Effects of Repetition on Attention in Two-Part Counterpoint

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Repetition and novelty are essential components of tonal music. Previous research suggests that the degree of repetitiveness of a line can determine its relative melodicity within a musical texture. Concordantly, musical accompaniments tend to be highly repetitive, probably facilitating listeners' tendency to focus on and follow the melodic lines they support. With the aim of contributing to the unexplored area of the relationship between repetition and attention in polyphonic music listening, this paper presents an empirical investigation of the way listeners attend to exact and immediate reiterations of musical fragments in two-part contrapuntal textures. Participants heard original excerpts composed of a repetitive and a nonrepetitive part, continuously rating the relative prominence of the two voices. The results indicate that the line that consists of immediate and exact repetitions of a short musical fragment tends to perceptually decrease in salience for the listener. This suggests that musical repetition plays a significant role in dynamically shaping listeners' perceptions of musical texture by affecting the relative perceived importance of simultaneous parts.

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Prior research has acknowledged the importance of repetition in music perception (for a review, see Margulis, 2014). To our knowledge, however, little attention has been given to the effects of repetition of any kind on the relative salience of simultaneous lines in a polyphonic texture. This paper contributes to this unexplored area of research by presenting an empirical investigation of the effects of exact and immediate repetition on the listener's attention to simultaneous lines in two-part tonal counterpoint.

"Repetition progressively frees the mind from attention to details . . . and reduces the extent to which consciousness must concern itself with the process" (Huey 1908/1968, p. 104). Whether it is starting a new sport, understanding a new concept, learning a new song, determining if an animal is dangerous, or analyzing the source of an unfamiliar scary sound in the middle of the night, processing novelty and change demands levels of attention that become unnecessary with repeated encounters. Repetition leads to automatization, allowing attention to focus elsewhere.

Music is a highly repetitive phenomenon. Its repetitiveness is manifested in the most diverse ways, including the tendency of most composers to restate material within and across pieces. Similarly, musical accompaniments tend to be highly repetitive, perhaps facilitating a listener's tendency to naturally focus on and follow the melodic lines they support. Based on this rationale, which is supported by previous research showing that changes in the auditory field attract attention and that melodic lines are less repetitive than nonmelodic lines, this paper investigates the effects of musical repetition on the way listeners attend to the simultaneous lines of two-part contrapuntal textures.

A considerable amount of literature in vision and audition supports the idea that changes in the physical properties of a stimulus can enhance our perception of it, particularly when the visual or auditory field is relatively simple (see Spence & Santangelo, 2010, for a review in audition; and Dalton & Spence, 2008, and Cowan, 1995, for summaries in vision and audition). For instance, studies have shown that the introduction of new and relatively salient acoustic features, such as a change in gender of a speaking voice within a message that participants are instructed to disregard, can capture attention (Lawson, 1966; Treisman & Riley, 1969). It has also been demonstrated that pre-exposure to an audio message that is used as a distractor during a succeeding memory task that requires either auditory (Waters, McDonald, & Koresko, 1977) or visual attention (Morris & Jones, 1990) facilitates performance, further suggesting that relatively familiar audio lines may play a role in directing the attentional focus to other, more novel stimuli occurring concurrently. The notion that changes in acoustic features can trigger a shift of attention—the orienting response (Pavlov, 1927/1960)—constitutes the basis of many proposed models of selective auditory attention, such as Sokolov's (1963),

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Mackworth's (1969), and Synder's (2000) habituation models, and Gati and Ben-Shakhar's (1990) and Cowan's (1995) theories of attention and memory. The orienting response hypothesis has also received important support in the field of auditory neuroscience (for a review, see Näätänen, Paavilainen, Rinne, & Alho, 2007).

Undoubtedly, the attention-capturing effect of a sound is accompanied by its segregation from the auditory environment. Although it is still debatable whether the separation process precedes or follows the attentional attitude (for a review, see Francis, 2011), researchers generally agree that listeners are able to separate almost instantly the sounds they attend to. Furthermore, in many auditory scenarios, attending to a specific component is a voluntary action, rather than an automatic one. This seems to be the case for music, where multiple meaningful or attractive sounds frequently occur in simultaneity. In most relatively simple polyphonic musical settings, listeners can differentiate textural components by parsing the acoustic input into streams—a process defined as "stream segregation" by Bregman (1990)—which can then be individually attended to in a voluntary manner (Bregman, 1990; Bregman & Rudnicky, 1975). This is to say that listeners can choose to follow a distinct musical line within the polyphony, such as the main melody, the bass or the line of a particular instrument. Research has shown that, even in simple polyphonic textures, listeners tend to focus their attention on only one stream (Bregman, 1990; Kahneman, 1973), incorporating the remaining textural components either in a figure-ground relationship (Sloboda and Edworthy's, 1981, figure-ground model) or in a more integrative polyphonic whole (Bigand, McAdams, & Foret's, 2000, integration model; and Davison & Bank's, 2003, experimental study on two-part counterpoint, particularly for voices moving in parallel). In other words, dividing attention equally is extremely difficult during polyphonic music listening, even in simple two-voice textures.

The important role that stream segregation and attention play in polyphonic music listening has inspired the investigation of the perception of simultaneous parts in music. Studies have ranged from examining the diverse aspects of stream segregation in multivoiced music listening (Huron, 1989, 2001; Huron & Fantini, 1989; Palmer & Holleran, 1994; Thompson, 1993) and performance (Gingras, 2008; Palmer, 1996), to computational models based on specific musical features (for a review, see Temperley, 2013). Nevertheless, research that specifically focuses on the connections between attention and the perception of simultaneous musical streams is noticeably sparse. Beyond the few studies mentioned above, Francis (2011) proposes, to our knowledge, the most comprehensive model of attention in polyphonic music listening. She describes a set of preference rules to account for the effects of different musical (bottom-up) factors on attention in polyphony: registral position, loudness, timbre, articulation, chromatic pitches, accented nonchord tones, variety in pitch, rhythm, and texture, and of particular relevance to our study, repetition. Her study provides experimental evidence for the perceptual salience of the highest part in a three-voice texture and of lines containing chromatic pitches or accented nonchord tones, as well as analytical, score-based support for the remaining attention-capturing factors. Half of the preference rules proposed by Francis (2011) account exclusively for the attention-capturing potential of novel musical events. These include: (1) the variety rules, which refer to the preference for lines that are relatively diverse in terms of their pitch or rhythmic content; (2) the harmonic novelty rules related to the preference for lines that contain chromatic pitches or nonchord tones; and (3) the texture change rule, which favors the entrance of a new line. The importance of novelty for textural aspects of polyphonic music has also been supported by several theoretical (Meyer, 1956, Chapter V; Rahn, 1982) and computational models (Duane, 2012; Madsen & Widmer, 2007), demonstrating that lines that are more melodic have higher information content (more variability) than do lines that are less melodic. This literature, along with Francis's preference rules, is consistent with the intuition that listeners more naturally pay attention to melodic rather than accompanimental lines. Musical compositions are usually remembered by their melodies rather than by their accompanying figurations.

To summarize our discussion up to this point, prior research indicates that (1) changes in the auditory environment capture attention, and (2) melodic lines, which are the textural component most naturally attended to by listeners, are less repetitive than accompaniments. Taken together, these two points suggest that simple polyphonic passages composed of streams that differ greatly among each other in terms of their repetitive surface quality could induce an attention preference for a less repetitive line occurring at that moment. This hypothesis, however, does not imply that any kind of repetitive line tends to discourage attention from the listener in all types of multi-voiced music. In polyphonic music, the effects of repetition on attention to a particular stream would seem to depend on at least two factors: the specific features of all the component musical lines beyond their degree of repetitiveness and the ways in which the restatement takes place. With respect to the first factor, several musical attributes can influence the way listeners naturally attend to the different textural components of polyphonic music. In tonal music, a line that contradicts the expected syntax may capture attention independently of how repetitive the line is. Similarly, the specific timbral, rhythmic, intensity, or melodic features of a musical layer could induce attraction. In regard to the second factor, musical repetition occurs in many different forms, from the reiteration of a single note to the restatement of an entire passage. Furthermore, variations of a musical passage are often regarded as forms of repetition, and the degree of similarity that is required for a fragment to be considered a modification of another segment is highly dependent on the context and the listener.

Taking this into account, the effects of repetition on attention are likely to be determined by the kinds of repetition and variation that occur. At least five aspects seem particularly relevant in this respect: (1) the immediacy of the repetition (i.e., whether the repeated segments are adjacent or separated by other musical material); (2) the length of the restated fragment; (3) the number of reiterations; (4) the degree of variation of the musical restatement; and (5) the complexity of the texture where the repetition takes place.

In reference to the first point, the immediate repetition of a single pitch might attract the listener's attention in certain musical settings, whereas the return of a given musical note after an intervening passage of music can be extremely difficult to notice. Conversely, a melodic line is more likely to capture the listener's attention when it returns after a passage of contrasting melodic material (i.e., when it has a recapitulary function) than when it functions as an ostinato (i.e., when it repeats persistently and uninterrupted).

With respect to the length of the restated fragment and the number of times it is reiterated (points 2 and 3 above), Margulis's (2012) and Lidov's (2005) work is particularly relevant. Margulis found that repeated listening to a musical segment—either through a single exposure to a musical composition that contains repeated fragments or through multiple exposures to the same musical piece—facilitates repetition detection for long repetitive units, but impairs it for short units, especially when the passage is reiterated immediately. In other words, as listeners are exposed to a musical passage several times, their attention moves from shorter to longer musical sections—from local to global levels of the formal structure. Intuiting the different ways in which musical repetition can influence attention, Lidov distinguishes among formative, focal, and textural repetition. Formative repetition refers to single immediate restatements of a musical fragment and to single and multiple returns of a musical idea after intervening material. According to Lidov, it logically fulfills a formal, segmenting function and does not necessarily attract attention. Focal repetition applies to passages in which a fragment is adjacently restated three or four times and to repetitions that extend across the boundaries of the large-scale formal structure. This type creates a hypnotic state that results from a focus on the repeating action rather than on the repeated material. Textural repetition—which is most relevant to this paper—takes place when a fragment is immediately restated more than three or four times. It differs from focal repetition in that it draws the listeners' attention to a feature that changes or to a different voice within the texture.

Concerning the fourth point—the degree of variation of the musical restatement—varied and exact repetition can often have opposite attentional effects. Compositional and performance practice suggests that the incorporation of certain modifications during the restatement of a musical line (the line being melodic or not) can effectively capture the listeners' attention. Based on similar grounds, paradigmatic music analysis (Nattiez, 1975; Ruwet, 1972) puts repetition and variation at the center of musical syntax. And finally, concerning the fifth point, the attentional effects of repetition might be determined by the complexity of the polyphonic texture: a single repetitive part occurring simultaneously with many novel lines might affect the listeners' attention in a different way than many repetitive parts happening concurrently with one nonrepetitive part.

Based on this literature on attention and stream segregation, we hypothesize that when one line of a two-part contrapuntal texture consists exclusively of immediate and exact repetitions of a relatively short fragment, listeners will more naturally attend to the other, more changing part. The experiments presented in this paper tested this hypothesis.

Experiment 1

METHOD

Participants. Forty participants (aged 18-39 years, $M = 22.8$, $SD = 4.41$, 25 females) were recruited through McGill Classifieds Online and were paid for their participation. Four participants identified themselves as professional musicians and five other participants reported having played an instrument for at least five years. All participants received an audiogram before the experiment and had a threshold lower than 20 dB HL (ISO 389-8, 2004; Martin & Champlin, 2000).

Stimuli. The stimuli were 24 two-part keyboard musical excerpts. They were played through Sennheiser HD280 Pro headphones (Sennheiser Electronic GmbH, Wedemark, Germany) at 60 dB SPL, as measured with a Bruel & Kjaer Type 2205 sound-level meter and Type 4153 artificial ear coupled with headphones (Bruel & Kjær, Nærum, Denmark). Each musical example was composed of a repetitive and a nonrepetitive part in 4/4 meter and was played back at a tempo of 80 beats per minute using the Finale piano sound samples. Each example was 25.5s long. To minimize potential confounding effects—namely the rhythmic and melodic profile of the two voices, their registral position and relative speeds, and the length of the repeating fragment—the musical stimuli were composed by the first author to ensure similarity and, to the extent possible, equality of repetitive and nonrepetitive parts in terms of pitch-class and scale-degree content, rhythmic patterns and register, global and local melodic contours, approximate proportion of skips/leaps vs. stepwise motion, and timbral and intensity characteristics. The examples were written in a free counterpoint style, and, at times, violate voice-leading principles because of the compositional limitations imposed by the experimental conditions and the attempt to control for confounding factors. The repetitive part consisted of two or four exact repetitions of a four-measure or two-measure fragment, respectively. The nonrepetitive part avoided repetition as much as possible. In an effort to simplify and control for confounding effects, the rhythm of each part was kept constant, consisting of sixteenth notes, eighth notes, or quarter notes. The repetitive unit was composed according to four different patterns: arpeggiated, melodic (simple), Alberti bass, and compound melodic. Ascending and descending arpeggios delineating triads or seventh chords were favored in the first type, stepwise motion with occasional leaps was featured in the second type, broken chords with a preference for low-high-middle-high pitch sequences prevailed in the third type, and an implied polyphony often emerged within the voices of the examples representing the fourth type. These four patterns were used in order to control the degree of melodicity of the stimuli: half of the stimuli—simple and compound melodic—represent pattern styles that most frequently have a melodic role, whereas the other half—arpeggiated and Alberti bass—correspond to figurations that most commonly have an accompanying function. In addition, the nonrepetitive part was written to match the pattern style of the repetitive part to the extent possible. In this way, the two parts were quite similar in terms of their internal melodic construction and the harmonic stability of their component notes. An example of each stimulus type can be seen in Figure 1 and heard online (Taher, 2013a), and scores for the totality of the stimuli can be consulted online (Taher, 2013b). The examples shown in Figure 1 were chosen to represent a variety of levels of the experimental factors. For instance, Figure 1.a illustrates an arpeggiated four-measure repetitive unit in the lower part. In this case, the repetitive voice moves slower than the nonrepetitive voice in a 1:2 relationship (two notes against one). In other stimuli, other rhythmic relationships were used, as explained below.

Procedure. The 24 stimuli were presented in random order to the participants, who performed a continuous-rating task on the relative perceived prominence of the two voices in each excerpt. All participants completed the experiment using a slider on a continuous scale. After ensuring that participants were familiar with the concept of voice/part, they were told to use a slider box to continuously indicate whether they heard the top or the bottom voice/part as more prominent, or the two parts as exactly equally prominent. For visual purposes, the slider box was separated into three regions of contrasting colors that corresponded to prominence of the upper voice, equal prominence of both voices, and prominence of the lower voice. All participants were instructed to use the box continuously and it was carefully explained to them that only the middle point of the central, equal-prominence region of the device—rather than the entire middle region—corresponded to an actual and absolute equivalence in the salience of the two voices. Analyses of the continuous response data revealed gradual changes in slider values with high and low peaks rather than plateaus, confirming that the participants used the slider box in a continuous way. Presuming that the participants would pay equal attention to both voices at the very beginning of each example, the slider had to be positioned in the center of the middle region before starting each trial.

Experimental design. The experimental design consisted of four factors: (a) Registral Position of the repetitive part, which referred to the location of the repetitive part–-either in the lower or the upper voice; (b) Temporal Position, which compared the first and second half of each musical example;[1] (c) Relative Speed of the repetitive part with respect to the nonrepetitive part, which could be faster, equal or slower—the faster and slower speeds represented by 1:4 (one note against four) and 2:1 (two notes against one) proportions, respectively; and (d) Length of the repetitive unit, which consisted of two or four measures. Each cell of the experimental design corresponded to two musical stimuli (i.e., a total of two musical excerpts per cell;

FIGURE 1. Examples of the four types of repeating structures in the musical stimuli.

consequently, only two of the four pattern-style types were represented per cell, because the four pattern styles were not intended to be an experimental factor, but rather a way to control for confounds—i.e., to have stimuli representing both melodic and accompanimental common patterns). This design allows not only for the examination of the effects of repetition on voice prominence under controlled situations, but also for the investigation of the potential influence of the relative speeds of the two parts and the length of the repetitive unit on the perceived prominence of the repetitive part. Each of the pattern-style types (arpeggiated, melodic, Alberti bass, and compound melodic) was distributed in a balanced manner within the experimental design. Specifically, within each pattern-style type, half of the stimuli had two-measure repetitive units, whereas the other half had four-measure repetitive units. A different half of the same pattern-style type corresponded to upper repetitive parts, whereas the other half corresponded to lower ones. A third of the examples (of the same pattern-style type)

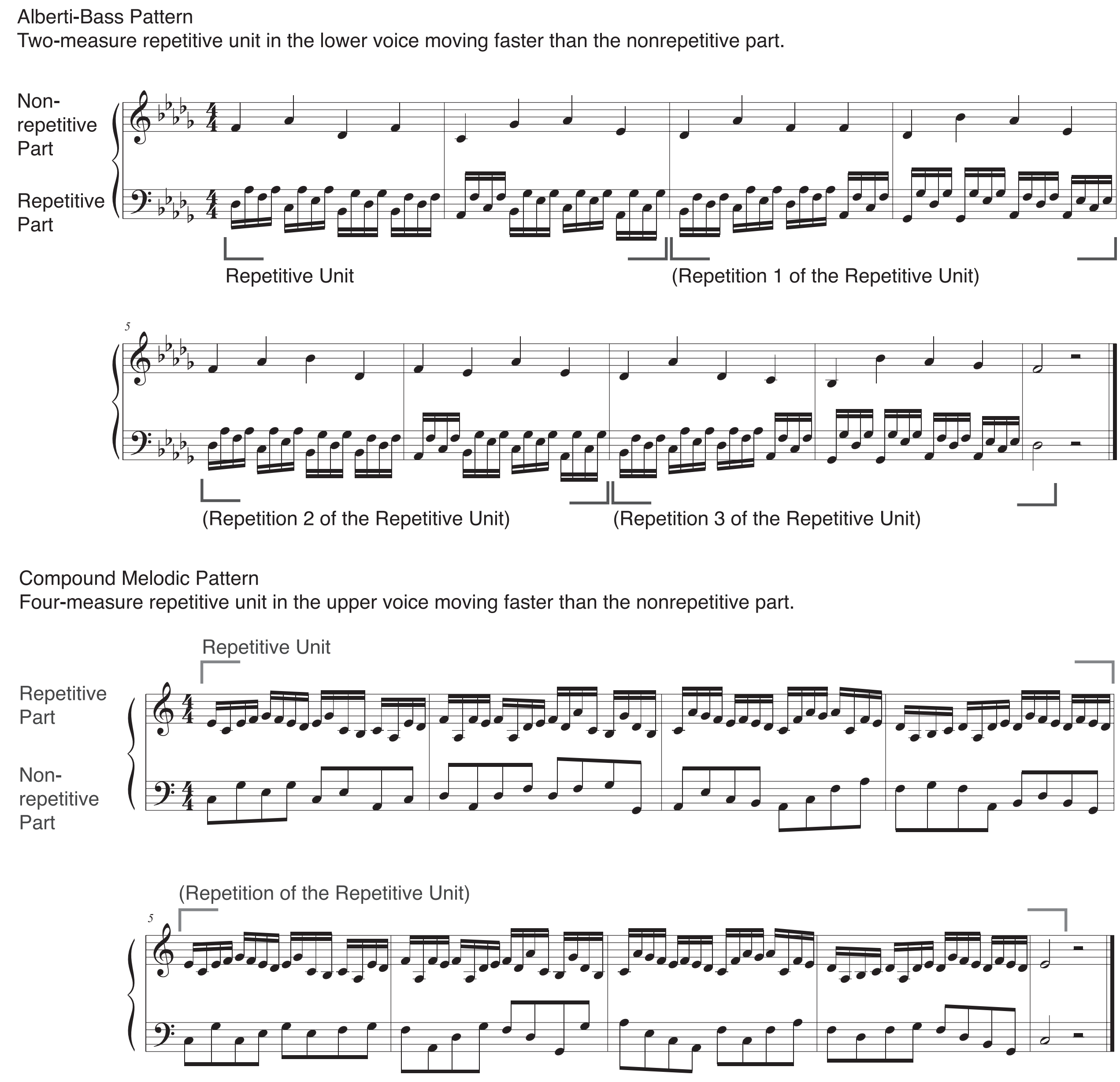

FIGURE 1. [Continued]

each consisted of repeating parts moving at the same speed, faster or slower than the nonrepeating part. Nevertheless, the specific combinations of the levels of the experimental factors were not the same for each pattern-style type; as indicated above, the four pattern styles were incorporated for controlling purposes only and not as levels of an experimental factor.

Data analysis. The dependent variable was the average slider position values for the first and second halves of each trial. The raw data—i.e., exact values of the slider position, ranging from 0 to 1, every half second for all participants—were analyzed using a four-factor repeated-measures ANOVA, with average perceived prominence as a dependent variable. The values of the dependent variable corresponded to the position of the slider and could range between 0 and 1, with 0 and 1 corresponding to maximum possible prominence of the lower and higher voice respectively and with 0.5 indicating exact equal salience for the two parts. Because the participants were instructed to place the slider in the center of the middle region of the slider box in order to indicate equal prominence for both voices at the beginning of each musical example, the data corresponding to the first 3s (first measure) of each stimulus were excluded from the statistical analyses. In this way, the results reported here should not be affected by behaviors that could have merely resulted from the instructions of the experiment rather than from the participants' own choices. Because of this 3-s ommission, the averaged values compared seconds 3–11.5 (first half of the entire stimulus—equivalent to the first two statements and the initial presentation of the repetitive unit in the stimuli with two-measure and four-measure repetitive units respectively—minus the first 3s) and seconds 12–23 (second half of the entire stimulus including the final long note).

RESULTS

The statistical analysis revealed that in two-voice textures in which one line consisting exclusively of exact and immediate iterations of a musical fragment is placed in counterpoint with a line that avoids repetition, the latter (more novel) part tends to be perceived as more prominent. This was reflected in a significant effect of Registral Position, $F(1, 39) = 9.48$, $p = .004$, $\eta_p^2 = .20$. A lower mean for those situations in which the repetitive part was the upper voice ($M = .51$, $SD = .17$), with respect to those conditions in which it was the lower voice ($M = .54$, $SD = .16$), indicates that the upper voice was perceived as relatively more prominent when the repetitive part was positioned in the lower voice, and the lower voice was perceived as relatively more prominent when the repetitive part was located in the upper voice. This effect of repetition on voice salience is a generalization, as it does not consider how the listeners' attention might fluctuate between the two lines over time. With respect to the temporal evolution of the listeners' attention, the Registral Position × Temporal Position interaction shows that the perceived prominence of repetitive parts decreases over the course of the music, whereas the perceived prominence of nonrepetitive parts increases over the course of the music, $F(1, 39) = 14.18$, $p = .001$, $\eta_p^2 = .27$. The mean of perceived prominence for the excerpts in which the repetitive part was positioned in the upper voice decreased from .52 ($SD = .15$) in the first half of the stimuli to .50 ($SD = .18$) in the second half, whereas the mean of perceived prominence for the stimuli with lower repetitive parts increased from .53 ($SD = .13$) to .55 ($SD = .18$). This suggests that the listeners' attention initially tends to focus more naturally on the higher voice—an idea that is supported by previous experimental research (Francis, 2011) and by the slight overall tendency of the participants in our study to perceive the higher voice as more prominent (GM = .52, 95% CI [.51, .54]). Attention then gradually moves towards the more novel part, independently of its relative registral position. In other words, perceived prominence for the higher voice increases when the repeating fragment is in the lower part, and it decreases from a position that indicates salience of the upper voice to a position that corresponds to equal prominence when the repeating fragment is in the upper part. This interaction effect appears to be present in two-measure repetitive units but not in four-measure units, as reflected in the Registral Position × Temporal Position × Length interaction, $F(1, 39) = 7.74$, $p = .008$, $\eta_p^2 = .17$ (Figure 2).

In order to have a better understanding of the effects of repetition on the listeners' attention over time and to examine the possibility that the twofold division of the stimuli in the data analysis could be averaging an effect occurring at a specific point during the second half of the musical examples with four-measure repetitive units—hypothetically, towards the very end of those stimuli—the mean perceived prominence was plotted every half second (Figure 3), and a follow-up analysis considered four (rather than two) levels of the Temporal Position factor (Figure 4). The four levels corresponded to the four statements of the two-measure repetitive units and to the first and second halves of each of the two presentations of the four-measure units, with the first measure (3s) omitted from the initial statement. The results confirmed the effects observed through the analysis with the bisected stimuli. The Registral Position × Temporal Position interaction was significant for the two-measure stimuli, $F(3, 39) = 16{,}14$, $p < .001$, $\eta_p^2 = .29$, but not for the four-measure stimuli. The pattern of means showed that, in the case of two-measure units, perceived prominence of the nonrepetitive part increased gradually and consistently from the original presentation of the repetitive unit to its third statement (second repetition), remaining fairly stable during the fourth (final) statement of the repetitive unit (Figure 4). Keeping in mind that the total number of repetitions of short repetitive units was twice that of long repetitive units, the exclusivity of the effect for short units suggests that the number of repetitions of the repetitive unit may affect its perceived prominence. Put differently, the more a musical segment is repeated, the less attention listeners pay to it. Short repetitive units were stated four times, whereas long units were introduced twice. In addition, two-measure repetitive units were repeated once in the first half of the stimuli and two more times

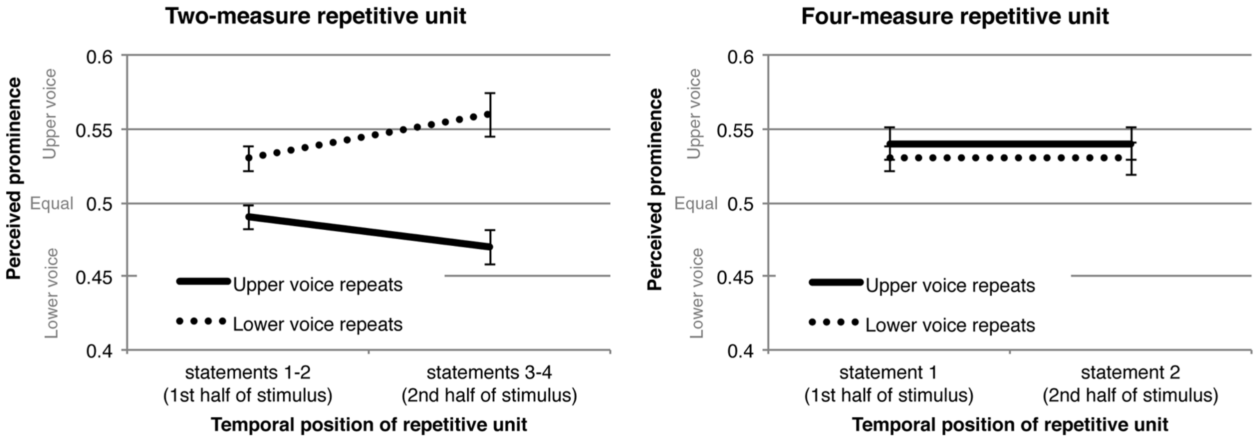

FIGURE 2. Mean perceived voice prominence as a function of Registral Position (solid and dotted lines) and Relative Speed of the repetitive part (2- and 4-measure units) and Temporal Position within the stimulus (first and second half). Upper Voice Repeats means a higher registral position of the repetitive part with respect to the nonrepetitive part, and vice versa for lower voice.

in the second half, whereas four-measure units were repeated only once during the second half of the examples. It is thus possible that the apparent lack of the effect for four-measure repetitive units reported here simply reflects the fact that long units were repeated only once within each musical example. One repetition is likely to be insufficient for the effect to take place. Furthermore, it is possible that listeners do not detect a repetition until a considerable section of the fragment is restated. In the case of the stimuli with four-measure repetitive units, then, listeners could have detected the (only) repetition when the musical examples were coming to an end (or even after they have concluded). Experiment 2 investigated this further.

The Registral Position × Relative Speed interaction was significant, indicating that lines that are higher in register and faster in speed than their concurrent line are perceived as more salient, independently of whether they consist of a repeating pattern or not, and that homorhythmically moving parts are perceived as equally prominent unless there is a repeating pattern in the lower voice that drives the listener's attention to the upper voice; $F(2, 78) = 31.82$, $p < .001$, $\eta_p^2 = .45$ (Figure 5). These findings suggest that the listeners' tendency to follow the higher part is particularly strong when that part is moving faster and, more importantly for the present study, that such a tendency disappears when there is a repeating pattern moving faster in the lower voice or moving slower in the higher voice. This effect appears to be more pronounced in the second half than in the first half, as reflected in the Registral Position × Temporal Position × Relative Speed interaction, $F(2, 78) = 11.17$, $p < .001$, $\eta_p^2 = .22$ (Figure 6), especially

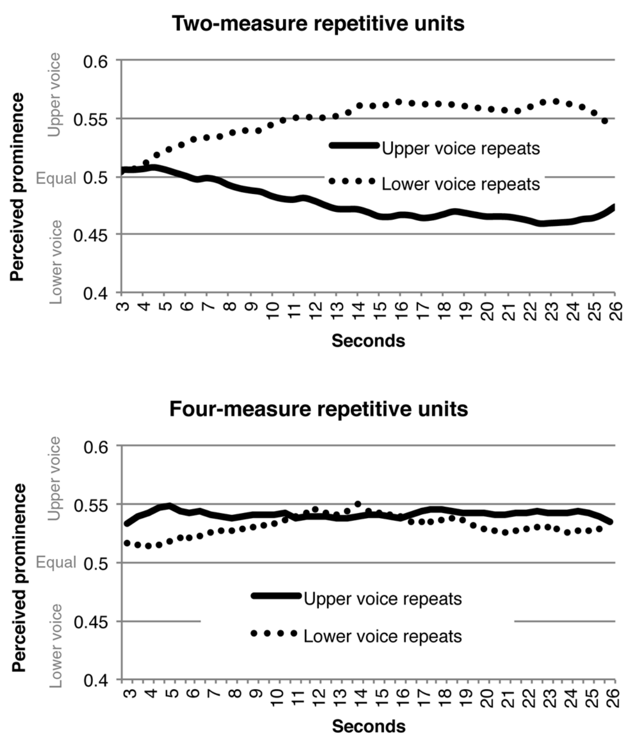

FIGURE 3. Mean perceived voice prominence as a function of time for both Registral Positions and Temporal Positions within the stimulus. The mean perceived prominence is plotted every half second.

for longer repetitive units as shown by the four-way interaction, $F(2, 78) = 10.63$, $p < .001$, $\eta_p^2 = .21$ (Figure 7).

Finally, it is important to point out that the limitations in the composition of the musical examples that were caused by the experimental conditions, along with an

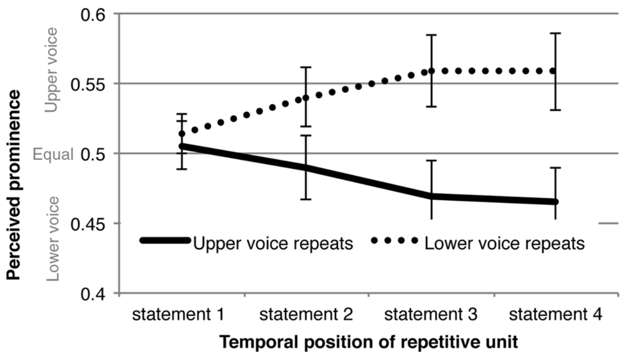

FIGURE 4. Mean perceived voice prominence as a function of the four statements of the repetitive unit for the two Registral Positions. The x-axis displays four equivalent divisions of the musical stimuli except for the initial 3s.

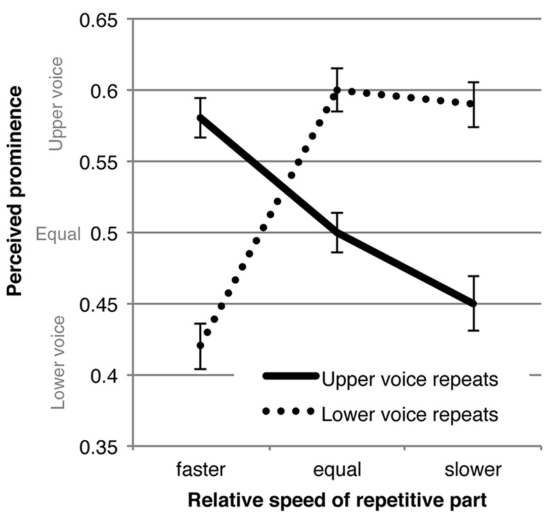

FIGURE 5. Mean perceived voice prominence as a function of the Relative Speed of the repetitive part for both Registral Positions. The x-axis displays the speed of the repetitive part with respect to the nonrepetitive part.

attempt to control for confounding effects, might have diminished the effects reported here. As repetition is an essential characteristic of tonal music from the Common-Practice period, the extreme lack of repetition that characterized the nonrepetitive parts might have added an unnatural quality to them, diminishing their potential to catch the attention of the listeners. Similarly, the totally unchanging rhythmic profile (constant rhythmic values) of the nonrepetitive part in the stimuli featuring Alberti Bass patterns is not typical of lines accompanied by Alberti Bass figuration representing the Common-Practice repertoire.

Experiment 2

METHOD

Participants. Twenty participants (aged 18-41 years, $M = 23.9$ years old, $SD = 5.9$, 10 females) completed the experiment. One participant identified himself as a professional musician and five other participants reported having played a musical instrument for at least five years. Payment, recruitment, and hearing-testing procedures were the same as in Experiment 1.

Stimuli. The stimuli of Experiment 2 consisted of the 12 musical examples with four-measure repetitive units from Experiment 1 repeated once (with the final measure of the original examples stated only once at the very end), so that the repetitive units were stated four times and the original nonrepetitive part was consequently stated twice. Based on the results from Experiment 1 for longer repetitive units, and given that 16-measure musical excerpts with a voice that avoids repetition of any kind would be unnatural for music from the Common-Practice period, we concluded that stating the nonrepetitive part from the original stimuli twice (i.e., repeating an eight-measure unit once) should not interfere with the listener's attention in a different way than a part that is nonrepetitive in its entirety. The stimuli of Experiment 2 were played at the same sound level and through the same sound system as in Experiment 1.

Procedure. The experimental procedure was identical to that of Experiment 1.

Experimental design. The experimental design consisted of three factors: (a) Registral Position of the repetitive part, which referred to the location of the repetitive part—either in the lower or in the upper voice; (b) Temporal Position, which compared the first and second half of each musical example; and (c) Relative Speed of the repetitive part with respect to the nonrepetitive part, which could be faster, equal or slower—the faster and slower speeds represented by 1:4 and 1:2 proportions. Compared to the main experiment, Length was removed, because the aim of the follow-up experiment was to investigate the effect of four-measure repetitive units only. Each cell of the experimental design corresponded to one musical stimulus. A three-factor repeated-measures ANOVA was conducted with average perceived prominence as the dependent variable.

RESULTS

The results indicated a nonsignificant Registral Position × Temporal Position interaction for the musical stimuli with four statements of the long repetitive units, $F(1, 19)$

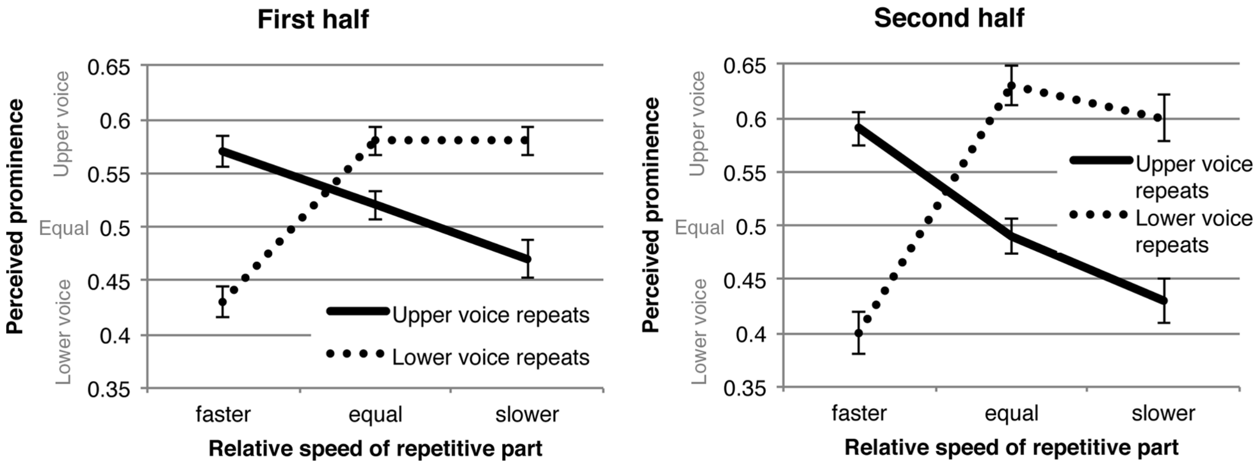

FIGURE 6. Mean perceived voice prominence as a function of the Relative Speed of the repetitive part for both Registral Positions and Temporal Positions.

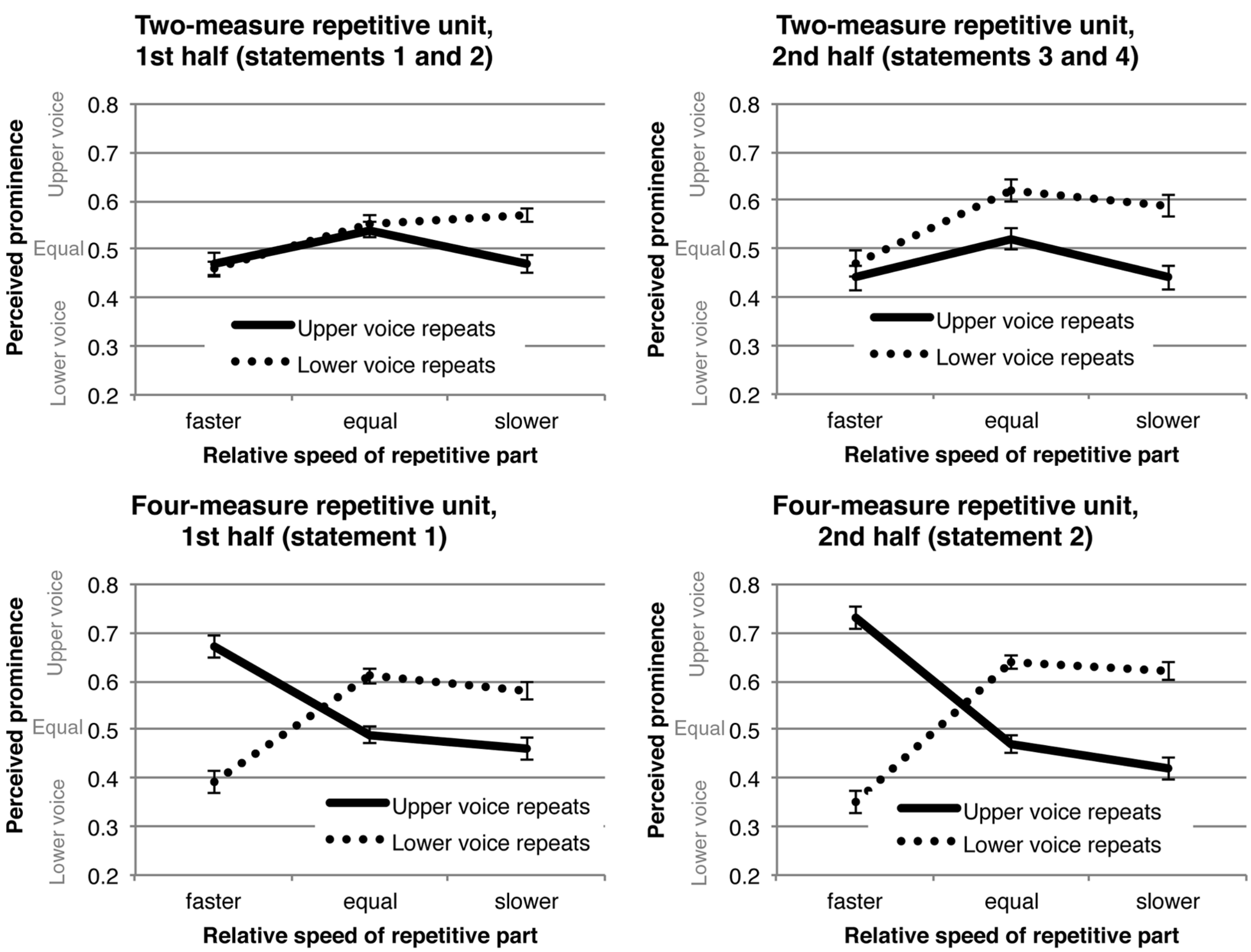

FIGURE 7. Mean perceived voice prominence as a function of the Relative Speed of the repetitive part for both Registral Positions. The upper panels present the results for two-measure repeating units and the lower panels for four-measure units. Left and right panels are for the first and second halves, respectively.

< 1: over the course of the music, perceived prominence remained constant for both the repetitive part (composed of 4 four-measure repetitive units) (*M* [1st half] = .53, *SD* = .16, *M* [2nd half] = .53, *SD* = .18) and the less repetitive part (composed of nonrepetitive eight-measure units repeated only once) (*M* [1st half] = .54, *SD* = .16, *M* [2nd half] = .55, *SD* = .18). An analysis with four levels of the Temporal Position factor—corresponding to the four statements of the repetitive unit with the first 3s omitted from the first statement—confirmed these findings by revealing a nonsignificant Registral Position x Temporal Position interaction, $F(3, 19) < 1$: perceived prominence neither decreased for the repetitive parts (composed of 2 four-measure repetitive units) over the course of the music (*M* [mm. 2-4] = .52, *SD* = .14, *M* [mm. 5-8] = .53, *SD* = .18, *M* [mm. 9-12] = .53, *SD* = .19, *M* [mm. 13-17] = .52, *SD* = .18) nor increased for the less repetitive parts (composed of nonrepetitive four-measure units repeated only once) (*M* [mm. 2-4] = .53, *SD* = .15, *M* [mm. 5-8] = .54, *SD* = .18, *M* [mm. 9-12] = .55, *SD* = .19, *M* [mm. 13-17] = .55, *SD* = .18).

Discussion

This study presented an empirical investigation of the effects of exact and immediate repetitions of a musical fragment on the listener's attention to the concurrent streams of two-part contrapuntal passages. The results suggest that repetition plays an important role in the perception of the individual layers (voices, parts, or streams) of musical textures. Specifically, the relative perceptual prominence of the voices of a two-part contrapuntal texture seems to be partly guided by their repetitive or nonrepetitive structure. When one of the two lines consists of immediate and exact reiterations of a short fragment, listeners generally attend to the other, concurrent more varying line. This suggests that immediate and exact musical repetition can affect the way listeners follow the different textural components of polyphonic music. As the repeated part does not change, the listeners' attention moves to other, more attractive and novel parts. Consequently, this study sheds light on current models of the dynamics of music listening by illuminating the way in which attention fluctuates between two simultaneous musical voices as they unfold in time as a function of their repetitiveness.

Our findings indicate that this effect of repetition on the perception of musical texture is exclusive to relatively short (2 measures or 6s) repetitive musical fragments. The incorporation of repetitive units of longer duration (4 measures or 12s) did not seem to affect the direction of the listener's attention to one of the two voices of the counterpoint. Nevertheless, these results do not imply that long repetitive units cannot influence the listener's attention to different parts of the texture. It is possible that repetitive units longer than a given duration require more than four successive statements in order to have an effect on the listener's attention and, consequently, on their perception of voice prominence. This could be due to the difficulties in recalling and automatically processing longer musical fragments, a hypothesis supported by the real-time plot of the four-measure repetitive units (top of Figure 3). As shown, when the lower voice consists of four-measure repeating fragments, listeners have a slight tendency to direct their attention to the nonrepetitive, upper part at the beginning of the repetition. This brief tendency to attend to the more novel upper part during the beginning of the repetition of the lower part was confirmed by the analysis that divides the stimuli in four, where the mean perceived prominence corresponding to the first two measures (or first half) of the repetition was the highest of the four. Notwithstanding, the difference between this mean and the other means did not reach statistical significance. This last point, in tandem with the results from Experiment 2, leads us to hypothesize that the nonsignificant effect in Experiment 2 could simply reflect the possibility that 12-s units require more than four statements in order to have a significant effect on the listener's attention. Unfortunately, designing an experiment that would allow us to empirically confirm this hypothesis has practical limitations. Five statements of a four-measure repetitive unit would require 20-measure musical stimuli, and musical excerpts containing a voice that avoids any kind of repetition for that long would be too distant from melodic patterns characteristic of the Common-Practice period. Attempting to solve this problem by repeating the nonrepetitive part, like we did in the follow-up experiment, has obvious restrictions; stating the less repetitive part more than once certainly puts into question its ability to fairly represent nonrepetition.

Repetition and novelty are complementary concepts that have occupied a central place in the literature on musical expectation. Each reiteration of a musical pattern increases the listener's ability to predict it, especially when the repeated fragment is short—as it is the case for the two-measure repetitive units in this study. In this sense, novel musical events are less predictable than repeated ones. This suggests that, beyond any stylistic and contextual considerations, musical novelty is more unexpected than musical repetition. Nevertheless, musical change can be either surprising or expected depending on when it occurs. In the repertoire from the Common-Practice period, musical change tends to be very surprising when it interrupts the repetition of a fragment, but highly expected after a few immediate repetitions of a pattern. Following this, novel musical events appear to be particularly apt to play with the listener's expectations. Meyer (1956, Chapter I) suggested that musical emotion arises from interrupted expectations. Unexpected novel musical events can arouse emotional responses by virtue of their ability to inhibit, thwart, or block ongoing listening expectations. Similarly, expected novel musical events can lead to affective reactions by virtue of their relative lack of specificity.

The idea that repetition and novelty can lead to musical affect by playing with a listener's expectations implies a certain degree of voluntary or involuntary attention to the musical events in question. Furthermore, in music, to expect means to wait for a musical event to happen, which is a way of listening for or attending to that event. In this context, the link between musical repetition and emotion depends on attention: attention is necessary to generate the musical expectancies that are essential for emotional affect. In this sense, a study of the effects of repetition on attention can contribute to our understanding of musical emotions. Margulis (2014) has proposed that repetition contributes to musical pleasure in many different ways that go beyond expectation theory. According to Margulis, repetition creates a sense of embodiment by facilitating the listener's ability to anticipate the future, activating motor circuitry in the brain, increasing the sense of musical involvement, and inviting an overt or virtual communal participation. Based on the findings from the present study and on Margulis's description of the relationship between involvement and musical emotion, we would like to suggest that repetition could contribute to pleasure in music by facilitating the discovery of new musical features and paths during the listening experience, consequently leading to greater involvement and better acquaintance with the music. Our results are consistent with the notion that repetition—ubiquitous to many experiential domains—leads to automatization, allowing attention to be focused elsewhere. If musical repetition can be processed automatically, it is likely that it would enhance the listener's ability to attend to musical events that would otherwise remain unexplored due to the difficulties in dividing attention among simultaneous lines during music listening. Accordingly, through its effect on the perceived prominence of simultaneous musical parts, repetition reveals to the listener the many corners and curves that refine the unique multidimensional beauty of music.

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References

Bigand, E., McAdams, S., & Forêt, S. (2000). Divided attention in music. *International Journal of Psychology, 35*(6), 270-278.

Bregman, A. (1990). *Auditory scene analysis: The perceptual organization of sound*. Cambridge, MA: MIT Press.

Bregman, A. S., & Rudnicky, A. I. (1975). Auditory segregation: Stream or streams? *Journal of Experimental Psychology: Human Perception and Performance*, *1*(3), 263-267.

Cowan, N. (1995). *Attention and memory: An integrated framework*. New York: Oxford University Press.

Dalton, P., & Spence, C. (2008). Attention and memory in mammals and primates. In J. Byrne (Ed.), *Learning and memory: A comprehensive reference* (Vol. 1, pp. 243–257). Oxford, UK: Elsevier.

Davison, L. L., & Banks, W. P. (2003). Selective attention in two-part counterpoint. *Music Perception, 21*, 3-20.

Duane, B. (2012). Agency and information content in eighteenth- and early nineteenth-century string-quartet expositions. *Journal of Music Theory*, *56*(1), 87-120.

FRANCIS, K. A. (2011). *Attention and polyphonic music* (Unpublished doctoral dissertation). University of Rochester, Rochester, NY.

GATI, I., & BEN-SHAKHAR, G. (1990). Novelty and significance in orientation and habituation: A feature-matching approach. *Journal of Experimental Psychology. General, 119*(3), 251-63.

GINGRAS, B. (2008). *Expressive strategies and performer-listener communication in organ performance* (Unpublished doctoral dissertation). McGill University, Montreal, Canada.

HUEY, E. B. (1968). *The psychology and pedagogy of reading.* Cambridge, MA: MIT Press. (Original work published 1908)

HURON, D. (1989). Voice denumerability in polyphonic music of homogeneous timbres. *Music Perception, 6*, 361-382.

HURON, D. (2001). Tone and voice: A derivation of the rules of voice-leading from perceptual principles. *Music Perception*, *19*, 1-64.

HURON, D., & FANTINI, D. (1989). The avoidance of inner-voice in polyphonic music: Perceptual evidence and musical practice. *Music Perception*, *9*, 93-104.

ISO 389-8. (2004). *Acoustics – Reference zero for the calibration of audiometric equipment – Part 8: Reference equivalent threshold sound pressure levels for pure tones and circumaural earphones* [Tech. Rep.]. Geneva, Switzerland: International Organization for Standardization.

KAHNEMAN, D. (1973). *Attention and effort*. Englewood Cliffs, NJ: Prentice-Hall.

LAWSON, E. (1966). Decisions concerning the rejected channel. *Quarterly Journal of Experimental Psychology, 18*, 260-265.

LIDOV, D. (2005). *Is language a music? Writings on musical form and signification*. Bloomington, IN: Indiana University Press.

MACKWORTH, J. F. (1969). *Vigilance and habituation: A neuropsychological approach*. Harmondsworth, UK: Penguin.

MADSEN, S. T., & WIDMER, G. (2007). Towards a computational model of melody identification in polyphonic music. In M. Veloso (Ed.), *Proceedings of the 20th International Joint Conferences on Artificial Intelligence* (pp. 459-464). Hyderabad, India: IJCAI.

MARGULIS, E. H. (2012). Musical repetition detection across multiple exposures. *Music Perception, 29,* 377-385.

MARGULIS, E. H. (2014). *On repeat: How music plays the mind.* Oxford, UK: Oxford University Press.

MARTIN, F. N., & CHAMPLIN, C. A. (2000). Reconsidering the limits of normal hearing. *Journal of the American Academy of Audiology*, *11*(2), 64-66.

MEYER, L. B. (1956). *Emotion and meaning in music*. Chicago, IL: University of Chicago Press.

MORRIS, N., & JONES, D. M. (1990). Memory updating in working memory: The role of the central executive. *British Journal of Psychology, 81,* 111-121.

NÄÄTÄNEN, R., PAAVILAINEN, P., RINNE, T., & ALHO, K. (2007). The mismatch negativity (MMN) in basic research of central auditory processing: A review. *Clinical Neurophysiology, 118*, 2544-2590.

NATTIEZ, J. (1975). *Fondements d'une sémiologie de la musique* [Music and discourse: Toward a semiology of music]. Paris, France: U.G.E.

PALMER, C. (1996). On the assignment of the structure of music performance. *Music Perception 14*, 23-56.

PALMER, C., & HOLLERAN, S. (1994). Harmonic, melodic, and frequency height influences in the perception of multivoiced music. *Perception and Psychophysics*, *56*, 301-312.

PAVLOV, I. P. (1960). *Conditioned reflexes: An investigation of the physiological activity of the cerebral cortex* (G. V. Anrep, Trans. & Ed.). New York: Dover Publications. (Original work published 1927)

RAHN, J. (1982). Where is the melody? *In Theory Only*, *6*, 3-19.

RUWET, N. (1972). *Langage, musique, poésie* [Language, music, poetry]. Paris, France: Editions du Seuil.

SLOBODA, J. A., & EDWORTHY, J. (1981). Attending to two melodies at once: The effect of key relatedness. *Psychology of Music*, *9*, 39-43.

SNYDER, B. (2000). *Music and memory: An introduction.* Cambridge, MA: MIT Press.

SOKOLOV, E. N. (1963). *Perception and the conditioned reflex*. New York: Macmillan.

SPENCE, C., & SANTANGELO, V. (2010). Auditory attention. In C. J. Plack & D. R. Moore (Eds.), *The Oxford handbook of auditory science: Hearing* (pp. 249-270). Oxford, UK: Oxford University Press.

TAHER, C. (2013a). *Effects of repetition – Musical examples* [Podcast]. Retrieved from https://soundcloud.com/ctaher-1/sets/effects-of-repetition-examples April 15, 2015

TAHER, C. (2013b). *Effects of repetition – Scores* [Supplemental material]. Retrieved from http://www.music.mcgill.ca/smc/Taher_2015_MusPercept_Scores.pdf April 15, 2015

TEMPERLEY, D. (2013). Computational models of music cognition. In D. Deutsch (Ed.), *The psychology of music* (3rd ed., pp. 327-368). San Diego, CA: Academic Press.

THOMPSON, W. F. (1993). Modeling perceived relationships between melody, harmony and key. *Perception and Psychophysics*, *53*, 13-24.

TREISMAN, A., & RILEY, J. (1969). Is selective attention selective perception or selective response? A further test. *Journal of Experimental Psychology, 79*, 27-34.

WATERS, W. F., MCDONALD, D. G., & KORESKO, R. L. (1977). Habituation of the orienting response: A gating mechanism subserving selective attention. *Psychophysiology, 14*, 228-236.