ever possess remains to be discovered.

It has yet to be determined whether AP is a genetic ability or whether it can be learned. Since only a very small percentage of the population has AP, it is a difficult variable to examine. On the other hand, most, if not all, musicians possess relative pitch (RP). RP is the ability to name a note when given another tone with which to compare it.

In studies of auditory evoked potentials (EPs), differences between AP possessors and nonpossessors have been observed for the P300 component (Barnea, Granot, & Pratt, 1994; Klein, Coles, & Donchin, 1984; Hantz, Crummer, Wayman, Walton, & Frisina, 1992). The P300 is evoked by new or deviant stimuli and is thought to reflect the neural manifestations of the updating of working memory (Hantz et al., 1992), whose peak amplitude occurs 250-500 ms after the onset of a novel stimulus but not a standard stimulus.

The distribution of underlying brain activity appears to be different between participants with absolute pitch (AP) and those with relative pitch (RP) as evidenced by research of the P300 (Barnea et al., 1994). When presented with auditory notes that were followed by a visual probe note, those participants possessing AP had significantly faster reaction times and were significantly more accurate at change detection than subjects with RP. When an auditory probe followed the visual notes, participants possessing AP had significantly greater accuracy than participants with RP. Furthermore, the P300 of participants with AP had a negative amplitude at frontal and central electrode sites while participants with RP had very small positive amplitudes at parietal sites during the presentation of a reference piano tone and human voice. In response to comparison stimuli, the P300 amplitudes of AP possessors were much larger at frontal, central, and parietal sites for piano tones than for human voice stimuli and much larger than the response of RP possessors in either condition.

It was postulated that people who possess AP do not produce a P300 when processing tones (Klein et al., 1984). However, another study considering the effects of musical training and AP on the neural processing of melodic intervals produced somewhat different results. Hantz et al. (1992) found that musical training increased the amplitude and decreased the latency of the P300 while the possession of AP shortened the latency and only decreased, not eliminated, the amplitude of the P300 .

Oddball Paradigm

The passive oddball task permits the study of selective attention through the assessment of ERP brain responses to ignored relevant and irrelevant stimuli. The task involves ignoring the auditory stimuli, often while attending to stimuli in another modality. This paradigm captures the potentially alerting response to a novel occurrence in one's environment through automatic change detection (Näätänen, 1992). When a series of frequent stimuli is interrupted by a deviant stimulus, a mismatch negativity (MMN) is produced. The MMN is the difference between standard and deviant ERPs following a stimulus that is deviant among frequent stimuli. It begins about 100 ms after the onset of a deviant stimulus and continues until about 250 ms after the onset of the stimulus (Näätänen, 1992). Deviances in intensity, frequency, tempo, spatial origin, phonemes, and omission of stimuli are all known to elicit an MMN (for reviews, see Näätänen, 1992; Sokolov, et al., 2002).

Many physical properties of auditory stimuli will elicit an MMN. Several studies have shown that temporal deviances elicit a clear MMN. For example, Ford and Hillyard (1981) found that MMN-like negativities could be produced by deviances in the timing, or tempo, of the occurrence of an auditory stimulus.

Nordby, Roth, and Pfefferbaum (1988a) compared the ERPs elicited by infrequent pitch-deviant and time related tones under different attentional treatments (button press to odd pitch, early ISI, or read). They found that the mismatch negativities elicited by deviations in ISI are qualitatively the same as the mismatch negativities elicited by deviances in pitch.

In a later study, Nordby, Roth, and Pfefferbaum (1988b) found that the neuronal system that triggers a MMN can encode the temporal ordering of pitches. To determine this, they presented participants with tones alternating between 500Hz and 1000Hz with a constant ISI of 800 ms and 400 ms. MMNs were elicited by a deviance in the ISI between repeated tones. MMNs were also elicited by deviant pitch patterns, or tones. Since this system encodes both pitch and tempo, deviations in each will elicit an MMN.

Koelsch et al. (1999) examined the elicitation of MMNs in musicians and non-musicians using chords and single tones. Eleven expert musicians (violinists trained for professional purposes) and eleven music novices (lacking musical expertise) were exposed to five treatment conditions. In the first condition, participants read a self-selected book while auditory chords were presented in the oddball paradigm. Participants were instructed to ignore all auditory stimuli. They were not told of the occurrence of deviant stimuli. In the second condition, participants were presented with auditory chords in the oddball paradigm but were instructed to attend to them and to detect the deviant impure chords among the common pure chords. Participants indicated detection of a deviant chord by pressing a response button. In the third condition, participants were once again presented with auditory chords in the oddball paradigm, but were instructed to ignore the auditory stimuli and to read a self-selected book. The fourth condition attempted to determine the preattentive ability under ignore conditions when the deviant tone was not embedded in a chord. Finally, the fifth condition consisted of single tones with large frequency differences between the common and deviant tones and served as the control condition.

No nonmusicians reported detecting an impure chord, and only six of the eleven violinists recognized the occurrence of an impure chord during the first condition. The MMN was elicited in musicians, regardless of whether or not they reported recognizing the presence of impure chords, but nonmusicians demonstrated no MMN. In the second condition, musicians demonstrated superior auditory discrimination while attending to the stimuli. Musicians detected 83% of the impure chords, whereas nonmusicians detected only 13%. ERPs revealed that in addition to a distinct MMN, an N2b-P3 complex was elicited in nonmusicians. This complex reflects higher cognitive processes associated with conscious detection and evaluation of deviant stimuli. In condition three, nonmusicians still showed no MMN, while musicians did. The authors reported that no N2b-P3 complex was present in this condition indicating that musicians were truly ignoring the auditory stimuli. The fourth condition demonstrated an effect for stimulus type where MMNs were elicited in both groups, but no interaction was found. Hence, nonmusicians were able to detect an impure single tone when not embedded in a chord. The fifth condition was truly a control condition as the MMNs between musicians and nonmusicians were statistically identical. The authors, therefore, concluded that musicians have a superior preattentive ability for musical stimuli relative to nonmusicians. They further postulated that the long-term experience present in musicians is able to modify preattentive neural memory mechanisms and that this is responsible for their superior preattentive ability.

The results of this study raise interesting questions regarding the methodology utilized. The authors reported that the MMN occurred 300 ms after stimulus onset. Based upon a review of the literature, Näätänen (1992) states that the MMN peaks between 100 and 150 ms. This suggests that Koelsch et al. may not have identified a component other than the MMN. Their "MMN" does not meet the criteria as it is accepted in the literature. Furthermore, their MMN was potentially confounded as the ISI was only 300 ms, thus, overlapping of late and early ERPs may have occurred. Regardless, the underlying theory for their investigation does have a solid foundation. Given the support for neurological differences between musicians and nonmusicians, and the theory of the influences of practice on automatic processing, musicians should exhibit superior preattentive automatic processing compared to nonmusicians.

In past research, the group "musicians" has been loosely defined and is diverse among the literature, from one who plays a musical instrument or sings with no formal training to one that has played any instrument for at least one year, to one who specifically plays the violin professionally. There is a lack of one common definition for the group "musicians"; therefore, it is difficult to compare across studies when the samples are not comparable and not necessarily representative of the population. Many people who play a musical instrument or sing, regardless of training, also play the piano as a second instrument. While it is acknowledged that a large number of people play musical instruments and sing at expert levels though they have never had a formal music lesson, for the purpose of this study, musicians were defined as individuals who had at least ten years of musical training and for whom the piano is either their first or second instrument. This ensured that the musicians in this study had extensive training in musical elements. Pitch, tempo, timbre, melody, and rhythm are a few of the musical elements with which musicians had overexposure. This level of exposure and practice should result in better automatic attentional processing of these elements in musicians.

In musicians, the ability to hear qualitative differences in musical stimuli, for example, pitch, tempo, rhythm, timbre, and melody, becomes more automatized than in nonmusicians as a result of training and experience. Therefore, the efficiency of automatic processing for musical stimuli is superior in musicians than nonmusicians.

The generalizability of an enhanced efficiency for automatic processing beyond that of musical stimuli is of further interest in this study. Phonemes were presented in the oddball paradigm to determine whether musicians are also better able to discriminate verbal stimuli than nonmusicians. Evidence of superiority during verbal stimuli would offer support to the proposal that musicians are superior in auditory processing at the preattentive level for both musical and verbal stimuli, and that the enhanced preattentive ability is generalizable to nonmusical stimuli.

Goals and Hypotheses

The purpose of this study was to advance the understanding of preattentive automatic auditory processing abilities of musicians compared to non-musicians. It examined whether or not early automatic processing differences are limited to musical stimuli or are generalizable to nonmusical stimuli, specifically, phonemic stimuli. To do this, trained musicians and nonmusicians were exposed to four sets of stimuli: chords, phonemes, chords with deviant ISIs, and tones with deviant ISIs in the oddball paradigm. Furthermore, differences between musicians who possessed AP were proposed to be compared with musicians who did not possess AP and nonmusicians. Since no musician in this study possessed absolute pitch, this assessment was not performed. The formal hypotheses were:

1) Musicians would have larger MMN amplitudes at fronto-central sites in both the right and left hemispheres compared with nonmusicians in all conditions.

2) The MMN latency would be shorter for musicians than nonmusicians.

3) The MMN amplitude in musicians was expected to be similar in the left and right hemispheres, while the MMN amplitude in nonmusicians was expected to be larger on the right compared with the left hemisphere for musical stimuli.

4) Specific to the conditions, the right hemisphere would yield larger MMN amplitudes for the chord condition, and the left hemisphere would yield larger MMN amplitudes for the phoneme and interval conditions.

5) Furthermore, two self-report measures of absorptive and attentional abilities were administered to assess whether musicians would report greater absorption in environmental experiences.

Method

Participants

Participants were 22 trained musicians (11 men), and 22 nonmusicians (11 men). They were recruited from the Virginia Tech Psychology subject pool, the Virginia Tech music department, and the surrounding community. They were between the ages of 18 and 48 years (musicians: M = 22.68, SD = 6.16; nonmusicians: M = 21.23, SD = 5.00). One additional participant was rejected for scoring above the inclusionary criteria on the Beck Depression Inventory.

Participants reported no history of major illness, neurological disorder, major head injury, or concussions. Indication of a medical condition believed to interfere with EEG recordings was cause for exclusion from participation in this experiment. All participants were medication free (with the exception of birth control and allergy medication). They did not use any tobacco products and refrained from caffeine use for at least 3 hours and alcohol use for at least 24 hours prior to the experimental session.

Participants were not depressed, as measured by the Beck Depression Inventory (M = 2.34, SD = 2.65; Beck, 1961). Participants reported no history of hearing impairment; this was confirmed by a hearing test. All participants were right-handed for writing and had a strong right lateral preference, as assessed by the Lateral Preference Questionnaire (Coren, Porac, & Duncan, 1979). None reported having been diagnosed for attention deficit or learning disorders.

Of the musicians, none possessed absolute pitch, and only three possessed relative pitch (had greater than 90% accuracy on the relative pitch assessment). Nine musicians scored above 50% accuracy, and six scored above 70%.

Group Assignment Criteria

Musicians. Inclusionary criteria for musicians was at least ten years of formal musical training in an instrument or voice. All musicians had to have some knowledge of the piano although it may not have been their primary instrument. Additionally, musicians had to be involved in musical activities on a regular basis at the time of the research.

Nonmusicians. A nonmusician was an individual who had no formal musical training, be it from playing an instrument, singing in a choir, or taking a class in music theory or music appreciation. These participants were unfamiliar with specific musical elements and their terminology.

Preliminary Screening

Materials

The Virginia Tech Institutional Review Board approved the research design and Informed Consent Form (Appendix A) used in this study. Consent of all potential participants was obtained prior to any screening or experimental procedures.

The Medical History questionnaire (Crawford, unpublished; Appendix B) was used to assess the existence of a medical condition that might interfere with EEG recordings in a potential participant. It addressed issues such as head injuries, surgeries experienced, and medications being taken.

The 13-item Lateral Preference Questionnaire (Coren et al., 1979; Appendix C) is a behaviorally validated measure of hand, eye, foot, and ear preference. Each “right” response received a score of +1, each “left” response received a score of –1, and each “both” response received a score of 0. The sum of the responses yielded the total score. A minimum score of +7 (maximum score = +13) was the inclusionary criteria for right hand dominance and participation in this experiment.

The Beck Depression Inventory (Beck, Ward, Mendelson, Mock, & Erbaugh, 1961) is a 21-item scale that measures the intensity of depression in both clinical and normal individuals. The inventory assesses how a participant perceives his or her mood over the past week. This measure is valid for individuals aged 13-80 years. Total scores can range from 0 to 63. For inclusion in this study, a total score could not exceed 10.

A hearing test was administered to assess auditory acuity. A Qualitone Acoustic Appraiser (Model WR-C) and Qualitone TD-39 headphones were used to administer a pure tone test using an ascending method of limits (Stelmachowicz, Beauchaine, Kalberer, Kelly, & Jesteadt, 1989) which assesses the thresholds for 1000 Hz, 1500 Hz, 2000 Hz, 3000 Hz, 1000 Hz, 750 Hz, and 500 Hz in this order. Because the stimuli used in this study were less than 500 Hz, the thresholds for 400 Hz and 300 Hz were also assessed. No one was rejected on these criteria. All participants had an average hearing threshold level (HTL) of 20 dB or less for all tested frequencies.

Musicians were additionally requested to report their musical background (Appendix D). This evaluation included listing the instruments played, number of years trained in each instrument, and relevant activities such as band and choir.

Procedure

Participants were welcomed to the lab and introduced to the researchers. All potential participants were screened for inclusionary criteria prior to participation in the experiment. At the beginning of the experimental session, each potential participant completed the Informed Consent Form, questionnaires to assess inclusionary and exclusionary criteria, and a hearing test. Musicians also completed the musical background evaluation.

Participants were told that the purpose of this experiment was to examine the differences between musicians' and nonmusicians' abilities to pay attention to visual information while distracting auditory stimuli were present. Participants were naïve about the occurrence of deviancies in the auditory stimuli.

Experiment Proper: Oddball Task

Stimuli

Auditory stimuli were presented using the STIM stimulus generator software (Neurosoft, Inc., Sterling, VA). Piano chords and tones were initially generated using a Casio CT-655 keyboard and edited with the STIM software. All auditory stimuli were presented at 60dB through speakers placed approximately 75 cm on either side of the participant. The amplifiers of the speakers were monaural (rather than in stereo), so the same signal was sent to each speaker. Visual stimuli were presented on a computer monitor, with the screen attenuated to 9cm x 13cm to minimize eye movement, approximately 1 meter before the participant. Each of the four conditions had a running time of approximately 5 minutes.

Chord. The chord condition employed a single deviant tone embedded in two other single tones presented as a chord. Chords are complex auditory stimuli that are structurally musical and, therefore, more closely represent the auditory properties in which musicians are trained to detect. Similar to Koelsch et al. (1999), a major triad (439 Hz, 557 Hz, and 659 Hz) was presented to the participants; this was the standard chord occurring in 80% of the trials. The third of the chord was changed from 557 Hz to 550 Hz to make up the slightly impure deviant chord, which occurred in 20% of the trials. The chords had a 60 ms duration and 5 ms rise and fall times. The ISI was 500 ms.

Phoneme. The phoneme condition consisted of nonmusical phonemic stimuli. "Ba” and “ta” with 26.6 ms and 26.4 ms duration respectively, were used. “Ba” was the standard phoneme occurring in 80% of the trials and “ta” was the deviant phoneme occurring in 20% of the trials. The ISI was 500 ms.

Chord Interval. The chord interval condition consisted of standard and deviant interstimulus intervals (ISIs). An A major chord (A, C#, E) was presented with deviancies in the ISIs. The standard ISI was 800 ms (occurring in 80% of the trials), and the deviant ISI was 600 ms (occurring in 20% of the trials). These stimuli presented temporal differences to the participants. The chords had a 60 ms duration and 5 ms rise and fall times.

Tone Interval. The tone condition was identical to the chord interval condition with the exception that single tones were presented rather than chords. A single tone of 440 Hz (first note of the A major chord) was presented with a standard ISI of 800 ms (occurring in 80% of the trials), and a deviant ISI of 600 ms (occurring in 20% of the trials). The tones had a 60 ms duration and 5 ms rise and fall times.

Video Clip. Excerpts from Walt Disney's 1940 animated film Fantasia were used in this study. Participants watched Dance of the Hours from 0:00 to 4:48 minutes of video during the chord condition. During the phoneme condition they watched Beethoven’s Pastoral Symphony from 0:00 to 4:24 minutes. They watched 4:50 to 10:05 minutes of Dance of the Hours during the chord interval condition. During the tone interval condition, they watched from 5:35 to 11:12 minutes of the Pastoral Symphony.

Procedure

Participants were seated in a comfortable chair in an acoustically and electrically shielded, sound attenuated testing chamber. In this within subjects design, participants were exposed to each condition. Four sets of stimuli (chords, phonemes, tones with deviant ISIs and chords with deviant ISIs) were presented one at a time.

The chord stimulus was the first condition presented to all participants; the phoneme, chord interval, and tone interval conditions were counterbalanced across participants. They were instructed to attend only to the Fantasia video on the monitor, to become as focused on it as they could, and to ignore everything else. They were further instructed to prepare to answer questions about the clips upon each one’s completion. While watching each video clip, one condition was presented and continuous EEG was recorded. Participants answered questions (Appendix E) about the video excerpts upon completion of each condition. This was done to insure that attention was focused on the visual information and not the auditory stimuli.

EEG Recording

EEG was recorded using Neuroscan® 32 channel EEG/ ERP workstation using 4.1 software. Continuous EEG (bandpass 0.1-70 Hz; 500 Hz sampling rate) was recorded using a cap (Electro-Cap International, Inc.) at 30 electrode sites (impedance <5 kÙ) during stimuli presentation. Additionally, horizontal eye movement was recorded from the outer canthi of the right and left eyes (HEOG) and vertical eye movement was recorded from above and below the left eye (VEOGL). All electrodes were referred to linked ears and grounded to a location directly in front of Fz.

Musical Abilities and Attentional Abilities Assessment

After the EEG recording, all participants were evaluated for musical and attentional abilities. Two separate tests were employed for evaluation of musical ability: relative pitch assessment and the musical abilities test. Finally, two assessments of attentional abilities were used. These measures indicated the ability of the participants to become absorbed in environmental stimuli and/ or ignoring distracting stimuli.

Assessment of Absolute Pitch and Relative Pitch

Musicians were evaluated for possession of absolute pitch (AP) and relative pitch (RP). Surprisingly, no musician reported having absolute pitch; thus, no AP assessments were given. To determine possession of RP, participants were given 35 random piano tones between A2 and A5 using a Casio CT-655 and were told the names of the tones. Next, they were given a second tone and were asked to write the name of the second tone on a form. This task required knowledge of musical intervals. Participants accurately naming >90% of the second tones were considered to possess relative pitch. This procedure is similar to the Pantev et al. (1988) evaluation of absolute pitch.

Music Audition Musicianship Survey

The Virginia Tech music department utilizes a computer-based test of musical ability for all new music majors. Permission was given to use this test for the purpose of determining a person's ability to visualize auditory musical phrases. This multiple choice test consisted of two practice questions (the first demonstrated by the researcher and the second performed by the participant) and 10 test questions. For each question, four measures of music were displayed on the computer screen. Participants were instructed to study each measure and try to determine how they should sound. Next, they activated the play feature and one of the measures was played. Participants decided which measure was played and made their selection with the mouse. Each correct answer was awarded 10 points. A total of 100 points was possible.

Tellegen Absorption Scale

All participants completed the Tellegen Absorption Scale (TAS; Appendix F), taken from Tellegen's Multidimensional Personality Questionnaire (Tellegen, 1981; Tellegen &

Atkinson, 1974). It contains 34 self-descriptive statements with true or false answers. The internal reliability coefficient alpha is .88 (Tellegen, 1981), and the test-retest reliability is .91 (Kihlstrom, 1989).

Differential Attentional Processes Inventory

The Differential Attentional Processes Inventory (DAPI; Appendix G; Crawford, Brown, & Moon, 1993; Grumbles & Crawford, 1984) was administered last. The DAPI contains 40 self-descriptive statements relating to experiences of focused attention and ignoring of distractions, as well as experiences of carrying out multiple tasks simultaneously. Participants were asked to rate themselves as to the degree to which they can carry out the activities on a 7-point scale of 1 (not at all) to 7 (always). Factor analytic analyses revealed four major scales within this questionnaire: moderately focused attention (8 items), an individual's perceived ability to sustain moderately focused attention with distractors around; extremely focused attention (12 items), that assesses one's perceived proclivity to engage one's total attentional resources to the task at hand without awareness of outside stimuli; dual attention to tasks (cognitive, cognitive) (4 items) and dual attention to tasks (cognitive, physical) (5 items). Test-retest reliability for the DAPI was .90 as reported by Lyons and Crawford (1997).

Data Analysis

EEG analyses were carried out using NeuroScan$^{®}$ 4.1 software. The raw data was filtered (lowpass = 30 Hz, highpass = .1 Hz) and 512 ms (-50 ms to 462 ms) epochs were created. The epochs underwent a linear detrend and baseline correction (-50 ms to 0 ms). Next, they were submitted to automatic eye movement and artifact (above or below +/- 50ì V in the HEOG, VEOGL, Fp1, Fp2, F7, and F8 channels) rejection. All epochs were then subjected to visual inspection by two researchers to verify rejected epochs and remove additional artifacts. Epochs containing artifacts were excluded from the data analyses. Averages of epochs for the standard stimuli and for the deviant stimuli were created for each condition of each participant. The standard average was then subtracted from the deviant average within a condition to create the difference wave from which the MMN were identified. The difference waves (deviants minus standards) for anterior frontal (Fp1, Fp2), medial frontal (Fz, F3, F4), frontocentral (FCZ, FC3, FC4), and central (Cz, C3, C4) electrode sites were analyzed for the MMN, N2b, and P300 components.

Two separate methods of analyses were performed to assess the MMNs: 1) Peak MMN amplitude and latency, and 2) mean amplitude within a latency window selected on the basis of the group's peak MMN amplitude.

First, choosing the greatest amplitude within a latency window is common practice in MMN research. The parameters for the latency window used for the MMN, N2b, and P300 were 100-250, 150-300, and 300-400 ms, respectively. An MMN was apparent for most participants, but the N2b and P300 components were so variable, often nonexistent, or beyond the parameters established at the onset of the analysis, that results for these two components could not be reliably obtained. Therefore, only results for the MMN will be reported herein.

Second, the mean amplitude for a latency window within each condition was examined. Grand averages of the participants' difference (deviant minus standard) evoked potentials were made for each condition. The latency of the peak amplitude for each group's grand average was determined and a window of +/- 50ms was prescribed as the parameters for the mean amplitude. The latency windows were 150-250 ms for the chord condition, and 100-200 ms for the phoneme, chord interval, and tone interval conditions. Next, using Nueroscan® 4.0 software, the mean amplitude (the area under the difference wave) within the latency window for each condition was extracted from the data as the mean of all sample points within that window.

Results

Musicians vs. Nonmusicians: Musical Ability and Attentional Differences

Nonmusicians had no musical training, formal or otherwise, and musicians had at least ten years of formal musical training ($M = 12.52$, $SD = 2.61$). Musicians played a wide range of instruments including guitar, organ, piano, clarinet, trumpet, violin, and voice. Piano, band and voice were common musical experiences among this group of musicians. As expected, musicians had a significantly better ear for music than nonmusicians, as measured by the Music Audition Musicianship Survey. Musicians ($M = 78.18$, $SD = 24.03$) performed significantly better than nonmusicians ($M = 51.36$, $SD = 21.88$), $t(42) = 3.87$, $p < .05$.

Musicians ($M = 24.77$, $SD = 5.81$) reported that they were significantly more absorbed in daily environmental settings, as assessed by the TAS, than nonmusicians ($M = 21.00$, $SD = 6.57$), $t(42) = 2.01$, $p < .05$. No significant differences were found for the DAPI subscales.

MMN: Peak Amplitude

Using the peak amplitude technique to identify MMN, it was found that not all participants had an identifiable MMN in the four conditions. Thus, in this section, only participants for whom the MMN was apparent were included in the analysis for each condition. The grand averages for the standard and deviant stimuli for musicians who exhibited an MMN are presented in the Figure 1 (a. chord, b. phoneme, c. chord interval, and d. tone interval) and for nonmusicians who exhibited an MMN in Figure 2 (a. chord, b. phoneme, c. chord interval, and d. tone interval). The MMN grand averages are presented in Figure 3 (a. chord, b. phoneme, c. chord interval, and d. tone interval).

A 2 (Group: musicians, nonmusicians) x 2 (Hemisphere: left, right) mixed design ANOVA was conducted for each region (anterior frontal: FP1 & FP2; frontal: F3 & F4; frontocentral: FC3 & FC4; and central: C3 & C4) within each condition (chord, phoneme, chord interval, and tone interval). Means and standard deviations for the two groups are presented in Table 1 for the four conditions.

Chord

Musicians were significantly more likely to exhibit an MMN than nonmusicians, $\div^2$ (1) = 4.13, p = .04. Of the 22 musicians, 19 participants exhibited an MMN, whereas of the 22 nonmusicians, only 13 participants exhibited an MMN.

Anterior Frontal. There were no significant main effects or interactions.

Frontal. At the frontal region, the MMN peak amplitude was significantly larger in the right than left hemisphere [right M = -1.48, left M = -1.21; F (1,31) = 5.44, p = .02]. See Table 2 for ANOVA summary. There were no other significant main effects or interactions.

Frontocentral. There were no significant main effects or interactions.

Central. There were no significant main effects or interactions.

Phoneme

Not all participants had an identifiable MMN in the phoneme condition. Of the 22 musicians, 14 had an identifiable MMN, while of the 21 nonmusicians, 15 had an identifiable MMN. Chi square was not significant for this difference. One participant had missing data.

Overall, the MMN was larger in the right than left hemisphere [right M = -1.14, left M = -.88; F (1,29) = 12.85, p = .001]. See Table 3 for ANOVA summary.

Anterior frontal. At the anterior frontal region, the MMN peak amplitude was significantly larger in the right than left hemisphere [right M = -1.05, left M = -.81; F (1,29) = 9.95, p = .004]. See Table 4 for ANOVA summary. There were no other significant main effects or interactions.

Frontal. At the frontal region, the MMN peak amplitude was significantly larger in the right than left hemisphere [right M = -1.20, left M = -.97; F (1,29) = 4.52, p = .04]. See Table 5 for ANOVA summary. There were no other significant main effects or interactions.

Frontocentral. At the frontocentral region, the MMN peak amplitude was significantly larger in the right than left hemisphere [right M = -1.21, left M = -.89; F (1,29) = 10.78, p = .003]. See Table 6 for ANOVA summary. There were no other significant main effects or interactions.

Central. At the central region, the MMN peak amplitude was significantly larger in the right than left hemisphere [right M = -1.11, left M = -.85; F (1,29) = 5.66, p = .02]. See Table 7 for ANOVA summary. There were no other significant main effects or interactions.

Chord Interval

Not all participants had an identifiable MNN in the chord condition. Of the 22 musicians, 20 had an MMN, while of the 21 nonmusicians, 19 had an MMN. Chi square was not significant for this difference. One participant had missing data.

Anterior frontal. There were no significant main effects or interactions.

Frontal. At the frontal region, the MMN peak amplitude was significantly larger in the right than left hemisphere [right M = -1.57, left M = -1.38; F (1,38) = 4.71, p = .03]. See Table 8 for ANOVA summary. There were no other significant main effects or interactions.

Frontocentral. There were no significant main effects or interactions.

Central. There were no significant main effects or interactions.

Tone Interval

Most of the participants in each group exhibited an MMN. Of the 22 musicians, 21 had an MMN, and of the 21 nonmusicians, 17 had an MMN. Chi square was not significant for this difference.

Anterior frontal. At the anterior frontal region, the MMN peak amplitude was significantly larger in the right than left hemisphere [right M = -1.03, left M = -.92; F (1,36) =

3.88, p = .05]. See Table 9 for ANOVA summary. There were no other significant main effects or interactions.

Frontal. There were no significant main effects or interactions.

Frontocentral. At the frontocentral region, the MMN peak amplitude was significantly larger in the right than left hemisphere [right M = -1.12, left M = -1.32; F (1,36) = 4.52, p = .04]. See Table 10 for ANOVA summary. There were no other significant main effects or interactions.

Central. There were no significant main effects or interactions. However, the MMN peak amplitude for musicians had a tendency to be more negative than the MMN peak amplitude for nonmusicians at the central region [musicians M = -1.31, nonmusicians M = -.79; F (1,36) = 2.99, p = .09].

MMN: Peak Latency

A 2 (Group: musicians, nonmusicians) x 2 (Hemisphere: left, right) mixed design ANOVA was conducted for each region (anterior frontal: FP1 & FP2; frontal: F3 & F4; frontocentral: FC3 & FC4; and central: C3 & C4) within each condition (chord, phoneme, chord interval, and tone interval) for the MMN latency. Means and standard deviations for the two groups are presented in Table 11 for the four conditions.

There were no significant main effects or interactions at any region for three of the conditions: chord, chord interval, and tone interval. One significant effect emerged in the phoneme condition at the frontocentral region. There was a significant Group X Hemisphere interaction, F (1, 29) = 6.15, p = .01 (See Table 12). As seen in Figure 4, the differential hemispheric activation was in the opposite direction for the musicians than the nonmusicans. Musicians had a shorter latency in the left than right hemisphere while nonmusicians had a shorter latency in the right than left hemisphere.

MMN: Mean Amplitude

A second analysis approach was employed to assess the mean amplitude within a 100 ms window surrounding the mean MMN peak amplitude for each condition. This approach permitted the inclusion of all participants. A 2 (Group: musicians, nonmusicians) x 2 (Hemisphere: left, right) mixed design ANOVA was conducted for each region (anterior frontal: FP1 & FP2; frontal: F3 & F4; frontocentral: FC3 & FC4; and central: C3 & C4) within each condition (chord, phoneme, chord interval, and tone interval). Means and standard deviations for the two groups are presented in Table 13 for the four conditions.

Chord

There were no significant main effects or interactions in the anterior frontal, frontal, frontocentral, or central regions for this condition.

Phoneme

Overall, the MMN was larger in the right than left hemisphere [right M = .37, left M = .56; F (1,41) = 11.50, p = .002]. See Table 14 for ANOVA summary.

Anterior frontal. There were no significant main effects or interactions. However, the MMN peak amplitude showed a tendency to be more negative in the right than left hemisphere in the anterior frontal region [right M = .51, left M = .42; F (1,41) = 3.49, p = .06]. See Table 15 for ANOVA summary.

Frontal. There were no significant main effects or interactions. However, the MMN peak amplitude showed a tendency to be larger in the right than left hemisphere in the frontal region [right M = .62, left M = .47; F (1,41) = 3.03, p = .08]. See Table 16 for ANOVA summary.

Frontocentral. At the frontocentral region, the MMN peak amplitude was significantly larger in the right than left hemisphere [right M = .33, left M = .61; F (1,41) = 15.48, p = .000]. See Table 17 for ANOVA summary. There were no other significant main effects or interactions.

Central. At the central region, the MMN peak amplitude was significantly larger in the right than left hemisphere [right *M* = .26, left *M* = .50; *F* (1,41) = 12.00, *p* = .001]. See Table 18 for ANOVA summary. There were no other significant main effects or interactions.

Chord Interval

There were no significant main effects or interactions in the anterior frontal, frontal, frontocentral, or central regions for this condition.

Tone Interval

Overall, the MMN was larger in musicians than nonmusicians [musicians *M* = -.66, nonmusicians *M* = .01; *F* (1,41) = 7.84, *p* = .008]. See Table 19 for ANOVA summary.

Anterior frontal. At the anterior frontal region, the MMN peak amplitude for musicians was significantly larger than the MMN peak amplitude for nonmusicians [musicians *M* = -.53, nonmusicians *M* = .04; *F* (1,41) = 5.59, *p* = .02]. See Table 20 for ANOVA summary.

Frontal. At the frontal region, the MMN peak amplitude for musicians was significantly larger than the MMN peak amplitude for nonmusicians [musicians *M* = -.74, nonmusicians *M* = -.04; *F* (1,41) = 6.55, *p* = .01]. See Table 21 for ANOVA summary.

Frontocentral. At the frontocentral region, the MMN peak amplitude for musicians was significantly larger than the MMN peak amplitude for nonmusicians [musicians *M* = -.74, nonmusicians *M* = -.01; *F* (1,41) = 7.45, *p* = .009]. See Table 22 for ANOVA summary.

Central. At the central region, the MMN peak amplitude for musicians was significantly larger than the MMN peak amplitude for nonmusicians [musicians *M* = -.65, nonmusicians *M* = .05; *F* (1,41) =8.28, *p* = .006]. See Table 23 or ANOVA summary.

Discussion

Overview of Findings

This study addressed differences in preattentive processing abilities between musicians and nonmusicians. Superior preattentive auditory processing, as determined by the presence or absence of an MMN, in musicians was found most obviously during the presentation of chords, with no evidence of such superiority during phonemic processing and interval processing. The findings specific to my formal hypotheses are:

1) As predicted, during the tone interval condition, musicians had a greater MMN peak amplitude in the central region, and had a greater MMN mean amplitude in the anterior frontal, frontal, frontocentral, and central regions. Contrary to the hypothesis, this did not emerge in the chord, phoneme, or chord interval conditions.
2) Differential hemisphere effects were found between groups for MMN latency in the phoneme condition but not the others. Contrary to the hypotheses, no differences were found for MMN amplitude.
3) As predicted, and consistent with Koelsch et al. (1999), musicians were more likely to exhibit an MMN than nonmusicians in the chord condition.
4) Finally, there was the expected stronger preattentive processing in the right hemisphere MMN for the musical stimuli. Contrary to the literature, there was an unexpected stronger right hemisphere bias for phonemic stimuli.

Presence of MMNs in Musicians and Nonmusicians

Of theoretical importance, superior pre-attentive auditory processing in musicians was documented in the present study. Koelsch et al. (1999) was the first study to report evidence for superior pre-attentive auditory processing to chords in musicians using the MMN. As a replication and extension to that study, participants in this study ignored chords (A major chord) that were one whole step higher in pitch with longer ISIs (500 vs 300 ms) than theirs. In the present study, significantly more musicians (86%) than nonmusicians (59%) exhibited an MMN. Koelsch et al. (1999) reported that 100% of their musicians and none their nonmusicians exhibited a recognizable MMN. However, only 54% of the musicians reported that they recognized that deviant chords were presented, something that was not asked of the participants in the present study. Whether participant characteristics or stimuli difficulty levels contributed to the percentage differences in the number of musicians and nonmusicians exhibiting an MMN between the two studies is not determinable. Their study only used violinists (N = 11) who had studied violin for professional purposes, while the present study was not limited to musicians having played one specific instrument. Furthermore, few had studied music for professional purposes (3 of 22).

Unique to this study was the inclusion of nonmusical stimuli, specifically phonemes ("ba" and "ta"), to assess whether superior preattentive auditory processing was limited to musical stimuli or could be generalized to other auditory stimuli. The findings showed that superiority was limited to musical stimuli as the distributions of those with recognizable MMNs were similar in the phoneme condition. That there were no distribution differences in the interval condition, whether chords or simple tones were presented, suggests that the superior preattentive processing in musicians may not be generalizable to all musical stimuli. However, MMN amplitude during the tone interval condition suggests that the superiority may be generalizable to other musical stimuli. Further work that examines additional elements of music, such as timbre, rhythm, and melody, is needed.

An underlying question is whether these differences in preattentive processing of chords are due to genetic and/or environmental influences. As reviewed previously, studies have shown that the brain anatomy and physiology of musicians differs from that of nonmusicians (e.g., Meserli et al., 1995; Pantev et al., 1998; Schlaug et al., 1995, and Zatorre et al., 1998). Considering the argument that automatic processing improves with practice (Schneider et al., 1984), one could argue also that the enhanced chord preattentive processing of musicians is most likely the result of many years of musical training. However, it may also be the case that people choose to study music because they have a natural propensity for distinguishing between similar but different auditory stimuli, which is an obvious asset to a musician. Only longitudinal studies of children’s MMN responses to musical and nonmusical stimuli, thus far not carried out in the literature, could assess such questions.

Differences in MMN Amplitude

MMN amplitude in the frontal region was larger in the right than left hemisphere during the chord condition. This was expected as processing of pitch is believed to occur in the right hemisphere in the general population (Messerli et al., 1995; Tervaniemi et al., 2000; Branucci & San Martini, 1999). This finding was not significant in the other regions during the chord condition, but the patterns of hemisphericity in the other regions were similar to that of the frontal region.

The EPs to the standard and deviant stimuli in this condition appeared to have a different morphology (See figures 2 and 6) than EPs in the other three conditions. A prominent N1 component was not present in many participants. This made the MMN difficult to discern. Pilot data did not reveal this difference, so initially it was thought that many of the participants simply did not exhibit an MMN. However, through contact with other MMN researchers (Kimmo Alho, personal communication, March 2002), it was discovered that EPs to phonemes are often unique compared with other stimuli and difficult to identify. Additionally, Wunderlich and Cone-Wesson (2001) found that individuals were less likely to exhibit an MMN for differences in words and consonant vowel combinations ("ba" & "da") than to differences in tone (frequency). Data in this condition prompted the use of the mean amplitude method of analysis suggested by two leading researchers in the field (Mari Tervaniemi and Kimmo Alho, personal communication, March 2002) in order that all participant data could be included.

Since language (specific phoneme) processing is typically found in the left hemisphere, larger MMNs were expected to be found in the left than right hemisphere. Since phonemes are processed in the left hemisphere (Näätänen, 1992), one would hypothesize that the greater MMN amplitude would be found in the left hemisphere. Contrary to expectations based on Hugdahl's report, in this study, both MMN peak and mean amplitude was greater in the right hemisphere across all regions examined regardless of musicianship during the phoneme condition.

Hemisphere differences in the chord interval condition are similar to those in the chord condition in that a significant difference (R > L) was only found in the frontal region. However, the qualitative difference between the standard and deviant stimuli in the chord interval condition were temporal. This most closely resembles rhythmic changes (a steady beat interrupted by an early beat) in the stimuli, although it was not a steady, predictable rhythm. Rhythm is generally processed in the left hemisphere (Peretz, 1990), so the finding that the MMN amplitude in the chord interval condition was greater in the right hemisphere is surprising. One explanation for this finding is that participants may have been primed by the chord condition (which was always presented first). One way to address this question is to counterbalance across all conditions.

Interestingly, hemisphere differences during the tone interval condition differed by region. In the anterior frontal region, MMN peak amplitude was greater in the right hemisphere, yet in the frontocentral region, MMN peak amplitude was greater in the left hemisphere. There is evidence that there are two MMN generators: (1) a sensory-specific one which is automatic and preperceptual change detecting MMN, that is localized bilaterally in the supratemporal auditory cortex, and (2) an attention switching one that is located predominantly in the right hemisphere (Giard, Perrin, Pernier, & Bouchet, 1990; Näätänen & Michie, 1979). The present data offers support to this proposal. Attention switching and inhibition is primarily a function of the anterior frontal cortex (Kandel, Schwartz, & Jessell, 1991; Sokolov et al., 2002) which may explain why the MMN was stronger in the right hemisphere for that region. Furthermore, as tone is usually processed in the left hemisphere (Peretz, 1990), the region closest to the auditory cortex is the frontocentral region where the MMN amplitude was stronger in the left hemisphere than in the right.

Similar, if not identical, results were expected for the chord interval and tone interval conditions. The only difference between the two sets of stimuli was that the participant heard either a single tone, or a chord made up of 3 tones presented simultaneously. Since the differences occurred in the ISI, the auditory stimuli themselves should not have made a difference. But, that was not the case. Thus, there must be something about the qualitative differences between the chord and the interval that facilitated differential areas of the brain to discriminate between the ISIs even at a preattentive level. It is possible that the complexity of the chord utilized more of the discriminating resources than the simple tone; therefore, fewer resources were left to discriminate between the ISIs when chords were presented. While these resources may not be directly contributing to the MMN, they may or may not be occurring simultaneously with the MMN, and thereby influencing the results.

While hemisphere differences within individual conditions were somewhat surprising, visual inspection of the patterns of asymmetry at the frontal region during all conditions, significant or otherwise, revealed an interesting overall pattern (Figure 5). Hemisphere asymmetry seemed to increase as the complexity of the auditory stimuli increased. Wunderlich & Cone-Wesson (2001) demonstrated that MMN amplitude decreased as the complexity of the stimuli increased. In contrast, Tervaniemi, Schröger, Saher, and Näätänen (2000) found that spectrally rich sounds elicited greater MMNs compared with sinusoidal tones. Data in the present study appear to support the findings of Wunderlich and Cone-Wesson (2001). In the tone interval condition, MMN peak amplitude was 11% greater in the left hemisphere. In the chord interval, chord, and phoneme conditions, MMN peak amplitude in the right hemisphere was 13%, 22%, and 23%, respectively, greater than MMN peak amplitude in the left hemisphere. The least complex auditory signal used in this study was a simple piano tone used in the tone interval condition. Next in complexity was the chord interval with 3 tones presented simultaneously without changing through the duration of the condition. The chord interval was even more complex because, in addition to the 3 tones being present simultaneously, an impure chord was also presented 20% of the time. Finally, phonemes presented by a recorded human voice is the most complex stimuli in this study as they have temporally changing characteristics to process in order to distinguish between two phonemes. Post hoc analyses revealed no significant differences between the asymmetries across all conditions. However, since the present study was not specifically designed to determine the influences of complexity on MMNs, nonsignificance is not surprising.

Previous studies suggest that sensory processing for physical features of auditory stimuli may predominantly be a right hemisphere function (for review, see Sokolov et al., 2002). Memory trace is believed to play a major contributing role in the facilitation of MMNs (Näätänen, 1992). This may explain the overall pattern of the MMN having a right hemisphere bias regardless of condition.

Differences in MMN Latency

Examining the latency of the MMN provides information about speed of processing deviants during preattentive auditory processing. Shorter MMN latencies indicate faster speed of processing and, it can be inferred, better processing of the information (Näätänen, 1992). Differences in latency were only seen in the frontocentral region during the phoneme condition in this study. An interaction of group by hemisphere was significant, but no simple effects within the interaction were significant nor was there a region by hemisphere interaction. Musicians had a shorter latency in the left hemisphere, whereas nonmusicians had a shorter latency in the right hemisphere. Therefore, musicians are able to discriminate between standard and odd phonemes in the left hemisphere faster than in the right. This finding is consistent with Tervaniemi et al.'s (2000) findings that processing of phonemes and verbal information has a left hemisphere bias, as well as with Messerli et al. (1995) whose dichotic listening tasks demonstrated that musicians had a left hemisphere advantage and Schlaug et al. (1995) who demonstrated that musicians had a larger left planum temporal than nonmusicians. Interestingly, the present data suggests that nonmusicians are better able to discriminate between standard and odd phonemes in the right hemisphere than in the left. This finding is inconsistent with the literature. Whether this result is a true reflection of the population or merely artifactual is indeterminable at this point.

Musical and Attentional Abilities

Musicians scored significantly higher on the Music Audition Musicianship Survey than the nonmusicians. This finding was expected and verifies that the operational definition for musicians used in this study was adequate and appropriate for this research.

Musicians reported a greater ability to become absorbed in the daily environmental settings. This implies that they perceive themselves to be able to become highly focused on environmental stimuli. It is possible that the musicians became more absorbed in the video stimuli than the nonmusicians. This ability is important in tasks such as the ones employed in this study when one is asked to ignore one set of stimuli while actively attending to another. This finding combined with the superior preattentive processing to chords is intriguing. It seems that while musicians may be more perceptive of the auditory stimuli, that perception is less likely to come into awareness and they may be less likely to recognize the changes. To make any implications about whether musical training contributes to this ability is beyond the scope of the present study. However, future studies may investigate the time spent studying music and absorption abilities in a longitudinal study to tease out such findings.

Limitations and Future Direction

The present study contributed to the field in several ways, one of which was presenting new questions to be addressed. Future studies may include counterbalancing across all conditions rather than consistently starting with one condition and counterbalancing the rest. Doing so would help avoid any priming effects that may have been caused in the present study. Counterbalancing the video clips across conditions would further ensure that the results attained were not influenced by extraneous stimuli.

Another useful piece of information, acquired by Koelsch et al. (1999) but not in the present study, is he assessment of whether or not each participant was aware of the deviant auditory stimuli. Whether or not the auditory stimuli was brought into awareness was not of interest in the present study, but such information would have given insight to how successful each participant was at ignoring the sounds. Furthermore, it would be interesting to determine differences between those who brought the sounds into awareness and those who did not, whether or not they exhibited an MMN and their TAS scores.

Longitudinal studies, beginning in early childhood, of individuals participating in musical training would offer information regarding the etiology of differences seen in accomplished musicians compared with nonmusicians. Both genetic and environmental factors should be considered in such investigations. Comparisons could be made between those who discontinue training at different stages of their musical development and those who pursue music into adulthood.

Conclusions

The major contribution of the present study is further evidence that musicians exhibit superior preattentive processing for musical chords and intervals between tones. While this superior preattentive ability does not seem to generalize to phonemic stimuli, further research is necessary to specifically determine such. Furthermore, the superior preattentive ability may not even be generalizable to all musical stimuli. Interesting patterns regarding the complexity of the auditory stimuli and hemisphere asymmetry emerged when all conditions were considered together that prompts future exploration, as well.

Not only did preattentive abilities differ for musicians and nonmusicians, but so did attentive abilities, reflected by self-report to the TAS. The etiology of this finding is not determinable at this time, but future longitudinal studies may shed light on this matter.

This study seems to have created more questions than answers. Fortunately, these questions create opportunities for future research, within the specific population of musicians as well as the general population. MMN is a useful tool for determining preattentional abilities and, with refinement and consistency of the auditory stimuli across studies has the potential to advance the understanding of sensory and perceptual abilities of musicians.

REFERENCES

Barnea, A., Granot, R., & Pratt, H. (1994). Absolute pitch- electrophysiological evidence. International Journal of Psychophysiology, 16, 29-38.

Beck, A. T., Ward, C. H. Mendelson, M. Mock, J., & Erbaugh, J. (1961). An inventory for measuring depression. Archives of General Psychiatry, 4, 561-571.

Bever, T., G., & Chiarello, R. J. (1974). Cerebral dominance in musicians and nonmusicians. Science, 185, 537-539.

Brancucci, A. & San Martini, P. (1999). Laterality in the perception of temporal cues iof musical timbre. Neuropsychologia, 37, 1445-1451.

Broadbent, D. E. (1958). Perception and Communication. Oxford: Pergamon.

Coren, S. P., Porac, C., & Duncan P. (1979). A behaviorally validated self-report inventory to assess 4 types of lateral preferences. Journal of Clinical Neuropsychology, 1, 55-64.

Crawford, H. J, Brown, A. M., & Moon, C. E. (1993). Sustained attentional and disattentional abilities: Differences between low and highly hypnotizable persons. Journal of Abnormal Psychology, 120, 534-543.

Ford, J.M., & Hillyard, S.A. (1981). Event-related potentials (ERPs) to interruptions of a steady rhythm. Psychophysiology, 18, 322-330.

Giard, M. H., Perrin, F., Pernier, J., & Bouchet, P. (1990). Brain generators implicated in the processing of auditory stimulus deviance: A topographic ERP study. Psychophysiology, 27, 627-640.

Grumbles, & Crawford, H. J. (1981). Differential attentional skills and hypnotizability. Paper presented at the annual meeting of the Society for Clinical and Experimental Hypnosis, Portland, OR.

Hantz, E.C., Crummer, G.C., Wayman, J.W., Walton, J.P., & Frisina, R.D. (1992). Effects of musical training and absolute pitch on the neural processing of melodic intervals: a P3 event-related potential study. Music Perception, 10, 25-42.

Kandel, E. R., Schwartz, J. H., Jessell, T. M. (1991). Principles of neural science. Norwalk, CT: Appleton & Lange.

Kihlstrom, J. F. (1989). Daydreaming, absorption and hypnotizability. International Journal of Clinical and Experimental Hypnosis, 37, 332-342.

Klein, M., Coles, M. G. H., & Donchin E. (1984). People with absolute pitch process tones without producing and P300. Science, 223, 1306-1309.

Koelsch, S., Schröger, E., & Tervaniemi, M. (1999). Superior pre-attentive auditory processing in musicians. NeuroReport, 10, 1309-131.

Liegeois-Chauvel, C., Peretz, I., Babai, M., Laguitton, V., & Chauvel, P. (1998). Contribution of different cortical areas in the temporal lobes to music processing. Brain, 121, 1853-1867.

Lyons, L. & Crawford, H., J. (1997). Sustained attention and disattentional abilities and arousability: Factor analysis and relationships to hypnotic susceptibility. Personality and Individual Differences, 23, 1071-1084.

Messerli, P., Pegna, A., & Sordet, N. (1995). Hemispheric dominance for melody recognition in musicians and nonmusicians. Neuropsychologia, 33, 395-405.

Näätänen, R. (1992). Attention and brain function. London: Lawrence Erlbaum and Associates.

Näätänen, R., & Mitchie, P. T. (1979). Early selective attention effects on the evoked potential. A critical review and reinterpretation. Biological Psychology, 8, 81-136.

Nordby, H., Roth, W.T., & Pfefferbaum, A. (1988a). Event-related potentials to breaks in sequence of alternating pitches or interstimulus intervals. Psychophysiology, 25, 262-268.

Nordby, H., Roth, W.T., & Pfefferbaum, A. (1988b). Event-related potentials to time-deviant and pitch-deviant tones. Psychophysiology, 25, 249-261.

Pantev, C., Oostenveld, R., Engelien, A., Ross, B. Roberts, L.E., & Hoke, M. (1998). Increased auditory cortical representation in musicians. Letters to Nature, 392, 811-814.

Peretz, I. (1990). Processing of local and global musical information by unilateral brain-damaged patients. Brain, 113, 1185-1205.

Peretz, I. & Kolinsky, R. (1993). Boundaries of separability between melody and rhythm in music discrimination: a neuropsychological perspective. Journal of Experimental Psychology, 46, 301-325.

Posner, M I. & Snyder, C. R. R. (1975). Facilitation and inhibition in the processing of signals. In P. M. Rabbitt & S. Dornic (Eds.), Attention and performance: Vol. 5 (pp.669-682). San Diego, CA: Academic Press.

Schlaug, G., Jäncke, L., Huang, Y., Staiger, J., & Steinmetz, H. (1995). Increased corpus callosum size in musicians. <u>Neuropsychologia, 33,</u> 1047-1055.

Schlaug, G., Jäncke, L., Huang, Y., & Steinmetz, H. (1995). In vivo evidence of structural brain asymmetry in musicians. <u>Science, 267,</u> 699-701.

Schneider, W., Dumais, S. T., & Shiffrin, R. M. (1984). Automatic and control processing and attention. In Parasuraman & Davies (Eds.) <u>Varieties of attention</u> (pp. 1-27). San Diego: Academic press, Inc.

Sergent, J. (1993). Mapping the musician brain. <u>Human Brain Mapping, 1,</u> 20-38.

Sloboda, J. A. & Gregory, A. H. (1980). The psychological reality of musical segments. <u>Canadian Journal of Psychology, 34,</u> 274-280.

Sokolov, E. N., Spinks, J. A., Näätänen, R., & Lyytinen, H. (2002). <u>The orienting response in information processing.</u> Mahwah, New Jersey: Lawrence Erlbaum Associates, Publishers.

Stelmachowicz, P. G., Beauchaine, K. A., Kalberer, A., Kelly W. J., & Jesteadt, W. (1989). Normative thresholds in the 8- to 20-kHz range as a function of age. <u>Journal of Acoustical Society of America, 85,</u> 1384-1391.

Takeuchi, A. H. & Hulse, S. H. (1993). Absolute pitch. <u>Psychological Bulletin, 113,</u> 345-361.

Tellegen, A. (1981). <u>Brief manual for the multidimensional personality questionnaire.</u> Unpublished manuscript, University of Minnesota, Department of Psychology, Minneapolis.

Tellegen, A. & Atkinson, G. (1974). Openness to absorbing and self-altering experiences ("absorption"), a trait related to hypnotic susceptibility. <u>Journal of Abnormal Psychology, 83,</u> 268-277.

Tervaniemi, M., Medvedev, S. V., Alho, K., Pakhomov, S. V., Roudas, M. S., van Zuijen, T. L., & Näätänen, R. (2000). Lateralized automatic auditory processing of phonetic versus musical information: A pet study. <u>Human Brain Mapping, 10,</u> 74-79.

Tervaniemi, M., Schröger, E., Saher, M., & Näätänen, R. (2000). Effects of spectral complexity and sound duration on automatic complex-sound pitch processing in humans- a mismatch negativity study. <u>Neuroscience Letters, 290,</u> 66-70.

Ward, W. D. (1999). Absolute pitch. In D. Deutsch (Ed.), <u>The psychology of music</u> (pp.265-298). New York: Academic Press.

Wunderlich, J. L., & Cone-Wesson, B., K. (2000). Effects of stimulus frequency and complexity on the mismatch negativity and other components of the cortical auditory-evoked potential. Journal of the Acoustical Society of America, 109 (4), 1526-1537.

Zatorre, R.J., Perry, D.W., Beckett, C.A., Westbury, C.F., & Evans, A.C. (1998). Functional anatomy of musical processing in listeners with absolute pitch and relative pitch. Proceedings of the National Academy of Science USA, 95, 3172-3177.

Appendix A. Informed Consent Form

CONSENT FORM

TITLE OF EXPERIMENT: Preattentive Processing of musical and phonemic sounds: Differences in musicians and nonmusicians

This study compares brain wave activity of musicians and nonmusicians while listening to musical and phonemic sounds. You will be asked to watch videos on a computer monitor and be prepared to answer questions about the content of the videos. Your musical ability will be assessed after the experimental session. Additionally, you will be asked to complete two questionnaires for comparative purposes.

Based upon several criteria, you have been invited to assess your brain wave activity that is recorded with an electroencephalographic (EEG) machine.

You are to report to the experimenter if you are on any medications. You are not to have ingested alcohol in the last 24 hours or any caffeine-containing drinks for at least 4 hours prior to the experiment. You are to report any history of neurological disorders and prior concussion. You are to inform the experimenter of all known psychological disorders that you have had that might interfere with the experiment.

2. PROCEDURE TO BE FOLLOWED IN THE STUDY:

To accomplish the goals of this study, the research will be carried out in the Virginia Tech psychology department located in Derring Hall (Rm. 5092). This experiment will take approximately 2 1/2 hours.

Upon arrival, you will be administered the Lateral Preference Questionnaire (Coren et al., 1979) to ensure right-handedness. You will also be administered the Beck Depression Inventory (Beck et al., 1998) to ensure that depression is not a confound. Further, a hearing test will be administered to ensure auditory acuity. Those who meet inclusion criteria are invited to continue with the experiment.

EEG Study. You will be asked to put on an electrode cap which has electrodes permanently placed in the cap; the cap is like a swimming cap and may be slightly uncomfortable as it is attached to a harness that is fastened lightly around your chest to hold the cap in place. We will also place electrodes on your left and right ear lobes, and five near your eyes to measure eye movements and to provide a ground. Your skin will be cleaned with a mildly abrasive cleaner and may cause slight discomfort. You are to report any skin sensitivity or allergies, including a reaction to latex, to the experimenter. To insure your safety from infection, the experimenter has thoroughly sanitized and washed the electrodes and the electrode cap. The experimenter will wear clean rubber gloves while attaching the electrodes.

Following this, you will be asked to watch four short videos (approx 5 min each). After each video, you will be asked to answer questions pertaining to the content of the video. You are to ignore all other stimuli in the room during these videos. Afterwards, we will discuss your experiences and you will have the opportunity to see your recorded brain activity. You musical ability will be assessed at this time using several aptitude measures. You will also fill out several questionnaires that ask about your general involvement in experiences on a day-to-day basis.

You are to report to the experimenter if you are on any medications. You are not to have ingested alcohol in the last 24 hours. You are to inform the experimenter of any skin reactions from lotions or anything else you have had in the past. You are to inform the experimenter of all psychiatric disorders that you have had that might interfere with the experiment.

3. ANONYMITY OF SUBJECTS AND CONFIDENTIALITY OF RESULTS:

The results of this study will be kept strictly confidential. At no time will the researcher release your results to anyone without your written consent. The information you provide will have your name removed and only a subject code ill identify you during analyses and any write-up of the research. Should you report that you might harm yourself or others (on the Beck Depression Inventory), the researcher has the obligation to break confidentiality and report this information to the appropriate agency.

4. DISCOMFORTS AND RISKS FROM PARTICIPATING IN THE STUDY:

There are minimum risks to you from participation in this study. You have been chosen as having no known psychiatric disorders that might interfere with this experiment.

5. BENEFITS OF THIS PROJECT:

Your participation in this project today will help advance the scientific knowledge about the differences in attentional abilities between musicians and nonmusicians.

6. FREEDOM TO WITHDRAW:

You are free to withdraw from this study at any time without penalty.

7. COMPENSATION:

Participation will be completely voluntary. If you are enrolled in a psychology course at Virginia Tech, you *may* receive extra credit for this project regardless of whether you complete the experiment. Please check your course syllabi for information as to worth of this extra credit and for alternative ways by which to receive extra credit.

8. USE OF RESEARCH DATA:

The information from this research may be used for scientific or educational purposes. It may be presented at scientific meetings and/or published and reproduced in professional journals or books, or used for any other purpose that Virginia Tech's Department of Psychology considers proper in the interest of education, knowledge, or research.

9. APPROVAL OF RESEARCH:

This research project has been approved by the Human Subjects Committee of the Department of psychology and by the Institutional Review Board of Virginia Tech. You will receive a copy of this consent form.

10. SUBJECT'S PERMISSION:

I have read and understand the above description of the study. I have had an opportunity to ask questions and have had them all answered. I hereby acknowledge the above and give my voluntary consent for participation in this study. I further understand that if I participate I may withdraw at any time without penalty. I understand that should I have any questions regarding this research and its conduct, I should contact any of the persons named below:

Researcher: Jennifer N. Alfaro 231-6581

Faculty Advisor: Helen J. Crawford, Ph.D., Professor of Psychology	231-6520
Chair, Human Subjects Committee, D. Harrison, Ph.D.	231-4422
Chair, Institutional Review Board, David M. Moore Asst. Vice Provost for Research Compliance	231-4991

____
SUBJECT’S PRINTED NAME:

____
SUBJECT’S SIGNATURE

____
SUBJECT’S PHONE:

____
SUBJECT’S E-MAIL

____
DATE:

Appendix B. Medical History Questionnaire

Medical History Questionnaire

Neurocognition Laboratory
Helen J. Crawford, Director

The following information is required by th Institutional Review Board to screen for possible participation in EEG studies. We must know if you have had any medical problems that might keep you from participating. It is important that you be as honest as you can. This information is kept confidential.

Circle one: M F Age: ________

1. Since birth have you ever had any medical problems? Yes No If yes, please explain.

2. Since birth have you ever been hospitalized? Yes No If yes, please explain.

3. Have you ever hit your head and experienced a concussion? Yes No If yes, please explain.

4. Did you ever have problems where you saw a counselor, psychologist, or psychiatrist?
Yes No If yes, please explain.

5. Do you use tobacco (smoke, chew, etc.)? Yes No If yes, please explain.

6. Have you had any hearing problems? Yes No If yes, please explain.

7. What is your current weight and height?

8. Do you currently have or have you ever had any of the following? Circle Yes or No.

Yes No strong reaction to weather

Yes No circulation problems

Yes No tissue disease

Yes No skin disorders (other than facial acne)

Yes No arthritis

Yes No asthma

Yes No lung problems

Yes No heart problems/ disease

Yes No diabetes

Yes No hypoglycemia

Yes No hypertension

Yes No low blood pressure

Yes No high blood pressure

Yes No hepatitis

Yes No neurological problems

Yes No epilepsy or seizures

Yes No brain disorder

Yes No stroke

If you have circled yes to any of the above conditions, please explain.

9. Have you ever been diagnosed formally to have had:

Yes No learning deficiency or disorder

Yes No reading deficiency or disorder

Yes No attention deficit disorder

Yes No attention deficit hyperactivity disorder

10. Do you have

Yes No claustrophobia (high fear of smaller closed rooms)

Yes No high fear of needles or blood

11. List any over-the-counter medications you are presently taking:

12. Do you have or have you ever had any other medical conditions that you can think of? If yes please note them below.

Appendix C. Lateral Preference Questionnaire

Handedness Questionnaire

Subject# ____________________

Circle the appropriate number after each item.

	Right	Left	Both
With which hand would you throw a ball to hit a target?	1	-1	0
With which hand do you draw?	1	-1	0
With which hand do you use an eraser on paper?	1	-1	0
With which hand do you remove the top card when dealing?	1	-1	0
With which foot do you kick a ball?	1	-1	0
If you wanted to pick up a pebble with you toes, which foot would you use?	1	-1	0
If you had to step up onto a chair, which foot would you place on the chair first?	1	-1	0
Which eye would you use to peep through a keyhole?	1	-1	0
If you had to look into a dark bottle to see how full it was, which eye would you use?	1	-1	0
Which eye would you use to sight down a rifle?	1	-1	0
If you wanted to listen to a conversation going on behind a closed door, which ear would you place against the door?	1	-1	0
If you wanted to listen to someone's heartbeat, which ear would you place against their chest?	1	-1	0
Into which ear would you place the earphone of a transistor radion?	1	-1	0

# of Right + # of Left = Total Score

________ + ________ = __________

Is mother left or right hand dominant? _______

Is father left or right hand dominant? _______

Appendix D. Musical Background Evaluation

Please list the musical instruments you have played (including voice), how many years you've played them, and what activities you were involved in.

Instruments	Years	Activities

Appendix E. Video Question

Video Questions

Clip 1 (BATA) 0:00-4:24

1. Which appeared first, the Pegasus or the piper?
2. Which happened first, the Pegasus falling onto a limb or into a pile of petals?
3. Was the first adult Pegasus seen flying black or white?
4. What color was the little Pegasus that has trouble flying?

Clip 1 (A440-2) 5:35-12:17

1. Which came first, the centaur having her hair braided or the one filing her nails?
2. Which happened first, the centaur swinging on a swing or those having petals dropped onto them?
3. What type of animal was used as a hair piece for one of the female centaurs?
4. How did the cherubs get the lonely female and male centaurs together?
5. What color was the lonely female centaurs hair?
6. What fruit was everyone gathering towards the end of the clip?

Clip 2 (MMN Chord) 0:00-4:48

1. What fruit did the hippo eat when she first appeared?
2. What did the hippo appear out of?
3. What fruit were the ostriches fighting over (they fell into the water)?
4. How many hippos were there?

Clip 2 (AMAJ) 4:50-11:17

1. What type of animal did the elephant blow into a bubble?
2. What did one of the elephants get stuck on her foot?
3. What type of animal woke up the hippo?
4. How did the elephants leave the scene?
5. What was keeping the hippo floating in the air at one point during her sleep?
6. What article of clothing was the alligator wearing?

Appendix F. Tellegen Absorption Scale (TAS)

TAS (Tellegen & Atkinson, 1974)

Below you will find a series of statements a person might use to describe his/her attitudes, opinions, interests and other characteristics. Read each statement and decide which choice (TRUE or FALSE) best describes you.

If you think the statement is TRUE, circle the letter T
If you think the statement is FALSE, circle the letter F

Please answer every statement, even if you are not completely sure of the answer. Read every statement carefully, but do not spend too much time deciding on the answer.

1. T F Sometimes I feel and experience things as I did when I was a child.
2. T F I can be greatly moved by eloquent or poetic language.
3. T F While watching a movie, a TV show, or a play, I may become so involved that I forget about myself and my surroundings and experience the story as if it were real and as if I were taking part in it.
4. T F If I stare at a picture and then look away from it, I can sometimes “see” an image of the picture, almost as if I were still looking at it.
5. T F Sometimes I feel as if my mind could envelop the whole earth.
6. T F I like to watch cloud shapes change in the sky.
7. T F If I wish, I can imagine (or daydream) some things so vividly that they hold my attention as a good movie or story does.
8. T F I think I really know what some people mean when they talk about mystical experiences.
9. T F I sometimes “step outside” my usual self and experience an entirely different state of being.
10. T F Textures -- such as wool, sand, wood -- sometimes remind me of colors or music.
11. T F Sometimes I experience things as if they were doubly real.
12. T F When I listen to music, I can get so caught up in it that I don’t notice anything else.
13. T F If I wish, I can imagine that my body is so heavy that I could not move it if I wanted to.

14. T F I can often somehow sense the presence of another person before I actually see or hear her/him.
15. T F The crackle and flames of a wood fire stimulates my imagination.
16. T F It is sometimes possible of me to be completely immersed in nature or art and to feel as if my whole state of consciousness has somehow been temporarily altered.
17. T F Different colors have distinctive and special meanings for me.
18. T F I am able to wander off into my own thought while doing a routine task and actually forget that I am doing the task, and then find a few minutes later that I have completed it.
19. T F I can sometimes recollect certain past experiences in my life with such clarity and vividness that it is like living them again or almost so.
20. T F Things that might seem meaningless to others often make sense to me.
21. T F While acting in a play, I think I would really feel the emotions of the character and “become” her/him for the time being, forgetting both myself and the audience.
22. T F My thoughts often do not occur as words but as visual images.
23. T F I often take delight in small things (like the five pointed star shape that appears when you cut an apple across the core or the colors in soap bubbles).
24. T F When listening to organ music or other powerful music, I sometimes feel as if I am being lifted into the air.
25. T F Sometimes I can change noise into music by the way I listen to it.
26. T F Some of my most vivid memories are called up by scents and smells.
27. T F Certain pieces of music remind me of pictures or moving patterns of color.
28. T F I often know what someone is going to say before he or she says it.
29. T F I often have “physical memories”; for example, after I have been swimming I may still feel as if I am in the water.
30. T F The sound of a voice can be so fascinating to me that I can just go on listening to it.
31. T F At times I somehow feel the presence of someone who is not physically there.
32. T F Sometimes thoughts and images come to me without the slightest effort on my part.
33. T F I find that different odors have different colors.
34. T F I can be deeply moved by a sunset.

Appendix G: Differential Attentional Processes Inventory (DAPI)

DAPI (Grumbles & Crawford, 1981)

This questionnaire is an assessment of individual differences in the abilities to selectively attend and to carry out several tasks simultaneously. These abilities are NOT related to general intelligence. Describe your experiences in terms of frequency:

NEVER	**VERY RARELY**	**RARELY**	**OCCASIONALLY**	**OFTEN**	**VERY OFTEN**	**ALWAYS**
0	**1**	**2**	**3**	**4**	**5**	**6**

1. ____ Can you concentrate on reading or studying while in a noisy room?
2. ____ Can you get so involved in an activity that you don’t have extraneous thoughts (don’t think about other things)?
3. ____ Can you block out advertising commercials on TV or radio?
4. ____ Have you ever had the experience of not hearing or not remembering what a person said to you while you are involved in an activity and yet found yourself acting upon that person’s statement at a later time?
5. ____ Can you lose yourself in thought so that you are hardly aware of the passage of time?
6. ____ Can you ignore or reduce pain (without drugs) if you want to?
7. ____ Can you ignore music when you are reading or studying?
8. ____ Can you shift your attention away from bothersome noises or distractions in a room so that they no longer bother you?
9. ____ Can you concentrate easily on reading or studying when music is playing in the same room?
10. ____ Can you lose yourself easily in thought?
11. ____ Can you doodle at the same time that you are having a conversation with another person?
12. ____ Can you attend to music easily and not hear conversations going on nearby in the same room?
13. ____ When you are at a party, can you attend to one conversation and ignore another one which is close by and audible?

14.____ Do you ever miss or arrive late for appointments or class because you were so involved in something that you forgot the time?

15. ____ Can you drift off into your own thoughts or daydreams and still attend to someone else's conversation at the same time?

16. ____ While walking can you become so engrossed in thought that you do not recall the people or places you have passed?

17. ____ Can you forget that someone else is in the room with you?

18. ____ Can you ignore the discomfort of being in an environment that is too hot or too cold (within reasonable limits)?

19. ____ Can you "loose" a period of time where you cannot remember what you did?

20. ____ When you are at a play or movie, can you ignore or be unaware of disruptive movements or noises made by others around you?

21. ____ Can you write easily while at the same time listen to a conversation?

22. ____ Can you wander off into your own thoughts while doing an activity so that you actually forget what you were doing, and then find a few minutes later that you have finished the job without even being aware of having finished it?

23. ____ Can you daydream so deeply that you do not hear someone talking to you?

24. ____ Can you be so involved in reading or studying that when someone talks to you, you do not hear them?

25. ____ If you want to take a nap, can you easily ignore others conversing in the same room?

26. ____ Can you write easily while at the same time listen to the radio or TV?

27. ____ Can you be so involved in reading or studying that when someone talks to you, you do not hear them at the time yet later realize that they have spoken to you?

28. ____ Can you be so involved in dancing that you are almost not aware of your surroundings?

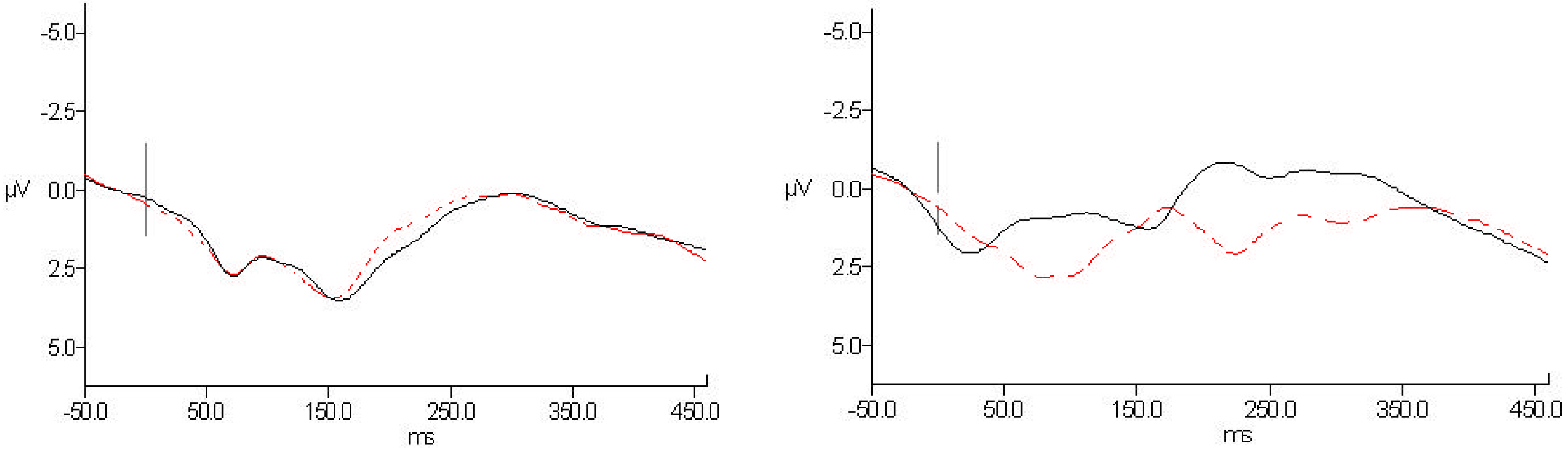
29. ____ Can you carry out a moderately complex activity at the same time that you are having a conversation with another person?

30. ____ Can you talk on the telephone while doing some other physical activity?

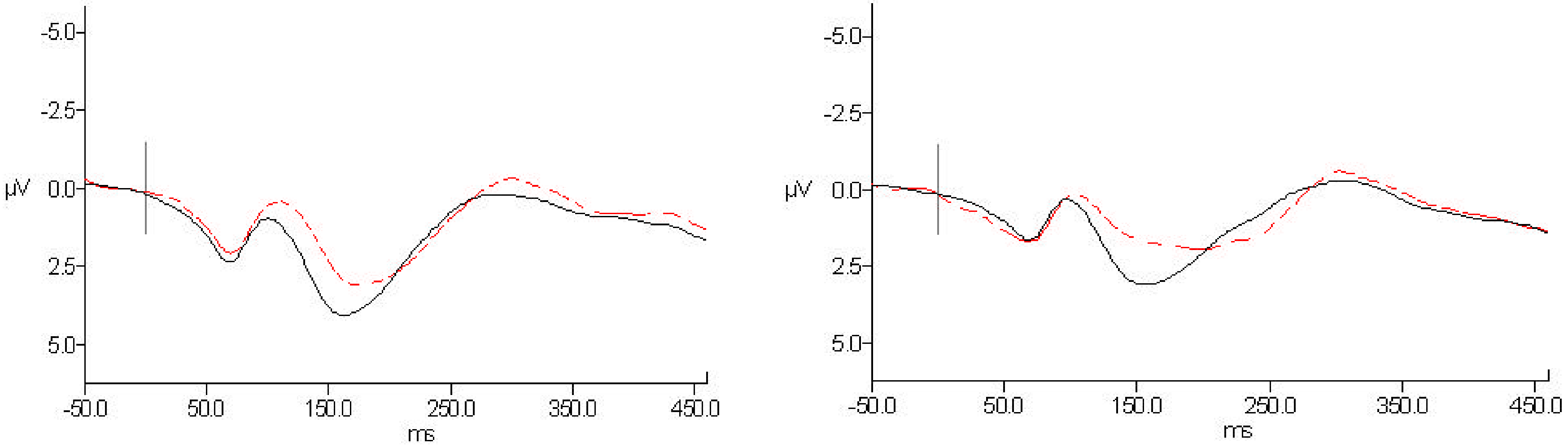
31. ____ Can you read or study easily while at the same time listen easily to a conversation?

32. ____ Can you read or study easily while at the same time listen to the talking of the radio or TV?
33. ____ Can you read or study easily while at the same time listen to music?
34. ____ Can you write easily while at the same time listen to music?
35. ____ Can you carry out a physical activity easily while listening to a conversation?
36. ____ Can you carry out a physical activity easily while listening to someone talking on radio or TV?
37. ____ Can you carry out a physical activity easily while listening to music?
38. ____ Can you wake up at night at some predetermined time during the night? (e.g., know you have to wake up at 4 AM and do so without any external help, such as an alarm clock)
39. ____ Can you read or study easily while actively involve in conversation?
40. ____ Can you listen to a conversation, be writing or studying at the same time, and also carry on some other internal thoughts unrelated to the first two at the same time?

Figure 1. Evoked potential grand averages for standard and deviant stimuli in musicians at FCZ.

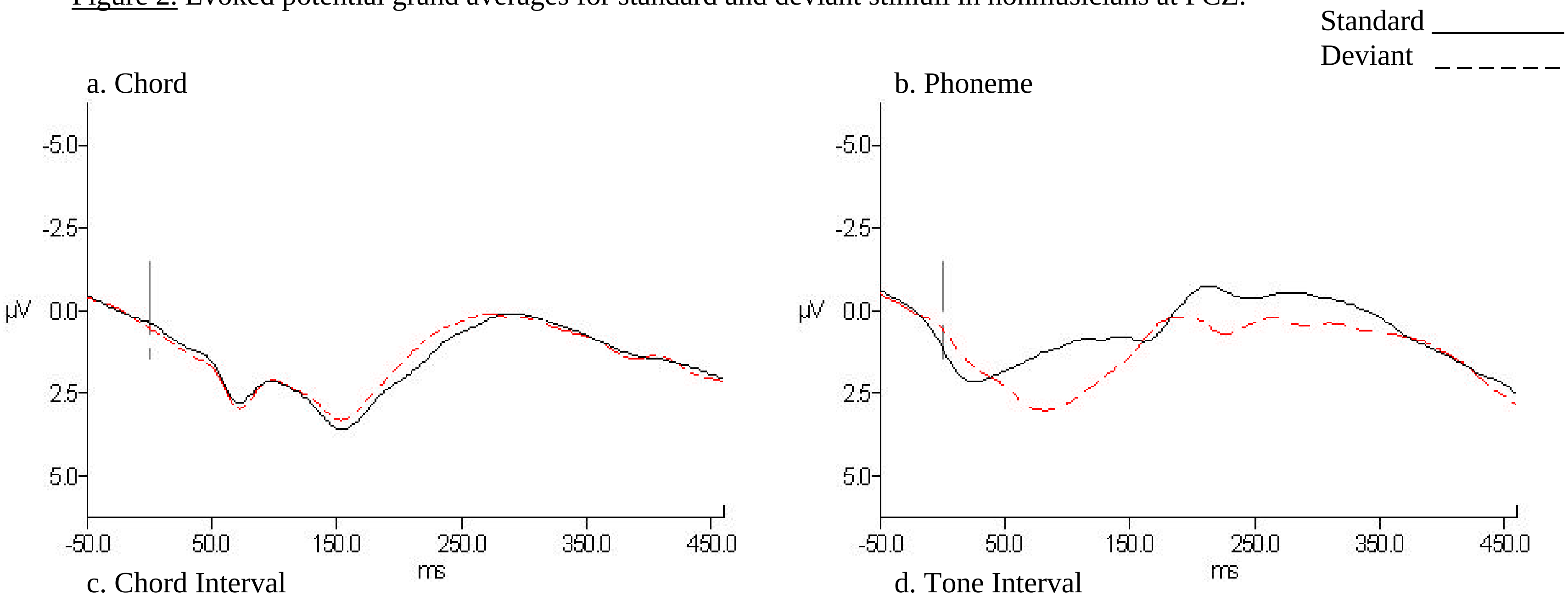

a. Chord

b. Phoneme


c. Chord Interval

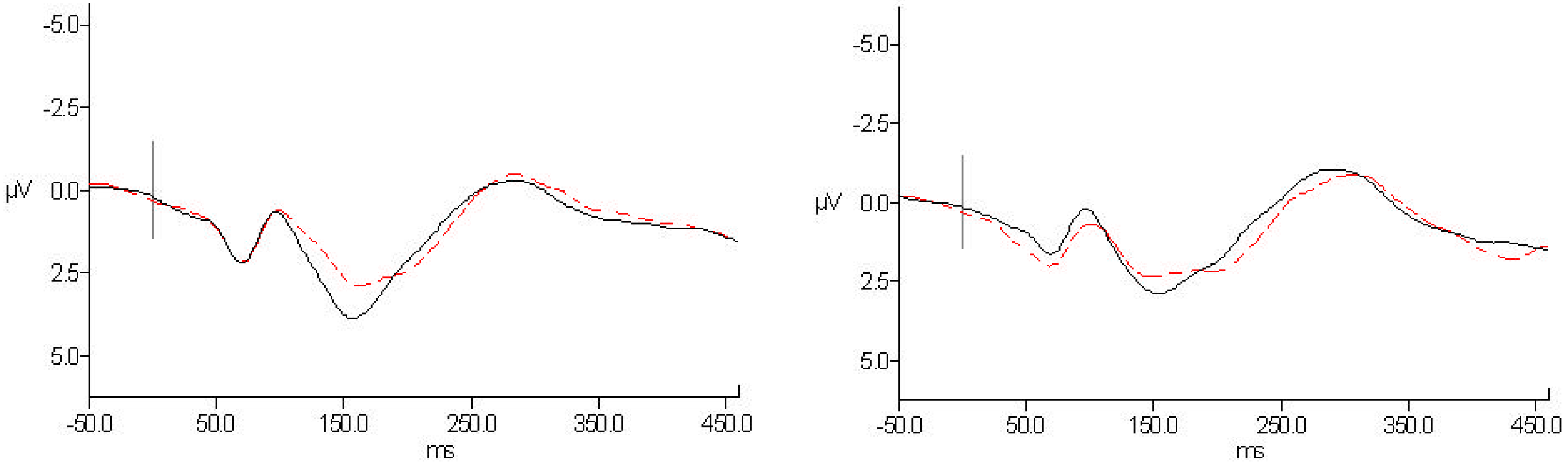
d. Tone Interval

Figure 2. Evoked potential grand averages for standard and deviant stimuli in nonmusicians at FCZ.



a. Chord

b. Phoneme



c. Chord Interval

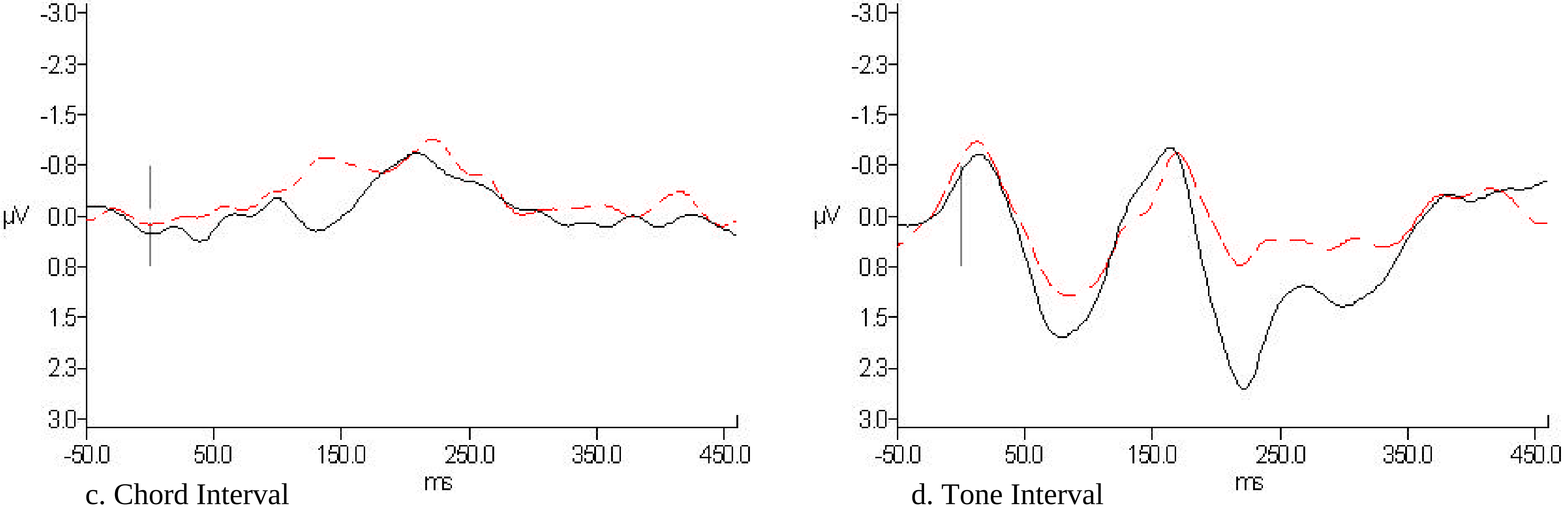
d. Tone Interval

Figure 3. Evoked potential grand averages for MMNs in musicians and nonmusicians at FCZ.

Musician ________
Nonmusician _ _ _ _ _ _

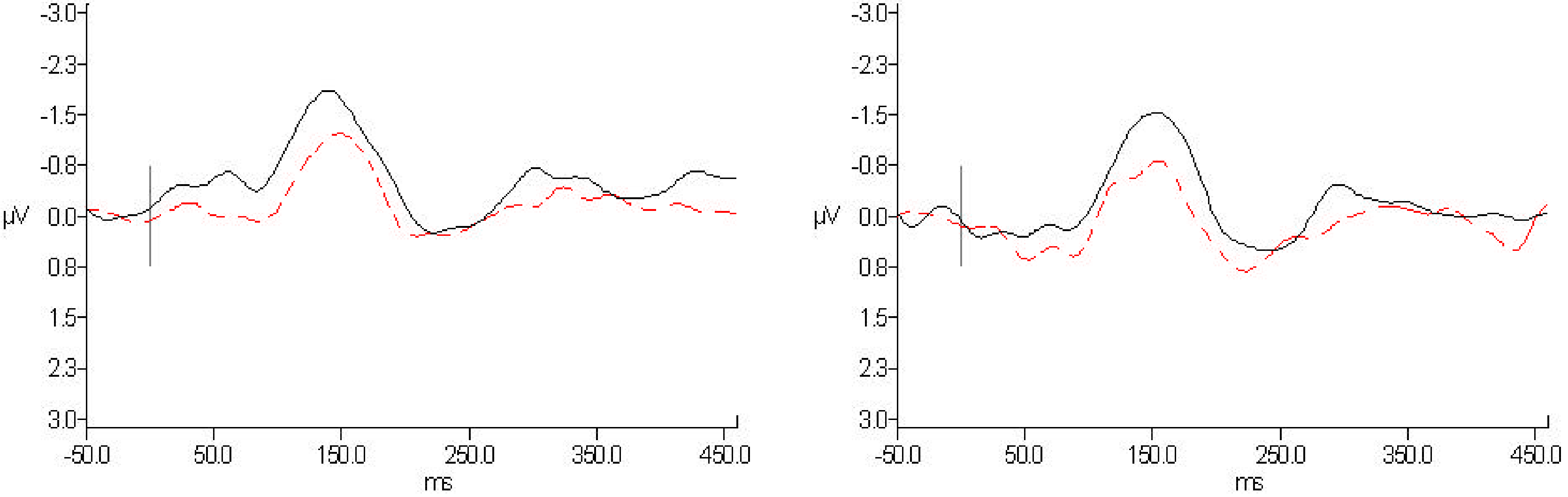
a. Chord

b. Phoneme



c. Chord Interval

d. Tone Interval



<u>Figure 4.</u> Mean MMN latencies for hemisphere in the frontocentral region (FC3 & FC4) for musicians and nonmusicians during the phoneme condition using peak amplitude data.

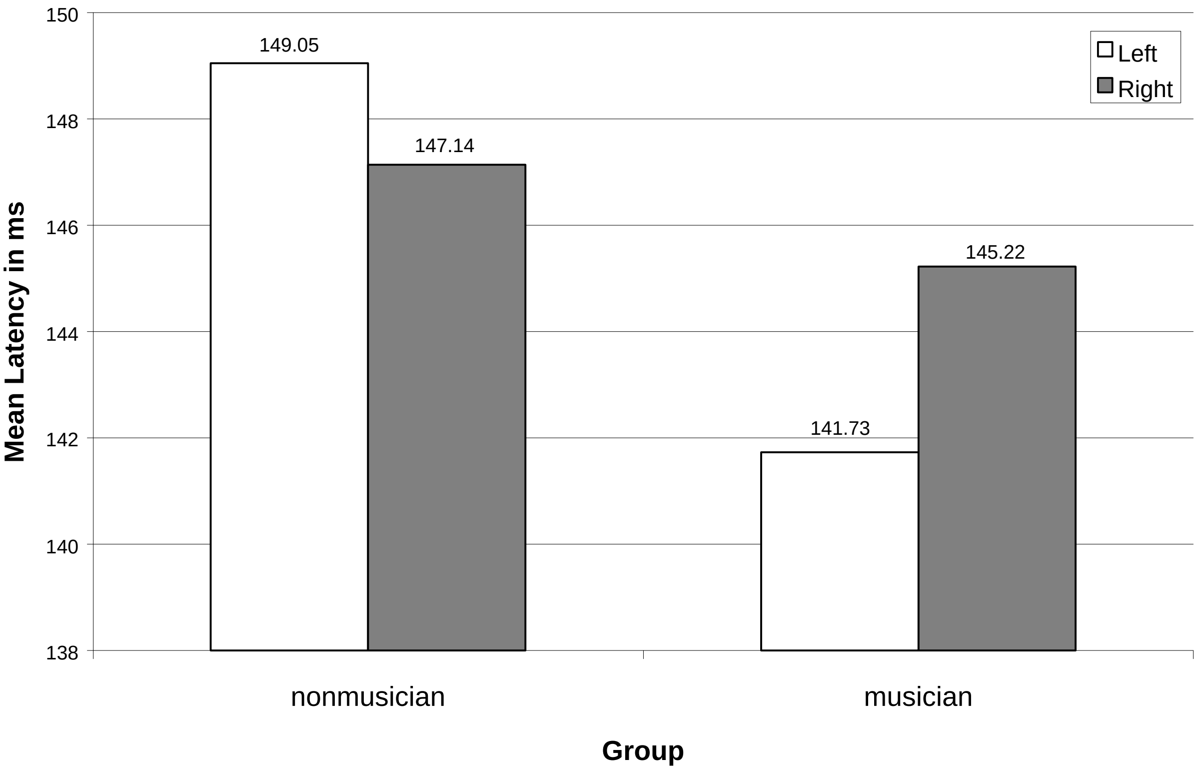


Figure 5. Hemisphere differences for peak amplitude in the anterior frontal, frontal, frontocentral, and central regions in all conditions.

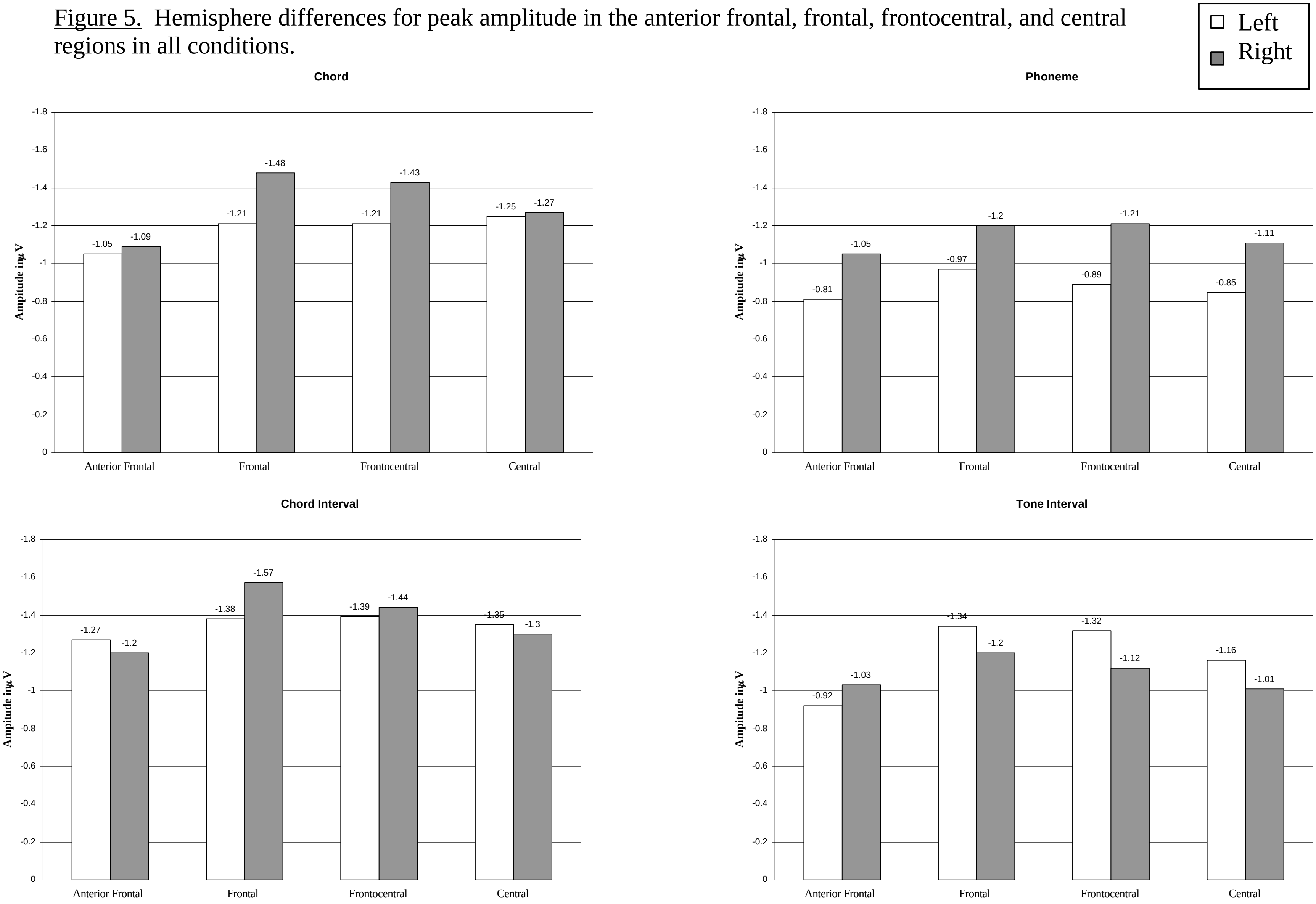


Table 1. MMN peak amplitude: Means and standard deviations for the nonmusicians (NM) and musicians (M) for all conditions.

		Chord		Phoneme		Chord Interval		Tone Interval	
		NM	MU	NM	MU	NM	MU	NM	MU
FP1	M=	-1.39	-.86	-.92	-.70	-1.18	-1.36	-.73	-1.08
	SD=	.60	.58	.80	1.15	.98	.92	.92	.84
FP2	M=	-1.31	-.97	-1.08	-1.03	-1.10	-1.29	-9.28	-1.13
	SD=	.69	.68	.74	1.00	.97	1.00	.74	.74
FZ	M=	-1.82	-1.44	-1.20	-1.32	-1.50	-2.18	-1.50	-1.73
	SD=	1.05	.66	1.32	.96	1.20	1.05	.85	1.07
F3	M=	-1.62	-.97	-.94	-1.01	-1.21	-1.57	-1.20	-1.45
	SD=	.82	.59	1.06	1.13	1.01	.80	.77	1.05
F4	M=	-1.69	-1.38	-1.04	-1.37	-1.40	-1.79	-.98	-1.38
	SD=	.89	.83	1.14	1.02	.95	1.09	.97	1.00
FCZ	M=	-1.64	-1.40	-.96	-1.28	-1.49	-2.11	-1.34	-1.74
	SD=	1.01	.69	1.42	.90	1.04	.99	.88	1.00
FC3	M=	-1.49	-1.02	-.73	-1.07	-1.19	-1.60	-1.11	-1.49
	SD=	.89	.52	1.13	.98	.88	.83	.84	1.07
FC4	M=	-1.56	-1.33	-1.01	-1.42	-1.32	-1.61	-.87	-1.32
	SD=	1.05	.80	1.39	1.03	.85	1.02	1.02	.94
CZ	M=	-1.50	-1.19	-.69	-1.12	-1.40	-1.82	-1.11	-1.52
	SD=	.92	.75	1.43	.86	.93	1.02	.89	1.02
C3	M=	-1.49	-1.13	-.63	-1.08	-1.13	-1.60	-.93	-1.35
	SD=	.97	.73	1.09	1.00	.79	.92	.87	1.16
C4	M=	-1.59	-1.07	-.86	-1.39	-1.18	-1.44	-.74	-1.23
	SD=	1.06	1.15	1.54	1.01	.83	1.12	.89	.88

Table 2. ANOVA for MMN peak amplitude at the frontal region (F3 & F4) during the chord condition.

Source	Sum of Squares	DF	Mean Square	F-value	Sig.
Hemisphere	0.78	1	0.78	4.26	0.04*
Group	3.77	1	3.77	2.38	0.06
Group X Hemisphere	0.48	1	0.48	2.04	0.11
Error	5.50	30	0.18		

Table 3. ANOVA for differential peak amplitude of Left (FP1, F3, FC3, & C3) and right (FP2, F4, FC4, & C4) hemispheres during the phoneme condition.

Source	Sum of Squares	DF	Mean Square	F-value	Sig.
Hemisphere	1.04	1	1.04	11.61	.002*
Group	0.86	1	0.86	0.50	0.48
Group X Hemisphere	0.08	1	0.08	0.95	0.33
Error	2.43	27	0.09		

Table 4. ANOVA for MMN peak amplitude at the anterior frontal region (FP1 & FP2) during the phoneme condition.

Source	Sum of Squares	DF	Mean Square	F-value	Sig.
Hemisphere	0.79	1	0.79	8.20	0.008*
Group	0.64	1	0.264	0.41	0.52
Group X Hemisphere	0.13	1	0.13	1.35	0.25
Error	2.60	27	0.09		

Table 5. ANOVA for MMN peak amplitude at the frontal (F3 & F4) during the phoneme condition.

Source	Sum of Squares	DF	Mean Square	F-value	Sig.
Hemisphere	0.76	1	0.76	4.00	0.05*
Group	0.81	1	0.81	0.39	0.53
Group X Hemisphere	0.32	1	0.232	1.69	0.20
Error	5.16	27	0.18		

Table 6. ANOVA for MMN peak amplitude at the frontocentral (FC3 & FC4) during the phoneme condition.

Source	Sum of Squares	DF	Mean Square	F-value	Sig.
Hemisphere	1.55	1	1.55	10.17	0.004*
Group	2.53	1	2.53	1.06	0.31
Group X Hemisphere	0.02	1	0.02	0.15	0.70
Error	4.13	27	0.15		

Table 7. ANOVA for MMN peak amplitude at the central (C3 & C4) during the phoneme condition.

Source	Sum of Squares	DF	Mean Square	F-value	Sig.
Hemisphere	1.16	1	1.16	5.57	0.02*
Group	4.09	1	4.09	1.60	0.21
Group X Hemisphere	0.008	1	0.008	0.04	0.84
Error	5.61	27	0.20		

Table 8. ANOVA for MMN peak amplitude at the frontal region (F3 & F4) during the chord interval condition.

Source	Sum of Squares	DF	Mean Square	F-value	Sig.
Hemisphere	0.78	1	0.78	4.68	0.03*
Group	2.72	1	2.72	1.58	0.21
Group X Hemisphere	0.006	1	0.006	0.03	0.84
Error	6.22	37	0.16		

Table 9. ANOVA for MMN peak amplitude at the anterior frontal region (FP1 & FP2) during the tone interval condition.

Source	Sum of Squares	DF	Mean Square	F-value	Sig.
Hemisphere	0.27	1	0.27	3.84	0.05*
Group	1.47	1	1.47	1.16	0.28
Group X Hemisphere	0.11	1	0.11	1.61	0.21
Error	2.53	36	0.07		

Table 10. ANOVA for MMN peak amplitude at the frontocentral region (FC3 & FC4) during the tone interval condition.

Source	Sum of Squares	DF	Mean Square	F-value	Sig.
Hemisphere	0.77	1	0.77	4.82	0.03*
Group	3.26	1	3.26	1.84	0.18
Group X Hemisphere	0.02	1	0.02	0.17	0.68
Error	5.81	36	0.16		

Table 11. MMN Latency: Means and standard deviations for nonmusicians (NM) and musicians (M) for all conditions.

		Chord		Phoneme		Chord Interval		Tone Interval	
		NM	MU	NM	MU	NM	MU	NM	MU
FP1	M=	152.73	168.93	148.05	144.81	135.25	134.77	140.32	139.83
	SD=	24.71	37.81	27.45	20.15	22.28	13.58	30.78	21.45
FP2	M=	153.93	169.72	147.34	144.36	135.65	135.46	140.23	134.97
	SD=	27.93	39.24	25.74	20.08	23.19	15.33	30.24	38.11
FZ	M=	154.18	167.77	147.91	144.11	137.66	138.30	140.54	142.58
	SD=	27.79	39.41	25.85	20.82	21.84	15.42	30.51	20.76
F3	M=	153.94	168.67	151.52	143.65	137.00	137.58	140.36	140.12
	SD=	28.63	39.15	22.47	20.19	22.81	16.58	30.96	22.76
F4	M=	153.29	169.60	147.91	145.27	136.05	136.63	141.92	143.27
	SD=	28.66	41.96	27.25	20.11	22.67	14.37	31.69	22.31
FCZ	M=	149.94	166.51	146.98	142.64	137.89	138.34	140.49	142.04
	SD=	27.95	39.53	25.08	22.41	20.81	15.94	31.21	19.74
FC3	M=	154.57	166.38	149.05	141.73	137.08	137.63	139.78	142.18
	SD=	28.01	39.93	24.80	21.76	21.57	17.11	30.61	19.60
FC4	M=	160.89	171.03	147.14	145.22	139.44	138.72	141.25	143.27
	SD=	31.21	42.15	25.02	21.23	24.47	14.53	31.58	23.93
CZ	M=	153.40	166.74	146.59	142.29	138.38	139.22	140.23	145.87
	SD=	26.64	39.75	26.08	22.98	21.01	16.58	31.16	21.54
C3	M=	151.88	165.12	147.44	142.24	140.04	138.15	141.75	141.67
	SD=	30.62	40.75	26.08	23.86	22.44	17.75	30.40	19.62
C4	M=	152.22	165.96	147.68	145.07	137.76	138.83	142.24	144.79
	SD=	29.71	42.19	22.94	21.99	22.46	15.87	32.97	23.69

Table 12. ANOVA for MMN latency of frontocentral regions (FC3 & FC4) during the phoneme condition.

Source	Sum of Squares	DF	Mean Square	F-value	Sig.
Hemisphere	9.71	1	9.71	0.53	0.47
Group	330.60	1	330.60	0.30	0.58
Group X Hemisphere	112.88	1	112.88	06.15	0.01*
Error	31032.79	29	1070.09		

Table 13. MMN mean amplitude: Means and standard deviations for nonmusicians (NM) and musicians (M) for all conditions.

		Chord		Phoneme		Chord Interval		Tone Interval	
		NM	MU	NM	MU	NM	MU	NM	MU
FP1	M=	-.16	-.35	.45	.57	-.42	-.64	.06	-.50
	SD=	.87	.67	1.10	1.17	.92	.84	.86	.84
FP2	M=	-.23	-.39	.40	.44	-.39	-.65	.02	-.57
	SD=	.86	.80	1.17	1.20	.81	.95	.82	.75
FZ	M=	-.38	-.49	.65	.68	-.60	-1.08	-.16	-.97
	SD=	1.22	.91	1.65	1.52	1.05	1.08	.99	1.06
F3	M=	-.25	-.27	.60	.64	-.46	-.75	-.09	-.73
	SD=	1.01	.74	1.32	1.28	.90	.84	.84	1.00
F4	M=	-.32	-.47	.53	.42	-.54	-.78	.006	-.75
	SD=	1.09	.97	1.49	1.49	.83	1.04	.81	1.00
FCZ	M=	-.40	-.46	.69	.69	-.61	-.98	-.10	-.92
	SD=	1.15	.90	1.63	1.38	.97	1.03	.96	1.02
FC3	M=	-.29	-.24	.62	.58	-.43	-.77	-.08	-.75
	SD=	1.08	.74	1.34	1.27	.80	.80	.85	.99
FC4	M=	-.27	-.39	.38	.29	-.56	-.73	.05	-.72
	SD=	1.08	.90	1.54	1.40	.77	.90	.78	.93
CZ	M=	-.37	-.32	.66	.59	-.57	-.85	-.02	-.73
	SD=	1.11	.88	1.48	1.31	.89	.95	.83	.96
C3	M=	-.27	-.20	.55	.44	-.44	-.75	.04	-.67
	SD=	1.12	.77	1.35	1.27	.66	.85	.75	1.00
C4	M=	-.22	-.29	.31	.22	-.50	-.70	.07	-.62
	SD=	.96	.90	1.47	1.31	.80	.86	.68	.85

Table 14. ANOVA for differential mean amplitude of left (FP1, F3, FC3, & C3) and right (FP2, F4, FC4, & C4) hemispheres during the phoneme condition.

Source	Sum of Squares	DF	Mean Square	F-value	Sig.
Hemisphere	0.72	1	0.72	11.50	.002*
Group	0.01	1	0.01	0.006	0.94
Group X Hemisphere	0.02	1	0.02	0.34	0.56
Error	2.59	41	0.06		

Table 15. ANOVA for MMN mean amplitude of anterior frontal region (FP1 & FP2) during the phoneme condition.

Source	Sum of Squares	DF	Mean Square	F-value	Sig.
Hemisphere	0.15	1	0.15	3.49	0.06
Group	0.14	1	0.14	0.05	0.81
Group X Hemisphere	0.03	1	0.03	0.88	0.35
Error	1.82	41	0.04		

Table 16. ANOVA for MMN mean amplitude of frontal (F3 & F3) during the phoneme condition.

Source	Sum of Squares	DF	Mean Square	F-value	Sig.
Hemisphere	0.47	1	0.47	3.03	0.08
Group	0.02	1	0.02	0.006	0.93
Group X Hemisphere	0.11	1	0.11	0.70	0.40
Error	6.45	41	0.15		

Table 17. ANOVA for MMN mean amplitude of frontocentral region (FC3 & FC4) during the phoneme condition.

Source	Sum of Squares	DF	Mean Square	F-value	Sig.
Hemisphere	1.55	1	1.55	15.48	.000*
Group	0.09	1	0.09	0.02	0.87
Group X Hemisphere	0.01	1	0.01	0.11	0.73
Error	4.10	41	0.10		

Table 18. ANOVA for MMN mean amplitude of central region (C3 & C4) during the phoneme condition.

Source	Sum of Squares	DF	Mean Square	F-value	Sig.
Hemisphere	1.17	1	1.17	12.00	.001*
Group	0.02	1	0.02	0.05	0.81
Group X Hemisphere	0.002	1	0.002	0.02	0.87
Error	4.02	41	0.09		

Table 19. ANOVA for differential mean amplitude of left (FP1, F3, FC3, & C3) and right (FP2, F4, FC4, & C4) hemispheres during the tone condition.

Source	Sum of Squares	DF	Mean Square	F-value	Sig.
Hemisphere	0.01	1	0.01	0.28	0.59
Group	9.92	1	9.92	7.84	0.008*
Group X Hemisphere	0.01	1	0.01	0.30	0.58
Error	2.47	41	0.06		

Table 20. ANOVA for MMN mean amplitude of anterior frontal regions (FP1 & FP2) during the tone interval condition.

Source	Sum of Squares	DF	Mean Square	F-value	Sig.
Hemisphere	0.05	1	0.05	1.17	0.28
Group	7.30	1	7.30	5.59	0.02*
Group X Hemisphere	0.005	1	0.005	0.11	0.73
Error	1.95	41	0.04		

Table 21. ANOVA table for MMN mean amplitude at frontal regions (F3 & F4) during the tone interval condition.

Source	Sum of Squares	DF	Mean Square	F-value	Sig.
Hemisphere	0.03	1	0.03	0.36	0.54
Group	10.51	1	10.51	6.55	0.01*
Group X Hemisphere	0.08	1	0.08	0.83	0.36
Error	4.08	41	0.09		

Table 22. ANOVA table for MMN mean amplitude at frontocentral regions (FC3 & FC4) during the tone interval condition.

Source	Sum of Squares	DF	Mean Square	F-value	Sig.
Hemisphere	0.13	1	0.13	1.90	0.17
Group	11.45	1	11.45	7.45	0.009*
Group X Hemisphere	0.05	1	0.05	0.81	0.37
Error	2.98	41	0.07		

Table 23. ANOVA table for MMN mean amplitude at central regions (C3 & C4) during the tone interval condition.

Source	Sum of Squares	DF	Mean Square	F-value	Sig.
Hemisphere	0.04	1	0.04	0.37	0.54
Group	10.71	1	10.71	8.28	0.006*
Group X Hemisphere	0.003	1	0.003	0.03	0.85
Error	4.35	41	0.10		

Jennifer Nicole Alfaro
Curriculum Vita

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Career Objective:

To pursue a doctoral degree in the area of Psychology with a special interest in psychoneurophysiology and cognitive neuroscience.

University Education:

Virginia Polytechnic Institute and State University
Master of Science
Cumulative GPA: 3.45
Expected Graduation Date: May 2002

Our Lady of the Lake University
Bachelor of Arts
Major: Psychology, Current GPA: 3.82
Minor: Music, Current GPA: 3.74
Cumulative GPA: 3.76
Graduation Date: May 1999

Academic Awards and Honors:

Dean's List	Fall 95, Spring 96, Spring 97, Spring 99
President's List	1995-1996, 1998-1999
National Dean's List	1995-1996,
All-American Scholar	1996
McNair Scholar	1996-1999
Alpha Chi	1997-1999
Psi Chi	1998-1999
Kappa Gamma Pi	1998-present
Who's Who Among American Colleges and Universities	1998-1999
AAAA Scholarship	1998
Virginia Tech Minority Scholarship	1999-2000

Research Experience and Presentations:

Alfaro, J., N. (2002). Automatic processing for musical and phonemic sounds: Differences in musicians and nonmusicians. Masters thesis, Virginia Polytechnic Institute and State University.

Alfaro J. N., Daugherty, S. A., & Crawford, H.J. (April, 2002). Music vs. verbal script induction of self-generated emotion: Differences in hemispheric EEG activation. Poster presented Virginia Tech

Alfaro J. N., Daugherty, S. A., & Crawford, H.J. (October, 2001). Music vs. verbal script induction of self-generated emotion: Differences in hemispheric EEG activation. Poster presented at the Society for Psychophysiological Research, Montreal, Canada.

Graduate School Tips for Success
Presented as part of McNair Workshop Series, April 21 Spring, 1999
San Antonio, TX

The Effects of Elements of Music on Physiological
Stress Responses and Perceived Stress Spring, 1999
Mentor: C. Christine Bow-Thomas, PhD
Presented at McNair Conference, January 29-31
Austin, TX

The Effects of Elements of Music on Physiological
Stress Responses and Perceived Stress Summer, 1998
Mentor: C. Christine Bow-Thomas, PhD
Presented at McNair Conference, October 30-November 1, 1998
Delavan, WI

The Effects of Elements of Music on Physiological
Stress Responses and Perceived Stress Summer, 1998
Mentor: C. Christine Bow-Thomas, PhD
Presented at McNair Research Symposium, September 26, 1998
Our Lady of the Lake University of San Antonio, TX

The Effects of Background Music on Learning Summer 1997
Mentor: Regina Cusack, MA, JD, PhD Canididate
Presented at McNair Conference, November 7-9, 1997
Delavan, WI

The Effects of Background Music on Learning Summer 1997
Mentor: Regina Cusack, MA, JD, PhD Candidate
Presented at McNair Research Symposium, September 22, 1997
Our Lady of the Lake University of San Antonio, TX

Research Conferences Attended:
National McNair Conference, November 7-9, 1997
Delavan, WI

Harmony: Creating Balance Through Body Mind and Spirit, September 26, 1998
San Marcos, TX

Penn State McNair Conference, August 7-9, 1998
State College, PA

National McNair Conference, October 30- November 1, 1998
Delavan, WI

Texas McNair Conference, January 29-31, 1999
Austin, TX

Human Brain Mapping 2000, June 12-16, 2000
San Antonio, TX

Memberships and Affiliations:
Danza Universal- Secretary and Costume Designer 95-96
Leadership Institute for Freshman Excellence (L.I.F.E.)- Member 95-96, Mentor 96-97
Lake Ambassadors- Member 96-98, Senior Lake Ambassador 98-present
Music Society- Founder – Vice President 96-97, President Spring 98-Fall 98, member
Provost Search Committee- Committee Member 1998-99
American Psychological Association- Student Affiliate 2000

Work Experience:
1/2002-Present Virginia Polytechnic Institute and State University Blacksburg, VA
Psychological Sciences- Teaching Assistant
-Assist a professor with class organization such as grading quizzes, grade bookkeeping, and upkeep of class web pages.

8/99-2001 Virginia Polytechnic Institute and State University Blacksburg, VA
Introductory Psychology- Recitation Instructor
-Teach several sections of recitation for the Introductory Psychology classes. Help students to better understand course material as well as help them to see the application of the material.

5/2000-8/2000 University of Texas Health Science Center San Antonio, TX
Research Imaging Center- Volunteer Research Assistant
-Assist in studies involving the research of music and neuropsychophysiology. Duties include recruiting and running subjects.

9/2001-Present St. Mary’s Catholic School Blacksburg, VA
Music Teacher

10/2001-Present St. Mary's Catholic Church Blacksburg, VA
Cantor
-Provide musical leadership for the congregation during weekly masses.

Summer 2000 St. Mary's Catholic Church Blacksburg, VA
Vacation Bible School (VBS)- Volunteer Music Teacher
-Teach singing and dancing to children ages 3-11. Organize production of material learned during VBS for the parents. Provide piano accompaniment for the VBS program.

7/2000-8/2000 University of Texas Health Science Center San Antonio, TX
San Antonio State Hospital- Clinical Research Unit- Research Assistant
-Record data for studies of treatment methods for patients with Schizophrenia.

1/99-5/99 Our Lady of the Lake University San Antonio, TX
Project Student Excellence Program- Tutor
-Assist students with course work in psychology and logic, teach basic test and note taking skills, assist in scholarship searches, and perform duties as assigned.

8/98-12/98 Our Lady of the Lake University San Antonio, TX
Campus Activities Office- Lake Ambassador
-Perform daily activities of the Lake Ambassador Program such as coordinating and facilitating programs and events, filing pertinent information, and keeping up student/administrative relationships.

6/98-7/98 Our Lady of the Lake University San Antonio, TX
Upward Bound Program- Resident Assistant
-Enforce rules and regulation in the residence halls, ensure that safety procedures are followed in the residence halls, and coordinate activities for the residents.

1/98-5/98 Our Lady of the Lake University San Antonio, TX
Project Student Excellence Program- Tutor
-Assist students with course work in psychology and logic, teach basic test and not taking skills, assist in scholarship searches, and perform duties as assigned.

8/97-12/97 Our Lady of the Lake University San Antonio, TX
Office of Residence Life- Resident Assistant
-Enforce rules and regulation in the residence halls, ensure that safety procedures are followed in the residence halls, and coordinate activities for the residents.

2/96-5/96 Our Lady of the Lake University San Antonio, TX
Learning Center- Tutor
-Assist students with course work in music and mathematics.

6/95-7/95 US Embassy, La Paz, Bolivia
USAID Student Work Program-

- Conduct inventories in the warehouse and office work and entered inventory into the books and PC. Also aided with the bookkeeping and phone charges in the department.