Attention Control in Musical Perception: Attention-Shifting as a Function of Musical Performance Experience

Talya Grumberg

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ABSTRACT

Attention Control in Musical Perception: Attention-Shifting as a Function of Musical Performance Experience

Talya Grumberg

Musical performance ability is an instance of a highly complex perceptual-motor skill that has been seldom studied with respect to the attainment of attentional fluency. The goal of the current study was to assess differences in attentional fluency in a group of pianists with varying ability levels (from novice to expert). Attentional fluency was operationalized in terms of shift costs exhibited on a musical auditory task shifting experiment (after R.D. Rogers & S. Monsell, 1995). Employing this paradigm, other researchers (M. Taube-Schiff & N. Segalowitz, 2005) have documented attention-directing functions of language that are related to fluency in another complex skill, that of second language (L2) performance. More specifically, grammaticized words were related to the ability to control attention in L2. For the purposes of the current study, it was hypothesized that dynamic and articulatory properties of music may serve a similar function to grammaticized words in L2. Furthermore, it was proposed that participants with increased musical experience should exhibit greater attentional fluency with musical materials than those with less musical experience. The results of the experiment directly contradicted this hypothesis; increased musical proficiency was found to be related to slower reaction times when shifting between musical properties of the stimulus. This result could not be explained by general attentional abilities. Results will be discussed in terms of the implications for the perceptual integrality of musical dimensions that may develop as a result of increased proficiency in the musical domain.

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The perception and performance of music are cognitively complex activities. The ability to perceive, think about and produce musical structures enlists multiple brain areas involved in audition, motor and executive functioning, and even emotional processing (Parsons, 2001). Music cognition, or the ability to appreciate and engage with music in our minds, encompasses a broad range of cognitive abilities. These include the ability to recognize, store, recall, transform and generate musical materials (Sloboda, 2000). In a recent book (2006), Levitin asserts "Music listening, performance and composition engage nearly every area of the brain that we have so far identified, and involve nearly every neural subsystem (p. 9)."

One interesting question about musical cognitive abilities concerns "fluency". In language, one can speak about second language fluency in terms of how fluidly a person can access word meanings, formulate a linguistic plan, and produce a coherent speech output that is relatively free from non native-like errors (Segalowitz, 1997; 2000). Similar questions can be raised regarding music cognition. What is musical performance fluency? A musical performance is considered fluent when it progresses at the intended tempo, with appropriate musical expression, and is relatively free from error and hesitations due to uncertainties, much like in the case of speech production. In order to achieve such a performance, the expert musician has to engage in many analogous processes as does the second language speaker in the example above. Connecting music on the printed page or in a stored memory representation to a fluent performance output requires the fluent operation of many cognitive abilities that underlie performance ability. A few examples of such cognitive abilities are attention, memory, problem solving abilities and motor skills. These skills must each operate in an efficient manner in order to yield a fluent performance output. For this reason, an important distinction has been made between performance fluency and the underlying cognitive fluency that supports performance abilities (Segalowitz, 1997; 2000).

Consider the case of an amateur pianist who plays jazz with a small ensemble for fun. In order to focus on his individual performance amid the overall performance of the ensemble, control processes will be engaged that allow his attention to be guided to the melodic line or bass line he is producing. If he is asked to alter the way he is playing, perhaps to play louder or softer in a given passage, or to change the articulation or phrasing of his part, this will require cognitive effort because he will need to alter his motor output and carefully monitor himself in order to achieve the desired effect. With increased practice these processes may become more automatic, (a concept which will be discussed in greater detail below) and the performer may be able to more flexibly adapt his performance to fit it with those around him. At the same time as his cognitive fluency is developing, he is liberating cognitive resources for other important tasks such as self-correction and self-monitoring. Underlying cognitive changes in cognitive fluency can therefore lead to improvements in overall performance fluency.

Neural Organization for Music Processing Among Experts and Novices

The ability to perform fluently as a musician is thus an interesting example of a highly complex perceptual-motor skill, like that of fluent language production. To date, much research in the musical domain has been at the level of perception of musical structures, with less research in the area of performance. A common approach to the study of music perception and production has been to include both musical experts and novices in research designs to document differences in the way they react to musical materials. This has led researchers employing neuroimaging techniques to discover differences in functional lateralization and brain morphometry between expert and novice musicians (Bever & Chiarello, 1974; Parsons, 2001; Schlaug, Jancke, Huang & Steinmetz, 1995).

Other research has gone beyond looking at structural differences in the brains of musicians to investigate differential electrophysiological activation patterns when musicians and non-musicians are engaged in musical tasks. In particular, researchers in this area have been interested in the perception of pitch and harmony, because pitch perception is seen as a prerequisite for the processing of melodic and harmonic content in both music and speech (Koelsch et al., 2001). Besson, Faita and Requin (1994) studied differences in the processing of melodic material. They presented musical phrases that ended either in a congruous or an incongruous note. The auditory evoked response potentials (ERPs, an indirect measure of electrophysiological activity) elicited by the task were examined for each condition (congruous and incongruous) and the researchers noted a faster negative ERP component in the expert group when they detected musical incongruities. Early negative ERP components, such as the N400, have been previously associated in language studies with the violation of syntactic expectancies (Hahne & Friederici, 1999). Besson and colleagues hypothesized that the negative ERP component observed in their study was due to the fact that musical expertise makes cognitive expectations clearer and more salient, hence in the expert group processing proceeded preattentively. The discovery of an electrophysiological component related to violation of harmonic expectancies that operates preattentively has been documented in other studies as well (Koelsch et al., 2001; Pei et al., 2004). It would thus appear that some aspects of music processing seem to be automatized, that is occurring prior to conscious awareness, and differential electrophysiological reactions are observed with violation of harmonic expectancies in music in a manner comparable with syntactic violations in language studies. Furthermore, musical expertise seems to confer some processing advantage whereby musical expectancies or schemas may be more accessible and therefore aid in processing of harmonic structures.

In a functional magnetic resonance imaging study (fMRI), Gaab and Schlaug (2003) discovered that musicians exhibited greater activity in the right posterior temporal and supramarginal areas relative to non-musicians who showed more activation of the left auditory association cortex, when they were asked to identify successive matching or non-matching tones. Both groups had equivalent performance scores for this task, suggesting that equivalent performance outcomes were achieved through different means in the expert and novice groups.

As a compelling instance of a highly complex perceptual-motor skill, musical performance has been studied with respect to developing a better understanding of motor programming and control (Sloboda, 2000). Behavioural data have supported the idea that expert musical performers exhibit superior motor abilities. With increased piano practice, a circuit involving cortical auditory, sensorimotor hand areas and right dorsolateral prefrontal areas becomes jointly activated for auditory as well as for mute motor tasks (Bangert, Haeusler & Altenmüller, 2001). After years of practice, this motor representation may become automatized and can even be activated preattentively.

All these results taken together suggest that the neural organization underlying behavioural manifestations of musical ability may differ with increased musical proficiency. Peretz and Zatorre (2005) speculated that a "complex interplay exists between structural changes that may accompany prolonged behavioral performance and neural responses that underlie that performance. A greater volume of tissue may reflect a reorganization, which in turn may manifest itself as recruitment of fewer neurons, or differently synchronized firing patterns, or different effective connectivity with other regions under different circumstances (p.103)." In sum, the attainment of performance expertise in the musical domain may reflect changes in underlying neural organization. Furthermore, changes in cognitive abilities that result from extensive practice in the musical domain can be reflected in behavioural changes, for example improvement in attentional or motor abilities (Bangert et al., 2001; Madsen & Geringer, 1990; Williamon, Valantine & Valantine, 2004).

Music perception: Auditory scene analysis

Music processing is complex because, like speech, music is a temporal phenomenon. Musical structures unfold over time and their physical characteristics (frequency, amplitude and timbre) are in a constant state of flux as a musical performance progresses. Musical representations leave a memory trace in short-term memory that is finite and subject to interference with distraction. Because music perception and production occur in real time, attentional abilities and short-term memory representations are paramount (Janata, Tillman & Bharucha, 2002).

How do people attend to task-relevant aspects of the incoming musical signal? Much research has addressed the complexity of the listener's perceptual parsing of the auditory input as it unfolds over time, and more specifically the research has addressed whether the properties of the incoming auditory signal are perceived as unitary or disparate. For example, the musical performer is able to differentiate the unique spectral pattern produced by their performance from those sounds produced by their colleagues in an ensemble, and further disentangle all these sounds from the sound of the ventilation in the practice hall. How are individuals able to achieve this?

The perception of individual sound sources in the environment is problematical because complex waveforms from multiple sound sources can share overlapping components of time and frequency. In order to perceptually group sounds, the listener must be able to detect relevant cues in the waveform and disentangle those that may belong to alternate sound sources (Turgeon et al., 2005). Bregman's research on auditory scene analysis (1990) has elucidated properties of the incoming auditory signal that allow the listener to decompose acoustic signals to form a tonographic representation. Sounds in the exterior environment that are perceived as belonging to different sound sources are grouped simultaneously, and those that are perceived as belonging to the same source are grouped sequentially according to the principles of auditory scene analysis. Sequential groupings yield a unitary percept referred to as an auditory "stream." Data have suggested that auditory streaming occurs automatically in several different circumstances such as when the human ear groups together sounds that share a common fundamental frequency, a similar location in space, or if the frequency components begin or end at a similar time (Carlyon, 2004; Turgeon et al., 2005). A question that has interested both auditory and visual researchers is the stage of perceptual processing at which grouping mechanisms occur. In the case of auditory perception, Bregman (1993) has distinguished between primitive mechanisms, which are largely data-driven and do not require attention, and schema-based mechanisms that are top-down and involve attentional processes (Carlyon, Cusack, Foxton & Robertson, 2001).

More recent studies have manipulated the attention of the listener to demonstrate the importance of attention in auditory streaming (Carlyon, 2004). This research exploited a documented perceptual phenomenon, whereby a single perceptual stream turns into a two-stream percept after several seconds of an alternating triplet tone pattern (Carlyon et al., 2001). The authors found that when attention was purposely diverted to the tones in the stimulus, the "build-up of streaming" was much less than in the baseline condition where the participants engaged in simple counting of tonal patterns.

Humans are able to perceive many different auditory streams simultaneously, as in the case of polyphonic music perception and production (Bigand, McAdams & Forêt, 2000; Chafe & Jaffe, 1986; Janata, et al., 2002). People are able to distinguish the timbre (or the sound quality) of individual instruments, and also to hear the entire orchestra playing simultaneously as a unified auditory stream (Levitin, 2006). When performing a concerto, the musician needs to focus attention on his or her musical output while concurrently regarding the orchestra for cues and disregarding other extraneous environmental noise, for example the patron in the first row with a hacking cough. For this reason, the performer needs to be able to flexibly allocate finite attentional resources in order to achieve a coherent musical percept and a fluent output.

Expertise in context

Changes in functional organization and some skills, such as motor skills, attention and memory for musical material that may underlie musical expertise have already been alluded to, but one can ask, what is expert performance in a more general sense? To answer this, it is worth first briefly considering a limitation of the human information processing apparatus, namely that it has a finite processing capability (Kahneman, 1973).

For this reason, successful performance in a given domain requires attention to task-relevant aspects, and disregard for irrelevant aspects of the incoming stimulus for processing and storage (Moors & De Houwer, 2006). In a classic series of experiments, de Groot (1946,1978) found that expert chess players accessed the best chess moves during their initial perception of the chess position, rather than after an extensive search of the chessboard. This finding implied that chess experts relied on pattern-based memory retrieval. In this same line of research, Newell and Simon (1972) demonstrated that pattern-based retrieval accounts for superior selection of chess moves and exceptional memory for chess positions operated without violating general limits to human information processing, including the limited capacity of short-term memory. In the case of music processing, it seems that experts may differentiate themselves from novices based on not on those aspects of music perception that related to pattern memory as such, but rather those that are considered automatic such as the processing of harmonic relations as noted above (Besson et al., 1994), and temporal information (Rammsayer & Altenmüller, 2006).

Expert performance can be seen as the end result of the "individuals' prolonged efforts to improve performance while negotiating motivational and external constraints" (Ericsson, 1993, p. 363). Research has looked at the development of expertise in a myriad of domains including music, sports, mathematics, drama, second language proficiency, and others. At first, researchers believed that simple repetition over an extended period of time would be sufficient to acquire expertise in a given domain. This gradually gave way to research that showed the importance of deliberate practice in the development of expertise (Ericsson, 1993). Bryan and Harter (1897, 1899) long ago demonstrated in a series of studies with a group of Morse code operators that mere repetition improved performance only to a certain point, after which it often plateaued. In order to improve further, the individuals had to effortfully reorganize the way they approached their task performance (Ericsson, 1993). Recent research on expert performance and expertise (Chi, Glaser, & Farr, 1988; Ericsson & Smith, 1991) has shown that important characteristics of experts' superior performance are acquired through prolonged experience and that the effect of practice on performance may be larger than previously thought. However, it seems that other factors such as innate (genetically predisposed) abilities, intrinsic motivation and external rewards may also play a role in the development of expertise, though these issues merit discussion that is beyond the scope of the present review (Ericsson, 1993; Levitin, 2006; see especially Simonton, 1999).

Automaticity and expertise

Automaticity is another hallmark of fluent expert performance (Moors & De Houwer, 2006; Segalowitz, 2000; Segalowitz, 2003; Segalowitz & Hulstijn, 2005; Segalowitz & Segalowitz, 1993). In the field of expertise research, there has been a distinction made between those processes that are seen as occurring without conscious awareness, referred to as implicit or automatic processes and those that require explicit cognitive resources or attention, referred to as attention-based processes. When one is learning a new skill such as playing the piano or speaking a second language, there are many aspects of performance that require conscious attention in order to produce a successful output. These are referred to as control processes. Control processes require cognitive effort, and proceed in a slow and deliberate manner. At early stages in the acquisition of a complex skill, the performance of the individual is variable and prone to interference (Segalowitz & Segalowitz, 1993). With increased deliberate practice, skills may become automatized. The effect of practice on the development of automaticity has been hypothesized to reduce or eliminate the influence of control processes, thereby resulting in faster and less variable processing. Segalowitz (1997) describes Ackerman's (1986, 1987, 1988, 1989) three-phase model of complex skill acquisition as it relates to language performance, though it is also applicable to the case of musical performance. At first, performance is based on the individual's declarative knowledge that is under conscious control. For example, the beginning pianist has to engage in problem solving when he looks at the note on the page in order to connect it with the appropriate musical representation in his mind and link that representation with a correct motor representation to enact a key press on the keyboard. With practice, the individual becomes less dependent on explicit knowledge of these connections and processing becomes more associative. By chunking sets of cognitive and motor representations that are necessary for performance, there is decreased load on current working memory capacities and attentional resources, allowing the performer to focus more on self-monitoring for example. Once musical notation has been strongly associated with mental representations and motor outputs, playing notated structures requires less cognitive effort. Furthermore, this fundamental reorganization leads to both faster and more stable performance.

A high level of skill is achieved when psychomotor aspects of performance become autonomous-that is they are implicitly executed without the influence of attention or conscious control processes (Segalowitz, 1997). Concert pianists are no longer thinking about the individual notes when performing, rather, they are concerned with a higher level of analysis of their overall fluent output, the goal of which is to express an intended overall musical message to the listener. In sum, gains in performance fluency are reflected by improvements in not only speed, but importantly in fluidity (smoothness of tempo) and accuracy as well. These can be seen to reflect reorganization of cognitive processes, and reallocation of attentional and memory resources.

Attention and fluency in music

So far, the discussion has focused on those processes that are automatized, but the non-automatic, or attention-based processing components involved in fluent performance deserve consideration as well. Attention can serve many different functions in fluent performance. People can also direct their awareness to the material being learned (Segalowitz & Hulstijn, 2005). This allows one to notice features of the music and focus on the form of the musical structures that may be important for learning how music functions. Selective attention may also be involved in fluency, for example as in the above case of auditory scene analysis where the listener is able to isolate discrete streams in a complex auditory environment. Furthermore, musical structures themselves may serve an attention directing function, as has been documented in language perception where language is seen as "shaping the way a listener or a reader builds a mental representation of the message being conveyed" (Segalowitz & Hulstijn, 2005, p. 378).

Expertise and performance fluency in L2

Performance fluency has been studied with respect to attention control in a second language (hereafter referred to as L2). This type of research is unique because it provides an example of a skill set, that of language comprehension and production, in which the same individual can be an expert in one language and a relative novice in their L2

(Segalowitz, 1997). Taube-Schiff & Segalowitz (2005) adapted an alternating runs paradigm (developed by Rogers & Monsell, 1995) to look at the attention directing function of L2 grammaticized words in visually presented contextualized sentence fragments. The pattern of trials established in such a paradigm is AABBAABB, etc…with A and B each representing distinct tasks. The authors operationalized attention control in terms of shift costs, that is, the increase in reaction time that is observed when a participant is required to shift attention from one type of decision (that reflects one aspect of task performance) to another type of decision on a subsequent trial. The shift cost is reflective of the extra load placed on attentional resources (Taube-Schiff & Segalowitz, 2005). In a series of studies, they presented bilingual participants with grammatical function words and nouns in their first and second languages. The authors believed that function words would serve to guide attention as meaning was constructed from the linguistic elements (Segalowitz & Frenkiel-Fishman, 2005). They found attention shifting costs for grammaticized elements (function words) in L2, but not for nouns. In this study, only linguistic control with grammaticized elements was related to language proficiency in L2. This effect was obtained after controlling for non-linguistic aspects of attention that are correlated with linguistic attention. This was accomplished by residualizing an individuals' first language performance against their performance in L2 to obtain an L2 specific measure of attentional fluency.

Are there analogous attention-directing structures in music? Composers have long used devices such as harmony, dynamics, rhythm and articulation to guide the listener along in a musical passage (Levitin, 2006). It would seem that these devices may serve an analogous function to grammaticized words in L2. However, it remains to be seen whether expertise in music is related to attentional fluency with musical features that serve an attention directing function akin to grammaticized words in L2 (Taube-Schiff & Segalowitz, 2005). Musical experts possess unique attentional skills (Madsen & Geringer, 1990). For the purposes of this study, the goal was to examine whether a musician's past performance experience in manipulating musical features such as dynamics and articulatory properties of the incoming auditory signal would result in an ability to more flexibly guide attention differentially to these properties of a musical stimulus. In order to address this question, we developed a musical auditory task-shifting paradigm based on the research described above. Auditory shift costs were taken to be reflective of a capability to shift attention between elements in the music that are hypothesized to have attention directing functions within the music itself. The first task was to develop an auditory paradigm that would be effective in eliciting shift costs. It was assumed that increased performance experience would be associated with greater expertise in manipulating musical dynamics and articulation for the purpose of achieving musical effects. Given this assumption, it was hypothesized that, in the context of the musical attention-shifting task described below, increased performance experience would be associated with smaller costs in shifting attention focus from one perceptual aspect of the musical stimulus to another, thus reflecting greater attentional fluency in more experienced performers.

The musical attention shifting task

In order to ascertain if there is indeed a connection between musical performance expertise and attention control abilities with respect to musical features such as dynamics and articulation, a musical attention-shifting task was developed. It followed an alternating runs structure modeled after Rogers and Monsell (1995), and included both piano and non-musical auditory stimuli in separate experimental blocks. The piano stimuli were recorded by an expert pianist with many years of performance and teaching experience. Participants with varying piano ability levels were recruited for this study. It was hypothesized that increased experience with musical structures would lead those with more musical experience to be able to more fluently guide their attention when asked to shift between different aspects of the musical stimuli. In an analogous control condition, non-musical environmental sounds were included. We hypothesized that the response to these control sounds should be relatively similar across participants regardless of their musical ability level, much like the effect observed with nouns in L2 (Taube-Schiff & Segalowitz, 2005).

Musical expertise and experience

All participants in this study completed a questionnaire that allowed us to gain information about their practice habits, and years of experience in a variety of musical activities such as solo and ensemble performance, teaching, and music theory training. In the expertise literature, practice of a skill over an extended period of time has been related to the attainment of expertise. Most studies cite approximately 10,000 hours of practice as being requisite to the attainment of expert status (Ericsson, 1993). For this reason, expertise was operationalized based on years of formal training and practice on the piano. In addition to this information, qualitative information was collected about the type and level of repertoire being performed on the piano and the individual's qualitative conceptualization of difficulties they faced in performing a challenging piece. This information, taken together, gave rise to an adequate picture of the performance abilities of the individual participants in the study.

The research hypotheses

The general hypothesis was that there would be evidence of a positive association between attention control abilities as operationalized in the attention shift task and performance experience as operationalized in the questionnaire measure. More specifically it was hypothesized that:

(1) all participants will provide evidence of attention shift costs in both the musical condition and the non-musical control condition.

(2) the magnitude of the attention shift cost in the musical condition will vary as a function of the participants' past musical performance experience, whereas the magnitude of the attention shift costs in the non-musical control condition will not.

In performing *complex* music, musicians have to be able to shift their focus of attention from one perceptual dimension of the music to another in order to achieve desired musical intentions. For example, in playing a three part fugue, the musician may wish to contrast the different voices by varying the articulation (staccato/legato quality) of the different voices and at the same time give the music its shape by varying the dynamics of the different voices as the music unfolds (say, a crescendo for one voice and simultaneously a decrescendo for a different). Skilled musicians must not only be able to prepare their performances in this way, they must be able to monitor the performance in real time in order to make moment by moment adjustments as needed to achieve the desired musical effects. The need for monitoring is especially important when one considers that pianists typically play on a different instrument from the one they normally practice on and they perform in settings (e.g., a hall with a large audience) that are radically different from where they practice (at home). A skilled musician will monitor closely the performance as it unfolds to ensure that all the nuances are delivered appropriately. This is why it is hypothesized that the ability to shift attention focus from one musically relevant perceptual dimension to another will vary as a function of performance experience.

Method

Participants

Subjects with novice to expert piano performance skill were recruited for this study. Thirty-four (25 female and 9 male, mean age=22.8 years, range = 18 to 35 years) students from two major universities were recruited through the use of advertisements placed on online classified websites and via posters.

Materials

Musical Performance Questionnaire. Musical activities and performance experience were assessed by the completion of a questionnaire that probed daily musical activities including performance, practice, teaching, solo and ensemble experiences, a listing of repertoire performed on the piano, as well as qualitative information regarding the participants conceptualization of the unique challenges of performing a difficult piece. For the purposes of this study we also asked about English language proficiency because all task instructions were delivered in English. All participants rated their English comprehension skills in the intermediate to fluent range.

Musical stimuli. All stimuli in the experimental condition were recorded on a Falcone 7'4" grand piano by an experienced pianist and performer. In the experimental condition, the target lines of the stimuli were ascending and descending figures that were articulated both as staccato and legato patterns in the following keys: B flat major and minor, C sharp major and minor, E major and minor, and G major and minor. An ascending and a descending melodic pattern were recorded in each of these keys (Appendix A). They were recorded in WAV format directly onto the hard disk of Fujitsu laptop computer (LifeBook E series), using a SONY ECM-999 MS-Stereo microphone into Adobe Audition Pro.

Stimuli were then manipulated on an E-machines PC using sound editing software Cool Edit Pro, (version 2.0, copyright Adobe Systems Inc.). Each recording was made to fit a durational window of 2000 ms, while preserving the pitch level of the stimulus. The performer was instructed to play each melodic figure for a duration of approximately 2 seconds, so the amount of mechanical alteration required was slight; the greatest amount that any individual line had to be altered was by 210 ms.

In an effort to have naturalistic stimuli that placed a sufficient burden on attention, we created musical figures with two individual melodic lines that were articulated concurrently, as one would encounter in many musical compositions. The second melodic line was formed by shrinking each target to half its length (i.e., 1000 ms) and pasting two successive articulations side by side to form a new figure with a total duration of 2000 ms. This figure was then transposed up one octave (with a frequency ratio of 2:1 relative to the target line), as we determined that this would allow the subjects to have sufficient melodic distance between lines to “pick out” the target and respond to the task demands while still placing a sufficient burden on attention. This figure comprised the distractor line for the target that shared the same notes but was opposite in melodic direction. For example, if the target line for a given trial was ascending and in G major, the paired distractor line would be descending in G major. The target and distractor lines were then mixed together using a stereo mix function in Cool Edit Pro. The next manipulation aimed to create bivalent stimuli by manipulating the dynamic properties of the trial. Preset amplitude changes were used on all trials to first ramp up amplitude over the 2000 ms window to create the effect of a crescendo. Another preset was then used on all original mixed files to ramp down amplitude over the 2000 ms window in order to create the effect of a decrescendo. In all, 16 trials were created for each of the following combinations (8 with ascending target and 8 with descending target lines): Staccato crescendo, staccato decrescendo, legato crescendo, legato decrescendo (total experimental trials=64).

Non-musical stimuli. In the control condition, we aimed to create an analogous bivalent structure comprised of two concurrent lines of sound. Furthermore, we wanted to create auditory stimuli that would not be differentially responded to based on varying levels of musical experience. We decided that telephone tones would provide an example of one such auditory phenomenon that all participants would have similar range of experience with in their daily lives. The two aspects of these non-musical targets we manipulated were the type of tone (that is, telephone ring or busy signal) and the speed with which the tones were articulated (fast or slow) within the 2000 ms trial window. The distractor line in this condition comprised short speech patterns that were recorded by the experimenter. These were then transformed in CoolEdit Pro to yield reverse speech patterns, which we believed would provide less distraction than natural language, but still make the task sufficiently challenging.

Different telephone ring and busy signal patterns were acquired from an Internet site which searches for free audio file content (http://www.findsounds.com/). These sounds were manipulated using the same editing software and equipment mentioned above. Four examples of telephone rings and four examples of busy signals in WAV format were selected and cropped or stretched to fit a durational window of 2000ms. The files were then transposed up and down by a tone (with a frequency ratio of 9/8), creating 8 different ring targets and 8 different busy signal targets at varying frequency levels. The individual tonal components within the rings and busy signals were then manipulated to be longer or shorter in duration depending on the individual duration of tones within each file. All these manipulated files were pilot tested on four individuals who were blind to the purpose of the study and they determined whether the tones sounded "fast" or "slow." Their ratings were in agreement for all the files that were selected for the experiment. The busy signal and ring targets were then stereo mixed with the reverse speech patterns to create our bivalent trial files. In all, 16 trials were created for each of the following combinations: fast busy trials, slow busy trials, fast ring trials, slow ring trials (total control trials=64). All mixed bivalent stimuli in both the experimental and control conditions were batch root mean square (RMS) normalized to 100% to ensure presentation at an equivalent peak amplitude. Finally all stimulus files were converted to AIFF format, which is supported by the experimental presentation software used in this experiment.

Design

A program was written using Hypercard 2.3 to counterbalance the order of presentation of the stimuli in each condition. This ensured that all stimuli were employed with equal frequency in varying orders of presentation to participants and occurred equally often on shift trials and no-shift trials. Another important counterbalancing procedure was implemented too. The stimuli were bivalent, that is, each stimulus could be responded to in terms of its features on one dimension or the other, even though only one of those was ever relevant on a given trial. It was important, therefore, to counterbalance whether the two features were congruent (required the same response) or incongruent (required different responses). This feature was counterbalanced within shift and no shift trials separately. Finally, the hand of response was also counterbalanced for each condition, so that a given hand was never associated with a particular type of response across participants.

Procedure

The experiment was programmed and presented via noise-cancelling headphones (Kensington, model 33084) on a PowerMac G3 using PsyScope, a freeware program. The experimental design is a modified musical auditory task-shifting paradigm (modeled after Rogers & Monsell, 1995) that required the participant to listen for a target melodic line amid a combination of two concurrent melodic lines on experimental trials and to make a speeded button-press response based on the quality of the target and trial task demands.

In the experimental condition, trials were structured such that the subject would make articulation decisions (deciding whether the target line was staccato or legato) alternating with dynamic decisions (deciding whether the target line was crescendo or decrescendo). The pattern of decisions followed a repeating AABBAABBAA... order where A represents one type of decision and B the other. The participant was required to complete the same decision task for two successive trials, and then shift their attention to another aspect of the stimulus in order to make another decision on the two subsequent trials. At the onset of each trial subjects saw a figure on the computer screen that indicated which task was to be performed on that trial (see Appendix B).

For the control condition, the two decisions required of the participants were the type decision (deciding whether the target was a telephone ring or busy signal) alternating with the speed decision (deciding whether the target line was fast or slow). This followed the same presentation structure described above. Reaction times in milliseconds were recorded for each response.

Participants completed two blocks of trials, one in the experimental condition and one in the control condition. The order of presentation of these blocks was counterbalanced across participants. Prior to each block, participants completed a practice block in which they were trained on the task demands for each block. They were instructed to respond as quick and accurately as possible once they heard the onset of the stimulus and were able to make a decision (Appendix C). They had 20 trials to practice each decision separately (for example 20 trials for the articulation decision and then 20 trials for the dynamic decision), and then another 28 practice trials during which they were required to shift from one task to the other (for example from the articulation to the dynamic decision). After the practice was completed, they performed four sets of 48 trials each (192 trials in all) in that condition. They then moved on to practice and complete the 192 trials in the other condition.

All participants were debriefed and financially compensated for their participation in the study.

Results

For all the analyses described below, the alpha level for significance was p = .05. In the attention shift task, only reaction times (RT) for correct trials were submitted to analyses. Unless otherwise specified, all t-tests are two-tailed.

The first step in the analyses was to select participants whose RT performance indicated that they had performed the tasks in a way that met the basic assumptions of the attention shift tasks and whose musical performance experience met appropriate criteria for retention. These issues are discussed first. Table 1 provides a summary of the characteristics of the 25 participants who were retained for further analyses.

Only data from participants who exhibited a mean attention shift cost reaction time in both the experimental and control conditions greater than 1/10 of a standard deviation unit were considered in our analyses. This removed data from participants whose performance on the attention shift task could not be deemed to reflect attention control because they lacked a meaningful shift cost. In total 34 participants completed the study. However, when the above criterion was enforced, data from 26 subjects remained for analysis. One of these participants was excluded because of his musical performance history; he had only one year of formal piano instruction, but approximately 20 years of violin training. For this reason, he could not be confidently classified as having his considerable musical performance abilities based on *piano* experience. Since the musical stimuli used in the study were based on piano examples, it was decided to remove this participant's data from further analysis.

Thus, for all the statistical procedures reported below, the sample size was 25 participants (19 female and 7 male, mean age=22.7 years).

Table 1

Summary of Repertoire Data Collected in Musical Performance Questionnaire

	Years training	Representative examples of repertoire cited
Low Experience Group	Mean = 3.38, Range = 1-10	No major works Own compositions Church choir music Beginner Piano pieces & technique exercises "When the saints go marching in" Mendelssohn concerto E min Beethoven Fur Elise Popular Beatles Songs "Autumn Leaves" Chopin: Nocturne in Bb min Gershwin: "Summertime" Mozart Rondo alla Turca, Sonata in C major; Bach: Preludes Brahms: Prelude #1 in A min
High Experience Group	Mean = 13.25, Range = 11-17	Chopin Nocturnes, Waltzes Bach: Fugues, Two part Inventions, Preludes, Goldberg Variations; Debussy Preludes; Sonatines Jazz Standards Original compositions and Improvisations Ravel Schumann Mendelssohn Rachmaninov: Preludes Mendelssohn songs without words Beethoven Sonatas

Musical Performance Questionnaire. Ratings on the musical performance questionnaire (Appendix D) indicated that participants had between 0 and 17 years (mean =8.12 years) of formal piano training. Of the 25 participants, 22 listed piano as currently their principal instrument. Of the three that listed other instruments, one played the synthesizer, another the guitar and one participant listed voice as their primary instrument. Twenty-one participants listed solo (unaccompanied) playing as their primary performance activity; whereas two listed accompaniment as their primary activity, one listed orchestral playing, and one listed playing in a chamber ensemble.

In terms of years of formal musical lessons, participants had a range of training from none (one subject was self taught) to 17 years (mean number of years of lessons=13.25). Participants rated their mean practice hours per day to be 1.6 (range=0.5 to 3.5).

On a self-rating scale of performance activities that ranged from 1 representing amateur musical activity (for example, plays at home for fun) to 10 representing high-level performance (solo stage and recording experiences, perform virtuosic works in the worlds' major concert halls), participants rated their mean ability level to be 3.88 (range from 1-6.5) which on this scale would represent serious amateur level performance (occasionally perform for friends, with an amateur ensemble).

Participants listed the repertoire that they had performed. This revealed that our sample played a variety of piano music with varying difficulty levels. For example, a participant with one year of piano lessons listed "beginner piano pieces" and "technique exercises"; whereas one participant with over 17 years of training listed Chopin

Nocturnes, Rachmaninov Preludes and "Moment Musical", and Mendelssohn's "Songs without Words," as examples of repertoire that they had played on their instrument.

We asked participants to describe qualitatively the difficulty in playing a piece that they found particularly challenging. Again, we observed a range of responses related to technical (production) challenges, such as coordinating the left and right hand musical parts for a participant who had less than one year of piano experience, to artistic and performance challenges such as expressing emotion and bringing out the composers' intentions in a musical passage for subjects with 14 and 13 years of experience, respectively.

Attention Shifting Task. Mean reaction times on correct responses for both shift trials and non-shift trials were calculated separately for each participant. Responses made within 150 ms or less of stimulus onset were considered to be impulsive, and were therefore excluded from our analysis.

The first step in the analyses was to calculate the mean RT on shift and repeat trials for each participant in the musical and non-musical control conditions. These are summarized in Table 2, along with the mean error rates. It can be seen from the table that there were significant shift costs in each condition. These results confirm that the musical and control versions of the alternating runs task succeeded in meeting the basic requirement of eliciting attention shift costs.

We hypothesized that greater performance experience and increased years of formal instruction on the piano would be related to lower shift costs in the musical condition in our sample. In order to investigate this hypothesis we first divided the

Table 2

Mean reaction time data and percentage of error for all subjects on shift and no shift trials

Condition		Mean RT (ms)	Std. Dev.	Mean % Error
Experimental				
	Shift	1648	306.899	10.30
	No Shift	1516	303.769	7.52
	Shift Cost*	132	61.107	
Control				
	Shift	1183	203.194	12.69
	No Shift	1029	154.887	10.86
	Shift Cost*	154	82.068	

* Shift costs were computed for each condition by subtracting mean RT on no shift trials from mean RT on shift trials.

sample of 25 participants into two groups, high versus low number of years experience performing. Inspection of the responses to the questionnaire revealed a natural break between participants with 11 or more years of formal instruction (n = 12; mean number of years experience =13.25, range = 11-17 years) and those with less than 10 years formal instruction (n = 13; mean = 3.38 years; range = 1-10 years). These two subgroups are henceforth referred to as the High and Low Experience groups respectively.

It was important to establish that these two groups did not differ from each other in significant ways that could impact on the main hypothesis to be tested. The RT data from the non-musical condition were submitted to a mixed between-within analysis of variance (ANOVA) with the between factor being Group (High, Low experience) and the within factor being Shift (Shift, No Shift). The results of this analysis revealed a significant shift cost main effect (RT on shift trials were 154 ms slower than on no shift trials; ($F(1, 23) = 84.685$, MSe = 3513.660, $p < .001$, partial eta^2 = .786) and no interaction effect with Group ($F(1,23) <1$), indicating that both groups showed a significant shift cost and did so equally when the stimuli were non-musical. Additional analyses revealed that the error rates of the two groups were not different in performing the non-musical attention shift task (high experience 14.7 %, low experience 10.8 %; t (23) = 1.08, p > .05) (Table 3).

The test of the main hypothesis was carried out by submitting the RT data from musical condition to a similar 2 x 2 ANOVA. Here the results revealed a significant shift

Table 3

Mean reaction time data and percentage of error for experimental and control conditions for high and low experience groups.

Condition			Mean RT (ms)	Std. Dev.	Mean % Error
Experimental					
	High Experience				
		Shift	1681	305.940	10.58
		No Shift	1521	312.853	7.89
		Shift Cost*	160	60.593	
	Low Experience				
		Shift	1618	316.952	10.04
		No Shift	1511	307.867	7.18
		Shift Cost*	107	50.742	
Control					
	High Experience				
		Shift	1142	174.129	14.70
		No Shift	988	140.296	12.11
		Shift Cost*	154	74.358	
	Low Experience				
		Shift	1221	226.915	10.83
		No Shift	1066	163.610	9.70
		Shift Cost*	155	91.655	

* Shift costs were computed for each condition by subtracting mean RT on no shift trials from mean RT on shift trials.

cost main effect (RT on shift trials were 132 ms slower than on no shift trials; ($F(1, 23) = 143.67$, MSe = 1549.650, $p < .001$, partial eta^2 = .862). In addition, there was a significant Shift by Group interaction effect ($F(1, 23) = 5.916$, MSe = 1549.650, p =.023, partial eta^2 = .205). Closer examination of this interaction effect revealed that, contrary to hypothesis, the High experience group showed a larger shift cost (1681 versus 1521 ms on shift and no shift trials respectively) than did the Low experience group (1617 versus 1511 ms on shift and no shift trials respectively). Subsequent post hoc t-tests, Bonferroni corrected, showed that the High and Low experience groups did not differ in their RTs on the baseline no shift trials and that the interaction effect was due to the High experience group being slower on the shift trials and not slower on the no shift trials than the Low experience group.

Finally, for completeness, a 2 x 2 x 2 ANOVA was conducted with the within subjects factors being Shift (Shift, No Shift), Condition (Musical, Non-musical) and Group (High, Low experience). This analysis revealed a main effect for Shift, indicating significant shift costs overall ($F(1, 23) = 195.242$, MSe =, $p < .001$, partial eta^2 = .874) and a significant Condition effect, indicating faster performance in the non-musical condition ($F(1, 23) = 143.67$, MSe = 1549.650, $p < .001$, partial eta^2 = .862). There were no other significant main effects or interactions (all Fs < 2.7, $p > .10$).

Discussion

This thesis addressed the question of whether musical expertise was related to attention control for musical elements (dynamics and articulation) in a group of pianists with varying ability levels.

To investigate this question, the alternating runs design of Rogers and Monsell (1995) was adapted for use with musical stimuli. This is the first time, to our knowledge, that this design has been used in this context. The main hypothesis was tested by comparing the attention shift costs in the musical condition between musicians with relatively more experience (11 years or more training) against those with less experience (10 years or less). The main findings were the following.

First, the high and low experience groups did not differ from each other on error rates in either the music or the non-music condition. Furthermore, no group differences were observed based on attentional fluency task shifting in the non-music condition. Moreover, the RTs in the non-musical condition were of the same order of magnitude as those in the musical condition; this increases our confidence that the non-musical condition provided an appropriate baseline measure of attention control. We can therefore conclude that there were no group differences related to basic attentional skill for non-musical auditory stimuli, and that any effects observed in other analyses were due to attentional control specific for musical material

The qualitative data obtained from the questionnaire showed that the participants had a range of musical performance experience that naturally permitted dividing them into two distinct groups based on the amount of formal training, level of performance experience and repertoire that they performed. Additionally the way in which they conceptualized unique performance challenges allowed us to note that novices were in general more concerned with motor challenges of playing pieces, such as coordinating their two hands, whereas those with more experience went beyond this simple concern (though they did report some motor difficulties on particularly challenging pieces) to describe challenges that regarded musicality and expressing the intentions of the composer.

The music condition was the condition of interest to establish if there was a connection between musical expertise and attentional fluency for musical elements such as dynamics and articulation. Surprisingly, the results of the analysis contradicted the a priori experimental hypothesis; the more experienced musicians showed a significantly *larger* shift cost in the music condition compared to the less experienced. Moreover, closer examination of the data revealed that the difference between the groups was reflected in performance on the shift trials and not on the no shift trials. This finding suggests that the two groups had comparable abilities to perform the basic judgment task on the no shift trials and that they differed only when there was the additional requirement to first shift attention focus from one dimension to another. This latter outcome was surprising. At first glance, it appears to indicate that there was a significantly greater burden on shift trials for the more experienced musicians. This is surprising because it would seem intuitively that their increased experience would have equipped them to handle the cognitive burden more successfully.

One possible account for this finding is the following. The slower latencies observed in the musical condition on shift trials in the high experience group may have reflected a *greater difficulty to disengage attention* from one dimension of the stimulus (for example, dynamics) in order to focus on another (for example, articulation) on the subsequent trial. Though one cannot be entirely sure what cognitive processes produce this “slow down” on shift trials, the following speculative account may be fruitful to consider.

The basic idea is that perhaps the more experienced musicians were perceptually more "involved" in the music than were the less experienced musicians, precisely because of their greater musical experience. This could mean that for more experienced musicians, the quality of the stimulus materials appeared different to them in some important way. Perhaps for the less experienced musicians it was easier for them to suspend their musical focus on the materials being presented and treat the stimuli as just another example of an auditory stimulus. In contrast, perhaps, the more experienced musicians heard the musical stimuli as more fully integrated as a musical whole, and for this reason found it more difficult to shift focus.

There is a literature that indirectly supports this account of what may have transpired in the present research, and of course, it would require follow-up research to test whether the account to be presented below will, in fact, be empirically supported. This account is based on Garner’s (1974) notion of the separability or integrality of perceptual dimensions.

Garner (1974) proposed that perceivers may group or dissociate perceptual elements in their visual and auditory environments by how perceptually separable or dissociable the individual dimensions may be. His work led to a tradition of research in which individuals tried to document (primarily in vision and less so in the auditory modality) how two or more perceptual dimensions of a stimulus may interact. For example, Imai and Garner (1968) found in speeded classification studies of nominal dimensions in vision that when individuals view a shape with a particular colour (a red triangle) they are easily able to perceptually disentangle these two pieces of information. In his research design, participants classified stimuli along one dimension (for example, shape), while the other task-irrelevant dimension (for example, colour) was varied in different ways depending on the experimental task. Individuals were able to perceive both the colour and the shape as independent features of the same stimulus. Garner referred to elements that can be dissociated in this fashion as "separable". By contrast, when individuals are asked to perceptually separate different properties of the same red triangle such as hue and saturation they are not able to do so reliably. According to Garner, this is because certain features of the stimulus are perceived as unitary, or "integral," whereas colour and shape are "separable."

Garner's principles about the difference between separable and integral dimensions have been applied to auditory processing as well. For example, some studies (Grau & Nelson, 1988; Marks, 1993; Neuhoff, Kramer & Wayand, 2002; Neuhoff, McBeath & Wanzie, 1999) have found that perceived loudness and intensity of auditory stimuli interacts with frequency, whereby participants perceived greater changes in loudness when they were presented with stimuli in a high frequency range than when they were presented with lower frequency tones. The authors of one study concluded that dimensions such as loudness and pitch are psychologically "real" and are processed in a unitary, or integral fashion (Grau & Nelson, 1988). In support of this view, Neuhoff and colleagues (1999) found that the perception of loudness may change as a function of static versus dynamic frequency changes.

Other studies have looked at musical properties of the auditory stimulus such as timbre (McAdams, Winsberg, Donnadieu, De Soete & Krimphoff, 1995). To study the effects of musical training on the perception of timbre, the authors had expert musicians, amateurs, and non-musicians judge timbral dissimilarities of synthesized instrument sounds. They used multidimensional scaling to specify unique attributes of each timbre and found that musicians gave more precise timbral judgments. It is important to note that in this study, the authors only examined the effects of timbral properties without attempting to see how timbre may interact with other musical dimensions. However, this work is important because it highlights the fact that musical properties such as timbre may themselves contain many different dissociable perceptual dimensions that can interact to yield a coherent musical percept.

Whereas some authors (Krumhansl & Iverson, 1994; Semal & Demany, 1991; Warrier & Zatorre, 2002) have looked at the interaction between perception of pitch and timbre in musically untrained listeners, Pitt (1994) examined the effects of this interaction as a function of musical experience. He included a group of musically trained and musically untrained participants and had them perform a speeded classification task (adapted from Garner, 1974) to ascertain whether the dimensions of pitch and timbre were differentially integrated based on musical experience. In the task, subjects classified stimuli on one dimension (e.g., pitch) while the other, irrelevant dimension (e.g., timbre), was manipulated across three conditions. Reaction time and accuracy scores across the conditions provide a profile of performance that was used to infer the perceptual relationship between the two dimensions. It has previously been found that when irrelevant and relevant stimulus dimensions vary predictably with each other, there is an observed perceptual facilitation effect in speeded classification judgments. This has been referred to as a "redundancy gain", whereby the listener is capitalizing on two stimulus dimensions with complimentary information that in concert speed perception of the stimulus (Melara & O'Brien, 1987). By contrast when the task pits the stimulus dimensions against each other in an unpredictable manner, interference resulting in a perceptual slow down may occur, whereby the more salient stimulus dimension for that individual may influence perception (Pitt, 1994). In this study, the author found that when non-musicians classified pitch, they exhibited interference effects when the irrelevant (unattended) stimulus dimension (timbre) varied unpredictably. Musically trained listeners in this study were less sensitive to the timbral dimensions of the stimulus than were untrained listeners, and actually exhibited redundancy gains when classifying timbre, showing that they made use of the irrelevant stimulus dimension (pitch) to facilitate their judgments on this task. The author of this study concluded that musical experience plays a role in the perceptual separability of the musical dimensions of pitch and timbre.

To the best of our knowledge, no studies have yet empirically examined the musical perceptual dimensions associated with articulation and dynamics from this perspective. We propose that more expert musicians may perceive these dimensions in a holistic or "integral" fashion due to greater experience over their lifetime with musical material. We believe that when the expert group was asked to shift attention from dynamics to articulation, they exhibited a slower latency because the dynamic and articulation dimensions of the stimulus were less perceptually separable (or to put it differently, more integral). For this reason, they may have had difficulty shifting attention from articulatory to dynamic cues in the music condition because they were focusing on the "forest" rather than the individual "trees" as the task required. By contrast, the lower experience group may have been advantaged on this task because they had less experience with musical material. This allowed them to differentially allocate their attention to one aspect of the stimulus or the other according to the task demands.

Only data from participants who exhibited a mean attention shift cost reaction time in both the experimental and control conditions greater than 1/10 of a standard deviation unit were considered in our analyses. This discounted data from participants whose performance on the attention shift task could not be deemed to reflect attention control because they lacked a meaningful shift cost. It is important to note that the significant main effects of shift cost reported in the above analyses would not have been significant if all participant's data had been included in the analyses. Participants who did not exhibit shift costs in this study were employing cognitive strategies in response to the task demands that could not be explained by attention shifting alone, therefore their performance was not addressed by any a priori experimental hypothesis. For this reason, it was deemed acceptable to analyze only data that met the inclusion criteria. Due to the exclusion of the above data, the study had a limited sample size; perhaps with greater statistical power the three-way interaction between expertise, attention shifting and musical or non-musical conditions would have reached significance.

Conclusion

The results of this experiment provide new insight with regard to what is known about the relation between attentional control and expertise. Certain features of music such as dynamics and articulation may serve an attention-directing function in a musical context that is similar to that of grammaticized elements in a second language. For this reason, these musical features should be more susceptible to shift cost expertise effects. In the case of musical performance expertise, it would seem that greater experience might result in perceptual dimensions of musical stimuli being perceived as integral, although clearly additional research is needed on this. For this reason, those with greater musical expertise may exhibit *greater*, not smaller, attention shift costs when responding to musical material. This may not, however, reflect reduced attention fluency so much as an integrated perceptual representation of music that is formed by repeated musical encounters over the lifetime. Such integrated perceptual representations may interfere with responding when experts are asked to attend differentially to only one stimulus dimension, but this may not necessarily occur in the course of real-time performance. Future studies should investigate the link between expertise and perceptual integrality in music, as well as in a variety of other domains.

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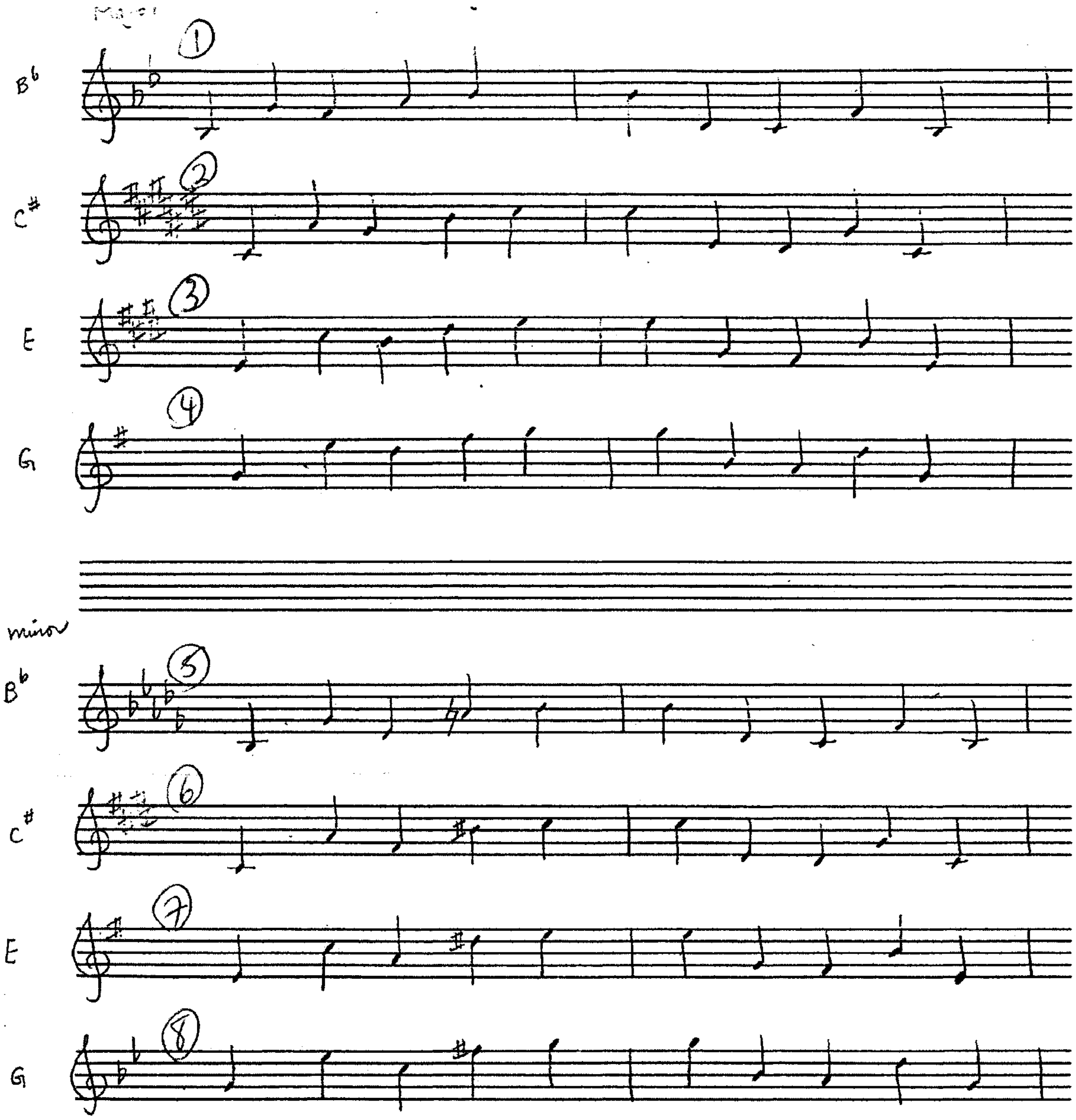
Appendix A

Musical Target Note Patterns (Ascending and Descending)

Appendix A

Musical Target Note Patterns (Ascending and Descending)



Appendix B

B1. Visual Cue for Attention Shifting in the Experimental (Music) Condition: Articulation Decision

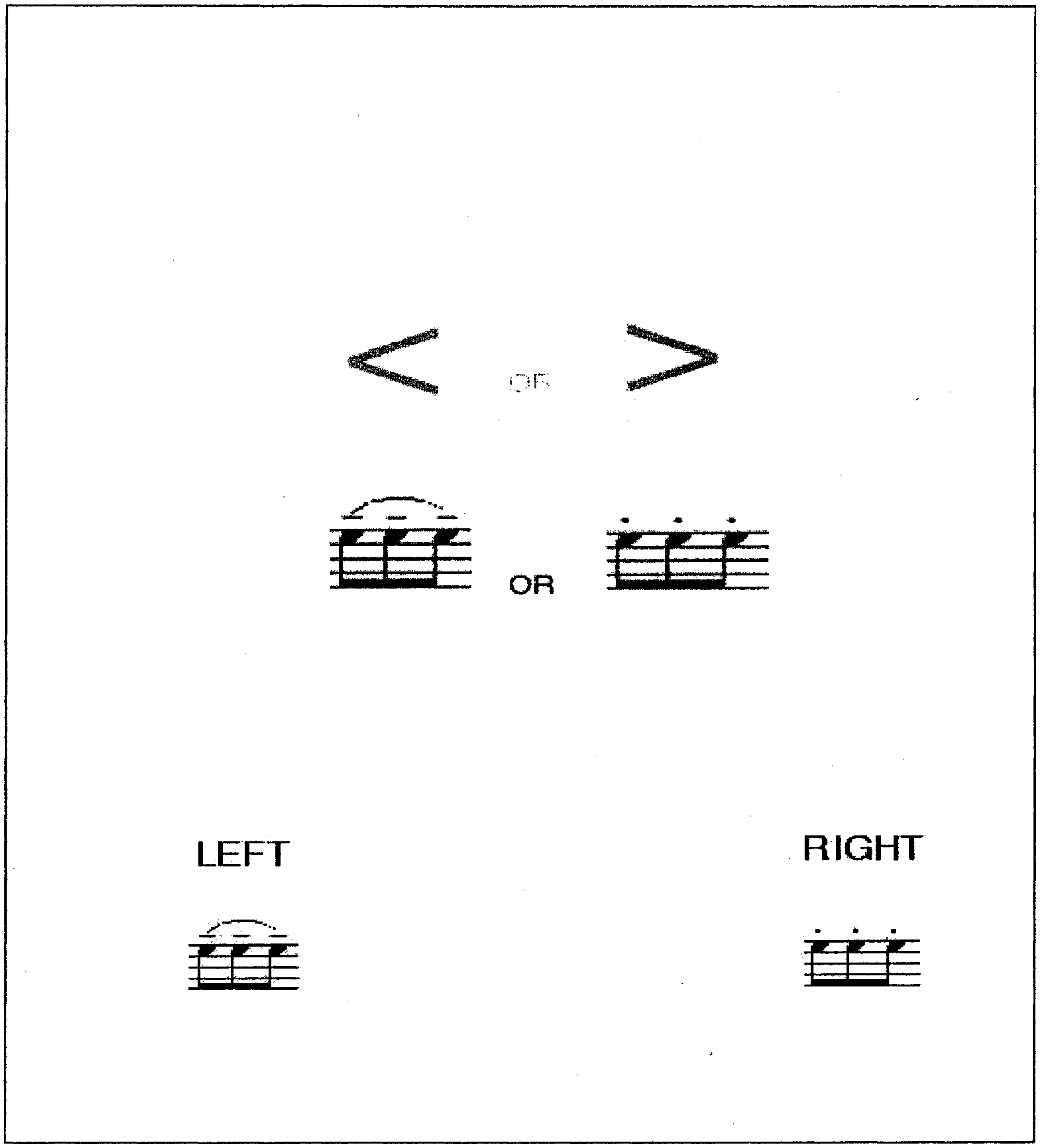
B2. Visual Cue for Attention Shifting in the Experimental (Music) Condition: Dynamic Decision

B3. Visual Cue for Attention Shifting in the Control (Non-Music) Condition: Type Decision

B4. Visual Cue for Attention Shifting in the Control (Non-Music) Condition: Speed Decision

Appendix B1

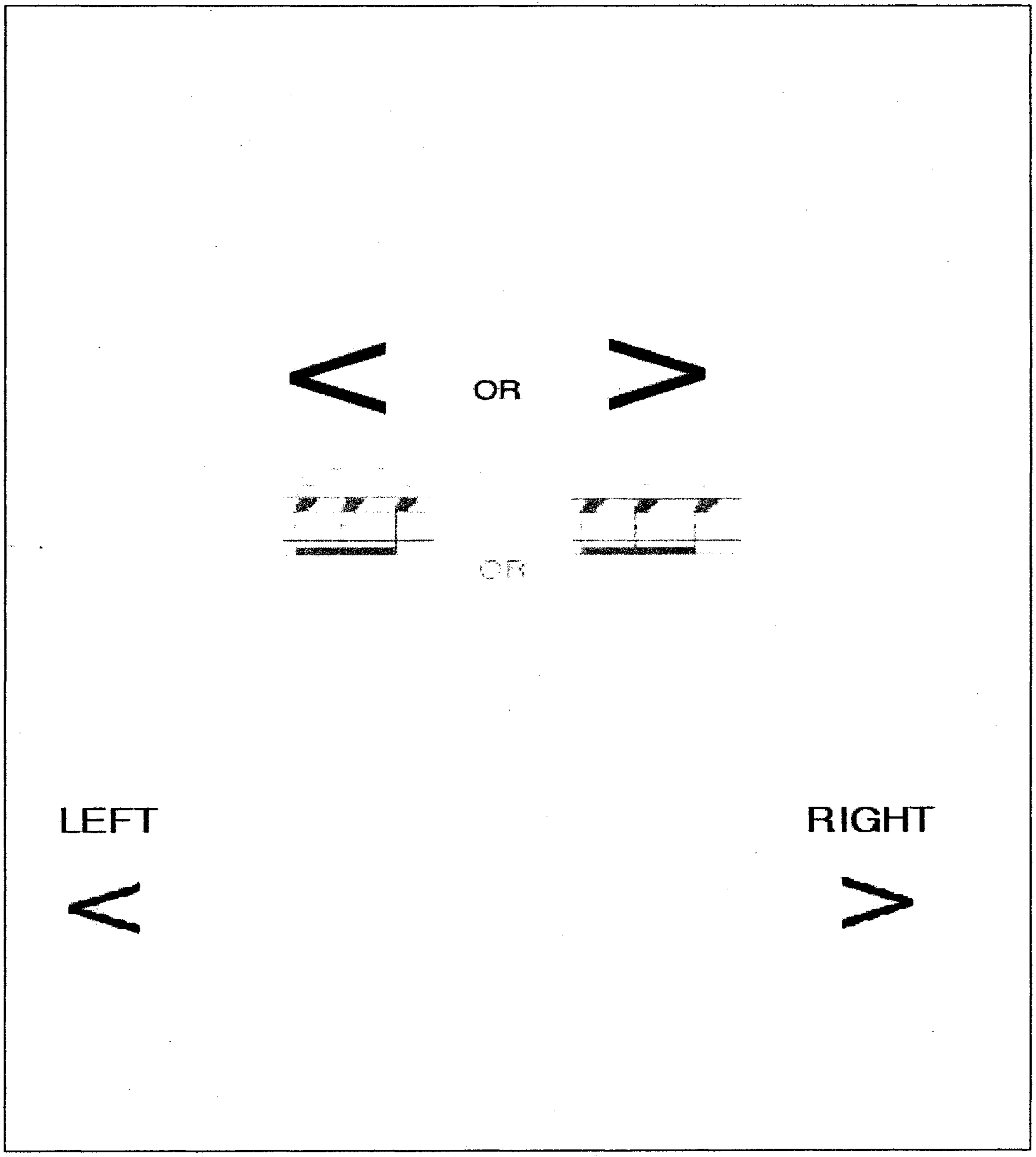
Visual Cue for Attention Shifting in the Experimental (Music) Condition: Articulation Decision



Appendix B2

Visual Cue for Attention Shifting in the Experimental (Music) Condition:

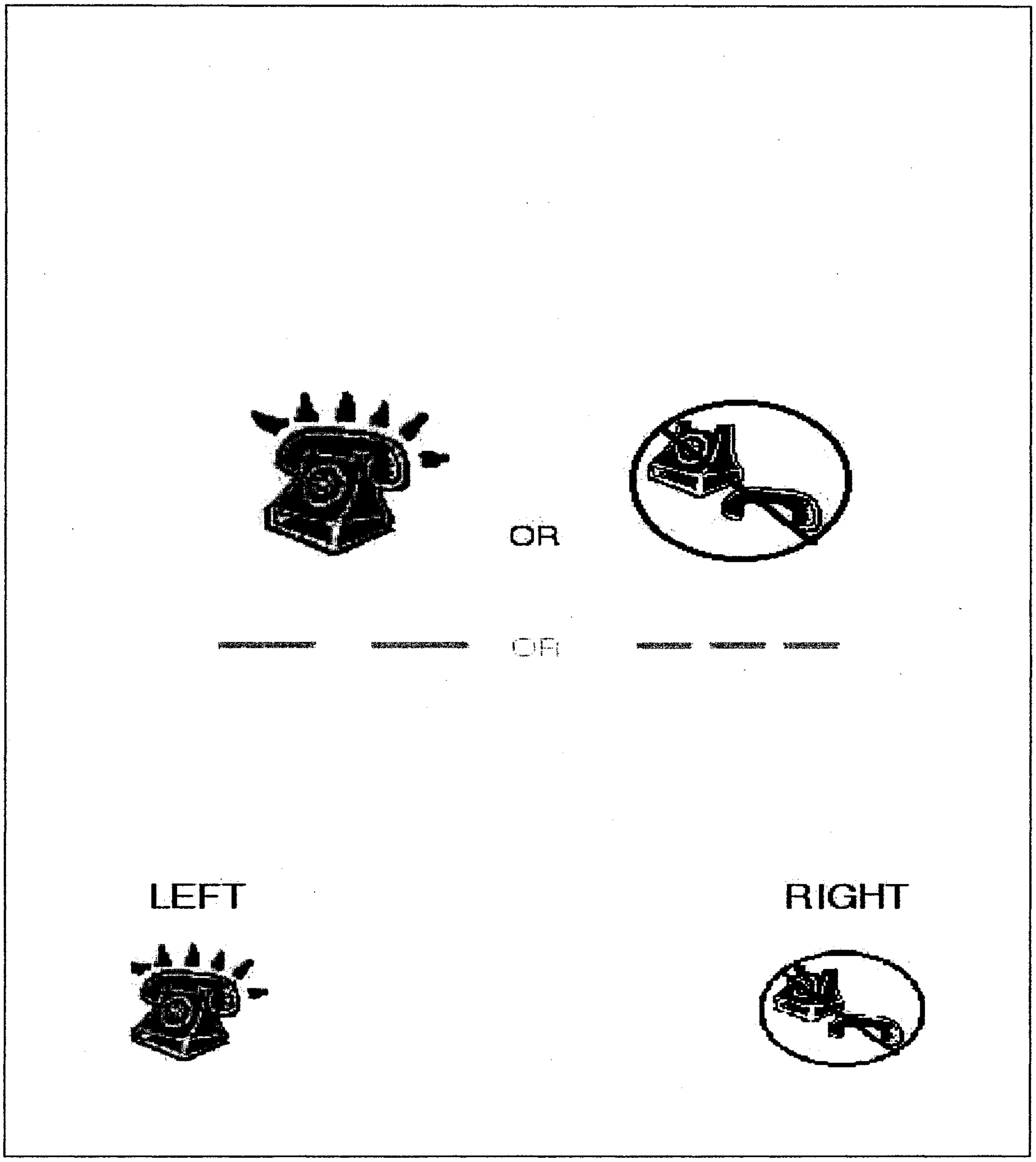
Dynamic Decision



Appendix B3

Visual Cue for Attention Shifting in the Control (Non-Music) Condition:

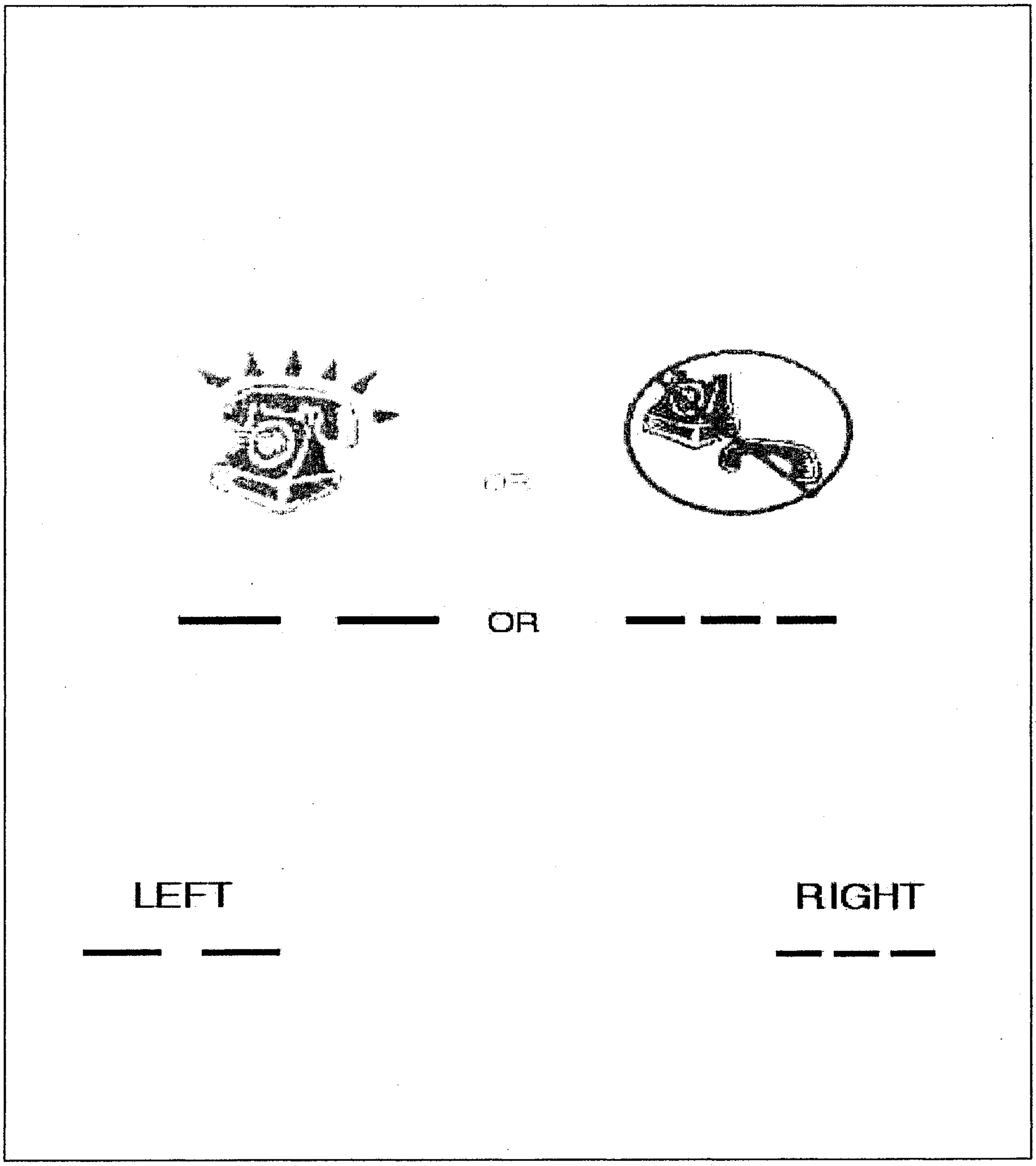
Type Decision



Appendix B4

Visual Cue for Attention Shifting in the Control (Non-Music) Condition:

Speed Decision



Appendix C

C1. Experimental (Music) Condition Task Instructions for the Attention Shifting Task

C2. Control (Non-Music) Condition Task Instructions for the Attention Shifting Task

Appendix C1

Experimental (Music) Condition Task Instructions for the Attention Shifting Task

In this experiment, we ask you to make decisions about piano and other sounds that you hear through a set of headphones.

On every trial you will hear a combination of two separate sound streams, or lines of sound; the "target" stream, or the line on which you will base your response, and a "background" stream, or the line which is to be ignored.

In the first part of the experiment, you will hear two **separate** piano lines. They will not sound coordinated, like two people practicing in the same room at the same time.

The "target" line is always the **lower pitched line**. You will be asked to make one of two possible choices regarding the target line:

1) Is the target line crescendo or decrescendo?

< OR >

2) Is the target line staccato or legato?

OR

The above symbols will appear on the screen. The question you have to answer on a given trial will be shown by highlighting the appropriate symbols.

Respond to what you hear in the headphones by pressing the **right** button on the keypad if the notes in the target are **decrescendo** or are **legato**; and press the **left** button on the keypad if the notes in the target are **crescendo or staccato**.

Please respond as quickly and accurately as possible. You will now have a chance to practice this task. When you are ready to begin the practice, press any key.

Appendix C2

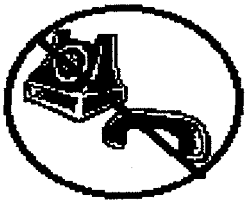
Control (Non-Music) Condition Task Instructions for the Attention Shifting Task

In this part of the experiment, you will hear two **separate** sound streams.The "target" stream is the series of telephone tones.

For these trials, you will be asked to make one of two possible choices regarding the target line:

1) Are the tones in the target line a telephone ring or a busy signal ?

OR



2) Are the tones in the target line slow or fast?

—— —— OR — — —

The above symbols will appear on the screen. The question you have to answer on a given trial will be shown by highlighting the appropriate symbols.

Respond to what you hear in the headphones by pressing the **right** button on the keypad if the tones in the target stream are a **busy signal** or are **fast**; and press the **left** button on the keypad if the tones in the target stream are a **telephone ring** or are **slow**.

Please respond as quickly and accurately as possible. You will now have a chance to practice this task. When you are ready to begin the practice, press any key.

Appendix D

Musical Performance Experience Questionnaire

Appendix D

Musical Performance Experience Questionnaire

General Information
Age: _____ Sex: female____ male____

Born (country): _________ Current residence (country): _______________

How long have you resided in the country of your current residence: _____ years

Is English your first language? yes____ no____ (specify: _______________)

If not, how well do you understand English:
poorly___ fairly___ moderately well___ fluently____

Musical background:

principal instrument or voice: _______________________

Number of years of formal training on principal instrument: _______________________

Number of years of formal piano training: _______________________

Main Musical Activities: (circle the appropriate items):

solo accompaniment studio

orchestra (position:___________)

chamber (position:____________)

teaching ______________________

other (include ability on other instruments if applicable):
____

1) In order for us to be able to place your responses in proper perspective, it would be very helpful for us to have some idea of your performance background. We recognize that each performer's background and experience is unique and cannot be summarized in a few words. We would find it useful, however, if you could give us a global idea of your performance activities. Please indicate (by placing a mark on the scale line provided), which description most nearly matches your situation. Feel free to place your response between two descriptions if that is where you feel your abilities are most accurately represented. If none really applies to you, we would be grateful if you could give details in the space provided below.
If none of the above profiles comes near to describing your performance situation, please provide some details below.

1	2	3	4	5
Amateur: Play at home for fun		**Serious Amateur:** Perform occasionally for friends, local recitals		**Ensemble Performance:** Perform occasionally with an amateur ensemble

6	7	8	9	10
Solo Stage/ Ensemble Performance: Have participated in major competitions; occasionally prepare and perform large-scale works		**Solo Stage & Recording Apperances:** Have successfully competed at international level; regularly perform large-scale works from the virtuoso repetoire		**Solo Stage & Recording Career (major labels):** Normally perform large-scale virtuosic works in the world's major concert halls

____

____

____

2. Please comment briefly on how you organize your practice in a typical week. Please include among other things an indication of how many hours per week, time(s) of day, goals, and materials used.

approximate number of hours/week ________ time(s) of day:_________

organization of practice (choice of exercises, pieces, sequencing, etc.):

____

____

____

____

____

____

____

____

3. Please indicate some of the repertoire you have performed on your instrument(s):

____

____

____

4. Please identify a piece which you found challenging to perform, and describe the unique challenge(s) of that piece.

We thank you once again for participating in this study. You contribution will be of great help to us in understanding more about human performance.