Effects of Background Music on Cognitive Tasks

Garrett Myles

Honors Psychology Thesis
Department of Psychology
University of Western, Ontario
London, Ontario, CANADA
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Thesis Advisor: Dr. Jessica Grahn, Ph.D.

Abstract

Many students listen to music when engaging in academic activities, with several of these tasks considered to be cognitively demanding. As such, it is beneficial to understand the effects of music on cognition to create optimal environments for performance. Using the Cambridge Brain Science Battery (CBSB), the current study investigated the effects of background music on several subsets of cognition. In two separate experiments, undergraduate students from Western University were tested on three distinct cognitive tasks under four auditory conditions: noise, silence, music with lyrics and music with no lyrics. The first experiment had 15 participants and the second had 20. Each group was tested on a different set of tasks. All participants were further measured on differences in introversion/extroversion levels using the Eysenck Personality Questionnaire. A 3 x 4 repeated measures ANOVA showed no significant effects of music on task performance in either of the experimental groups at the 0.05 level. A significant block x task interaction was noted in the second experiment ($F(6,114) = 2.91$, $p = 0.029$). Additionally, there was no correlation between introversion/extroversion ratings and task performance at the 0.05 level. Therefore, significant conclusions cannot be drawn for optimal performance environments with respect to music use. Future studies should consider additional manipulations of both music and task choice.

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Effects of Music on Cognition

Many individuals listen to music while studying for a test, completing homework assignments, and reading for a class - all of which can be described as fairly complex tasks. With entrance into schools having such high academic cutoffs, it is critical for things such as studying to take place in an environment where maximum performance can be attained. Furthermore, it is becoming a must to outcompete peers for entrance into upper-level schooling programs to be qualified for high paying jobs. Therefore, by understanding the interaction between music and cognition, optimal study conditions for improved academic performance can be determined.

Cognition is defined as the mental action or process of acquiring knowledge and understanding through thought, experience and senses (Miller & Wallis, 2009). Some of these cognitive processes refer to mental actions that include verbal memory, short-term memory and reasoning. These subfields involve such things as memory for words and properties related to language, the ability to store things in mind for a short period of time, and the ability to think logically and sensibly about a topic. Thus, it can be argued that when an individual is engaging in the previously stated academic tasks, there are many cognitive processes involved. With the extreme effort that is required, the brain needs to filter out any irrelevant stimuli that are not contributing to the task at hand. If the brain processed all incoming visual, sensory and tactile stimuli, an individual's performance would be compromised (Miller & Wallis, 2009). This is because the brain would not be fully directing its energy and attention to the task. As such, by filtering out these distracting stimuli it allows only input that is relevant to the task at hand to be processed, which then leads to an optimal behavioural output.

Reviewing previous literature, there are several different cognitive processes that have been examined in the context of music. These processes include working memory, reading comprehension, visuospatial abilities, serial recall and arithmetic. Across these studies however, results on the exact effect that music has on performance remain inconclusive. It is possible that this unsettled argument is due to the differences in the methods and procedures of past studies.

Working Memory and Music

The ability to hold, process, and manipulate information in memory is a core executive function known as working memory, and is important in both reasoning and decision-making. Examined across two distinct study conditions, silence and a preferred music choice, high school students were measured on their performance on a working memory test (Smith & Morris, 1997). Students who completed the test after spending 10 hours in a silent study condition outperformed their counterparts who studied to a preferred music track before completing the test (Smith & Morris, 1997). This investigation demonstrates that music hinders performance on tasks requiring working memory.

When studied in a younger sample of 10-12-year-old students, Hallam, Price and Katsarou (2002) found a different effect of music on working memory however. The primary grade students were separated into different groups and asked to complete a simple task to test their working memory ability under one of three conditions: silence, a music source quantified as calming and relaxing, or a music source quantified as aggressive (Hallam, Price & Katsarou, 2002). Unlike the previous study where individuals performed best in the silent condition, there was no noted difference between students performing the task in silence, or with the presence of calm, relaxing music. However, for the group performing the task while listening to aggressive music, performance was found to be much below the average of the other two conditions (Hallam, Price & Katsarou, 2002). These results suggest that music may have different effects depending on the type of music one listens to.

Using a different music piece yet again, Mammarella, Fairfield and Cornoldi (2007) played either a classical track from Vivaldi's four seasons or left the individuals in silence while also performing a working memory task, much like those of the previous two studies. Specifically, 24 participants with a mean age of 81 years old were required to take part in a digit span task while listening to music, white noise or silence. Due to the fact individuals were required to remember two sets of digits and keep both separate from each other, the task was a measure of working memory (Mammarella, Fairfield & Cornoldi, 2007). Participants were set up with the audio, if any, 1-minute before the task began, which lasted until the completion of the study. The music was played over a set of speakers where the participating individuals could control the volume level. Results showed that those who were assigned to the music condition performed significantly better than those listening to either white noise, or those who completed the task in silence (Mammarella, Fairfield & Cornoldi, 2007). The age of participants (older people have worse hearing) and ability to control the level of volume (to a point of which they might not even be able to hear the music) are two separate factors that may contribute to the differences noted in performance. As such, the design of the study should be taken into consideration when assessing the validity of these results.

Reading Comprehension and Music

Studying the relationship between music and reading comprehension, researchers Perham and Currie (2014) broke down the variable of music further into categories of non-lyrical (NLYR), liked lyrical (LLYR), and disliked lyrical (DLYR). Participants were required to read four separate passages, each with an accompaniment of six multiple-choice questions taken from SAT practice exams (Perham & Currie, 2014). During the reading comprehension task, participants were either listening to a form of music, or were working in silence. It was found that performance was greatest for both the quiet and NLYR condition, and poorest for the two lyrical music conditions (DYLR and LLYR). Although individuals perceived themselves to have performed best in the LLYR condition following a self-report measure, it was demonstrated that music impaired the performance of individuals on the reading comprehension tasks. Explicitly, performance was impaired by music with lyrics.

In addition to studying the presence of lyrics, music has also been examined in terms of its affect and tempo, as seen in the study by Thompson and Schellenberg (2012). Having either a slow or fast tempo, and a low (negative) or high (positive) affect, participants were asked to complete a four-minute reading, followed by a series of questions to measure reading comprehension (Thompson & Schellenberg, 2012). Twenty-five participants were randomly assigned to one of four groups that manipulated both the affect and tempo of the played music - slow and low, slow and high, fast and low or fast and high, (silence being used as a baseline control). From each condition, the only significant difference was found in individuals who read the passages and answered questions during a fast and high music track. Repeatedly, individuals listening to music with a fast tempo and positive affect performed the worst (Thompson & Schellenberg, 2012). Because music with lyrics is similar to language in the sense that there is a hierarchical order of elements, the overlap of these cognitive processes is believed to account for the effects of music on performance (Thompson & Schellenberg, 2012). However, the differences in affect and tempo between conditions highlight these two musical aspects as potential confounding variables.

In contrast, other studies examining reading comprehension found that performance increased during music without lyrics (Patson & Tippet, 2011) and that performance also increased during calm music with lyrics (Hallman et al., 2000). Despite the paradoxical results, with the use of differing music genres and task types in these studies, it is possible that there is a some sort of relationship between the presence of lyrics in music and reading comprehension performance.

Visuospatial Ability and Music

Visuospatial ability has also been studied with relationship to background music and this research likewise, shows inconsistent results. Using a sample of undergraduate students, participants either sat in silence for 10 minutes prior to the assigned task, or in a condition in which Mozart music was played (Schellenberg, 2005). Those students assigned to the Mozart condition before completing the visuospatial puzzle had a significantly greater performance than those sitting in silence prior to the task (Schellenberg, 2005). Adversely, Patson and Tippett (2016) found in their study of background music on visuospatial task, that there was no effect on performance when the sample consisted of both musicians and non-musicians. The three auditory conditions in this study included music played correctly, music played incorrectly and silence (Patson & Tippett, 2016). Both conditions of music were composed of four piano pieces (without lyrics). Overall, the study of visuospatial ability and background music demonstrates further inconsistencies to the definite effects that music has on cognitive performance, as well as additional dimensions for the variable of music that have been examined.

Serial Recall and Arithmetic with Music

Despite the incongruent results for several cognitive measures and their relationship with background music, there are certain subfields of cognition that have displayed more consistent findings across studies. Serial recall is a task that requires participants to recall a list of items or numbers in a specific order (Smith & Morris, 1997). When an individual engages in a serial recall exercise, it has consistently been demonstrated that performance is worse with the presence of any background noise (Perham & Vizard, 2011). Moreover, measures of arithmetic have been consistent across research, highlighting no real effect of music in these areas of mathematics (Furnham & Strback, 2002). These results establish that music can have specific, cross-study effects on cognition.

Current Investigation

The previous literature discussed clearly presents that there are many inconsistencies across past research. Samples used have included a variety of individuals ranging from primary students to undergraduate students, with differences in their musical experience (non-musician to musician). The use of samples at different ages may pose an issue with respect to neural development. Having individuals at different developmental stages or with differences in their musical experience may have each sample reacting cognitively differently to the presented stimuli in each study. The way that music is presented is also not consistent. In some studies music is presented before the task while other studies play music during the task. Furthermore, the types of music used include genres from classical to pop, with songs sometimes chosen by the researcher and sometimes chosen by the participant. Some music included lyrics while others did not. Finally, although testing similar cognitive processes, the tests used in each of the studies varied. This makes it challenging to determine if results on these tests are due to the presence of background music, or the difficulty level of the task. Therefore, the differences noted above make it impossible to compare results across studies. It is for this reason that a clear-cut, standardized conclusion regarding the effect that music has on cognitive abilities, has yet to be reached.

By noting faults in previous research investigations, the current study looks to draw a more precise conclusion of the effects of music on cognition by more carefully controlling the variables used. The Cambridge Brain Science (CBS) tests are computer based cognitive assessments based on well-developed psychological measures that have been thoroughly researched (Hampshire et al., 2012). These tests assess separate domains of cognition including verbal processing, reasoning and short-term memory. Verbal processing is the ability to process words and properties of language. An example of this test would be the ability of a participant to remember a brief description that applies to an image, and correctly judge the accuracy of the statement. A second example would be a challenge similar to that of the Stroop Task, where individuals have to process discrete differences between word meaning and word colour. Reasoning is an individual's ability to think logically and sensibly and can be measured by having participants manipulate objects spatially in their mind, and then deduce whether the two are similar or not. Short-term memory requires individuals to hold information in their mind that is then recalled later in the task. The ability to test different cognitive domains in the same individual, during a single testing session, will allow for comparing the effect of music on a variety of cognitive tasks – using subjects as their own control (Hampshire et al., 2012).

The current study will have four separate testing conditions: music with lyrics, music without lyrics, silence, and noise (scrambled music). All songs will be from an unfamiliar source to ensure that the level of familiarity is consistent across individuals, and that each participant is hearing the music for the first time in the study. With the same music source, both music with lyrics and music without lyrics will be tested to determine the potential effects of lyrics on cognitive performance. Finally, musical aspects such as affect and tempo will be controlled for, ensuring the results gathered are due to the presence of the music and not the induced affect (positive or negative). Specifically, the songs chosen for each individual will be similar in terms of beats per minute, and frequency. This will guarantee that the speed is consistent from one participant to the next and theoretically should induce the same emotional state, if any. Furthermore, the silent condition will be used as a baseline measure for cognitive performance, and the noise condition (scrambled versions of the song with the same audio frequencies) to control for effects as a result of auditory stimulation.

Personality and Music

A question remains however as to why individuals have differences in their preferred study habits. Some individuals are more inclined to listen to music, whereas others prefer silence. Consequently, the way people react to music, and therefore music's ability to affect their cognition may have to do with individual differences. Previous studies have shown specifically that these differences may be related to personality.

The most studied personality dimension with respect to music and cognition is introversion/extroversion. Defined on the Eysenck Personality Scale as the degree to which a person is outgoing and interactive with people, introverts fall lower on that scale being more reserved and isolated, whereas extroverts are higher up on the scale, and are more engaging with their peers. In a study carried out by Furnham and Allass (1999), serial recall was tested in introverts and extroverts in the presence of background music. Participants listened to music categorized as simple (single instrument), or complex (multiple instruments) (Furnham & Allass, 1999). Researchers found a difference across personality such that introverts performed better than extroverts in the simple music condition, whereas extroverts excelled in the condition where complex music was played. Similarly, a personality difference was found when testing measures of reading comprehension. After reading seven passages and answering a series of multiple-choice questions, Furnham and Strbac (2002) noted a significant difference in performance between introverts and extroverts. In the presence of background music, it was found that introverts performed worse on the reading comprehension task when compared to extroverts (Furnham & Strbac, 2002).

Predictions

Through the inspection of previous literature, hypotheses were developed for the current study. In conditions testing verbal processing, it is hypothesized that performance will be worst in conditions where music with lyrics is presented, similar to the study conducted by Patson and Tippett (2016). When testing measures of reasoning, it is hypothesized that it will be affected equally in both conditions of lyrics and no lyrics. Therefore, as shown in other studies such as Perham and Currie (2014), individuals completing measures of reasoning in the presence of background music will perform worse than if they were to complete the tasks in silence. Lastly, short-term memory will be most affected in conditions where music with lyrics is played. When trying to hold things in memory, individuals will perform the worst when they are listening to music that contains lyrics. It is additionally hypothesized that introverts will be more affected by music than extroverts in both conditions of music with lyrics and no-lyrics as seen in studies such as Furnham and Strback (2002).

Methods

Participants

Thirty-five undergraduate students from Western University participated in this study: 15 in the first experiment and 20 in the second. SONA, an online research participation website for first year psychology students, and On-Campus advertisements were used to recruit participants. All participants were required to have normal to corrected normal vision and hearing as testing took place on a computer with the presence of background music.

In experiment one, five participants were male with a range of 17-24 years of age (*M* = 19.07*, SD* = 1.94). In experiment two, seven participants were male with a range of 18-25 years of age (*M*= 21.06*, SD* = 1.78). Age calculations in experiment two are based on a sample of 18 individuals, as two participants were excluded due to lack of demographic information. Participants received $10.00/hour or one SONA credit for their time.

Materials

Demographics Questionnaire. Participants completed a demographic questionnaire prior to testing in both experiments, as a means of gathering information including age, sex, gender, education level, musical experience, etc. Questions from the GOLD-MSI inventory (Müllensiefen, D., Gingras, B., Stewart, L., & Musil, J., 2013) were also included (See Appendix A). These questions specifically exposed individual differences in musical sophistication that may account for differences in performance across participants. The questionnaire has a stated Cronbach's α value ranging between 0.80 and 0.92 (Müllensiefen, Gingras, Musil, & Stewart., 2014)

Cambridge Brain Science Battery (CBSB). The Cambridge Brain Science (CBS) tests are computer based cognitive assessments, derived from well-developed psychological measures that have been thoroughly researched (Hampshire et al., 2012). Three separate tasks were chosen from the CBSB for each experimental condition. In experiment one tasks were chosen based on their factor loading in each cognitive domain tested by the CBSB (Hampshire et al., 2012) as well as their feasibility in a future Electroencephalography (EEG) study (i.e. did not require a lot of mouse movements to complete). In experiment two, the tasks were chosen based on previous results from our lab showing effects of music on performance (Unpublished Results). Performance on each of the tasks make up the three dependent variables in each study.

Music. The auditory conditions used in both experiments included four, unfamiliar, songs written by Dr. Adrian Owen. Every participant only heard one song, with each song having three distinct versions: one with lyrics, one without lyrics (using the program garage band lyrics were removed to leave only the music), and a scrambled noise version (the music track was scrambled to present audio with the same frequency information as the music but without the structure of music). All songs were presented at 140 beats per minute to control for further musical characteristics including tempo and affect. A silence condition was also used, creating a total of four different 'music' conditions as the independent variable in both experiments.

Self-Assessment Manikin (SAM). The Self-Assessment Manikin (SAM) is an emotion assessment tool that uses graphic scales, depicting cartoon characters expressing three emotion elements: pleasure, arousal and dominance (Bradley, M. & Lang, P.J., 1994). SAM has a Cronbach's α value between 0.83 and 0.89 as proven by Mohammad and colleagues (2012) signifying promising validity and reliability. The purpose of SAM was to gather both affect and preference ratings for each auditory condition experienced by participants in both experiments (See Appendix B).

Eysenck Personality Questionnaire. A questionnaire that assesses the personality traits of a person, referred to as the Eysenck Personality Inventory (EPI) (Eysenck, S.G.B. & Eysenck H.J., 1965). Personality dimensions include Introversion/Extroversion, Neuroticism/Stability, Psychoticism/Socialization and a Lie scale. For the purpose of the current study, only measures from the Introversion/Extroversion scale were used, having a Cronbach's α value between 0.85 and 0.90. An online, self-completed, Qualtrics survey was created to gather an overall score of an individual's Introversion/Extroversion level. Higher scores indicate that the participant is more extroverted. This survey was administered to participants halfway through the study.

Cognitive Tasks: Experiment 1

Verbal Reasoning Task. A distinct measure of verbal memory where two shapes are displayed on the center part of the computer screen, accompanied by a brief description of their spatial relationship. The individual must respond with either true or false to whether the description accurately describes the relationship of the two images. The participant completes as many trials as possible within 90 seconds, and a computerized score is calculated based on the individual's performance (See Appendix C).

Spatial Rotation. A measure of reasoning in which two similarly coloured grids are presented on the screen. The individual is required to determine whether the second grid is a rotated version of the first. The grids are rotated by a multiple of 90 degrees and participants state through a button click on the computer whether the two images are a 'match' or a 'mismatch'. The participant completes as many trials as possible within 90 seconds, and a computerized score is calculated based on the individual's performance (See Appendix D).

Spatial Span. 16 squares are displayed on a 4 x 4 grid. During the task, a sub-set of the grid squares will flash in a random sequence, and participants must repeat this sequence by clicking on the squares in the same order in which they flashed. If the participant responds correctly, the number of flashing squares in the next sequence increases by one. If the participant responds incorrectly, the number of flashing squares in the next sequence decreases by one. The task ends after three errors (incorrect response) and a computerized score is calculated based on the individual's performance (See Appendix E).

Cognitive Tasks: Experiment 2

Colour-Word Remapping. A measure of verbal memory, much like the Stroop task. On the computer screen, three names of colours are displayed: two at the bottom and one at the top.

Participants must indicate which word at the bottom correctly describes the colour the word at the top is printed in. The participant completes as many trials as possible within 90 seconds, and a computerized score is calculated based on the individual's performance (See Appendix F).

Paired Associates. A measure of short-term memory using randomly displayed boxes across the computer screen. These boxes open one after the other to reveal an enclosed object. Once all the boxes have displayed their content, objects are displayed in a random order in the middle of the screen. The individual must then click on the box containing the presented image. If the participant responds correctly, the number of boxes on the next trial increases by one. If the participant responds incorrectly, the number of boxes on the next trial decreases by one. The task ends after three errors, and a computerized score is calculated based on the individual's performance (See Appendix G).

Self-Ordered Search. A task measuring short-term memory where several boxes are displayed on the screen. The participants are required to find a hidden 'token' by clicking on boxes one at a time to reveal their contents. Once found, the token is hidden within another box. On any given trial, the token will not appear in the same box more than once, and so participants must search until the token is found in each box once. Looking in the same empty box more than once counts as an error. If the participant responds correctly, the number of boxes in the next trial increases by one. If the participant responds incorrectly, the number of boxes on the next trial decreases by one. The task ends after three errors, and a computerized score is calculated based on the individual's performance (See Appendix H).

Procedure

The procedure for experiment 1 and 2 is identical. Testing took place at the Brain and Mind Institute (BMI), where the experimental setup consisted of a desk, computer and pair of speakers. Prior to testing, participants were required to read the Letter of Information for the study, highlighting details of the instructed task. Upon completion, participants were further instructed to fill out and sign both a consent form and a demographic questionnaire for the experiment.

Once participants completed the required paperwork, they were registered with a randomized email (created with YOPmail) and password that allowed them access to the CBSB website. An email is required to access the CBSB and YOPmail provides a randomized, disposable email to ensure anonymity and confidentiality of individuals. Participants first completed a practice block to familiarize themselves with each task before the administration of the testing blocks. Unpublished results from our lab have also highlighted a practice effect of tasks between the first and second trial, therefore the practice block acts to remove potential bias in the remaining trials as well.

The experiment was set up as a block design, consisting of a total of five blocks – one block as a practice trial, and four additional blocks of testing. Within each block, participants completed each of the three tasks in a randomized order. Across blocks, the order of the auditory conditions was also randomized. For example, one participant might have received the version of music with lyrics in their first block, music without lyrics in second, silence in third and the noise condition in their fourth. The next participant would have received these conditions in a different order. This allowed us to account for effects due to condition order.

Four songs were used in this experiment and each participant only heard one song. Randomization allowed for control of song choice, granting researchers the ability to account for effects due to the type of audio presented. At the completion of each testing block, the researcher immediately entered the room to gather both the preference and affect ratings for how the individual felt about the audio condition they just experienced. Three separate ratings were gathered, each on a scale of one to nine using the SAM. Measures included the participant's levels of like/dislike, calm/excited and happy/unhappy (See appendix B). Between blocks two and three of the experiment (halfway through the experiment) the Eysenck Personality Questionnaire was completed.

Finally, after all four blocks, participants were given a debriefing form and the chance to address any questions or concerns they had about the study.

Results

Experiment 1

Music and Performance. Two 3(tasks) x 4(music conditions OR blocks) repeated measures ANOVA were used to test the effects of both music condition and block order on individual task performance using SPSS. Results showed no main effect of condition ($F(3,42) = 0.86$, $p = .191$) and no condition x task interaction ($F(6,84) = 0.83$, $p = .224$). There was also no main effect of block order ($F(3,42) = 1.93$, $p = .404$) and no block x task interaction ($F(6,84) = 0.46$, $p = .134$). Greenhouse-Geisser p values were reported and significance was tested at the 0.05 level.

Affect/Preference Ratings and Performance. A correlational analysis was run to examine relationships between SAM ratings and task performance. A significant, positive correlation was seen between Unhappy(1)/Happy(9) Rating x Noise/Spatial Span Score ($r = 0.55$, $p = .04$) with an Unhappy(1)/Happy(9) x Noise rating mean of 4.2, and Noise x Spatial Span z-score mean equal to 0.13. This positive correlation implies that individuals who rated the noise condition as more 'happy' performed better on the Spatial Span task compared to those rating the noise condition as more 'unhappy'.

Personality and Performance. A second correlational analysis was used to test a significant relationship between Eysenck Personality Questionnaire Results of all 15 participants and task performance under each music condition. Results showed no significant correlation between Introversion/Extroversion scores and CBS task scores. No further effects were found.

Experiment 2

Music and Performance. Two 3(tasks) x 4(music conditions OR blocks) repeated measures ANOVA were used to test the effects of both condition and block on individual task performance using SPSS. There was no main effect of condition ($F(3,57) = 0.37$, $p = .758$) and no condition x task interaction ($F(6,114) = 1.18$, $p = .324$). There was no main effect of block ($F(3,57)$, 1.10, $p = .352$) but a block x task interaction was found ($F(6,114) = 2.91$, $p = .029$). This interaction seems to be driven by the Colour Word Re-mapping scores across blocks (See Figure 1). Greenhouse-Geisser *p* values were reported and significance was tested at the 0.05 level.

Affect/Preference Ratings and Performance. A correlational analysis was also run to examine relationships between SAM ratings and task performance. A significant negative correlation was found for Calm(1)/Excited(9) Rating x Noise/Colour Word Re-mapping Score ($r = -0.53$, $p = .160$) with a Calm(1)/Excited x Noise rating mean of 5.4, and a Noise x Colour Word Re-mapping z-score mean equal to -0.13. This negative correlation suggests that those who rated the noise condition as more exciting compared to calm, performed worse on the Colour-Word Re-mapping task. A second significant correlation was seen between Disliked(1)/Liked(9) Rating x Silence/Self- Ordered Search Score ($r = 0.57$, $p = .010$) with

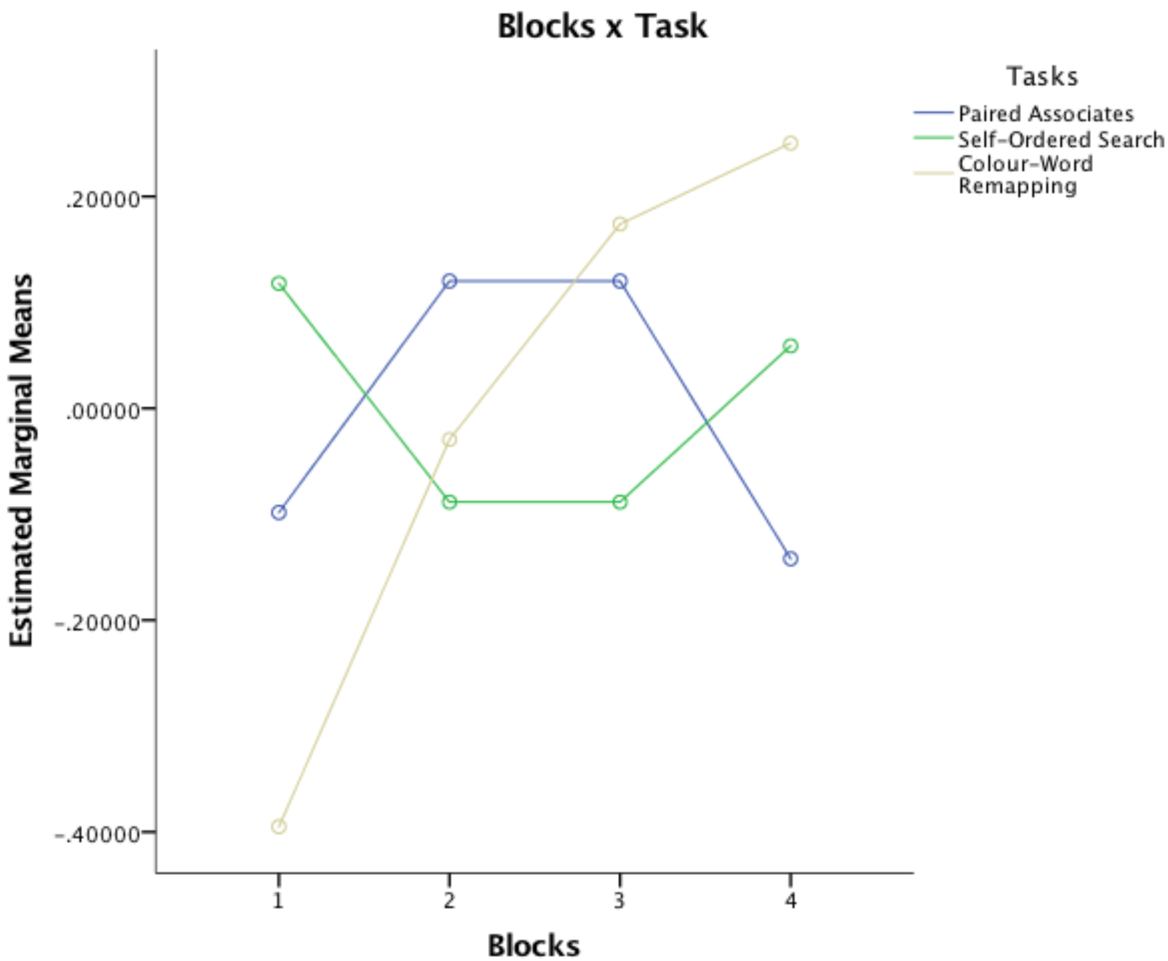

Figure 1. Marginal mean differences in performance for Paired Associates, Self-Ordered Search and Colour-Word Remapping tasks across blocks.

a Disliked(1)/Liked(9) x Silence rating mean of 5.35 and a Self-Ordered Search z-score mean equal to 0.06. This positive correlation implies that individuals who rated the silent condition as more 'likeable' performed better on the self-ordered search task compared to those rating the silent condition as more 'dislikable'.

Personality and Performance. A third correlational analysis was used to test a significant relationship between Eysenck Personality Questionnaire Results of all 20 participants, and task performance under each music condition. Results showed no significant correlation between Introversion/Extroversion scores and CBS task scores. No further effects were found.

Discussion

Both experiment one and experiment two failed to show effects of background music on cognitive tasks. As such, results failed to provide support for the hypotheses that verbal memory, reasoning, and short-term memory, would be affected by manipulating variables of music (i.e. presence of lyrics). Consequently, we are unable to make claims that help understand optimal performance environments that include music. In other words, a more consistent and controlled approach to studying background effects of music on cognitive tasks failed to show any significance. This suggests that the presence or absence of lyrics in music does not affect an individual's performance when completing CBS tests any differently than silence or noise. Therefore, variables of music other than that of lyrics may be the underlying source of previously identified effects.

Music and Cognitive Performance

Results from previous literature have ranged in conclusions about music, stating both beneficial and adverse effects in different testing situations. For example, Cockerton and colleagues (1997) found beneficial effects of background music on undefined cognitive tests (i.e.

they did not specify the type of tests used), while Salamé and Baddeley found that vocal music caused significantly more disruption than instrumental music when individuals completed a verbal memory task (1988). With the goal of the presented study to test the effects of background music in a more consistent and controlled manner, it is possible to conclude the results of this study did just that. Controlling for both unidentified music soundtracks and cognitive tasks referenced in past literature, there was no directional effect of music (either beneficial or adverse) on performance as seen in previous studies. Instead, a more neutral result (no effect) was found. Therefore, our study can act as a reference point where researchers can continue to maintain a high level of control, while manipulating variables outside the presence of lyrics.

Reflecting on the design of the study, there are potential limitations that may be responsible for why effects of background music were not seen. Individuals were instructed to set the volume of the speakers to a level they considered background noise. This would have resulted in volume differences across participants. Correspondingly, some individuals may have set the volume to such a low level that a threshold of noise was not met to cause an effect of music on cognitive performance. In addition, the CBSB tasks may have been too easy. With its main use as a neuropsychological battery (assessing cognitive function to examine consequences of brain damage, disease or illness), the difficulty of tasks may not be the same as the levels of difficulty presented in previous research, or even an accurate measure for healthy individuals. Lastly, it is possible that the unfamiliar music was more easily ignored than if the music used in the study was familiar. If participants were familiar with the song played in each condition, they may have been more inclined to follow the music and sing along for example. This would have caused the music to be more distracting and might have caused a significant, negative effect on cognitive performance

Considering the dates of referenced literature (many studies being conducted in the 80's and 90's), it may be the year in which this study was conducted that led to non-significant results as well. Due to the fact music is more apparent and more accessible in peoples' lives today (e.g. through technology, phones, computers etc.), a potential habituation of music may exist. More specifically, because individuals have greater exposure to music in their everyday activities (e.g. driving, exercising, chores etc.) they are accustomed to the presence of music when engaging in different tasks. This could lead to diminished effects of music as individuals are adapted to its presence. Conversely, in previous studies examining the effects of music, participants might not have been exposed to music as frequently in their everyday life. As such, music would have been considered more distracting to them, leading to results showing significant effects of music on cognitive performance. Ultimately, there was no significant evidence to support the first three hypotheses of this research investigation.

Cognitive Performance, Music and Personality

No difference was seen in task performance for individuals identifying as extroverts (higher scores) on the Eysenck scale compared with those whom identified as introverts (lower scores). This is also inconsistent with past literature. Many studies have demonstrated that introverts are more adversely affected by background music than extroverts, such as the study by Furnham and Bradley (1997). On a recall task, individuals labeled as introverts performed significantly less well than extroverts on the same task, where memorizing a list of objects while listening to pop music was carried out. Unlike the current study, findings such as this led to implications for the study habits of introverts on different cognitive tasks (Furnham & Bradley, 1997).

By having participants in the current investigation self-complete a personality questionnaire, untrue claims in their ratings may have skewed results. Despite the reliability measure of the Eysenck Personality scale having a high Cronbach's α value between 0.85 and 0.90, discrepancies may exist in terms of true personality measures. Knowing they were watched behind a one-way glass, participants might have engaged in the act of self-report bias. Answering simple questions, participants could have been aware of the basis for the questions being asked and wanted to report themselves as more of an extrovert where, truth be told, they engage in more introverted tendencies. This reporting bias would have the potential then to affect correlation measures which might be why non-significant results were obtained.

Noting again that participants could control music volume, if they chose to set it to a low enough level, the loudness might not have passed a threshold that would have made differences between introverts and extroverts apparent. Therefore, because the music may have been too quiet, there was no difference in the effect of music on performance based on personality.

Finally, as the Eysenck Questionnaire is an older tool and present research makes use of different scales like the Myers-Brigg Type Indicator (Briggs, 1976), the choice of questionnaire used might not have been completely suitable for the study. As such, there is no evidence to support the fourth hypothesis of this research that introverts would perform worse on cognitive tasks in the presence of background music compared to extroverts.

Cognitive Performance, Affect Ratings and Preference

Not discussed in the set of proposed hypotheses was a relationship between both affect and preference ratings with task performance. Despite three, significant, moderate correlations of preference and performance (one in experiment one and two in experiment two), mean rating scores of each correlation were around a neutral level of five. Because this neutral rating does not highlight a specific feeling (i.e. either calm or excited) and rather an 'in-between' measure of both feelings labeled on the scale, it does not signify that a specific feeling better relates to performance over the other. Thus, there is little interpretation of these results.

Despite lack of interpretation, SAM and affect ratings should continue to be implemented in future studies examining the effect of background music on cognitive tasks. Much like the study of Thompson, Schellenberg and Husain (2001), where individuals performed better on a spatial task when listening to Mozart (a pleasant, energetic piece) than those in silence, research has provided evidence for how differences in mood and arousal (induced through music) might affect performance. Therefore, if future studies manipulate 'arousal and mood' through music, affect and preference ratings may help to identify emotional differences that could account for variation across performance.

Future Research

Results from our experimental efforts can assist in planning both future research endeavors, as well as implement further exploration into the current study. The demographic questionnaire for this project used items from the GOLD MSI (Müllensiefen, Gingras, Stewart, & Musil., 2013), allowing differences in musical experience across participants to be noted. This includes information such as the ability to play an instrument, years of formal music training, number of hours per day one engages in practicing music etc. Due to the fact past literature has shown that differences in cognitive performance, with the presence of background music, can vary depending on individuals' musical backgrounds (i.e. musician vs non-musician), results from these questionnaires should be correlated with task performance to see if this notion holds true in the current study.

Further improvements for the investigation would be to standardize background music volume to be equal across all participants, including the potential use of headphones (as most individuals use headphones when listening to music). Different cognitive tasks, ones more extreme in their difficulty, should also be used. This is because the difficulty of tests in the current investigation may not have been appropriate in testing individuals outside those who have experienced brain damage (the common use of neuropsychological batteries). Finally, to remove areas where self-report bias may exist, the Personality Questionnaire chosen should be administered to a close friend of the tested individual as well. This would ensure a more reliable and accurate measure of personality. By having a friend complete the questionnaire, results between both people can be examined for consistency, thus avoiding potential instances of self-reporting bias.

Conclusions

Overall, the current investigation was unable to replicate any previous findings where background music produced an effect on cognitive performance. As a result, optimal environments for performance cannot be further understood. Directions for future efforts are noted, although research should look to improve the limitations of this thesis study first.

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Appendix A

Participant Number: ____________

Music Questionnaire

You are free to leave any question blank.

Date: ____________________ Time: ____________________

Male ☐ Female ☐ Age: ____________

1. Which hand do you write with? (circle one) Right Left

2. What level did you attain in school or are currently working towards? (please check one)

Level	
Elementary School	☐
Less than Grade 12	☐
High School Diploma	☐
Some university undergraduate schooling	☐
College Degree (2 years)	☐
Bachelor's degree	☐
Postgraduate degree	☐
Other (please specify):	☐

3. What is your first language? ____________

4. What other languages do you know? (please also rank your degree of fluency 1-very fluent, 6-not very fluent)

____

____

5. How would you describe your musical skills/experience (please circle one number) (not skilled/experienced) 1 2 3 4 5 6 (very skilled/experienced)

Participant Number: ____________

6. Have you ever played and/or had formal training on any instrument (including vocal training)? Yes ☐ No ☐
   If yes, indicate below which instruments, how long you played, and whether or not you still play. **Please include vocal training.**

Instrument	Number of years played	I still play
		☐
		☐
		☐
		☐

Please circle the most appropriate category:

7. I engaged in regular, daily practice of a musical instrument (including voice) for **0 / 1 / 2 / 3 / 4-5 / 6-9 / 10 or more** years.
8. At the peak of my interest, I practiced **0 / 0.5 / 1 / 1.5 / 2 / 3-4 / 5 or more** hours per day on my primary instrument.
9. I have had formal training in music theory for **0 / 0.5 / 1 / 2 / 3 / 4-6 / 7 or more** years.
10. I have had **0 / 0.5 / 1 / 2 / 3-5 / 6-9 / 10 or more** years of formal training on a musical instrument (including voice) during my lifetime.
11. I listen attentively to music for **0-15min / 15-30min / 30-60min / 60-90min / 2hrs / 2-3hrs / 4hrs or more** per day.
12. I have music playing in the background for **0-15min / 15-30min / 30-60min / 60-90min / 2hrs / 2-3hrs / 4hrs or more** per day.
13. What device(s) do you most use to listen to music? ____________
14. Do you listen to music when you study? Yes ☐ No ☐
15. How often do you listen to music while you study? (please circle one number)
    (sometimes) 1 2 3 4 5 6 7 8 9 10 (always)
    I never listen to music while I study ☐
16. How important is music to your identity (please circle one number)
    (not important) 1 2 3 4 5 6 (very important)
17. Do you wear a hearing aid? No Right Left Both
18. Do you have ringing in your ears? Sometimes Always Never
    If sometimes or always, which ear(s)? Both Right Left
19. How would you describe your general hearing abilities?
    (bad) 1 2 3 4 5 6 (good)

Participant Number: ______________

20. When you talk with someone in a place that strongly reverberates/echoes (e.g. church or train station), can you understand what the person says?
(not at all) 1 2 3 4 5 6 (perfectly)

21. When you are with a group (5 people) in a lively restaurant, can you follow the group's conversation?
(not at all) 1 2 3 4 5 6 (perfectly)

22. Based on the sound of a bus or truck, can you tell whether it is moving towards or away from you?
(not at all) 1 2 3 4 5 6 (perfectly)

23. When you are in an unknown environment, can you tell from which direction a brief sound originates?
(not at all) 1 2 3 4 5 6 (perfectly)

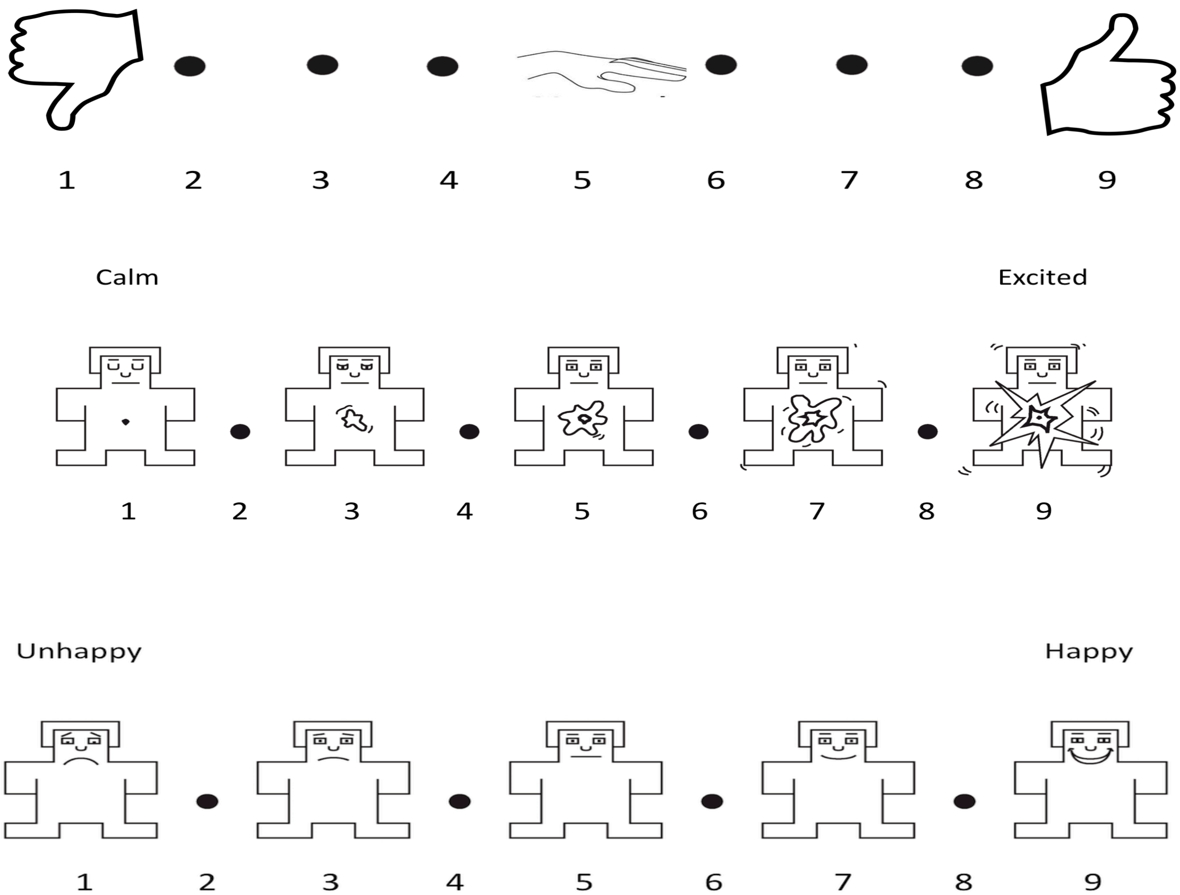
24. Are you able to ignore distracting sound when you concentrate on a specific aspect of your acoustic surrounding?
(not at all) 1 2 3 4 5 6 (perfectly)

Participant Number: ______________

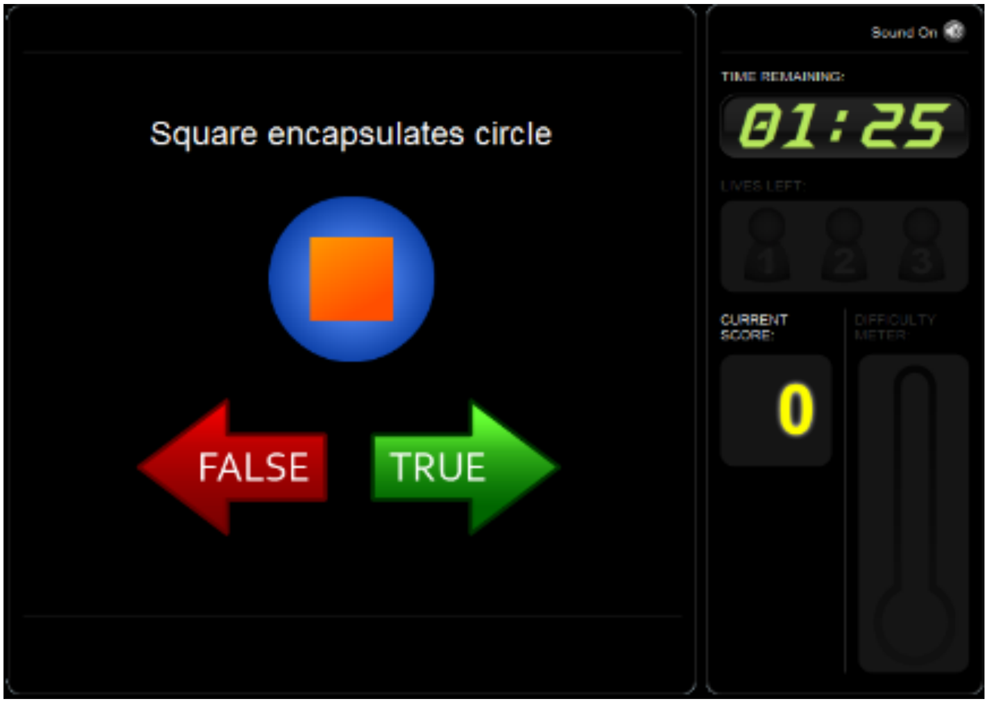
Please circle the most appropriate category using the following scale:
1 = Completely Disagree
2 = Strongly Disagree
3 = Disagree
4 = Neither Agree nor Disagree
5 = Agree
6 = Strongly Agree
7 = Completely Agree

1. I am able to judge whether someone is a good singer or not.	1	2	3	4	5	6	7
2. I usually know when I am hearing a song for the first time.	1	2	3	4	5	6	7
3. I find it difficult to spot mistakes in a performance of a song even if I know the tune.	1	2	3	4	5	6	7
4. I can compare and discuss differences between two performances or versions of the same piece of music.	1	2	3	4	5	6	7
5. I have trouble recognizing a familiar song when played in a different way or by a different performer.	1	2	3	4	5	6	7
6. I have never been complimented for my talents as a musical performer.	1	2	3	4	5	6	7
7. I can tell when people sing or play out of time with the beat.	1	2	3	4	5	6	7
8. I can tell when people sing or play out of tune.	1	2	3	4	5	6	7
9. When I sing, I have no idea whether I'm in tune or not.	1	2	3	4	5	6	7
10. When I hear a piece of music I can usually identify its genre.	1	2	3	4	5	6	7
11. I would not consider myself a musician.	1	2	3	4	5	6	7

Appendix B


1 2 3 4 5 6 7 8 9
Calm
Excited
1 2 3 4 5 6 7 8 9
Unhappy
Happy
1 2 3 4 5 6 7 8 9

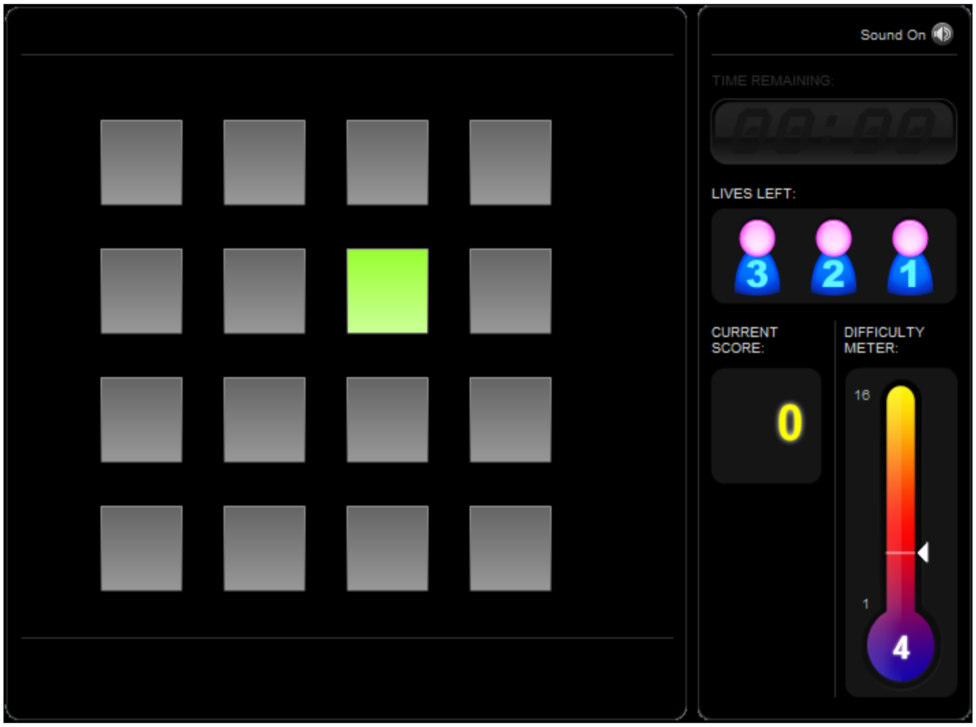
Appendix C


Sound On
TIME REMAINING:
01:25
Square encapsulates circle
FALSE
TRUE
LIVES LEFT:
CURRENT SCORE:
0
DIFFICULTY METER

Appendix D


Sound On
TIME REMAINING:
01:15
LIVES LEFT:
1
2
3
CURRENT SCORE:
14
DIFFICULTY METER:
20
1
6
MATCH
MISMATCH

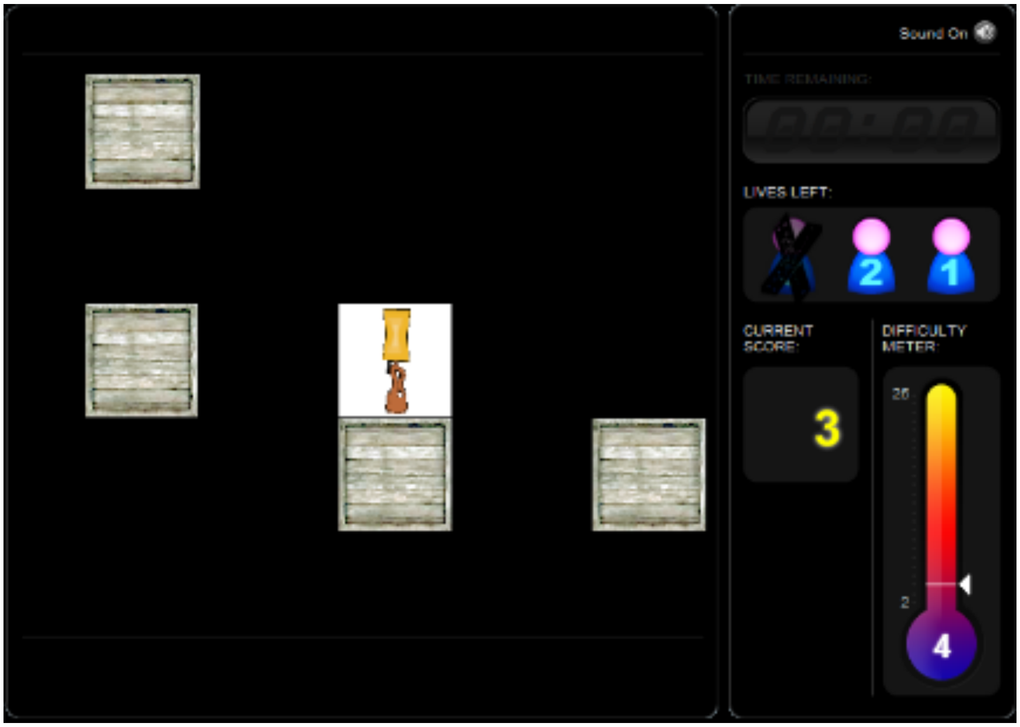
Appendix E


Sound On
TIME REMAINING:
LIVES LEFT:
3
2
1
CURRENT SCORE:
0
DIFFICULTY METER:
16
1
4

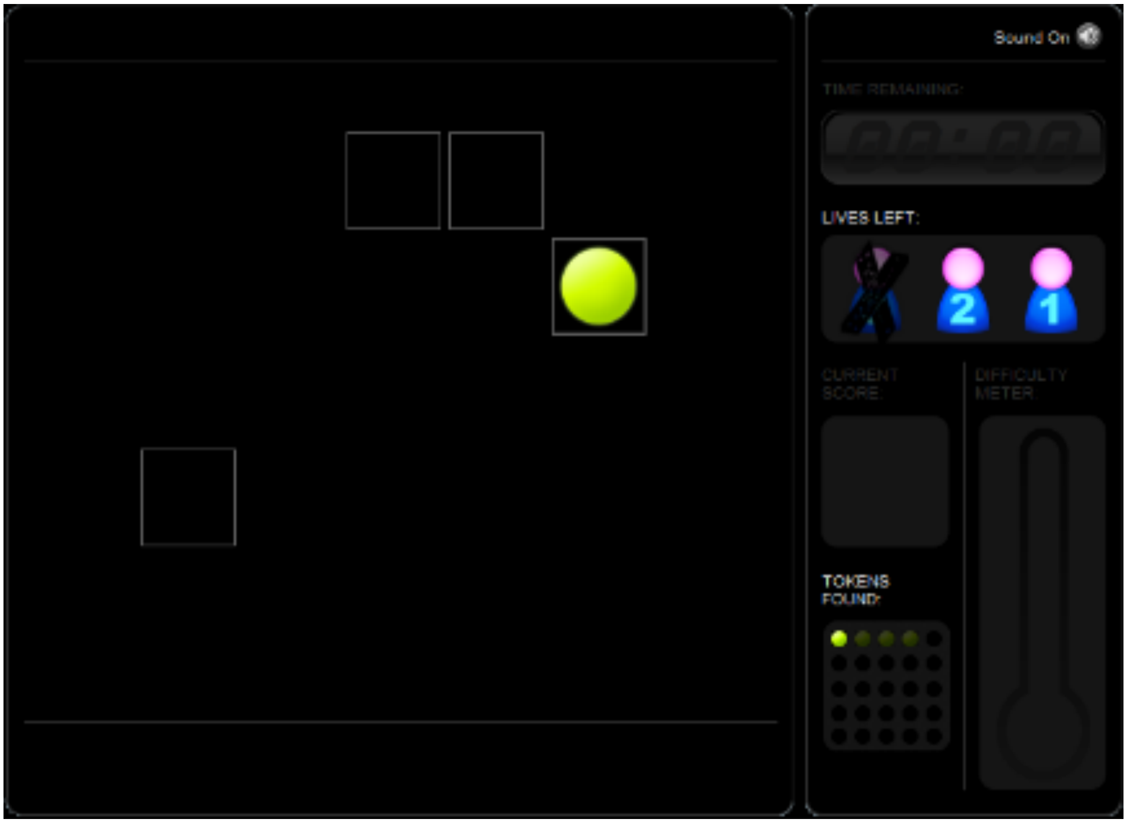
Appendix F


Sound On
TIME REMAINING:
01:29
LIVES LEFT:
1
2
3
RED
BLUE
RED
CURRENT SCORE:
0
DIFFICULTY METER:

Appendix G


Sound On
LIVES LEFT:
2
1
CURRENT SCORE:
3
DIFFICULTY METER:
26
2
4

Appendix H


Sound On
TIME REMAINING:
LIVES LEFT:
2
1
CURRENT SCORE:
DIFFICULTY METER
TOKENS FOUND: