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The Effects of Background Music on Sustained Attention Tasks and Workload Perception

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Abstract

In the world that we live in that is populated by music many of the places we go, it is important to question how this music could impact our ability to work. This study aimed to observe the relationships between different classifications of background music and performance on a sustained attention task, as well as the perception of workload. 55 participants were randomly assigned to a difficult or easy attention task and to a music condition. Building off of prior research in workload and sustained attention, this study approaches these topics through the lens of stimulating and relaxing background music.

Our affinity for music can be shown easily through how often we can hear it in passing during our day to day lives. Often, the music we hear is not sought out or listened to with much intention, but it acts as ornamentation to other tasks to which we attend. While driving, doing homework, or exercising, people will often have music playing in the background, though it may not attract their full focus. College students demonstrate this in our daily lives, with a study by Calderwood et al. (2014) showing that 59% of students enrolled at a university used some form of music as an aid to their studying. In many college libraries in the U.S., it may be difficult to avoid altogether the sight of someone wearing headphones. With all of this in mind, it is important to always consider the exchange between the music, listener, and situation in which these components are interacting (Furnham & Bradley, 1997). This study aims to observe the effects of different types of auditory and musical stimuli on sustained attention tasks varying in task demand. By having participants complete different measures of attention in conjunction with musical selections playing as background noise, I assessed if background music has any significant impact on sustained attention tasks and perceived workload.

It is hard to argue that the presence of background music acts as a backing track for many aspects of daily life. A study by Rauscher et al. (1993) can be seen as the root of an idea in popular culture that listening to the music of Mozart makes you smarter. While this study observed differences in spatial reasoning tasks—there was a temporary increase in spatial reasoning ability—these results were not long lasting. In spite of the specificity of this test, these results are often overgeneralized to general intelligence, in part due to a New York Times publication (Ross 1994) that misstated the results. Even if this misreport was what garnered more attention than the actual results, the possibility of music having an impact on a given task leaves much to pursue. The impact of music is often psychological and physiological—many have experienced getting chills while listening to a moving song—and it is not uncommon for music to play a role in someone's mood. The idea that one's mood can be impactful in cognitive performance tasks by increasing physiological arousal is known as mood arousal theory. (Thompson et al. 2001). Initially the musical aspects were believed to be the root of increase in arousal, but further studies have shown the ability of nonmusical auditory stimuli to increase cognitive performance (Nantais & Schellenberg, 1999). Thompson et al. (2001) had participants complete a spatial abilities task, some listening to a Mozart sonata (in line with the initial Mozart effect) and some listened to a slower, "sad" piece by Albinoni, and found that participants who listened to Mozart scored significantly higher than those listening to Albinoni- they also scored lower on a *negative* mood scale. Their work provides evidence that the Mozart effect is result of heightened mood and arousal. Thompson and his colleagues believe that it is misleading to suggest that exposure to music leads to brief augmentation of a nonmusical skill. They prefer the idea that enjoyable stimuli will increase arousal and improve affect, which could help performance in many tasks.

Because music itself is a kind of noise, the types of interactions between noise in general and performance on tasks is important. The search for effects of any kind of noise on attention has initiated much testing, through which many distinctions of noise have arisen. Szalma and Hancock (2011), in a meta-analysis, examined the impact of "noise schedule", or the timing and duration of noise during a variety of tasks. They argue that one of the most detrimental forms of noise to a task is that of intermittent noise, those which appear abruptly, as opposed to sustained noise over a long period of time. The two postulated that this type of noise, when introduced at high intensities, briefly draws someone's attention away from a task and re-orients it to the noise. Increased arousal caused by noise is another consideration, which leaves decreased ability to distribute attention (Easterbrook, 1959). By this logic, while low arousal would decrease the breadth of attention, this loss would still benefit performance on a task, because it would decrease the attention given to any distractions. Alternatively, if this arousal were too high, this decrease in attention would begin to detriment task performance (Szalma & Hancock, 2011). A way of approaching noise that focuses on stress is found in the "maximal adaptability theory" as presented by Hancock and Warm (1989), dividing stress into three aspects—input, adaptation, and output. Input includes any factors that could impact performance on a task, such as noise or task difficulty. Adaptation is a person's ability to acclimate to these factors, while output is the response that follows the processing of these prior two aspects. Output is often shown by the ability of an individual to perform well on a given task. In the context of this theory, noise can often impair an individual's ability to process auditory information that is important to a task, such as heard instruction. According to this theory, while people can adapt to a wide range of stress, the extreme ends of high or low stress begin to show detriment to adaptation. It is interesting to note that while noise as a stressor would be often used on the high end of the spectrum (such as having a distracting sound playing intermittently during a task) noise conditions that approach the lowest possible point, such as those that can be reached in sound isolation chambers, can also have an adverse effect on performance.

While music is a type of noise, there are clearly differences between music and noise that make us seek out the former and avoid the latter. Since this experiment deals with music and background music in the context of a cognitive task, it is important to observe prior research where this has also been studied. Cassidy and Macdonald (2007) observed effects of background music on several cognitive tasks. Participants completed the Stroop test, and three recall tasks--immediate, free, and delayed. Participants experienced one of four conditions for noise: music that was labeled relaxing (low arousal), music labeled aggressive (high arousal), background noise—such as office sounds, and silence. They also viewed the participants through introversion and extroversion ratings, predicting that their results on tasks would be different relative to their classification. This hypothesis showed some support with introverts performing significantly better on all tasks but the Stroop task, which they were worse on. The one interesting result of music condition and temperament occurred during the Stroop task, with those who were introverted performing significantly worse when high arousal music or noise was introduced. This suggests that different personalities may have different levels to which they are impacted by high arousal music. The results showed that participants performed poorer in the conditions with sound than in silence, but not all of these differed equally. They found that high arousal music as well as background noise reduced performance significantly on all of the given tasks, and that subjects performed better on all tasks in the low arousal condition compared to background noise, except for a free recall task. While this experiment showed no improvement by addition of different music conditions, the fact that performance was different across the conditions leaves promise of musical facilitation of a task, when in the right context. Further emphasis can be seen here on the importance of arousal level and how stimulating or relaxing music is. It is also important to consider that this experiment used musical excerpts that contained lyrics, with research having shown that irrelevant speech is more disruptive to memory than auditory stimuli without speech when someone is receiving high levels of information (Jones & Morris, 1992). Because the present study aims to look for any benefits of background music, music that contains lyrics have been excluded from the selection.

The Present Study

The aforementioned research sets up many viewpoints through which to approach the idea of background music. The present study seeks to examine the impact of background music on sustained attention performance. A conundrum when approaching music is how to operationally define different aspects of the music itself. Often times people will group types of music into genres, such as rock music, but even within these categories there leaves room for much variation (speed of music, types of instruments used, etc.) Kiger (1989) proposed categorizations which grouped music according to amount of stimulation. Music with “low information load”—having less variation, lower volume and slower tempos improved results on a reading comprehension task when measured against silence. Music with “high information load” impeded performance on the same task.

A similar approach to the grouping of music comes from North and Hargreaves (1999) who argued that listening to any music demands cognitive work. By this assertion, music that is more demanding cognitively leaves less attention to be distributed. Less arousing (and therefore less cognitively demanding) music would by this logic allow for more attention to be given to other tasks. By looking at low demand and high demand driving game tasks, paired with high arousal (140 bpm, 80 dB) and low arousal music (80 bpm, 60 dB), they found that performance was best in the interaction between low demand tasks and low arousal music. These selections show the importance of arousal in considering the interactions of music and performance.

It should be considered that people will sometimes do things that hinder their performance in certain areas without knowing it. Furnham and Strbac (2002) propose that music may be equally as distracting as noise, but the resulting impact on mood is different. They propose that while noise may be distracting and annoying, music that is listened to during a task is often put on by the listener and the change in mood that it causes may have an effect on performance if sustained. Considering earlier discussion of mood and arousal, this is something to keep in mind. Their study proposes that while music may be beneficial on tasks that are repetitive, music could be just as adverse on tasks that are more complex.

Lemaire (2019) listed music into two classifications- stimulating and relaxing music. Lemaire defined relaxing music as having tempos which fall between 64-96 BPM (beats per minute), while stimulating music was defined at 145-160 BPM. Her selections were from the classical music catalogue and contained no sung lyrics, only instruments. Lemaire's study also employed a nonmusical element, that of pink noise. While white noise has equal power over all frequencies, pink noises power negatively correlates with its frequency. Because of this, the lower ends of the frequency spectrum have more power in pink noise, resulting in less high-pitched frequencies and a sound that is less harsh. Participants performed a memory task, and the group assigned to stimulating music performed better than the relaxant and control noise groups, but only when IQ was considered. She found a significant interaction between IQ scores and music type, that those who scored higher on an IQ test performed better on a memory recall task. When those who scored higher on an IQ test were placed in the group with stimulating music, there was increased performance. These results suggest that intelligence as well as other individual difference variables, should be considered when studying effects of background music.

This study attempts to apply Lemaire's definitions of stimulating and relaxing music to attention, as well as adjust the criteria for these classifications. While Lemaire's working definitions of musical categories allow precise classification by the use of beats per minute, this study tried to refine this to fit into the traditions of classical music. In today's popular music, many aspects of songs are often controlled in a digital space. The speed of a song is often locked into an exact metronomic speed, with no room for speeding up or slowing down as the computer will not allow it. Live music, especially live performances of classical music, operate in a different manner. Since a conductor is controlling the tempo of the music for the performers, it is not possible for a truly consistent tempo to be maintained, without some speeding up or slowing down. For this reason, the present study chose to use tempo markings instead of beats per minute to assign stimulating or relaxing music. Tempo markings are words at the top of a piece of music that describes a general speed that the piece should be played at- such as *lento* meaning "slowly". The relaxing selection was made up of pieces marked *adagio*- which means that a piece is meant to be played slowly and expressively. The stimulating pieces all ranged from *allegro* to *allegro vivace*, meaning fast and very fast, respectively. The general beats per minute were close to the Lemaire's measure, but this method seemed to account more for fluctuation of tempo. By focusing on levels of arousal in relation to music type while considering the prior information on noise and performance, the present study has formed a lens through which to observe sustained attention and perceived workload.

Sustained attention, or vigilance, is the continued awareness of stimuli over a long period of time. Rosvold et al. (1956) designed the first Continuous Performance Task (CPT) to assess attention dysfunction in brain-damaged patients. These tests are still employed to assess typical and atypical vigilance. CPTs present two types of stimuli: a "signal" to which the observer must respond, and a "distractor" from which the observer must withhold response. This experiment used two attention tasks, one easy and one difficult.

Workload, especially in the field of human factors, is often measured through self report of individual's perception of their own experience. Hart and Staveland (1988) describe workload as "the perceived relationship between the amount of mental processing capability or resources and the amount required by a task". Workload is frequently assessed following attention tasks. Jafari et al. (2019) examined the effects of noise on workload following the completion of auditory or visual attention tasks. Different volume levels of background noise beginning low and rising in fixed increments yielded different effects, but when the volume reached 95 Db, the increase in mental workload proved statistically significant.

The goal of the present study is to examine the effects of background music on performance in easy and hard vigilance tasks. Specifically, participants would experience either stimulating or relaxing music, or pink noise while either performing an easy or hard vigilance task. With the established research this study predicts that there will be a relationship between the difficulty of the task and whether music is stimulating or relaxing. Using North and Hargreaves' (1999) work as a guide, I predict that stimulating music will create more processing demands while trying to focus attention, and there may be some performance decline if the task is too hard. In addition to examining sustained attention performance, I was also interested in whether participants would rate their workload experiences on the easy and hard vigilance tasks differently depending on the music or noise they heard. I predicted that workload would be higher in conditions with the difficult task and stimulating music. Finally, because Lemaire reported an interactive effect with intelligence and music, I included an assessment of cognitive abilities.

Method

55 participants, 46 women and 9 men were selected from the pool of Otterbein students through the online SONA Systems. Testing sessions were given in groups of four or less, with partitions between each computer. Vigilance tasks as well as Ravens Progressive Matrices tasks were given using SuperLab.

Music Selections and Noise Control

Since musical selections were made based on tempo, the instrumentation varied. There was no specificity regarding the instruments used or timbre, which is the specific sound an instrument possesses.

Stimulating. This study grouped all musical pieces by classical tempo markings. Pieces ranging from “allegro” to “allegro vivace” were used as stimulating selections. These pieces maintained a fast pace and were played with more intensity. All pieces were played one after another, with the pieces fading into the following one- that is as the volume of the playing piece went down the volume of the next would increase- to minimize silence. These selections can be seen in Table 1.

Relaxing. Pieces marked adagio were used as the relaxing selections. The tempo of these were slow, withheld and did not fluctuate much in terms of speed. The same method of playing the music was used as in the stimulating condition. As was the case with the stimulating pieces, all chosen music was written in a major key to keep some continuity in harmonic musical content. Major keys are often regarded as sounding “bright” or “happy”. These selections can be found in Table 2.

Pink Noise. A sustained tone of pink noise was used as a control group in the same way as the other two conditions. Pink noise is similar to white noise in the frequencies it contains, but while white noise has equal power in every frequency, pink noise has lower power the higher the frequency gets. Because of this, the lower frequencies are more defined in pink noise, resulting in a less harsh sound than white noise.

Measures

Vigilance Tasks. This study used the highly sensitive tasks designated as "Signal Presence" (Figure 1) and "Signal Absence" (Figure 1b) employed by Finomore et al. (2013). In the Signal Presence task, the distractor consists of five unfilled circles; the critical signal contains the same five circles, but a vertical line bisects one circle. In the Signal Absence task, the distractor contains the same five circles, each bisected by a vertical line; the critical signal occurs when a vertical line is absent from one of the five circles. Adult research reveals that performance efficiency declines significantly in the Absence task (Finomore et al., 2013). In one period of watch, there were 135 neutral events and 15 critical signals, with each period of watch lasting 4 minutes.

Workload. The NASA Task Load Index (TLX) was used as a measure of workload and given to participants immediately after everyone was done with their respective vigilance task. This measurement provides six subscales that participants rate from zero to one hundred. This task measures Mental, Physical, and Temporal demand, as well as Performance, Effort, and Frustration. Explanations of scales given to participants are presented in Table 3.

Raven's Progressive Matrices. The Raven's Progressive Matrices were used to assess intelligence. This task involves showing the participant a sequence of images and then from a selection of different choices, they must choose which one seems like it would come next in that sequence. A short form of the Raven's Progressive Matrices (Arthur & Day, 1994) was administered to participants on the computer after they completed the vigilance task and workload assessments. The short form consisted of ten problems and participants were given unlimited time to complete the tasks. Most participants needed approximately 20 minutes to complete the task. An example of a problem is presented in Figure 2.

Procedure

Participants were asked to arrive five minutes prior to the scheduled time, and whatever music condition was assigned to their group was playing when they arrived. The experiment was approved by the Institutional Review Board. All subjects were asked to fill out a written consent form for the experiment. Participants were randomly assigned a vigilance task (Absent or Present) and asked to read written instructions for their task and were given the opportunity to ask questions before the session started. After all participants completed the vigilance task, their perceived workload of the task was measured using the NASA TLX. Finally, all participants completed the Ravens Progressive Matrices task. Participants read instructions on the computer screen and were given an opportunity to ask questions, as before. Participants were asked to wait to leave until the whole group had completed the test to reduce distractions. Once all participants were finished, a final opportunity for questions was offered and the group was dismissed.

Results

Vigilance Data. The percentage of hits was determined for each participant at each of the experimental conditions. Means for the absent and present tasks in each of the three music conditions are presented in Table 4. These data were submitted to a 2 (Vigilance Task: Absent, Present) x 3 (Music Condition: Stimulating, Relaxing, Pink) x 4 (Periods of Watch) mixed ANOVA with repeated measures on the variable of watch. The main effects for Vigilance Task and Watch were significant, (Wilks' lambda = .845, F (3, 47) = 2.88, p = .047, η_p^2= .155). These main effects were modified by a significant Music Condition x Watch interaction, (Wilks' lambda = .766, F (6, 94) = 2.23 p = .047, η_p^2 = .125). This two-way interaction is best interpreted by the Vigilance Task x Music Condition x Watch interaction that approached significance, (Wilks' lambda = .776, F (6, 94) = 2.12 p = .058, η_p^2 = .119). This interaction appears in Figure 4 as a function of Watch. As can be seen in the figure, the present task showed pretty consistent performance until a decline in the stimulating group during the last two periods. The absent task scores were generally lower, however a slight incline in the present group can be seen until period 3 when they start to decrease again. This could be tied to the work of North and Hargreaves who propose that all music listening requires mental work. Interestingly, there was a slight increase in performance with a combination of stimulating music and a difficult task, before falling back down at the end. This could be close to theories of mood and arousal, and it is possible that stimulating music could be helpful on more demanding tasks, although clearly with threshold.

Workload Data. The workload ratings for the six dimensions were obtained for each participant at each experimental condition. Means for the absent and present tasks in each of the three music conditions are presented in Table 5. These data were submitted to a 2 (Vigilance Task: Absent, Present) x 3 (Music Condition: Stimulating, Relaxing, Pink) x 6 (Workload Dimensions) mixed ANOVA with repeated measures on workload dimensions. As expected, the main effect for Dimensions was significant, (Wilks' lambda = .097, F (5, 45) = 83.76 p = .000, η_p^2 = .903).. This main effect was modified by a significant Vigilance Task x Workload

Dimensions interaction, (Wilks' lambda = .684, F (5, 45) = 4.16 p = .003, η_p^2 = .316). This interaction is plotted in Figure 3 as a function of workload dimensions. As can be seen in the figure, most ratings were higher on the difficult task, those who had the absent task felt as if the test took longer. Interestingly, the frustration levels were higher on the easy task. It is possible that if a task is too easy or mundane, that it may be perceived as more tiresome.

Raven's data. The relationship between cognitive abilities and performance in specific music conditions were unable to be analyzed due to small number of participants per music condition. I examined, however, whether there might be a relationship between perceived workload and cognitive abilities. A stepwise regression analysis was performed to identify if any workload subscales contributed to cognitive abilities, as indexed by the Raven's APM. Stepwise regression was chosen due to the exploratory nature of the work. The independent variables included all subscale dimensions except for Physical Demand since there was no expectation for the subscale to have an impact on a cognitive task. A significance level of .05 was set for entry into the model. Results indicated a significant overall model, F (1,53) = 6.78, p = .012. Temporal demand accounted for 11.3% of the variance. As Temporal Demand increased, items correct on the Raven's APM decreased (beta = -.337).

Discussion

This study aimed to observe the interactions between different levels of arousal through music, sustained attention tasks, and workload. Objective performance revealed that the two attention tasks varied in difficulty—the more difficult of the two was the Absent test. Establishing an easy and a hard task permits examination of the interactive effects of difficulty and music condition. This should be viewed through the perspective of Furnham and Strbac (2002)—that if a task is more difficult and complex, then music could have an adverse effect. What the tasks shared was the standard decline in performance over time—or what is referred to as the vigilance decrement (Warm, Dember & Hancock; 1996; Warm & Jerison, 1982). This is to be expected of a sustained attention task—the longer that participants were focusing on the screen, the harder it became for them to focus their full attention, regardless of the difficulty of the task. These findings establish standard vigilance tasks that can be looked at within the context of background music.

The interaction between music condition, vigilance task, and period of watch proved to be of interest. Across the four periods of watch in the Present task, performance was somewhat steady in the relaxing music and pink noise conditions; however, in the stimulating condition there was a 10 percent decline. In the Absent condition stimulating music brought low performance across all four periods. In that condition, the stimulating music caused declines across all four periods, but relaxing music started higher and slowly declined, and pink noise started lower and slowly fell. These results suggest that using stimulating music during a difficult task may cause some harm to performance and could be tied to Hancock and Warm’s (1989) work on maximal adaptability theory. From this perspective stimulating music has provided too much stress for it to be of benefit to the task, and therefore begins to impede it.

The interaction between task and workload subscales showed the workload rating was affected by the task. On the easy task, the mean of the pink noise rated highest in frustration while relaxing scored the lowest. During the difficult task frustration levels of pink noise was much lower- 44.38 percent vs the 67.78 on the present task, which was only 3.38 points higher than the lowest mean score. This could suggest that during an easier task, using noise to focus may actually increase frustration but on a difficult task it may help to maintain composure. During the difficult task, pink noise also showed the highest rating on mental demand, while stimulating music scored the lowest. Even if those listening to stimulating music did not perform better on the difficult task than those listening to pink noise, they still felt as though there was less being demanded of them mentally. This could be detrimental to those who listen to stimulating music while they work—it could make them think that what they are doing requires less attention than it actually does. This could be related to the work of Furnham and Strbac (2002), as one possible explanation is that the music increases their mood and may have led to them thinking that the task was less demanding than it was.

It is interesting to note that music influenced objective performance, but it did not influence the perception of workload. Even if people are listening to music that may impact their performance negatively, this is not perceived as a change in workload. This suggests that it is possible that people do not know that the music they are listening to makes attention more difficult and could be hindering themselves unintentionally. This is in line with the thinking of Easterbrook (1959), that when arousal is increased by sound, the attention that can be distributed to other tasks decreases. Of course, the abilities of people vary with what they can attend to, but this could provide some reason to be more selective about what kind of music to listen to while working.

Due to an interruption in data collection, I could not collect enough data to accurately assess any interactions between the Ravens data and other data. Lemaire (2019) found an interaction between IQ and the music condition, but the number of participants per cell was not large enough to perform analyses on this data. Recall Lemaire reported that IQ had a marginally significant positive correlation with results on a recall task. It is possible that those with higher levels of intelligence can have an easier time on the tasks given, and because of this can work well with music regardless of task. If a larger pool of participants can be gathered, further research on this area in particular could lead to some interesting results.

This study also observed the relationship between workload and IQ. It has been evidenced that individual differences can affect judgements of workload. The results showed that individuals that scored lower on the cognitive abilities task also reported greater temporal demand. Jensen (2006) and others (Frey, 2011) have consistently reported that people with greater cognitive abilities often respond faster in reaction time tasks. Further, Laurie-Rose, Frey and Zamary (2014) have demonstrated higher workload in children considered “typical” compared to children identified as “gifted”—children who scored higher on a variety of cognitive abilities tests. This result suggests that participants that score lower on a cognitive abilities task feel more pressure in terms of time to complete the task. Any future studies should incorporate this into their perspective.

Limitations and Relevance

This study aimed to extend the work of Lemaire (2019) in providing a meaningful reason to work towards the operational definition of music categories. While this study offers many interesting results and shows trajectory toward significance in some areas, the interruption in data collection limits my interpretation. It is possible that deep analysis of musical excerpts would have provided more consistency between selections for elements other than tempo, as was done by Kiger (1989). If musical pieces are analyzed for what kinds of instruments used, or for other musical aspects it is possible to make a repertoire of musical pieces that are more similar to one another, and this could be something to approach if this research is furthered.

With how many people in our world today use music in a way that they believe may be productive, it is more important than ever to be aware of the kinds of impacts this can have on our productivity and performance on what we wish to accomplish. Researching the impacts of music on cognitive performance holds practical value that would serve much of the population, as it is important for people to know how what they are exposing themselves to is playing a role in how well they can operate on a task. When much of our daily lives are engulfed in music and sounds outside our immediate frame of reference, it is necessary to know how these kinds of stimuli can help or hinder us, and what—if any—music should be the best for us to listen to while working on important tasks.

Table 1. *Selection of music in the Stimulating Music Condition*.

Piece Title	Composer
Symphony No. 8 in F Major, Op. 93 IV- Allegro Vivace	Ludwig Van Beethoven
Piano No. 18 in E Flat Major, Op. 31 No. 3: II Allegretto Vivace	Ludwig Van Beethoven
Piano Concerto No. 4 In G Major, Op. 58. III. Vivace	Ludwig Van Beethoven
Sonata for Piano & Violincello in A Major, Op. 69. IV. Allegro Vivace	Ludwig Van Beethoven
Concertone in C Major, K. 190: III. Tempo di menuetto	Wolfgang Amadeus Mozart
Piano Concerto No. 18 in B Flat Major, K. 456: III Allegro Vivace	Wolfgang Amadeus Mozart
Piano Concerto No. 11 in D Major, Hob. XVIII: 11 1: I Vivace	Franz Joseph Haydn
Piano Concerto No. 9 in E-Flat Major, K. 271, 'Jeunehomme': III. Rondo (Presto). Alla breve	Wolfgang Amadeus Mozart
Piano Concerto No. 21 in C Major, K. 467: III. Allegro vivace assai	Wolfgang Amadeus Mozart

Table 2. *Selections for the Relaxing Condition*.

Piece Title	Composer
String Trio in E-Flat Major, Op. 3: IV. Adagio	Ludwig Van Beethoven
Violin Sonata No. 10 in G Major, Op. 96: II. Adagio espressivo	Ludwig Van Beethoven
Piano Concerto No. 5 in E-Flat Major Op. 73 "Emperor": 2. Adagio un poco moto	Ludwig Van Beethoven
Violin Sonata No. 6 in A Major, Op. 30 No. 1: 2. Adagio molto espressivo	Ludwig Van Beethoven
Piano Sonata in C Major, WoO 51: II. Adagio	Ludwig Van Beethoven
Symphony No. 4 in B-Flat Major, Op. 60: II. Adagio	Ludwig Van Beethoven
Violin Sonata No. 5 in F Major, Op. 24 "Spring": II. Adagio	Ludwig Van Beethoven

Table 3. *Original Rating Scale Definitions for the Subscales of the NASA-TLX*

Subscale	Definition
Mental Demand	How much mental and perceptual activity was required (e.g., thinking, deciding, calculating, remembering, looking, searching, etc.)? Was the task easy or demanding, simple or complex, exacting or forgiving?
Temporal Demand	How much time pressure did you feel due to the rate or pace at which the task or task elements occurred? Was the pace slow and leisurely or rapid and frantic?
Physical Demand	How much physical activity was required (e.g., pushing, pulling, turning, controlling, activating, etc.)? Was the task easy or demanding, slow or brisk, slack or strenuous, restful or laborious?
Performance	How successful do you think you were in accomplishing the goals of the task set by the experimenter? How satisfied were you with your performance in accomplishing these goals?
Effort	How hard did you have to work (mentally and physically) to accomplish your level of performance?
Frustration	How insecure, discouraged, irritated, stressed, and annoyed versus secure, gratified, content, relaxed and complacent did you feel during the task?

Table 4. *Means and standard deviations for vigilance scores for the each of the three music condition for the Absent and Present tasks*.

Music Condition	Task	Per. 1	Per. 2	Per. 3	Per. 4
Stimulating	Absent				
	M	.741	.793	.822	.755
	SD	.147	.117	.124	.156
	Present				
	M	.993	.985	.963	.075
	SD	.022	.029	.075	.238
Relaxing	Absent				
	M	.880	.793	.747	.780
	SD	.093	.211	.315	.253
	Present				
	M	.993	.993	.980	.980
	SD	.021	.21	.032	.044
Pink	Absent				
	M	.808	.675	.842	.693
	SD	.129	.149	.127	.717
	Present				
	M	.992	.993	.978	.970
	SD	.022	.008	.033	.035

Table 5. *Means and standard deviations for workload scores for the each of the three music conditions for the Absent and Present tasks*.

Music Condition	Task	Mental		Temporal		Physical		Performance		Effort		Frustration	
		M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Stimulating	Present	38.33	25.74	53.33	20.62	10.00	10.00	69.44	14.67	39.44	25.3	52.78	27.51
	Absent	41.67	31.82	77.22	24.38	16.11	25.71	55.56	21.86	48.89	28.48	48.89	27.59
Relaxing	Present	43.00	31.29	59.00	29.231	5.00	7.07	71.00	17.29	43.00	24.97	50.00	24.50
	Absent	56.00	15.78	79.00	18.53	3.00	4.83	57.00	19.47	54.00	16.47	41.00	20.25
Pink	Present	33.33	25.98	63.33	31.23	8.93	18.56	61.11	24.21	45.56	32.45	67.78	29.91
	Absent	59.47	34.69	73.13	24.92	21.88	29.02	45.00	15.12	58.75	23.57	44.38	42.89

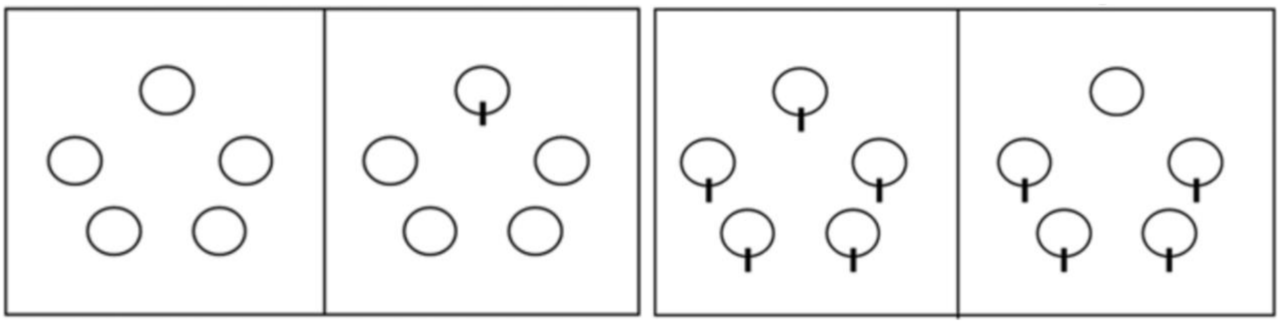


Figure 1. *Signal presence (left) vs. Signal Absence (right) with the critical signal displayed on the right of each panel and the critical signal on the left.*

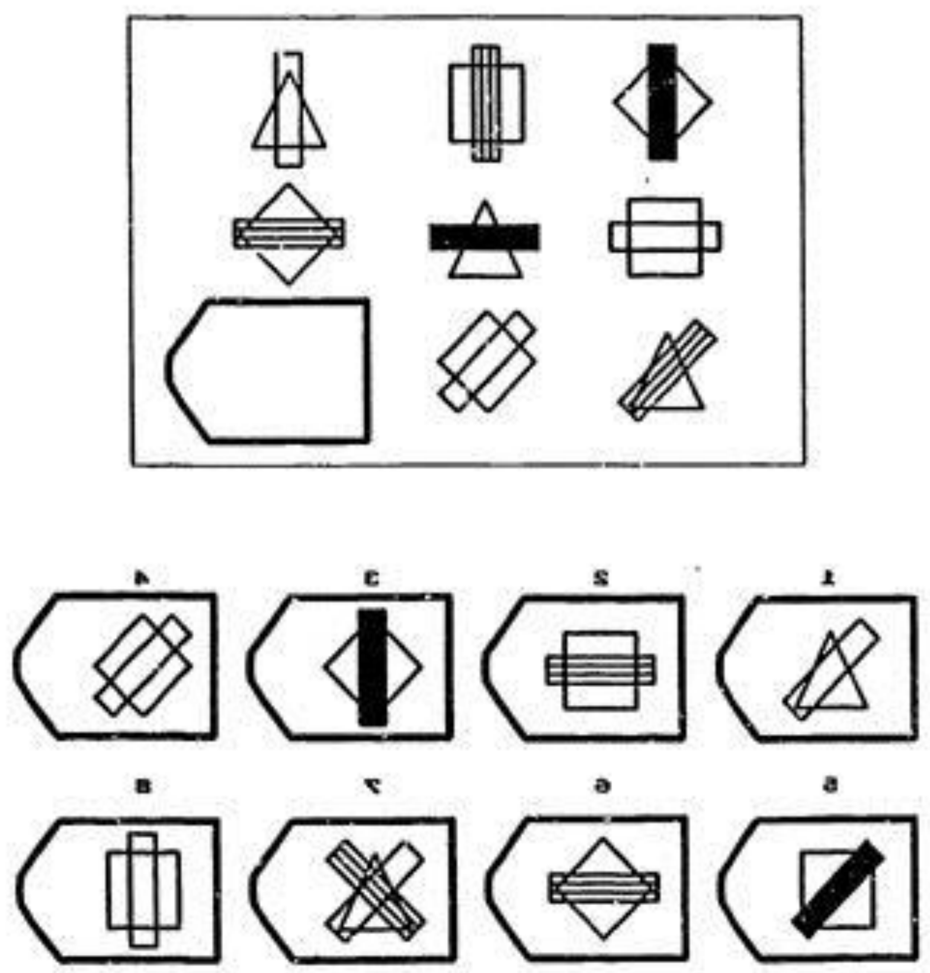


Figure 2. Example of a Raven's Progressive Matrix problem.

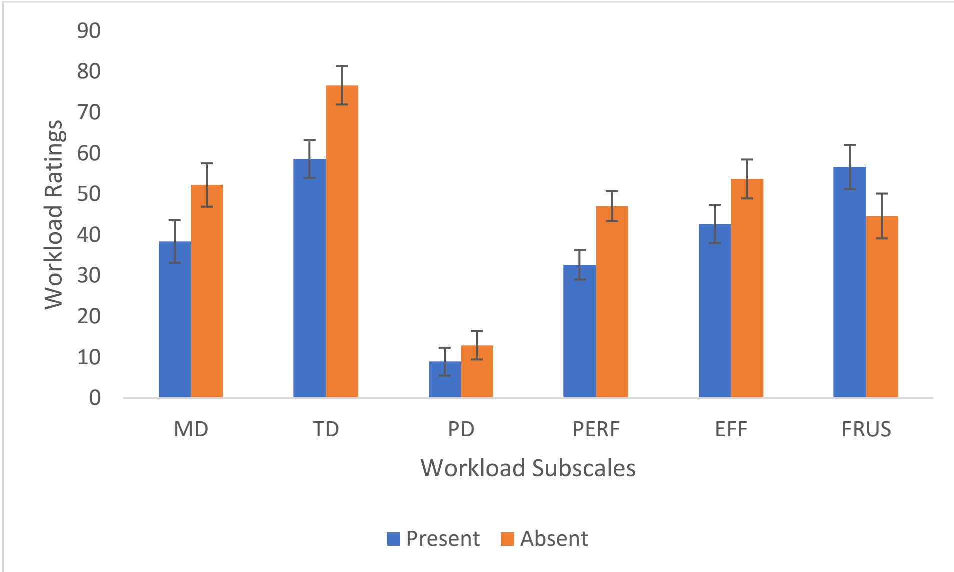
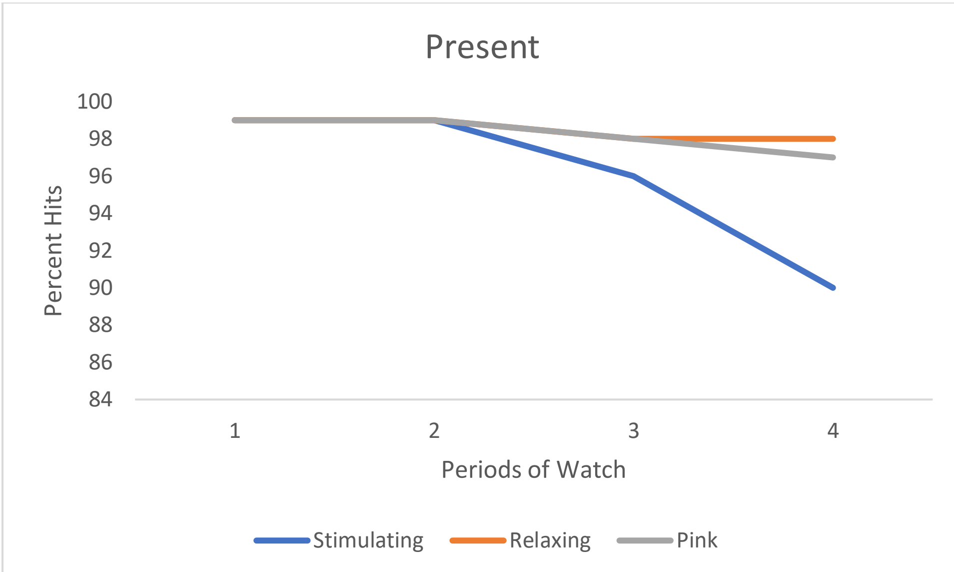


Figure 3. Workload ratings for the Present and Absent tasks as a function of workload subscales.



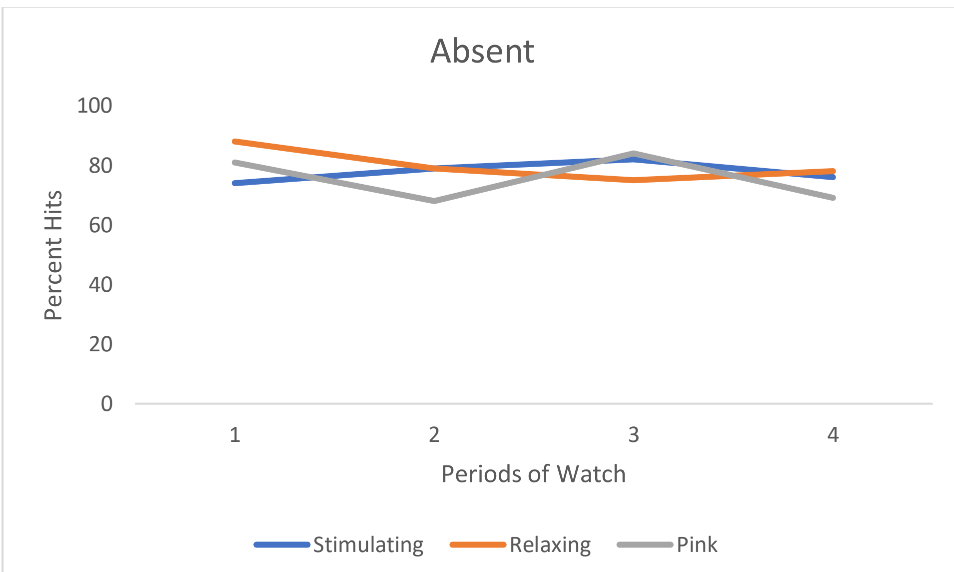


Figure 4. Percentage of hits as functions of periods of watch for the present and absent tasks.

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