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Fast and loud background music disrupts reading comprehension

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Abstract

We examined the effect of background music on reading comprehension. Because the emotional consequences of music listening are affected by changes in tempo and intensity, we manipulated these variables to create four repeated-measures conditions: slow/low, slow/high, fast/low, fast/high. Tempo and intensity manipulations were selected to be psychologically equivalent in magnitude (pilot study 1). In each condition, 25 participants were given four minutes to read a passage followed by three minutes to answer six multiple-choice questions. Baseline performance was established by having control participants complete the reading task in silence (pilot study 2). A significant tempo by intensity interaction was observed, with comprehension in the fast/high condition falling significantly below baseline. These findings reveal that listening to background instrumental music is most likely to disrupt reading comprehension when the music is fast and loud.

Keywords

background music, music and cognition, music and reading, reading comprehension

Although multitasking is common, it can lead to performance decrements. For example, driving errors are more frequent when drivers speak on a mobile phone compared to when their attention is allocated exclusively to driving (Redelmeier & Tibshirani, 1997). One common example of multitasking is listening to music while studying. With the pervasive use of MP3 players among teenagers and young adults, it is important to develop a complete

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understanding of effects of background music on studying (Beentijes, Koolstra, & van der Voort, 1996). Because studying typically includes reading, the present investigation examined the effects of background music on reading comprehension.

Reading places considerable demands on cognitive resources. According to Walczyk (2000), reading includes automatic processes such as letter identification and semantic access, as well as attention-demanding processes such as inference generation and text elaboration. Compared with automated or routine tasks, reading places heavy demands on attentional control and cognitive resources, and skill at attentional control is associated with reading comprehension (Carretti, Borella, Cornoldi, & De Beni, 2009).

There are several reasons for suspecting that listening to music will interfere with reading comprehension. Like language, music involves structured input that unfolds meaningfully over time and a hierarchical ordering of elements (Lerdahl & Jackendoff, 1983; Patel, 2003, 2009). Just as sentences can be broken down into lexicons and phonemes, musical phrases can be broken down into intervals and notes. As Patel (1998) states, "both language and music perception crucially depend on memory and integration in the perception of structural relations between elements" (p. 29). In other words, although domain-specific features of language (e.g., verbs) and music (e.g., chords) may be processed within separate, modular systems (Peretz & Coltheart, 2003), other features may engage overlapping cognitive processes.

Sensitivity to temporal order is also important for the processing of music and verbal information. Both language and music consist of a rapid succession of auditory events unfolding over time, and each event attains significance through its temporal contiguity with surrounding events (Drake & Bertrand, 2001). Some researchers have argued that music training enhances verbal abilities by facilitating temporal processing skills (Jakobson, Cuddy, & Kilgour, 2003). But if reading and listening to music both place demands on temporal processing skills, then they may also compete and interfere with one another.

Two perspectives account for the effects of background music on reading comprehension: the *Cognitive-Capacity* hypothesis and the *Arousal-Mood* hypothesis. Kahneman's (1973) capacity model maintains that a limited pool of resources must be distributed over cognitive processes at any given moment (see also Baddeley, 2003). Capacity limits are also assumed in models of reading comprehension (Carretti et al., 2009; Kintsch & van Dijk, 1978). When concurrent tasks compete for limited resources and their combined demands exceed the available capacity, *capacity interference* occurs (Norman & Bobrow, 1975). Only part of the task information is processed and performance deteriorates (Armstrong & Greenberg, 1990). Interference by task-irrelevant information also depends on the level and type of load involved in the processing of task-relevant information (Lavie, 2005; Lavie, Hirst, de Fockert, & Viding, 2004).

By contrast, the *Arousal-Mood* hypothesis posits that music listening affects task performance by influencing arousal and mood (Husain, Thompson, & Schellenberg, 2002; Thompson, Schellenberg, & Husain, 2001). Whereas arousal refers to the energetic and physiological elements of emotion, mood represents the experiential dimension that extends from positive to negative (Schellenberg, Nakata, Hunter, & Tamoto, 2007). Cognitive-motor benefits are associated reliably with enhanced mood (Isen, 2002) and heightened arousal (Duffy, 1972).

In short, the potential *cost* of background music listening for reading comprehension is that it places demands on attention. The potential *benefit* of background music listening is that it can enhance arousal levels and mood. The overall effect of background music on task performance may be a balance between these costs and benefits. When the costs outweigh the benefits, background music should interfere with primary task performance. When the benefits outweigh the costs, background music should facilitate primary task performance. These conflicting forces are likely to be a principal reason why a recent meta-analysis on background music revealed an overall null effect (Kämpfe, Sedlmeier, & Renkewitz, 2010).

The available literature confirms that music listening interacts with concurrent cognitive-motor function. Early work suggested that background music interferes with performance on tasks such as typing (Jensen, 1931) and reading (Madsen, 1987). However, music listening can also benefit performance: it can temporarily enhance cognitive function (Thompson et al., 2001) and it is used therapeutically in clinical settings (Gold, Voracek, & Wigram, 2004). Music also affects behaviour in ways not easily classified as positive or negative. For example, people drink water faster while listening to fast music (McElrea & Standing, 1992), drivers make more steering wheel movements when listening to music (Konz & McDougal, 1968), and rhythmic auditory input can influence the timing of concurrent motor actions (Repp, 2006). On balance, the available findings suggest that music listening affects concurrent cognitive-motor function, but there is little understanding of the conditions under which background music leads to costs and benefits for concurrent behaviour.

A number of researchers have examined how different types of music influence cognitive function. Furnham and Stephenson (2007) showed that performance on reading comprehension, free recall, mental arithmetic, and verbal reasoning tasks is better while listening to calm music than to upbeat music. Presumably calm music reduces anxiety while upbeat music is distracting. Similarly, comprehension and recall are better while listening to slow-tempo than to fast-tempo music (Cassidy & MacDonald, 2007; Furnham & Strbac, 2002). In other words, detrimental effects of background music on reading comprehension likely depend on the characteristics of the music (Kämpfe et al., 2010).

To further examine this issue, we presented music that varied in tempo and intensity while participants completed a reading comprehension task. We expected that both manipulations would affect comprehension. Our reading stimuli were selected to be demanding so that central-processing capacity was likely to be exceeded when background music placed additional demands on attentional resources. An instrumental piano piece by Mozart – known to enhance arousal levels and mood (Husain et al., 2002; Schellenberg et al., 2007; Thompson et al., 2001) – was selected as background music because we were interested in the potential for non-verbal attributes of music to disrupt linguistic processing. Cognitive-capacity models predict that background music should be more likely to lead to decrements in comprehension when the music is fast with many events to process per unit of time, and/or loud and difficult to ignore. However, because music listening can also optimize arousal levels and mood – which enhance cognitive performance (Thompson et al., 2001) – cognitive *benefits* could counteract or reduce decrements arising from attentional limitations, at least in some contexts.

We conducted two pilot studies before running the actual experiment. The first was designed to determine an appropriate set of stimulus materials for the primary experiment, such that the tempo and intensity manipulations were comparable. The second established baseline levels for the reading comprehension test when it was complete in silence.

Pilot study 1

Because the goal of the principal experiment was to assess reading comprehension under high and low levels of musical tempo and intensity, and because tempo and intensity are associated with different scales of measurement, additional testing was needed to ensure psychologically-equivalent manipulations. The first pilot study was designed to establish equivalent manipulations of tempo and intensity for use in the primary experiment. Participants were presented with a target "tempo change" stimulus followed by a comparison "intensity change" stimulus. Their task was to judge the relative psychological magnitude of the changes in tempo and intensity.

Method

Participants. Participants were five females and four males from the Macquarie University community, Australia, ranging in age from 18 to 55 years ($M = 28.6$).

Materials. The music consisted of five second excerpts from Mozart's *Sonata for Two Pianos in D major*, K 375a (K 448)-1781 Allegro con spirito, starting from the third phrase of the sonata (www.kunstderfuge.com/mozart.htm). Tempo and intensity were manipulated using ProTools software (version 7.3). The "tempo change" stimuli consisted of two presentations of the excerpt at an intermediate intensity (66 dB): a slow (110 bpm) and fast (150 bpm) version. There were eight "intensity change" stimuli. Each consisted of two presentations of the excerpt at an intermediate tempo (130 bpm): a low intensity version (60 dB) and one of eight higher intensity versions. The eight higher intensity versions ranged from 61 dB to 82 dB in 3 dB increments. Intensity levels were confirmed through the use of a Digitech QM-1589 sound level meter with measurements taken at the headphones.

Procedure. Presentation of stimulus materials and collection of responses were computer controlled with Experiment Creator software (www.psy.mq.edu.au/me2/). On each trial, the target tempo change was followed by one of the eight versions of the intensity change stimuli. Each version was presented twice with presentation order randomized. Participants were tested individually in a sound-attenuated testing room while they listened to the stimuli through Sennheiser HD-580 headphones. After hearing the target "tempo change" stimulus and the comparison "intensity change" stimulus, participants provided a rating from 1 (the intensity change is smaller in psychological magnitude than the tempo change) to 5 (the intensity change is larger in psychological magnitude than the tempo change).

Results

Mean ratings extended from 1.33 ($SD = 0.17$) for the smallest intensity change to 4.56 ($SD = 0.17$) for the largest intensity change. Simple linear regression was used to model the association between the set of eight intensity changes and the standard change in tempo. By solving the regression equation using a rating of 3 (or "the same"), we estimated an intensity change that was psychologically equivalent to the target tempo change. The target tempo change (110 to 150 bpm) was psychologically equivalent to an intensity change from 60 dB to 72.4 dB.

Pilot study 2

The second pilot study was used to establish baseline performance on our reading comprehension task. Participants completed the task in silence (no background music).

Method

Participants. Participants were 10 females and six males from the Macquarie University community, Australia, ranging in age from 19 to 48 years ($M = 23.9$). They had an average of 3.8 years of formal music lessons ($SD = 3.4$ years; range: 0 to 10 years).

Materials. Reading comprehension material was based upon the Graduate Management Admission Tests (GMAT), as used in other studies of the effects of background music on reading (Furnham & Allass, 1999; Furnham & Bradley, 1997; Furnham, Trew, & Sneade, 1999). The GMAT reading comprehension tests measure the ability to understand, analyze, and apply concepts from written information (Martinson & Ellis, 1996). Four passages were selected from the practice GMAT reading comprehension test. Passages were approximately 500 words in length and comprehension was assessed for each passage with six multiple-choice questions.

Procedure. Participants were tested individually in a sound-attenuated room. The four comprehension tests were administered one after the other in random order with five-minute breaks between each test. Participants had four minutes to read each passage and wore Sennheiser HD-580 headphones (no sound). They then took the headphones off and had three minutes to complete the six multiple-choice questions.

Results

Across the 16 participants and the four passages, the mean number of correct answers was 2.77 (SD = 0.85). This value provided an estimate of baseline performance on our reading comprehension measure (i.e., no background music).

Principal experiment

Method

Participants. Participants were 25 undergraduates (16 females, nine males) ranging in age from 17 to 26 years (M = 19.7 years). Musically-trained participants (n = 12) had at least two years of music lessons (M = 6.7, SD = 4.0, range: 2 to 14). Other participants (n = 13) had virtually no lessons (M = 0.2, SD = 0.4, range: 0 to 1).

Materials. The reading material was identical to that used in pilot study 2. The music was based on the same MIDI file used in pilot study 1. Using ProTools software (version 7.3), tempo and intensity were manipulated to produce four conditions: slow/soft (110 bpm, 60 dB); slow/loud (110 bpm, 72.4 dB); fast/soft (150 bpm, 60 dB); and fast/loud (150 bpm, 72.4 dB). Each version was four minutes in length. Intensity levels were confirmed through the use of a Digitech QM-1589 sound level meter measured at the headphones.

Procedure. The procedure was identical to pilot study 2 except that music was played through headphones (Sennheiser HD-580). The order in which the four comprehension tests were administered was randomized separately for each participant, as was the order in which the four music stimuli accompanied the reading passages.

Results

Descriptive statistics are illustrated in Figure 1. Initial analyses compared performance to baseline (no music) levels using four separate independent-samples t-tests. Performance was similar to baseline in three of the four conditions (slow/soft: M = 2.38, se = .25; slow/loud: M = 2.43, se = .28; fast/soft: M = 2.96, se = .31), ps > .2, but significantly worse in the fast/loud condition

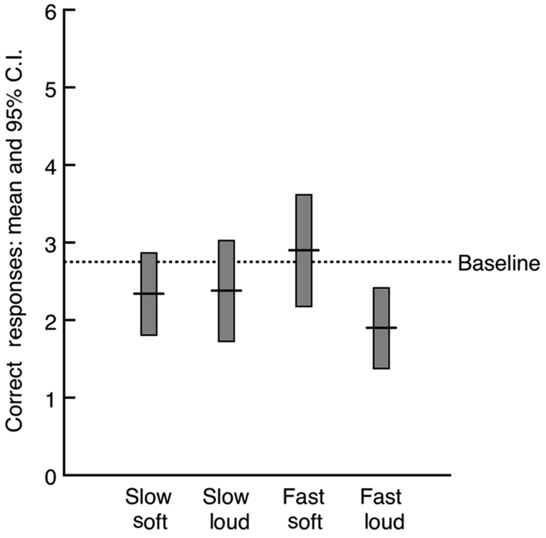

Figure 1. Mean correct responses and 95% confidence intervals for reading comprehension as a function of the four music-listening conditions. The horizontal line represents baseline performance in a no-music condition

($M = 1.95$, se = .21), $t(39) = 2.37$, $p < .05$. A mixed-design Analysis of Variance (ANOVA) with tempo (slow or fast) and intensity (soft or loud) as repeated measures and music training as a between-subjects factor revealed an advantage for musically-trained over untrained participants in reading comprehension, $F(1, 23) = 18.45$, $p < .001$, which is consistent with other findings revealing intellectual advantages for musically-trained over untrained participants (Schellenberg, 2004, 2006). There was also a two-way interaction between tempo and intensity, $F(1, 23) = 8.14$, $p < .01$. Follow-up tests of simple main effects revealed that the intensity manipulation had no effect for excerpts presented at a slow tempo, $F < 1$. At a fast tempo, comprehension was worse when the music was loud, $F(1, 23) = 7.93$, $p < .01$. There were no other significant effects.

Discussion

Our findings indicate that listening to background instrumental music is most likely to disrupt reading comprehension when the music is fast and loud. Music listening may consume more of listeners' finite attentional resources when it comprises a greater number of auditory events per unit time that are difficult to ignore because of greater intensity. By contrast, slow-tempo music may allow for continuous and spontaneous recovery from acoustic interference, permitting simultaneous verbal comprehension even when the music is loud. Such recovery may not be possible with fast music (with events occurring in more rapid succession), rendering readers vulnerable to the distracting effects of loud music.

Because reading comprehension was unaffected by slow or soft classical music, we predict that disruptive effects on reading comprehension would be similarly limited to fast and loud music from other genres. Such effects may also depend on the presence of vocals (Furnham et al., 1999), personality variables (Furnham & Allass, 1999; Furnham & Bradley, 1997), details of the primary task (North & Hargreaves, 1999a, 1999b), and preattentive processes that analyze the auditory environment (Macken, Phelps, & Jones, 2009). Intelligence and working memory capacity may generally affect the capacity to perform cognitive tasks while listening to music (König, Bühner, & Mürling, 2005). Preference and familiarity with music may also influence interference effects: one's favourite music may be difficult to ignore, but highly familiar music may also be efficiently processed and less distracting than unpredictable music. Such hypotheses are speculative given existing data (see Kämpfe et al., 2010), but are promising areas for future research.

Music that was slow and/or soft had no significant detrimental effects on reading comprehension, which is in conflict with the general conclusion reached by Kämpfe et al. (2010) based on their comprehensive meta-analysis of studies examining the impact of background music on concurrent task performance. They concluded that background music disrupts the reading process, but our data suggest that such interference effects are dependent on the structural characteristics of the music. Null results for other conditions are unlikely to be the consequence of a lack of power because: (1) our task was sensitive to individual differences in music training; and (2) the number of correct responses in the fast/soft condition was slightly *higher* than baseline performance. Indeed, music listening may have some benefits on performance vis-à-vis arousal and mood (Hallam, Price, & Katsarou, 2002; Thompson et al., 2001) that counteract the detrimental effects of reduced attentional resources. That is, the costs of music listening for reading comprehension may be offset by the benefits of music listening for mood and arousal, leading to no overall effect. Alternatively, background music listening may often have a benign impact on reading comprehension. Both possibilities are likely to be heartily endorsed by the many teenagers and young adults who enjoy listening to music while they study.

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