Music familiarity modulates mind wandering during lexical processing

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Abstract

Mind wandering has been investigated in a variety of sustained attention tasks. In the present research, we investigated the role of mind wandering while listening to familiar or unfamiliar musical excerpts, and its effects on linguistic processing. Participants performed a lexical congruity task involving judging the semantic relatedness of a list of word pairs while listening to familiar classical music, unfamiliar classical music, or non-music environmental sound clips. Mind wandering episodes were probed randomly and intermittently for participants to self-report their mind wandering episodes during the task. Results showed that listening to familiar music is associated with faster response times and lower frequency of mind wandering. Whereas mind wandering episodes tend to be more frequent when participants listened to unfamiliar music. Implications from previous attention models and theories of music familiarity suggest that familiar music might increase task enjoyment without compromising behavioral performance.

Introduction

Mind wandering is an ubiquitous phenomenon that dissociates processing of external stimuli in favor of processing of internal task unrelated thoughts (Smallwood & Schooler, 2006). Using probe-caught and self-caught methods of sampling mind wandering, research has shown that mind wandering predict errors on tasks that require sustained attention such SART (Smallwood, Davis, Heim, et al., 2004), word encoding (Smallwood, Baraciaia, Lowe, & Obonsawin, 2003), and more recently, reading (Feng, D'Mello, & Graesser, 2013). In Smallwood and colleagues' model, tasks that require little attentional resource load would give more leeway for the mind to wander (Smallwood & Schooler, 2006). However, attentional decoupling might also occur if the task is too demanding, as in reading, when the reader fails to construct a situation model (Feng et al., 2013). The nature of mind wandering in disrupting task-performance has shown to be similar to external distraction (Unworth & McMillian, 2014). One question that arises is what external distractions can prompt mind wandering during task performance, and which can reduce mind wandering during sustained-attention tasks. The currently research investigates the relationship between mind wandering and lexical task performance while listening to music, and how familiarity of the excerpts influences mind wandering and linguistic processing.

Previous research on whether music-listening improves or disrupts task performance has shown conflicting results. Music-listening disrupts task performance if the musical clip (e.g., lyrics) contains matching semantic information as the task (Marsh, Hughes, & Jones, 2009). So if one listens to music containing semantic information and he/she is also performing a semantic task simultaneously, task performance would be disrupted even if the musical sound is irrelevant. Similarly, Perham and Currie (2014) showed that listening to music with lyrics impairs reading comprehension more than listening to music with no lyrics or in silence, whether the participants liked the lyrics or not. On the other hand, it has been found that self-selected music-listening, relative to experimenter-selected, is not detrimental to task performance if there is a mismatch in information-processing pathway between the music and the task. For example, driving while listening to music with lyrics would not be as detrimental to the task of driving as would listening to music with lyrics while reading (Cassidy & McDonald, 2009). It is argued that self-selected music tends to be more familiar to the listener, therefore it reduces competition on attentional resources between music-listening and task performance. At the same time, listening to music, especially preferred or self-selected, can improve enjoyment and reduce anxiety. For example, it has been found that music-listening can reduce stress in workplace and improve work engagement (Haake, 2011). Music-listening has long been shown to increase arousal and may even increase cognitive abilities (Moreno & Bidelman, 2014; Perham, Lewis, Turner, & Hodetts, 2013; Schellenberg, 2012).

A growing body of evidence also supports the notion of a relationship between music and language (Patel, 2008). For example, musical harmonies seem to share cognitive resources in terms of syntax processing, but separate mechanisms are observed for the analysis of semantics (Slevc, Rosenberg, & Patel, 2009). Music and speech also seem to share similar brain mechanisms. For example, Cantonese-speakers, who speak a tonal language that closely mirror typical musical sequences, outperform their English-speaking counterparts in musical perception and pitch memory tasks (Bidelman, Hutka, & Moreno, 2013).

Other studies using magnetoencephalography have found that the perception of unexpected musical chords that violate the syntax of harmonic progressions (e.g., out-of-key notes), elicit a neurological response that is similar to unexpected syntax in language processing (Maess, Gunter, & Friederici, 2001). Yet at the same time, the response differs from language processing in that it is elicited in the right hemisphere instead of the left (Maess et al., 2001). Collectively, these studies show that musical processing and language processing share some common neural mechanisms, and therefore, may compete for similar cognitive resources.

While it can be suggested that both music and language share cognitive resources, one open question is whether *non-lyrical* music familiarity would increase or reduce attentional load while performing a language task. One hypothesis would be that since familiar music is generally preferred among listeners, listening to familiar selections might draw more attentional resources from executing a language task and inhibit performance due to its engaging nature. Previous research has found that increasing exposure of novel music increases emotional arousal, as well as the pleasure experienced during music listening (Bosch, Salimpoor, & Zatorre, 2013; Pereira, Teixeira, Figueiredo, et al., 2011). Consequently, an equally plausible hypothesis predicts that listening to familiar music may be less distracting than listening to unfamiliar music, and therefore less detrimental to the language task. In both cases, according to Smallwood and Schooler's (2006) model on mind wandering, mind wandering should occur less frequently when attentional resources are utilized to the extent to which the task can be still be performed, but little resources are left to allow the mind to wander. Investigating the frequency of mind wandering during music listening can also shed further light on the current debate regarding whether music can facilitate or disrupt language-related task performance (e.g., Thompson, Schellenberg, & Letnic, 2011).

In the present study, we used a semantic-congruity task paradigm paired with well-known and obscure non-lyric classical music to investigate the relationship between music familiarity, language processing, and attention. We reasoned that if familiar music causes less distractibility, there should be an increase in mind wandering frequency, which in turn should predict a faster response time per Smallwood and Schooler's (2006) model, and an increase of errors on task.

Method

Participants

Participants were 96 undergraduate students from the University of Memphis subject pool who participated in this study for course credit.

Experiment Design

Sound Excerpts. The experiment used a within-subject design with three sound excerpt listening conditions: *control*, *familiar*, and *unfamiliar*. The *control* condition consisted of a single sound clip, called "environmental soundtrack," which consisted of ambient nature sounds (e.g., birds chirping, trees rustling, water flowing). This control condition was intended to mimic a non-musical neutral background noise. The *familiar* and the *unfamiliar* condition consisted of a total of 12 classical musical excerpts by Bach, Mozart, and Beethoven evenly distributed. Six musical excerpts were categorized as familiar and the other six as unfamiliar. Familiar pieces included Mozart's Symphony # 40 in G minor, first movement, Beethoven's Symphony # 5 in C minor, and Bach's Cello Suite I in G major. Unfamiliar pieces include Mozart's Serenade in B minor, Beethoven's Violin Sonata # 10 in G major, and Bach's Partita I for Solo Violin in B minor. The pieces were judged as familiar or unfamiliar based on the frequency the popularity these pieces have been played (Moles, 1968; Simonton, in press). In both the familiar and unfamiliar conditions, there were two musical excerpts per composer. Participants listened to one sound excerpt per condition, played while performing the semantic congruity task. The musical excerpt in the familiar and unfamiliar conditions featured one piece that was randomly selected from among the six possible choices in its category.

Semantic Congruity Task. The semantic congruity task was a word-pair semantic relatedness judgment task. There were a total of 180 word pairs from the appendix of Relander, Rama, and Kujala (2008)—English-translated version. For each of the three sound excerpt conditions, participants were presented with 60 word pairs randomly selected from the 180 without repeats. In total, every participant completed the judgment of semantic relatedness of 180 word pairs (i.e., 60 per sound condition).

Procedure

After obtaining informed consent, participants were asked to fill out a demographic questionnaire regarding their education level, language background, and musical expertise.

Participants were then prompted to complete a computer task, with experimental instructions presented on a PC monitor. The task required the participants to listen to three sound clips and complete the series of word-relatedness judgments. Before the task started, participants also read a definition of mind wandering that was largely taken from Smallwood and Schooler (2006): "*Mind wandering is a term used to describe what occurs when your attention wanders from a task. Sometimes when your mind wanders, you begin thinking about personal events or concerns rather than your task. At other times, your mind can wander because you are bored or tired and you don't really know what you're thinking about; all you know is that you are no longer thinking about your task*." Participants were then told that they would randomly see messages periodically asking them “Are you mind wandering right at this moment?" The participants were to click either “Yes” or “No” via a button press on the computer screen for their response to these mind wandering probes. The three sound excerpt blocks were counterbalanced by a 3x1 Graeco -Latin square.

After each block, participants were asked to rate the sound excerpt on familiarity (“*How familiar are you with the clip that you’ve just heard?*”), distractibility (“*How distracting did you find the sound clip you’ve just heard?”),* and enjoyment (“*How much did you like listening to the sound clip you’ve just heard?”).* The ratings were on a 1 to 6 Likert Scale. Participants’ response times on the word-pair judgments were also recorded using a custom program coded in MATLAB 2013 (The MathWorks, Natick, MA).

Statistical Analyses. Analyses focused on individual response items, and items that corresponded to mind wandering thought probes. A mixed-effect modeling approach was adopted to analyze the data, because of the repeated and nested nature of the design (Bates & Maechler, 2010). Linear or logistic models were constructed on the basis of whether the dependent variable was continuous (response times) or binary (mind wandering and accuracy of lexical-semantic judgment), respectively. The random effects were participants (96 levels), and order of conditions (3 levels). Conditions functioned as a three-level (familiar, unfamiliar, control) categorical fixed effect. An α-level of p=0.05 was adopted for all statistical testing. Two-tailed tests were used throughout.

Results

Response times

A mixed-effects linear regression model for response time between the music conditions was not significant (F(2, 17277) = 2.28, p = 0.10).

It is possible that even though our manipulation showed evidence of support based on participants’ self-reported ratings on familiarity (familiar condition: M = 3.81, SD = 1.69; unfamiliar condition: M = 2.07, SD = 1.38; t(190) = 7.82, d = .49, p < .001), it was still not sensitive enough to show an effect. For example, in the familiar condition, 23 participants out of 96 rated the pieces they received as a 1 or 2, meaning they perceived the pieces to be extremely to moderately unfamiliar. Due to this consideration, we decided to use participants’ *self-ratings* instead of our pre-categorized conditions for subsequent analysis. We conducted a data-reduction technique and excluded familiarity ratings of 3 or 4 given these were neutral ratings without strong user preferences and to maximize the possibility of observing an effect between salient ratings (familiar, unfamiliar, control). Hence, a total of 4860 out of 17280 data points were excluded. We then combined data points from the two musical conditions corresponding to familiarity ratings of 1 and 2 as the unfamiliar condition (N = 5280), and combined data points corresponding to familiarity ratings of 5 and 6 as the familiar condition (N = 3000). The control continue to serve as a neutral comparison (N = 5760). In addition, in our original musical condition (i.e., excluding the control), data points corresponded to familiarity ratings of 1 and 2 outnumbered data points corresponded to familiarity ratings of 5 and 6 by 2280 cases after the exclusion of data points corresponded to familiarity ratings of 3 and 4. To circumvent Type I error inflation in our ANOVA due to differences in the number of observations, we randomly sampled 3000 data points out of 5280 data points corresponding to familiarity ratings of 1 and 2. We also randomly sampled 3000 data points out of 5760 data points from our original non-musical control condition as our new control condition. Bootstrapping was conducted to ensure the reliability/robustness of this data-reduction method.

A mixed-effects linear regression model using familiarity conditions to predict reading times was significant (F(2, 8997) = 23.25, p < 0.001) (Figure 1). Tukey corrected post hoc contrasts revealed that there was a reduction of 126-ms (i.e., B = -126, SE = 23 ms, p < 0.001; *Bootstrap bias* = 0.052, SE = 15.64) in response time when participants performed the semantic relatedness judgment task while listening to music that they reported to be familiar (M = 1244, SD = 628ms), than while listening to music that they reported to be unfamiliar (M = 1374, SD = 745 ms). There was also reduction of 133-ms (i.e., B = -133, SE = 20 ms, p < 0.001; *Bootstrap bias* = 0.06, SE = 16.21) in response time when participants judged semantic relatedness while listening to music that they reported to be familiar, than while they listened to the neutral non-musical control sound clip (M = 1362, SD = 753 ms). Response time between making semantic judgments while listening to unfamiliar music did not differ from that of the control condition (*Bootstrap bias* = 0.11; SE = 15.30). These findings suggest that participants were just as distracted while listening to our control sound clip as they were listening to (self-reported) unfamiliar music.

Mind Wandering Frequency

A mixed-effects logistical regression model for the presence (coded as 1) or absence (coded as 0) of mind wandering, using familiarity conditions as a fixed effect, yielded a significantly better fit than did a model with only the random effect but without the fixed effect ($\chi 2(2)$ = 7.48, p < 0.05). The coefficient was 0.786 when comparing the mind wandering frequency between familiar music listening to unfamiliar music listening (SE = 0.33, p < 0.05). This indicates that participants were 2.14 ($e^{0.786}$) times more likely to mind wander when performing the semantic relatedness task while listening to self-reported unfamiliar music than self-reported familiar music (Figure 2). The coefficient was 0.731 when comparing the mind wandering frequency between unfamiliar music listening to control (SE = 0.26, p < 0.05). This indicates that participants were ~2 ($e^{0.731)}$ times more likely to mind wander when performing the semantic relatedness task while listening to the non-musical control sound clip than while listening to self-reported unfamiliar music. There was no significant difference between listening to familiar music and listening to the control sound clip in terms of mind wandering frequency during semantic relatedness judgments. Bootstrapping results showed that bias on our resampling techniques were effectively zero for all musical conditions ($SE = 0.01$).

Semantic Relatedness Judgment Accuracy

On average, participants correctly judged 86% ($SD = 0.34$) of the word pairs in semantic relatedness while listening to familiar music, 86% ($SD = 0.34$) while listening to unfamiliar music, and 87% ($SD = 0.34$) while listening to the control excerpt. A mixed-effects logistical regression model for correct (coded as 1) versus incorrect (coded as 0) responses between the conditions was not significant ($\chi 2(2) = 0.89$, $p = 0.64$). This suggests that participants performed at near-ceiling levels regardless of the concurrent audio clip.

Mind wandering, response times, and accuracy

We investigated whether mind wandering predicted listeners' response times just prior to mind wandering probes. The resultant mixed-effect linear regression was marginally significant ($F(1, 748) = 3.29$, $p = 0.07$). There was also no interaction between mind wandering and sound excerpt in predicting response time ($F(2,744) = 0.085$, $p = 0.43$).

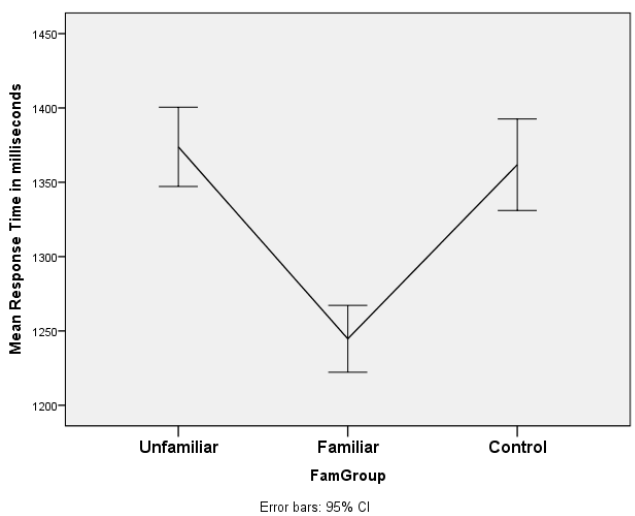

Figure 1: Mean response time per sound excerpt condition

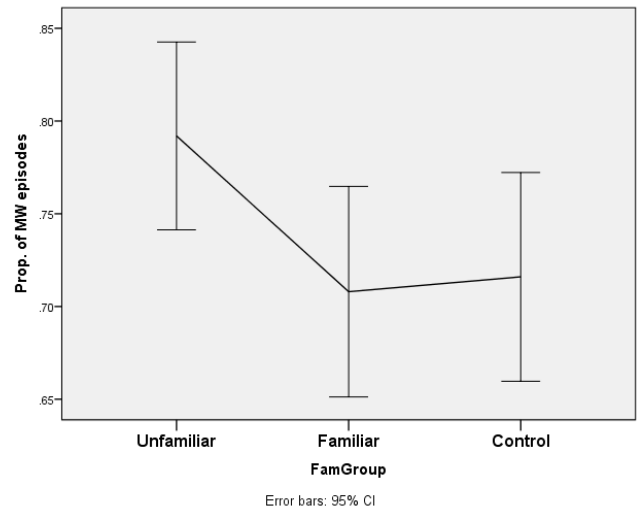

Figure 2: Proportion of mind wandering episodes per sound excerpt conditions.

Familiarity, Distractibility, and Enjoyment

We investigated the relationship between the ratings of familiarity, distractibility, and enjoyment. A Pearson-correlation analysis was conducted between the three ratings. Results suggest that there was no relationship between music familiarity and distractibility ($r = 0.12$, $p = 0.095$). On the other hand, how much participants enjoyed the musical excerpts was strongly negatively correlated with how distracting the musical excerpts were ($r = -0.41$, $p < 0.001$). Results also showed that, as with previous findings (e.g., Bosch et al., 2013), participants found familiar music to be more enjoyable ($r = 0.294$, $p < 0.001$).

Discussion

The goal of the present study was to examine the effects of music familiarity and mind wandering during language task performance. Our results indicate that listening to familiar music seems to be less detrimental to linguistic processing than listening to unfamiliar music as suggested by faster lexical-semantic decisions. Additionally, we found that mind wandering also occurred more frequently when participants listened to unfamiliar music than either familiar music or background noise (i.e., neutral environmental sounds).

Our results seem to support previous findings that suggest familiar music is less distracting than unfamiliar music (e.g., Cassidy & McDonald, 2009; Etaugh & Michals, 1975). However, our correlational analysis also showed that familiarity might not have a clear-cut relationship with distractibility. Perhaps depending on the task or the type of music one listens to, familiar music can vary in perceived distractibility. On the other hand, as with previous studies (e.g., Haake, 2011), participants did rate more familiar music to be more enjoyable, and enjoyment has shown to be strongly negatively correlated with distractibility. This suggests that how much a listener likes the music outweighs how familiar the music is in terms of determining distractibility of music-listening during task performance.

Our findings converge with those of previous studies that suggest greater emotional arousal and pleasure in response to familiar music can alleviate task performance stress (Haake, 2011; Bosch et al., 2013; Pereira et al., 2011). In our study, we found that listening to familiar music *facilitated* semantic-decisions (i.e., faster response times) above and beyond a neutral environmental sound track. Yet, response times when participants' listened to unfamiliar music did not differ from listening to background noise. Collectively, these results suggest that (i) concurrent audio stimuli that are unfamiliar (whether music or ambient noise) hinders language-related processing and (ii) familiar music seems to promote more rapid lexical access.

While our results replicate previous findings that showed that unfamiliar music is the most detrimental to task performance, they counter the extreme notion that mind wandering is characteristic of a reduction in response time across the board (Smallwood and Schooler, 2006). In our paradigm, participants' listening to familiar music did not seem to shift attentional resources allowing for the mind to wander, even though there was a reduction in response time—indicative of familiar music inducing task ease. This seems to suggest that music familiarity and music preference may increase task ease by inducing pleasure while alleviating mind wandering. Previous research suggests that mind wandering occurs during task performance is predominantly associated with boredom and negative moods (Kane, Brown, McVay, et al., 2007; Eastwood, Frischen, Fenske, et al., 2012; Smallwood, Fitzgerald, Miles, et al., 2009). We infer that listening to preferred music may actually counteract boredom without compromising task performance as an external distraction.

Of interest to further research is identifying the types of tasks that benefit from listening to preferred music, and the role of mind wandering in mediating task performance during music listening. Music training has long been associated with creativity (e.g. Coulson & Burke, 2014). It would be interesting to investigate whether mind wandering occurs with higher frequency while performing a creative task during music listening relative to a low-level sustained attention task. Another consideration is that music training has been in the past used as an aid for language learning. For example, music training has attempted to improve literacy skills in dyslexic children (Overy, 2000) and rhythmic musical interventions have been used to bolster reading and spelling skills in children (Bhide, Power, & Goswanmi, 2013). Music training has also been associated with better second language learning (Swaminathan & Gopinath, 2013). Futures studies are needed to further investigate whether there are specific types of tasks that can be aided by music listening or music training.

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