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The Effects of Musical Mood and Musical Arousal on Visual Attention

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Abstract

The presence of music is a visceral part of the human experience and its influence on cognitive function is a growing area of research in psychology. In particular, perceptual properties of music (mood and arousal) have been shown to significantly affect performance. There has been minimal research in the field on the interaction of mood and arousal and their influence on attention, thus the purpose of this study. Fifty undergraduate students currently enrolled at the University of Western Ontario were recruited for this study. Given that music is a highly subjective experience, participants rated an assortment of music clips on their mood and arousal levels. The clips that participants rated highest and lowest on mood (positive and negative) and arousal (low and high) were chosen for use on the Posner cueing task. This visual attention task was either performed in silence or while listening to music clips as per their ratings. Results indicated that musical mood and musical arousal, independently of one another, had no significant effect on visual attention. Rather, a significant interaction between the two perceptual properties was observed. The fastest reaction times were recorded when participants listened to high arousal positive music and the longest reaction times were found when participants listened to high arousal negative music. Intermediate performance occurred when participants listened to low arousal negative music and low arousal positive music. Future studies should investigate whether the combined modulatory effects of musical mood and musical arousal generalize to other attentional paradigms.

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The Effects of Musical Mood and Musical Arousal on Visual Attention

Music can most aptly be described as an integral part of human existence and its influence on different cognitive abilities is a growing area of research in psychology (Hallam, Cross & Thaut, 2009). Humans are surrounded by music on a daily basis, and many everyday tasks are fulfilled in its presence. For example, the majority of people drive while simultaneously listening to music. This undertaking is visually demanding and requires a high level of attentional processing, among other things. Therefore, it is essential for research to fully comprehend the effects of music on visual attention, a cognitive construct that underlies many routine tasks such as driving.

Early research on music and its effects on cognition suggested that listening to music, particularly classical music by Mozart, had beneficial effects on performance (Rauscher, Shaw & Ky, 1993). In this study by Rauscher et al. (1993), participants were subdivided into three groups. Each group was exposed to either: classical music by Mozart, relaxation strategies, or silence for the ten minutes preceding the experimental task. Each participant then completed three sets of standardized spatial-reasoning tasks taken from the Stanford-Binet Intelligence test. Results showed a temporary increase in spatial reasoning abilities, as measured by enhanced performance on the tasks, immediately following exposure to classical music as compared to relaxation or silence. The beneficial effect of music on performance was noted to be time-sensitive and did not extend for much longer than ten to fifteen minutes following exposure. These results led to the proposal of the *Mozart Effect* or the idea that listening to classical music could temporarily enhance spatial aptitude (Rauscher et al., 1993). This study provided evidence that music had a temporary and significant influence on certain aspects of cognitive function, and in particular spatial reasoning abilities.

However, further research indicated that the influence of music on cognition was not as simple as merely listening to music, or classical music for that matter. Thompson, Schellenberg and Husain (2001) hypothesized that exposure to any experimental condition, other than music, that could affect a participant's levels of mood and arousal could incur similar changes in spatial reasoning. By holding changes in the perceptual properties of music, such as mood and arousal, constant over experimental groups, the researchers invoked the disappearance of the *Mozart effect*. Thus, it appeared that this enhancement effect of music was actually an artifact of musical mood and musical arousal. Therefore, Thompson et al. (2001) offered an alternative explanation to the *Mozart effect* by proposing the *mood-arousal hypothesis,* which states that music has reliable effects on the emotional states (mood and arousal) of the listener, which in turn affect performance. This hypothesis served as the driving force behind the perceptual properties chosen for investigation in this research study.

General Effects of Music on Attention

Previous literature has found conflicting results regarding the effect of music on attention. Some research indicates that background music can enhance performance (Morton, Kershner & Siegel, 1990) whereas other studies indicate that background music actually distracts from the task at hand (Anderson & Fuller, 2010). It is this inconsistency, among others, that inspired further research to be conducted.

The effects of music, and its perceptual properties (mood and arousal), may be task-specific, thus explaining the lack of consensus in the research, to date. Different tasks employ disparate resources and different mechanisms have diverse effects. Therefore, it is important to use a variety of tasks in order to see whether findings are generalizable and not simply products of the chosen task.

Musical Mood and Musical Arousal

Musical mood could most fittingly be described as the affective state induced by music (Sloboda & Juslin, 2001). Thus, musical mood incorporates long-lasting emotions with results on cognition. In this research study, musical mood encompassed *positive* affective states such as happiness, excitement and elation, and *negative* affective states such as anxiety, anger and melancholy. To better understand the notions of *positive* and *negative* mood, self-report measures of these states include reference to adjectives that describe feelings and evaluations of mood such as sad, happy, discouraged, anxious, and angry (Sloboda & Juslin, 2001).

Musical arousal, on the other hand, consists of the degree of physiological activation or the intensity of the emotional reaction in response to music (Sloboda & Juslin, 2001). In this research study, musical arousal entailed *high intensity* evoking sensations such as increased energy, activity and wakefulness and *low intensity* perceptions provoking soothing and even drowsiness. Self-report measures of *high* and *low* arousal use adjectives that make reference to physiological states and intensity such as vigor and restlessness (Sloboda & Juslin, 2001).

In this study we were interested in investigating the interaction effect of musical mood and musical arousal on visual attention. Therefore, the stimuli that we used crossed both of these perceptual properties in order to better examine their effects. Four categories were defined (high arousal-positive music, high arousal-negative music, low arousal-positive music and low arousal-negative music) and employed as stimuli for use on the attention task. Other studies have looked at how musical mood and musical arousal affect cognitive processes such as memory and spatial reasoning (Rauscher et al., 1993; Greene, Bahri & Soto, 2010). Our study, however, focused on the effects of these perceptual properties on visual attention. The purpose was to determine how music affects performance of a basic attention task and in particular how mood and arousal directly affect visual attention.

Effects of Mood on Attention

The majority of previous research has looked at mood or arousal separately when examining their effect on cognition. In one study conducted by Olivers and Niewenhuis (2005), participants were quicker to identify targets in a visual sequence task when they listened to music as compared to silence. Results from this study indicated that listening to music had a positive effect on performance. Further research by Olivers and Niewenhuis (2006) revealed that generating a positive mood through the use of visual stimuli enhanced performance on an attentional blink task as compared to negative mood. Participants that were shown positive pictures (e.g., smiling babies, puppies, and etc.) were significantly faster in identifying targets on a classic attentional blink task then participants that had been exposed to negative pictures (e.g., syringes, snakes, and etc.). Arousal was controlled in this experiment through the use of the International Affective Picture System (IAPS) rating scale to avoid confounding with mood. These results were consistent with the *positive-affect hypothesis*, which states that positive mood has a beneficial effect on performance (Olivers & Niewenhuis, 2006). Concurrent with this prediction is research on patients suffering from unilateral neglect. These patients showed improved visual attention following the induction of a positive mood through musical stimuli (Chen, Tsai, Huang & Lin, 2013).

Research by Ashby, Isen and Turken (1999) also found that inducing a positive mood in participants lead to improved performance on cognitive tasks such as creative problem solving, decision-making, risk-preference and long and short-term memory. They proposed the *dopaminergic theory of positive affect*, whereby evoking a positive mood in participants increases the release of dopamine. This neurotransmitter has been shown to influence certain areas of the brain such as the anterior cingulate, improving both mental flexibility and performance on a variety of cognitively demanding tasks (Ashby et al., 1999; Isen, 1999). More importantly, they generalized the positive effect of mood on performance to numerous other cognitive processes, including attention. Green, Sedikides, Saltzberg, Wood and Forzano (2003) also found that positive mood decreased self-focused attention. Green et al. (2003) defined self-focused attention as the direction of attentional resources to one's own thoughts and feelings rather than the external environment. Therefore, decreased focus on the self, and one's own cognitions, should increase attentiveness to the external environment, thus enhancing task-related performance.

While there has been significant research on the effects of positive mood on cognition, the same cannot be said for research on negative mood. The effects of negative mood are much more complex and difficult to predict than those of positive mood (Isen, 1987). Although there is conflicting literature on the matter, negative mood has been shown to have a detrimental influence on cognitive performance and learning (Kovacs & Beck, 1977; Olivers & Niewenhuis, 2006; Sedikides, 1992; Salovey, 1992). Kovacs and Beck (1977) set out to investigate whether children suffering from chronically negative mood states performed worse than their peers in the classroom on a variety of tasks. Indeed, children exhibiting depression performed significantly worse than their peers and showed an injurious effect of negative mood on learning (Kovacs & Beck, 1977). The effect of mood on attention remains a growing area of research in psychology.

Effects of Arousal on Attention

There is some conflict regarding the effects of arousal on attention. For example, in research on the *Mozart effect,* increased arousal enhanced performance on a spatial-reasoning task (Thompson et al., 2001). However, research by Smilek, Enns, Eastwood and Merickle, (2006) showed that low arousal strategies had a facilitative effect on attention, whereas high arousal strategies had a distracting effect on attention. Essentially, performance on a visual search task, consisting of finding an item amidst a varying array of distractors, was significantly enhanced when participants were told to employ passive, relaxation strategies. Visual search tasks are particularly important in attentional research where they are considered model tasks (Muller & Krummenacher 2006). Furthermore, Yerkes and Dodson (1908) proposed an inverted-U relationship between arousal and task-related performance. Basically, arousal that was either too high or too low in nature, proved detrimental to performance, while moderate arousal was optimal for performance. This is consistent with research by Berlyne (1967) who also emphasized that, up to a certain level, arousal had a facilitating effect, after which there was a sudden decline in performance. Arousal is associated with increased activity in the norepinephric and acetylcholine neurotransmitter systems, which at increased concentrations, diminish performance on slow, reasoning tasks as compared to rapid, instinctive ones (Ashby et al., 1999). Additionally, high levels of arousal have a negative influence on difficult tasks as compared to simple ones (O'Brien & Crandall, 2003). It is as of yet unclear what the exact effects of arousal (high or low) are on attention.

Effect of the Interaction of Mood and Arousal on Attention

Although there is a lot of research in the field on the separate effects of mood and arousal, there has been very little research on their interaction and their consequent effects on attention (Jefferies, Smilek, Eich & Enns, 2008). Due to the lack of research, we will begin by examining the effects of musical mood and musical arousal on other cognitive constructs such as memory, before investigating what is known about their influence on attention.

One study by Greene et al. (2010) looked at the effects of musical mood and musical arousal, in conjunction with one another, on recognition memory. Following a study phase where abstract shapes were shown, participants listened to music that varied on dimensions of both mood and arousal. These dimensions entailed the creation of four music conditions: high arousal-positive music, high arousal-negative music, low arousal-positive music and low arousal-negative music. Participants completed a rumination phase where their emotional states were altered to match one out of the four conditions. Next, they completed a memory recognition task where they were asked to recall as many shapes from the study phase as possible. Results indicated that memory was enhanced in the positive mood-high arousal and negative mood-low arousal conditions (Greene et al., 2010). The interaction between mood and arousal levels proved significant emphasizing the importance of their combined effects, compared to their separate effects, on the enhancement of memory. Furthermore, in a study by Jefferies et al. (2008), musical mood and musical arousal were combined for the first time to examine their interactive effects on attention. In their study, Jefferies et al. (2008) used music and rumination to induce short-term emotional states, spanning a range of emotions that combined mood and arousal. It is important to note, that unlike our study, researchers selected the music used in the study and had the participants listen to clips for ten minutes prior to beginning the experiment. During this period of cogitation, researchers periodically assessed participants on their self-reported measures of mood and arousal. Next, participants performed an attentional blink task, which focused on a participant's ability to identify letters and ignore digits. Attentional blink tasks function on the supposition that if two targets are separated from each other by less than 500 ms than participants are often unable to identify the second target (Shapiro, Arnell & Raymond, 1997). If however, the two perceptual stimuli are separated by intervals greater than 500 ms, or if they are instructed to ignore the first target in the sequence, than they no longer experience trouble in identifying the second target. Results of the attentional blink task indicate that the second target is susceptible to decay in conditions where the two targets are separated by intervals lesser than 500 ms (Shapiro et al., 1997).

Jefferies et al. (2008) separated their participants into four groups depending on the interaction between musical mood (positive or negative) and musical arousal (high or low): sad (low-arousal negative music), calm (low-arousal positive music), anxious (high-arousal negative music) and happy (high-arousal positive music). After assessing the results of the attentional blink task, they found that participants in the sad (low arousal-negative music) group had the highest levels of performance whereas participants in the anxious (high arousal-negative music) group had the lowest levels of performance on the task. Participants in calm (low arousal-positive music) and happy (high arousal-positive music) groups performed at intermediate levels. This study was consistent with the *mood-arousal hypothesis,* whereby music modulates a listener’s internal mood and arousal to influence performance. Participants who had an induced positive mood, regardless of arousal had intermediate levels of performance with no significant difference between conditions. However, arousal appeared to play an important role for negative mood where high arousal led to detrimental performance and low arousal led to optimal functioning. Therefore, when the interaction between the perceptual properties of mood and arousal was explored it appeared that arousal had a modulatory effect on negative mood but no significant effect on positive mood. Results indicate that specific combinations of the two dimensions best predict performance as compared to separate analyses. Although results in this study showed that sadness (low arousal-negative music) enhanced performance on the attentional blink task, research on chronically dysphoric students versus nondysphoric ones offers a conflicting alternative. Chronically dysphoric participants showed significantly worse performance on a similar attention task than nondysphoric participants (Rokke, Arnell, Koch & Andrews, 2002). This may indicate that the effects of short-term mood manipulation on attention do not generalize to chronic states.

The Current Study

The aim of the present study was to look at the effects of musical mood and musical arousal on visual attention. Previous literature has looked in depth at these two perceptual properties separately and has shown that they significantly influence attention. However, very little has been done in terms of looking at these variables as an interactive whole. Past literature has indicated that this interaction is essential and should be explored (Jefferies et al., 2008; Greene et al., 2010). To further research in this field, the present study investigated the interaction of musical mood and musical arousal to determine whether they have a combined effect on visual attention. This research was axed on the hypothesis that mood and arousal interact to significantly affect performance (Thompson et al., 2001).

Prior to assessing the effects of musical mood and musical arousal on attention, participants in this study rated the mood and arousal levels of an assortment of music clips. It is a widely recognized fact that music is a very subjective experience (Christenson & Peterson, 1988). Although different types of music may evoke similar reactions, each person perceives music differently, as based on their own aesthetic experience. Therefore, it was doubtful that perceptions of musical properties would be uniform between students. In order to account for the subjective nature of musical research, participants rated music on dimensions of mood and arousal independently so that they did not confound with one another. Next, the clips that each individual rated highest or lowest on the four dimensions of mood and arousal (high arousal positive mood (HAP), high arousal negative mood (HAN), low arousal positive mood (LAP), and low arousal negative mood (LAN)) were sorted to produce individualized stimuli sets. This ensured that each experimental condition was subject-specific and void of biases imposed by the experimenter. This step was of particular importance in differentiating this study from past research, where the experimenter predominantly chose the music for the study.

Following this step, participants were given a simple visual attention task, known as the Posner Cueing task. This task was comprised of a brief fixation stage where participants focused on two boxes, followed by a cueing stage where an arrow appeared in the center of the screen pointing either to the right or to the left. The cueing arrow was on the screen for variable durations of time to counteract potential expectancy effects. During the final target stage, the arrow disappeared and a target stimulus appeared in either one of the two boxes. If the target appeared in the box consistent with the direction of the cueing arrow, then the participant indicated a congruent trial ‘match’. If the opposite occurred then the participant indicated an incongruent trial ‘mismatch’. Viewing and active participation were done either in silence or while listening to the musical clips chosen by the participant in the rating step of the experiment. Volume was preset at a comfortable listening level. The Posner cueing paradigm engages other mechanisms, but for the simplicity of this research study, focus was made on the visual and attentional aspects of the task.

Based on previous literature, we hypothesized that musical mood and musical arousal would significantly affect performance on the Posner cueing paradigm. First, it was believed that musical mood would have a significant effect on performance. In particular, positive mood would enhance performance as compared to negative mood consistent with *positive-affect theory* (Olivers & Niewenhuis, 2006) and the *dopaminergic theory of positive affect* (Ashby et al., 1999). Next, it was hypothesized that musical arousal would have a significant effect on performance with the emphasis being placed on better performance under low intensity conditions as compared to high intensity conditions (Smilek et al., 2006). Combining these variables, performance on the Posner Cueing task was predicted to be highest when participants listened to high arousal-positive or low arousal-negative music and lowest when participants listened to high arousal-negative music condition with intermediate performance when participants listened to low arousal negative music (Greene et al., 2010; Jefferies et al., 2008). Our hypotheses were consistent with the belief that the interaction of these variables produces significantly different effects on visual attention than their separate main effects.

Method

Participants

A sample of 50 first year undergraduate students (34 females and 16 males, M_{age} = 19.16, *SD* = 2.53 years) from the University of Western Ontario, between the ages of 17 and 30 were selected to participate in this study. Three participants were excluded from the final analysis. Two female participants were removed due to program malfunctioning and one male participant was removed due to a low overall performance accuracy of less than 50% (below chance). The final sample consisted of 47 individuals (32 females and 15 males; M_{age} = 18.98, *SD* = 2.04 years) between the ages of 17 and 29. The participants for this study were collected from the Psychology Research Participation pool (recruited through the SONA system) through the use of a sign-up poster (see Appendix A). Prior to engaging in the study, written consent was obtained from each participant. All individuals that took part in this research study were compensated with one research credit, regardless of completion. Any participants excluded from the final data set were appropriately documented in subsequent statistical analysis. Participants must have had normal or corrected-to-normal vision and hearing and proficiency in English in order to participate. Each participant was tested individually and could not have had any previous experience with the study.

Materials

Musical Stimuli. A total of fifty musical excerpts were used in this study. Music was selected based on previous rating studies (Nguyen, 2013). These stimuli consisted of 90-second instrumental clips from a variety of musical genres, including but not limited to: rock, punk, alternative, jazz, classical, and etc. These musical stimuli were clipped so that only the first ten seconds of the excerpt was used in the experiment. The excerpts were also normalized to control for volume using the computer software: Audacity (http://audacity.sourceforge.net).

Visual Stimuli. Participants were presented with three visual stimuli: a fixation screen with a cross situated between two empty boxes, a cueing screen with a central arrow pointing either to the right or left box, and a target screen with a star in either the right or left box. The three screens were created for the purpose of this experiment (Appendix B). The images were in black set on a white, opaque background.

Procedure

Before beginning the experiment, participants were given brief verbal instructions on the task as well as an explanation of the perceptual properties of music, such as those that modulate mood and arousal (Appendix C). Following these instructions, participants were given a letter of information (Appendix D) and asked to provide informed, written consent (Appendix E). This study consisted of an experimental paradigm created with the computer software E-Prime (2.0) (Psychology Software Tools, 2002; Schneider, Eschman & Zuccolotto, 2002). All participant responses were recorded using a computer keypad. Volume was preset at a comfortable listening level and could be adjusted at the request of the participant.

Rating Task

The first portion of the experiment was comprised of a ‘rating task’. In this part of the study, participants were asked to rate the musical mood and musical arousal of 50 different musical clips, selected from the predetermined database. First, the participant was instructed to listen to the music clip, after which a scale appeared on the screen and participants were instructed to make their rating, selecting the appropriate response on the computer keypad. Each music excerpt was approximately ten seconds in length and participants listened to the same 50 clips while rating both musical mood and musical arousal. Asking the participants to rate all 50 excerpts on one dimension, followed by the other, prevented confounds between the two variables.

Music is a highly subjective experience; the rating task was therefore an essential step because the perceptual properties of music, such as those that moderate mood and arousal, are idiosyncratic measures. The clips rated highest or lowest on the four dimensions of mood and arousal (high arousal positive mood (*LAN*), high arousal negative mood (*HAN*), low arousal positive mood (*LAP*), and low arousal negative mood (*LAN*)) were assembled to create the stimuli for the second portion of the experiment: the basic visual attention task. Out of the 50 music excerpts, E-Prime 2.0 (Psychology Software Tools, 2002; Schneider et al., 2002) was programmed to select 12 for the visual attention task: three for each of the four music conditions (HAP, HAN, LAP and LAN). The order of these conditions was randomized. E-Prime 2.0 (Psychology Software Tools, 2002; Schneider et al., 2002) was programmed to sort the music clips, following the completion of the rating task, and was given the exclusionary criteria that if the music excerpt was used in one of the four quadrants it could not be used in another (i.e., if the clip was rated as being LAN, it could not also be used as a HAN condition).

Mood. Participants rated the mood of the 50 preselected music clips. Mood was rated on an anchored seven-point Likert scale where ratings could range from -3 (*extremely negative mood*), through 0 (*neutral*) to +3 (*extremely positive mood*) (Appendix F). Mood was placed on a scale from -3 to +3 because mood in this experiment could be either positive or negative. Participants were instructed to make use of the full scale when providing their responses.

Arousal. Similar to mood, participants also rated the musical arousal of the same 50 music clips used in the previous task. Again, responses were made using a seven-point Likert scale, this time ranging from +1 (*extremely low arousal*) through +4 (*neutral*) to +7 (*extremely high arousal*) (Appendix G). Unlike mood, the arousal scale did not have a negative range because an individual cannot have negative arousal (unless they are dead, I suppose…). Therefore, the scale started at +1 (*extremely low arousal*) and went to +7 (*extremely high arousal*). Once again, participants were instructed to make use of the entire scale when deciding on their response.

Posner Cueing Paradigm Task

Following the rating task, participants performed a simple visual attention task, known as the Posner cuing paradigm. No one has systematically investigated how musical mood and musical arousal may interact using this particular paradigm. This task was comprised of three stages per trial. In each trial, first, a brief fixation stage occurred where participants were asked to focus on a cross, in the middle of the screen, situated between two empty boxes. The fixation stage was followed by the cue stage, which involved the appearance of an arrow, in the center of the screen, pointing either to the right or to the left box. The arrow from the cue stage then disappeared and a target stimulus appeared in either one of the two boxes. If the target appeared in the box matching the direction of the cueing arrow, then the participant was asked to indicate a congruent trial ‘match’. If the opposite occurred then the participant was asked to designate an incongruent trial or ‘mismatch’. Participants were asked to respond as quickly as possible by pressing the designated key on the computer keypad.

The length of the intermediate cueing stage (i.e., the duration of the arrow on the screen) varied from 1000 to 4000 milliseconds between trials in order to reduce expectancy effects. The fixation screens, as well as the ensuing target screens, were set to appear at fixed times of 1500 milliseconds. Music or silence was played in the background while the participant performed each individual trial.

The individual conditions were comprised of the 12 music clips chosen from the rating task (three of each condition: LAP, LAN, HAP and HAN) as well as three silence control conditions. Each condition consisted of 20 decision trials (fixation + cue + target + response) of which ten trials were congruent (five ‘left’ cue arrows, five ‘right’ cue arrows) and ten trials were incongruent (five ‘left’ cue arrows, five ‘right’ cue arrows). The order of these decision trials was randomized. Each condition was approximately two minutes in length resulting in 15 two-minute conditions of 30 minutes in length. All five conditions were repeated three times and averaged across the three blocks. Reaction times and accuracy of response were recorded.

The experiment in its entirety took approximately one hour to complete and required only one session. Finally, having completed the session, the participating undergraduate students were given a debriefing form (Appendix H).

Results

Design

Two dependent variables were measured during each participant's performance on the Posner Cueing task: reaction time and accuracy of response. Reaction time was defined as the length of time that it took for each participant to make a response after the target's appearance on the screen. Accuracy of response was simply related to whether they were correct in their assessment of whether the trial was congruent or incongruent ('match' or 'mismatch' response). Any response under 100 milliseconds or over 1000 milliseconds was excluded from the final analysis. Trials with reaction times over 1000 milliseconds, or timed-out responses, were eliminated in order to retain the validity of this experiment as a 'reaction time task'. Presumably, reaction times over 1000 milliseconds allowed the participant to actively think about the task, thus eliminating spontaneous response (Hayward & Ristic, 2013). Reaction times less than 100 milliseconds, or anticipatory responses, were likewise removed seeing as the average human reaction rate for complex visual processing is approximately 150 milliseconds (Thorpe, Fize & Marlot, 1996). Therefore, trials under 100 milliseconds were assumed to be the result of expectancy effects as opposed to actual response (Hayward & Ristic, 2013). Accuracy was used to omit any participants from the final analysis if their overall response accuracy across all trials was under 50 percent, or less than chance.

Ten conditions were assessed: high arousal-positive mood-congruent response (*HAPC*), high arousal-negative mood-incongruent response (*HAPI*), high arousal-negative mood-congruent response (*HANC*), high arousal-negative mood-incongruent response (*HANI*), low arousal-positive mood-congruent response (*LAPC*), low arousal-positive mood-incongruent response (*LAPI*), low arousal-negative mood-congruent response (*LANC*), low arousal-negative mood-incongruent response (*LANI*), silent-congruent response (*SC*) and silent-incongruent response (*SI*). The reaction times for each condition were averaged across all three trials (i.e.: 20 scores in all three HAPC trials were averaged to yield one score).

Performance on the visual attention task was analyzed in SPSS (18.0) using a 2 (mood) x 2 (arousal) x 2 (congruency) repeated measures analysis of variance (ANOVA), where mood, arousal and congruency were within subjects factors. The repeated measures analysis of variance design was used to assess whether the influence of the perceptual properties of musical mood and musical arousal would significantly affect the mean reaction times on the Posner Cueing task. It is important to note that in all cases, a lower score was indicative of a better performance.

Main Effects and Interactions

In general, the results indicated that music, regardless of condition, (M = 575.367, SE = 4.594) compared to silence (M = 584.075, SE = 13.970) yielded no significant difference in performance on the Posner cueing paradigm, $t(46) = 1.660$, $p = 0.104$. This indicated that regardless of whether or not participants were listening to music or silence their mean reaction time, and by extension their performance on the Posner cueing task, did not significantly differ.

Results indicated that there was no main effect of mood, $F(1, 46) = 1.409$, $p = 0.241$, for positive mood (M = 572.214, SE = 13.094) as compared to negative mood (M = 578.519, SE = 13.429), as seen in Figure 1. In other words, there was no significant difference in mean reaction time and performance on the attention task in conditions where participants listened to either positive or negative mood music. Paired *t*-tests were used to assess whether there was a significant difference between a specific condition and the silent control conditions. When positive mood was compared to silence, participants showed no significant difference in performance, $t(46) = 1.999$, $p = 0.052$, although it was interesting to note that this value was

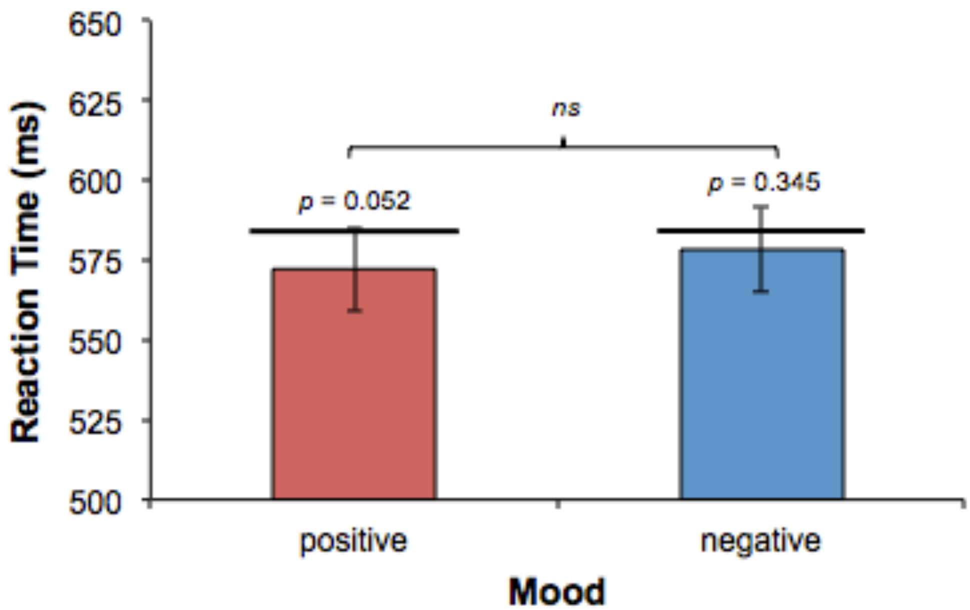

Figure 1. Main Effect of Mood on Visual Attention.
There was no significant difference between positive mood and negative mood on mean reaction time. Although the difference in performance between positive mood and the silent control condition is not statistically significant, it is almost at the threshold of significance, whereby positive mood would have an enhancing effect on mean reaction time as compared to silence. There is no significant difference in mean reaction times during negative mood trials and the silent control condition.

Notes: The solid horizontal lines represent performance with no music.
Lower scores represent better performance.
Bar colors are illustrative of the type of mood experienced by the participant, whereby red is indicative of positive mood and blue is representative of negative mood.

approaching significance. Furthermore, when negative mood was associated with silence there was also no significant difference between the mean reaction times, $t(46) = 0.953$, $p = 0.345$. In summary, participants reacted faster to target onset when listening to positive music than silence but showed no significant difference in performance when listening to negative music as compared to the silent control condition.

Likewise, there was no main effect of arousal, $F(1, 46) = 0.107$, $p = 0.746$ between high arousal ($M = 574.494$, $SE = 93.811$) and low arousal conditions ($M = 576.239$, $SE = 12.835$), refer to Figure 2. Participants did not show a significant difference in performance (mean reaction times) on the Posner Cueing task between high arousal or low arousal conditions. There was no significant difference between high arousal and silence conditions, $t(46) = 1.636$, $p = 0.109$ and low arousal and silence conditions, $t(46) = 1.324$, $p = 0.192$. Therefore, participants did not react significantly faster or slower when listening to high arousal or low arousal music as compared to silence. Arousal did not appear to have a significant effect on visual attention.

Finally, there was a very significant main effect of congruency, $F(1, 46) = 86.032$, $p < 0.001$ between congruent ($M = 549.534$, $SE = 13.318$) and incongruent ($M = 601.199$, $SE = 13.259$) conditions, see Figure 3. In general, participants displayed significantly quicker reaction times and enhanced visual attention on congruent trials as compared to incongruent ones. When congruency was compared to silence, there was a significant difference between congruent trials and silence, $t(46) = 2.062$, $p < 0.05$ but no significant difference between incongruent conditions and silence, $t(46) = 0.979$, $p = 0.333$. Participants reacted faster and performed significantly better during congruent conditions than silent ones but showed no significant difference in mean reaction time on incongruent trials as compared to silence. Congruent conditions therefore have an enhancing effect on visual attention. The lack of significant main effects for both mood and

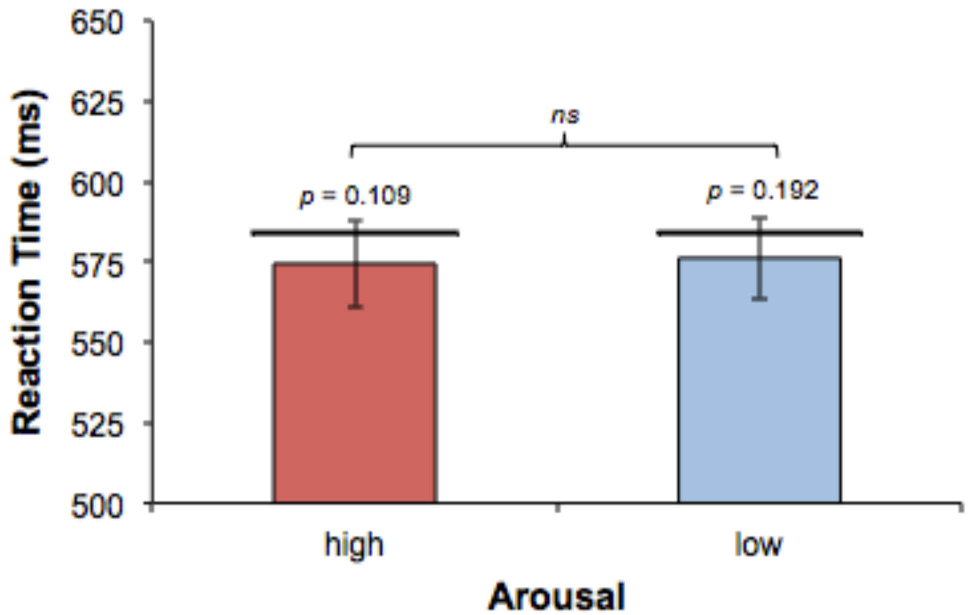

Figure 2. Main Effect of Arousal on Visual Attention.
There was no significant difference between low arousal and high arousal conditions on mean reaction time/performance. Furthermore, there were no significant differences between mean reaction times of high arousal conditions as compared to silence as well as between low arousal conditions and silence.

Notes: The solid horizontal lines represent performance with no music.
Lower scores represent better performance.
Bar colors are illustrative of the type of arousal experienced by the participant, whereby darker color is indicative of high arousal and lighter color is representative of low arousal.

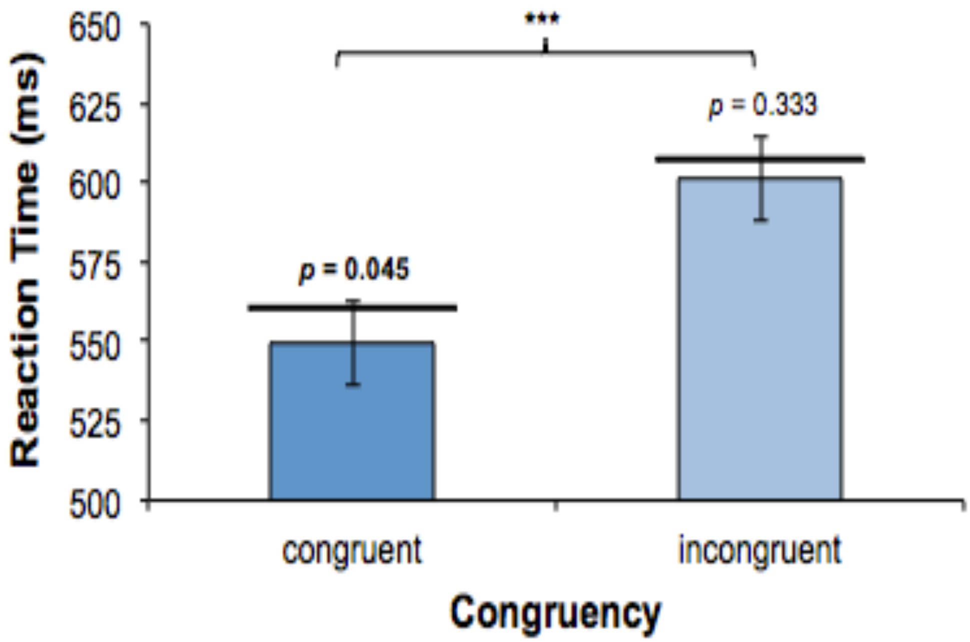

Figure 3. Main Effect of Congruency on Visual Attention.
There was a significant main effect of congruency on visual attention. Participants tended to react significantly quicker under congruent conditions as compared to incongruent ones. Also, there was a significant difference between mean reaction time during congruent trials as compared to silence, meaning that participants reacted significantly quicker under congruent conditions than silent control ones. There was no significant difference between incongruent trials and silence.

Notes: The solid horizontal lines represent performance with no music.
Lower scores represent better performance.
Bar colors are illustrative of the type of congruency experienced by the participant, whereby dark blue is indicative of congruent trials and light blue is representative of incongruent trials.
*$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.*

arousal should be interpreted in light of a significant interaction.

There was no significant two-way interaction between arousal and congruency on mean reaction time of the Posner Cueing paradigm, $F(1, 46) = 3.078$, $p = 0.086$. The effect of arousal on performance does not depend on congruency. Similarly, there was no significant two-way interaction between mood and congruency on performance, $F(1, 46) = 0.366$, $p = 0.548$ meaning that the influence of mood on mean reaction time is independent of congruency.

Finally, and most importantly, the results showed that there was a significant two-way interaction between arousal and mood on mean reaction time, $F(1, 46) = 4.207$, $p < 0.05$, see Figure 4. In general performance was better for high arousal compared to low arousal when participants were exposed to positive mood conditions. However, the effect was reversed when the conditions consisted of negative mood trials.

Due to this significant two-way interaction, post-hoc *t*-tests were conducted on all six possible combinations to determine which groups differed significantly from one another, refer to Table 1. As indicated in Table 1, although the difference between HAP and HAN was not significant according to statistical values of $p = 0.05$, it was close enough to be taken into consideration. Participants reacted significantly quicker when exposed to HAP conditions than HAN conditions. It is important to note however, that HAN trials were not detrimental to performance; they were simply no better than silent control conditions (no significant difference).

When each condition was compared to the silent control condition the following results were found. HAP ($M = 565.839$, $SE = 14.411$) and silence differed significantly from one another, $t(46) = 2.457$, $p < 0.05$, whereas HAN ($M = 583.149$, $SE = 14.336$) and silence, $t(46) = 0.128$, $p = 0.899$, LAP ($M = 573.890$, $SE = 13.553$) and silence, $t(46) = 0.825$, $p = 0.414$, and

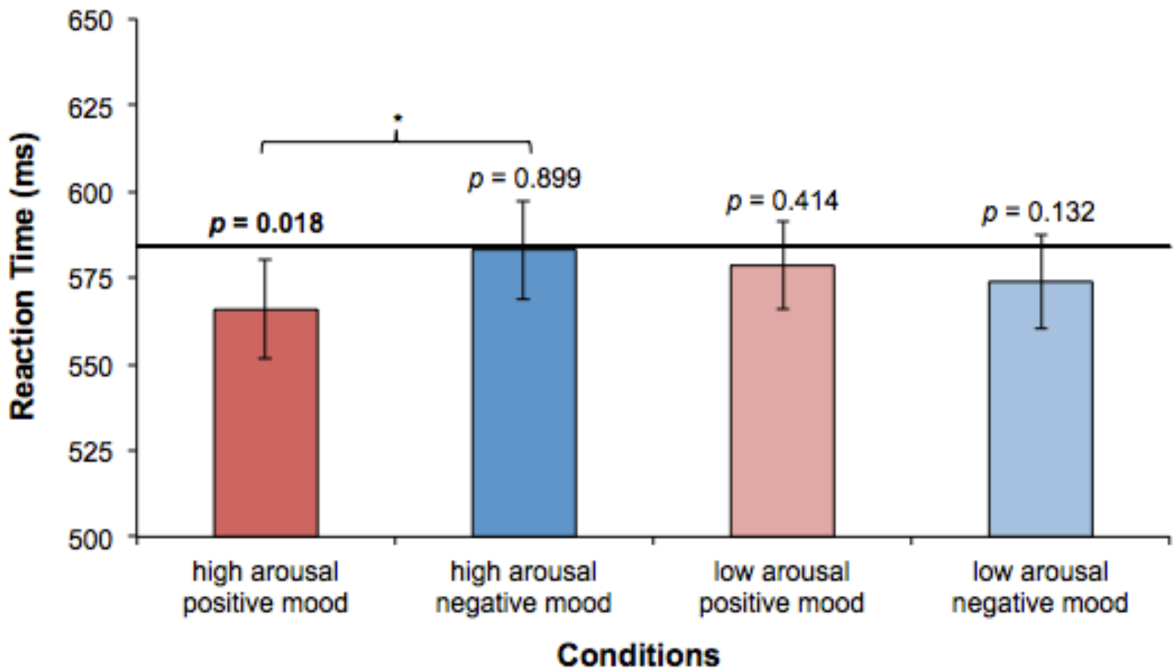

Figure 4. Interaction of Mood and Arousal on Visual Attention.
There was a significant interaction between musical mood and musical arousal on visual attention. Participants performed significantly faster on HAP conditions than on other conditions. In particular, participants showed significant differences in mean reaction times when listening to HAP music as compared to HAN music. Participants performed better than silence on HAP conditions, but showed no significant difference between music condition and silence for HAN, LAP and LAN conditions.

Notes: The solid horizontal lines represent performance with no music.
Lower scores represent better performance.
Bar colors are illustrative of the type of condition experienced by the participant: red (positive mood), blue (negative mood), darker colors (high arousal) and lighter colors (low arousal).
*$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.*

Table 1

Post-hoc t-tests Conducted on Every Possible Combination of the Experimental Conditions.

Condition Combination	*t* value	df	Sig. (2-tailed)
HAP-HAN	-1.968	46	0.055*
HAP-LAP	-1.678	46	0.100
HAP-LAN	-0.989	46	0.328
HAN-LAP	0.663	46	0.511
HAN-LAN	1.226	46	0.226
LAP-LAN	0.777	46	0.441

Note: The difference in mean reaction time of HAP and HAN conditions was approaching significance. No significant difference between mean reaction times/performance was found between any other group combinations.
$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

LAN (M = 578.589, SE = 12.809) and silence, $t(46) = 1.533$, $p = 0.132$, showed no significant difference in mean reaction times and by extension performance on the Posner Cueing task. Therefore, visual attention was enhanced during HAP conditions as compared to silence but showed no significant difference between silence and HAN, LAP and LAN trials. Overall, the trend showcased that participants performed better on HAP and LAN conditions than HAN and LAP conditions. Finally, the three-way interaction between mood, arousal and congruency, $F(1, 46) = 0.022$, $p = 0.884$, was not significant. In other words, there was no two-way interaction that varied across the levels of a third variable.

Discussion

The purpose of the present study was to examine how music affects visual attention. In particular, perceptual properties of music, such as those that modulate mood and arousal, were assessed in regards to their effects on the Posner Cueing task. In general, results showed that mean reaction times between the music conditions and silent conditions did not differ significantly. Past literature has offered conflicting results in regards to the effects of music on attention. Certain studies have proposed that music impairs attention performance (Anderson & Fuller, 2010) whereas others have shown that music enhances performance (Morton et al., 1990). The results of our study did not fall under either of these categories, but rather stipulated that music did not significantly affect attentional processes when compared to silence.

Based on previous literature, we predicted a significant main effect of mood on visual attention. In particular, we predicted that performance would be better when participants listened to positive music compared to negative music. This prediction is based on the *positive-affect hypothesis*, which states that positive mood has a favorable effect on performance (Olivers & Niewenhuis, 2006). However, contrary to the *positive-affect hypothesis*, our results did not yield a significant main effect of mood. Participants did not perform significantly different when listening to positive music as compared to negative music.

According to the *dopaminergic theory of positive affect*, proposed by Ashby et al. (1999), positive affect is correlated with an increased release of dopamine into the frontal cortical and anterior cingulate areas of the brain. Furthermore, heightened dopamine levels are associated with increased cognitive flexibility and enhanced performance on a variety of tasks including problem solving and decision-making. When examining the nature of different tasks, Ashby & Gott (1998) determined that there was a difference in the neural mechanisms implicated in explicit (i.e., requiring the application of verbal rules and active cognitive processes such as rule selection) and implicit (i.e., relative to non-rule based tasks where intuition and reactions are of importance) tasks. In particular, the researchers found that explicit tasks activated the prefrontal cortex and anterior cingulate and were mediated by increases in cognitive flexibility, whereas implicit tasks activated the basal ganglia and visual cortical areas and were independent of cognitive flexibility. In response to these research findings, Nadler, Rabi and Minda (2010) hypothesized that tasks that heavily rely on rule-based applications, will significantly benefit from positive mood inductions whereas those that are contingent on 'gut' responses will remain unaffected. In support of their speculations, results indicated that positive mood inductions, from music and videos, significantly enhanced performance of explicit tasks (Nadler et al., 2010). Consistent with the *dopaminergic theory of positive affect*, positive mood increased dopamine production in the anterior cingulate and the prefrontal cortex. This influx of dopamine, in turn, promoted cognitive flexibility and affected performance on these explicit tasks, necessitating activation of these brain regions. However, these results did not extend to the implicit tasks, which relied on different brain regions and applied neural mechanisms that were modulated by different neurotransmitters (Nadler et al., 2010). The researchers generalized that tasks requiring rapid, intuitive responses should be independent of the effects of mood and, in particular, positive mood. Since the Posner Cueing paradigm relies on the notion of 'gut' responses (i.e., reactions), similarly to implicit tasks, the absence of a significant main effect of mood was consistent with the literature. Additionally, research by Posner and Petersen (1990) found that there are a number of interacting systems within our brain, such as the posterior system, which mediates perceptual attention and the anterior system, which modulates executive attention. During tasks requiring the use of conscious attentional processing, requiring executive function, the anterior cingulate is activated (Posner & Petersen, 1990). Both visual and auditory perception tasks (such as the Posner Cueing task) do not activate these brain regions. Therefore, there is additional for our results, seeing as dopamine released during positive mood inductions affects both the prefrontal cortex and the anterior cingulate (Ashby et al., 1999).

Although the *positive-affect hypothesis* was derived from an attentional blink (implicit) task, participants were shown pictorial stimuli to induce mood (Olivers & Niewenhuis, 2006) rather than music as was used in our study. It is difficult to ascertain whether visual and auditory stimuli produce significantly different effects and/or activate different cortical regions. In other words, although positive affect was found to benefit performance on the attentional blink task used in the Olivers and Niewenhuis (2006) study, it is unclear whether these results were related to the method of induction (visual vs. auditory).

Research on the effects of negative mood on cognitive processes has been largely inconclusive. In one study by Isen, Daubman and Nowicki (1987) the effects of mood induction and exercise on creative problem solving were studied. Participants were divided into four groups: neutral affect, positive affect, negative affect, and exercise. Results indicated that negative affect (as well as exercise) had no significant effect on performance when compared to the control condition. In general, the effects of negative mood on performance appear to be much more complex and difficult to predict (Isen, 1990). The neural mechanisms underlying negative mood are different from those related to positive mood and may even be localized in different cerebral hemisphere (Davidson, 1992). In cases where negative mood was shown to produce detrimental effects on performance, it was as a result of chronic states, such as depression (Kovacs & Beck, 1977) and not temporarily induced states, such as the states induced during this experiment. Therefore, finding no significant difference between performance during negative music and silence was consistent with past literature.

Similar to mood, we also predicted a significant main effect of arousal. However, this prediction was not supported by our findings. Research into other domains such as problem solving and memory lend support to the absence of a main effect of arousal. In a study looking at arousal and problem solving by Isen et al. (1987) heightened arousal did not appear to significantly affect performance. Likewise, the effect of arousal was not significant on recognition memory (Greene et al., 2010; Nguyen, 2013). According to the Yerkes-Dodson law, the relationship between arousal and task performance can be defined as an inverted-U relationship (Yerkes & Dodson, 1908). Specifically, levels of arousal that are either too high or too low can have detrimental effects on performance, with moderate arousal providing optimal performance. Neither high nor low levels of arousal, as rated by the participants in the study, resulted in significant differences on the Posner Cueing task relative to the silence control condition. Therefore, it is possible that the music used in this study did not affect participants to the point that they significantly departed from the inverted-U relationship; so major detriments were not seen in their performance.

Although the main effects of mood and arousal were not significant, the main effect of congruency on attention was found to be very significant. Participant's mean reaction times were faster on the congruent trials compared to the incongruent trials. This particular finding was consistent with past literature on the Posner Cueing paradigm. The Posner Cueing task is comprised of three stages: a fixation stage, a cueing stage, and a target stage (Posner, 1980). During the cueing stage, appearances of cueing arrows serve to orient the individual's attentional resources to a desired location. This attentional shift is thought to incur enhanced processing at that particular location. Typically, participants are quicker at detecting targets at congruent locations (direction of the cue arrow matches the location of the target) than incongruent ones (the cue arrow does not successfully indicate the location of the target) (Eckstein, Shimozaki & Abbey, 2002). The *limited capacity attentional model*, or *filter theory* (Broadbent, 1958) postulates that humans possess a restricted amount of attentional resources, which they can devote to any given task at any one time. Therefore, when these resources are allocated to the cued location, individuals experience a performance benefit (Eckstein et al., 2002). However, this is not the case for incongruent trials where participants are forced to make an attentional shift, which requires a certain level of conscious processing (i.e., control and inhibition of response). The re-direction of valuable attentional resources results in decreased performance on the task. In our study, participants were found to perform significantly better on congruent conditions when listening to music compared to silence. This is consistent with past literature indicating that music can increase performance of cognitively simple and repetitive tasks (Fox & Embrey, 1972). Seeing as congruent trials were advantaged over incongruent trials, according to *filter theory* (Broadbent, 1958), they were both simple and repetitive in nature and did not require large amounts of cognitive processing. Thus, the main effect of congruency is consistent with past literature. However the main effects of mood, arousal and congruency need to be interpreted in light of a significant interaction between mood and arousal.

Based on past empirical findings, we predicted that mood and arousal would interact to affect visual attention. There have been numerous studies on the interaction of musical mood and musical arousal on a variety of cognitive processes such as memory (Greene et al., 2010; Nguyen, 2013) and spatial reasoning (Thompson et al., 2001). All of these studies have shown that the separate effects of mood and arousal are insignificant compared to their combined effects. Therefore, perceptual properties of music, such as those that modulate mood and arousal, are only as strong as they are united. The trend seen in our experiment indicated that mean reaction times on the Posner Cueing task were quickest in response to HAP and LAN music and slowest during LAP and HAN music. More specifically, HAP and HAN music differed significantly from one another. Upon closer examination, we found that our results closely mirrored the findings of Greene et al. (2010). Participants in their study were also exposed to four music conditions: high arousal-positive music, high arousal-negative music, low arousal-positive music and low arousal-negative music, to induce the same four desired emotional states. The researchers found that memory was enhanced when participants listened to high arousal-positive and low arousal-negative music. Greene et al. (2010) concluded that the interaction between musical mood and musical arousal was responsible for memory enhancement. Therefore, the interaction between mood and arousal levels emphasized the importance of studying them together rather than separately related to memory-based tasks.

To date, only one study has examined the effects of musical mood and musical arousal on visual attention (Jefferies et al., 2008). However, in their study, Jefferies et al. (2008) used an attentional blink task as opposed to the Posner Cueing task, in order to measure visual attention.

The researchers found that participants performed best with low arousal-negative music (sadness) and experienced the largest detriments in performance when listening to high arousal-negative music (anxious). Intermediate performance was observed when participants listened to high arousal-positive music (happy) and low arousal-positive music (calm). These results were very similar to our study with one important difference. Jefferies et al. (2008) found that the influence of arousal (high and low) on negative mood appeared to most significantly impact participants' performance of the attentional blink task. In contrast, in our study, mood played an important role for high arousal music. When high arousal was paired with negative mood, this led to detrimental performance, but when high arousal was paired with positive mood, this led to enhanced performance. One major difference between our study and Jefferies et al.'s (2008) study was that they did not use subject-specific ratings of mood and arousal for their music but instead opted to select the music used in the experiment. This could have introduced experimenter bias into the study and skewed the results.

Why did we see an enhancement in performance when high arousal was paired with positive mood? As was previously mentioned, positive mood can have an enhancing effect on performance as supported by the *positive-affect hypothesis* (Olivers & Niewenhuis, 2006). Although the effects of positive mood are well documented, performance with low arousal-positive music did not appear to exhibit the beneficial effects of positive mood. Therefore, it would appear that positive mood must be paired with high arousal. In one study by Keitz, Martin-Soelch and Leenders (2003) on the neural mechanisms underlying reward behaviour, they found that positive mood was associated with triggered dopamine release through a connection with increased motor activity (i.e., arousal). In other words, the effects of cognitive flexibility on performance are modulated through two separate, but interconnected mechanisms underlying mood and arousal. Therefore, when both positive mood and heightened arousal (associated with increased motor activity) occur at the same time, the release of dopamine into the prefrontal cortex and anterior cingulate occurs, thus enhancing performance. Furthermore, according to the Yerkes-Dodson law, there is an inverted U-relationship between incremental arousal and task performance (Yerkes & Dodson, 1908). More specifically, the initial upward slope of the curve is associated with energizing effects of arousal on performance. Therefore, as arousal increases so should performance on any given task, but only up to a certain point. Thus, heightened arousal has been shown to increase attention (Eysenck, 1976), thereby explaining why when participants were listening to HAP music their performance on the Posner Cueing task was better than the other three music conditions (HAN, LAP and LAN). Therefore, it is the interplay of mood and arousal, which appears to be the most significant predictor of their performance and not their effects alone, seeing as HAN music did not appear to display the enhancing effects of high arousal on performance. Thus, the effects of heightened arousal must be modulated by mood.

If the effects of arousal are indeed modulated by mood to enhance performance, why don't we see an enhancement of performance when high arousal is paired with negative mood? HAN conditions can also be referred to as 'anxious' conditions (Eysenck, Santos, Derakshan & Calvo, 2007; Jefferies et al., 2008). Eysenck et al., (2007) studied the effects of anxiety on short-lasting cognitive tasks. Anxiety was shown to have a negative impact on performance on tasks imposing significant demands on cognition where there is limited room for additional processing. According to *attentional control theory*, anxiety reduces the attentional focus dedicated to task performance (Eysenck et al., 2007). In particular, there is heightened allocation of attentional resources to stimuli-driven processes (i.e., response to music) as opposed to goaldriven processes (i.e., performance on the task) (Corbetta & Schulman, 2002). This is the case even when there are no threat-related, task-irrelevant stimuli present in the immediate environment (Eysenck et al., 2007). Furthermore, inhibition function, as seen in the Posner Cueing task is relevant to *attentional control theory*, as it requires attentional control to be used in a restraining manner to avoid allocating attentional resources to task-irrelevant stimuli and responses (Friedman & Miyake, 2004; Eysenck et al., 2007). Anxiety reduces attentional control therefore it should be detrimental to performance on a task such as the Posner Cueing paradigm. Research has demonstrably indicated that anxiety has a detrimental effect on tasks requiring both inhibition and shifting responses (Eysenck et al., 2007). In support of this research, performance on the Posner Cueing task as a result of 'anxious' conditions was significantly worse than performance on other conditions. In fact, high anxiety as compared to low anxiety resulted in similar accuracy on a variety of tasks but lengthened response time (Eysenck et al., 2007). This would explain why participants in our study performing with HAN music were the slowest to respond without significant detriments in accuracy. Although listening to high arousal-negative music caused participants to react slower, they did not perform significantly different from the silent control condition. As summarized by Eysenck et al. (2007) anxiety impairs efficiency (i.e., timeliness of response) not effectiveness, thereby supporting the results of our study.

Finally, it was interesting to note that, trend-wise, when participants listened to LAN music they performed slightly better than when they listened to LAP and HAN music. With LAN music (or sad music), research has shown that individuals under this emotional state have a tendency to focus more on local rather than global details of a scene (Gasper & Clore, 2002). In other words, attention to detail over gist is found in individuals experiencing negative affect relative to positive affect. Furthermore, low arousal-negative mood has been associated with decreased false positive recognition (Bless et al., 1996) and resistance to heuristic error (Gasper, 1999). Therefore, heightened attention to detail was found to be advantageous to tasks requiring rapid temporal processing.

In conclusion, when the interaction between the perceptual properties of mood and arousal on visual attention was explored it appeared that mood had an especially modulatory effect on high arousal with HAP music being most conducive to heightened visual attention compared to HAN music.

Limitations and Future Directions

It is important to keep in mind the effects of prior experience, relative to music, on performance. Certain people listen to music while performing everyday tasks whereas others prefer to perform them in silence. For example, people who study to music perform better when listening to music whereas those that do not study to music reliably perform better under silent conditions (Nantais & Schellenberg, 1999). This is consistent with research on context-dependent memory and contextual cues, which stipulates that if the learning and test environment are similar than performance on the task is enhanced (Baddeley, Eysenck & Anderson, 2009). In particular, state-dependent learning posits that physiological state at the time of learning can serve as a contextual cue (Eich, 1980). Music has been shown to reliably induce both emotional and physiological states (Jefferies et al., 2008). Therefore, listening to music when learning or performing tasks may generalize to the performance of other cognitive processes, with music serving as a contextual cue. Future research should record whether participants had prior experience in listening to music while performing attentionally demanding tasks such as driving and whether these individual differences contributed to significantly different performance of laboratory-based visual attention tasks.

Furthermore, the majority of this research was conducted on first-year undergraduate students at the University of Western Ontario. Most of the sample used for final analysis consisted of female participants as compared to male participants. It is, as of yet, unclear whether or not there are significant gender differences on the effects of musical mood and musical arousal on visual attention. Therefore, in order to better generalize these results it would be interesting to expand this study to include more male participants and explore whether there are significant gender differences both for preferred music condition and general performance. For example, research on gender differences has reliably indicated that males and females prefer significantly different music genres (Christenson & Peterson, 1988). In addition, males tend to use music for central and personal reasons whereas females tend to use it for social and instrumental means (i.e., what music can do for them). Both genders have a tendency to map music differently both in terms of genres, styles and appeal. All of these results appear to indicate the importance of studying gender differences in music research and in particular the use of music as an instrumental mean for females, may indicate that music plays a more significant role in increasing performance on a variety of tasks for females than it does for their male counterparts.

Another limitation seen in our study was the lack of attention to the confounding effects of volume on performance. Although, volume was preset at a comfortable listening level, preferences in terms of loud or soft background music may not have been taken into account as important factors for performance. Therefore, the volume used in this experiment may have been too loud or too quiet for certain participants and thus the effects of musical mood and musical arousal on attention may have been blanketed by individual volume preferences. For example, loud music has been shown to be detrimental to performance on reading comprehension tasks

(Thompson, Schellenberg & Letnic, 2012). Furthermore loud and harsh music has been shown to severely affect learning, concentration and task performance according to research by Crncec, Prior and Wilson (2006). In the future, it may be useful to examine volume (quiet, moderate or loud) as a third modulatory variable affecting visual attention. Volume, similarly to mood and arousal, should be rated independently by each participant and utilized accordingly.

Finally, all of the mood inductions in this experiment relied on short-term inductions and their effects on performance. However, as was seen in research on depressed and non-depressed children (Kovacs & Beck, 1977), the effects of musical mood and musical arousal may not generalize to chronic states. Future studies should examine the difference between short-term and long-term inductions of mood to determine whether there are significant effects on performance of visual attention tasks.

The practical implications of our findings suggest that listening to HAP music is beneficial to visual attention. Future studies should investigate whether the results observed in this study generalize to other attentional paradigms beyond the Posner Cueing task. Through continuing research into the domain of music and its wide-reaching effects on cognitive functioning, we hope to one day generalize our results to everyday tasks, such as driving. Music is a powerful tool, but in order for it to be utilized we must first embark on the quest to better understand its effects on the human mind, and in particular on cognitive processes such as visual attention.

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Appendix A

Sign Up Poster
The Effects of Musical Mood and Musical Arousal on Visual Attention

You are being invited to participate in this research study investigating the influence of music on attention conducted by Angela Marti Marca, Tram Nguyen, and Dr. Jessica Grahn. As a participant in this study, you will rate different music clips on their levels of mood and arousal. In addition, you will complete a simple visual attention task adapted from the Posner Cueing paradigm. For this task, you will fixate on a screen with two empty boxes. An arrow pointing either to the right or left box will appear on the screen for a brief second. A target stimulus will appear in either one of the two boxes and you must identify whether the trial is congruent or incongruent with the cued arrow. Viewing and active participating will be done either in silence or while listening to music. All responses will be made using a computer keypad. This study will take less than one hour to complete. For your time, you will be compensated one research credit.

Appendix B

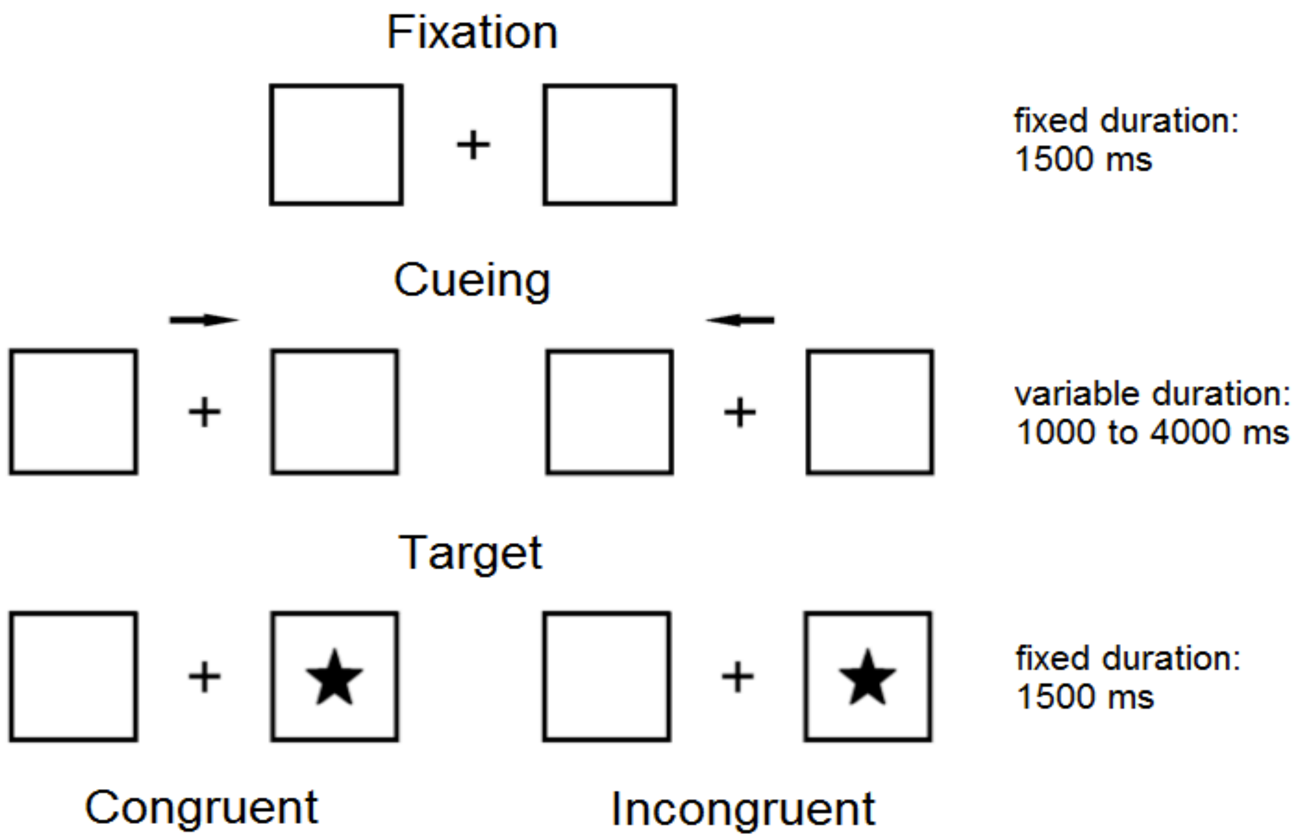

Figure 5. The Posner Cueing paradigm comprised of one fixation stage (top row), two cue stages with arrows pointing either to the right or to the left (middle row) and two target stages with a target either in the right or left box (bottom row).

Appendix C

Verbatim

Good (morning, afternoon, evening), my name is __________.

I would like to thank you for agreeing to participate in this study. Please remember that this is a voluntary study and you are free to leave at any time without repercussion. I would like to remind you that all of your responses will be kept anonymous and confidential and will be disposed of in the appropriate manner.

This experiment will deal with the perceptual properties of music, such as those that moderate mood and arousal.

What is mood? Musical mood can better be described as the affective state induced by music. For example, listening to a certain song can make you feel happy, whereas listening to another may make you feel sad.
What is arousal? Musical arousal is most aptly described as the degree of physiological activation in response to music. In other words, does listening to this particular song make you want to get up and dance? Or would your rather just go back to sleep?

The experiment is composed of two parts: a rating task and a basic attention task. It will take you approximately one hour to complete the entire experiment. You are allowed to take breaks in between (just wait until there is the possibility to do so without compromising the experiment) so if you feel like your concentration is beginning to lapse please let me know and we can take a brief pause.

In the rating task, you will be asked to listen to fifty music clips of different genres of music. Each clip will be approximately ten seconds in length. You will begin by rating the mood induced by each clip (i.e., does it make you feel happy or sad for example) on a scale from -3 (extremely negative) to +3 (extremely positive), where 0 is assigned a neutral value.
When making the rating we ask that you use the scale in its entirety.
After having completed this portion of the experiment, you will be asked to do the exact same thing for the same fifty music clips but this time for arousal (i.e., does it make you want to get up and dance or sleep for example). You will rate the arousal of each clip on a scale from 1 (extremely low arousal) to 7 (extremely high arousal), where 4 has been assigned a neutral value.
Once again we ask that you use the scale in its entirety.

Show participant the keys on the keyboard (marked accordingly) on which they will be making their ratings.

I would like to ask you to begin the study by filling out the consent form and reading the letter of information.

In the meantime, I recommend setting up the experiment.

Are you ready?

Allow participant to read the instructions.
Stay with the participant through the practice trial to make sure that they understand the task.

Please let me know if you feel like you need a break. Do you have any further questions?

Observe the participant through the practice trial of the arousal rating stage—ask them to tell you once they have reached this part of the experiment- to ensure that everything is understood.

We will now move on to the second part of the experiment.

In the second part of the experiment, you will be asked to perform a simple attention task. This task is composed of three steps: a fixation, a cue and a target. You will first be asked to fixate on the cross in the middle of the screen between the two boxes. After which, a cue arrow will appear pointing either to the right or to the left of the screen. Following the cue, a target will appear either in the right or the left box on the screen.
IF the target and the cue arrow match (i.e., the arrow points to the right and the target appears in the right box OR the arrow points to the left and the target appears in the left box) then we have a congruent trial and you will be asked to indicate this by pressing the key with a checkmark sign on it.
IF the target and the cue arrow do not match (i.e., the arrow points to the right and the target appears in the left box OR the arrow points to the left and the target appears in the right box) then this is an incongruent trial and you will be asked to indicate this by pressing the key with a cross on it.
Please respond as quickly as possible once the target has appeared on the screen.
We will now attempt a couple practice trials.

Sit with the participant through the practice trials to ensure understanding.
Do you have any questions?

Allow the participant to do the experiment.

Thank you again for your participation.
Allow participant to read the debriefing form.
Please feel free to address me with any final questions or concerns and contact me through email if you have anything else you would like to know regarding the experiment. Thank you!

Appendix D

Letter of Information

The Effects of Musical Mood and Musical Arousal on Visual Attention

Research Investigators:

Angela Marti Marca
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Tram Nguyen, MSc
Student Researcher
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London, Ontario, N6A 5B7
Email: jgrahn@uwo.ca
Phone: 519 661 2111 ext. 84804

Introduction:

You are being invited to participate in this research study investigating the influence of music on attention conducted by Angela Marti Marca, Tram Nguyen, and Dr. Jessica Grahn. The purpose of this study is to determine how musical mood and musical arousal affect visual attention. This letter is to provide you with information required for you to make an informed decision regarding participation in this research.

Inclusion and Exclusion Criteria:

Individuals who have normal hearing and normal or corrected-to-normal vision may participate in this research.

Research Procedures:

If you agree to participate, you will be asked to partake in the following tasks:

Music Rating Task:
You will rate short musical clips, of approximately 10 seconds in length, on their levels of mood and arousal. That is, you will specify whether the music is a happy, neutral, or sad piece and whether the music is a high arousing, moderate arousing, or low arousing piece. All responses will be made using a computer keypad.

Visual Attention Task:
You will complete a simple visual attention task adapted from the Posner Cueing paradigm. For this task, you will fixate on a screen with two empty boxes. An arrow pointing either to the right or left box will appear on the screen for a brief second. A target stimulus will appear in either one of the two boxes and you must identify whether the trial is congruent or incongruent with the cued arrow. Viewing and active participating will be done either in silence or while listening to music. All responses will be made using a computer keypad.

It is anticipated that both tasks will take less than an hour, over one session, to complete. The tasks will be conducted in the Natural Sciences Buildings at the Brain and Mind Institute. There will be a total of 50 participants.

Possible Risks and Benefits:

There are no known or anticipated risks or discomfort associated with participating in this study. There are also no direct benefits from participating in this study. However, the information gathered from this study may help us understand how musical emotions may influence visual attention. Results from this study may be used in further research to understand how music could influence potential treatments for individuals with attention deficit disorders.

Compensation:

You will be compensated one research credit for your participation in this study. If you do not complete the entire study you will still be compensated for your participation.

Participation:

Participation in this study is voluntary. You may refuse to participate, refuse to answer any questions, or withdraw from the study at any time with without loss of promised credit.

Confidentiality:

All data collected will remain confidential and accessible only to the investigators of this study. If the results are published, your name will not be used. Any data resulting from your participation will be identified by a number, without any reference to your name or personal information. Data will be stored on a secure computer in a locked room. After completion of the experiment, data will be archived on storage disks and stored in a locked room for a minimum of five years and a maximum of 15 years, after which they will be destroyed. Representatives of the University of Western Ontario Non-Medical Research Ethics Board may require access to your study-related records or may follow up with you to monitor the conduct of the study.

Contact Information:

If you require any further information regarding this research project or your participation in the study you may contact: Angela Marti Marca at amartima@uwo.ca, Tram Nguyen at tnguye95@uwo.ca, or Dr. Jessica Grahn at jgrahn@uwo.ca.
If you have any questions about your rights as a research participant or the conduct of this study, you may contact:

Office of Research Ethics
University of Western Ontario
Email: ethics@uwo.ca
Phone: 519 661 3036

Appendix E

Consent Form

The Effects of Musical Mood and Musical Arousal on Visual Attention

Research Investigators:

Angela Marti Marca (amartima@uwo.ca)

Tram Nguyen (tnguye95@uwo.ca)

Dr. Jessica Grahn (jgrahn@uwo.ca)

I have read the Letter of Information, have had the nature of the study explained to me and I agree to participate. All questions have been answered to my satisfaction.

Participant's Name (please print):

____

Participant's Signature:

____

Date:

____

Person Obtaining Informed Consent (please print):

____

Signature:

____

Date:

____

Appendix F

-3 **-2** **-1** **0** **+1** **+2** **+3**

Extremely negative Neutral Extremely positive

Figure 6. Anchored seven-point Likert scale used for rating of musical mood of a variety of music clips, where -3 is *extremely negative*, 0 is *neutral* and +3 is *extremely positive*.

Appendix G

+1 **+2** **+3** **+4** **+5** **+6** **+7**

Extremely low arousal Neutral Extremely high arousal

Figure 7. Anchored seven-point Likert scale used for rating of musical arousal of a variety of music clips, where 1 is *extremely low arousal*, 0 is *neutral* and 7 is *extremely high arousal*.

Appendix H

Debriefing Form
The Effects of Musical Mood and Musical Arousal on Visual Attention

Research Investigators:

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The purpose of this study is to examine how music may affect participants' performance on a basic visual attention task. In particular, this study seeks to determine whether perceptual information of music such as mood (positive and negative) and arousal (high and low) can directly affect attention and concentration.

Previous research has found conflicting results regarding the effect of music on attention and concentration. Sometimes background music distracts from the task at hand and at other times background music can enhance performance of the given task (Morton, Kershner, & Siegel, 1999). Further investigations have suggested that music has its impact on attention and concentration by modulating a listener's internal mood and arousal levels (Jefferies, Smilek, Eich, and Enns, 2008). For example, music with a positive mood can improve attention compared to music with a negative mood (Olivers & Niewenhuis, 2005). Furthermore, low arousing music has a positive effect on attention, whereas high arousing music has a negative effect (Smilek, Enns, Eastwood, & Merickle, 2006). However, it is unclear how mood and arousal together may affect attention and concentration. That is why in this study, a basic visual attention task was conducted while music with different levels of mood and arousal was played in the background. Since musical mood and musical arousal are subjective measures, prior to assessing their effects on attention and concentration, you were asked to rate the mood and arousal level of different music clips. The clips that you rated highest or lowest on the four dimensions of mood and arousal (high arousal positive mood, high arousal negative mood, low arousal positive mood, and low arousal negative mood) were the stimuli used during the visual attention task.

By participating in this study, you have provided us with data to explore the effects of musical mood and musical arousal on attentional networks. Your responses will be combined with the responses of others to determine how different types of music influence attention and concentration.

Your responses and participation were much appreciated. If you require any further information regarding this research project or your participation in the study you may contact: Angela Marti Marca at amartima@uwo.ca, Tram Nguyen at tnguye95@uwo.ca, or Dr. Jessica Grahn at jgrahn@uwo.ca.

If you have any questions about your rights as a research participant or the conduct of this study, you may contact:

Office of Research Ethics
University of Western Ontario
Email: ethics@uwo.ca
Phone: 519 661 3036

For further information regarding this research, you may wish to read the following articles:

Jefferies, L. N., Smilek, D., Eich, E., & Enns, J. T. (2008). Emotional valence and arousal interact in attentional control. *Psychological Science*, *19*(3), 290-295.

Morton, L. L., Kershner, J. R., & Siegel, L. S. (1999). The potential for therapeutic applications of music on problems related to memory and attention. *Journal of Music Therapy*, *27*(4), 195-208.

Olivers, C. N. L., & Niewenhius, S. (2005). The beneficial effects of concurrent task-irrelevant mental activity on temporal attention. *Psychological Science,* 16, 265-269.

Olivers, C. N. L., & Nieuwenhuis, S. (2006). The beneficial effects of additional task load, positive affect, and instruction on the attentional blink. *Journal of Experimental Psychology: Human Perception and Performance*, *32*, 364-379.

Smilek, D., Enns, J. T., Eastwood, J. D., & Merickle, P. M. (2006). Relax! Cognitive strategy influences visual search. *Visual Cognition*, 14, 543-564.