Inherently Distracting, Yet So Enjoyable. Can Music Improve Our Cognitive Endurance?

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Abstract

The current study focuses on the impact that music has on motivation as seen through persistence on a time-consuming task and task performance. Most previous research reveals that when music is coupled with a mentally challenging task, performance tends to be negatively impacted by the presence of music. The current research examined the influence music has on participants' desire to persist in a challenging and time-consuming task. The study assesses the hypothesis that when music is coupled with a mentally challenging / draining task, participants will spend longer on the task than participants completing the same task without music. To evaluate this hypothesis a study was created that examined performance and persistence on logic puzzles and a free writing task when participants completed these tasks with and without background music. Findings from the study revealed that, when performing logic puzzles, participants in the music condition took significantly longer to achieve the same level of accuracy as those in the no music condition, suggesting that the presence of music was detrimental to performance on this task. On the writing task, the number of words produced were not significantly different between the music and no music conditions, but participants who completed the task without music tended to spend more time writing their responses than those who completed the task with music in the background. These findings suggest that the presence of music was not detrimental to the writing task and may have increased the efficiency of the writing process. Interestingly these results do not support the primary hypothesis that the presence of music would lead to longer task persistence, though the music appears to have had a positive impact on the creative writing task. The results of this experiment suggest that the presence of music may be detrimental to some cognitive tasks but could potentially facilitate others.

Keywords: Cognitive Performance, Endurance, Multitasking, Music, Arousal, Persistence

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A survey run by Kononova and Yuan (2017) revealed that, in a sample of 524 college students, 72% of respondents reported that they habitually listen to music while studying or working, with the goal of increasing their level of enjoyment and relaxation. Some also reported using music for efficiency of work or for a sense of escape.

Listening to music while engaged in another activity is a dual task that falls under two purviews, both research on multitasking, and research that follows music and performance. Although multiple media streams may increase enjoyment during a task, this attempt to split attention can have negative consequences. However, it is worth stating multitasking studies, are complex as a relationship can change depending on the unique scenario. For example, two hundred participants took part in an experiment where they drove a car while talking on the phone; only 2.5% were not negatively impacted by multitasking (Watson & Strayer, 2010). Therefore, there are many published studies showing that the presence of background music may negatively impact task performance compared to silence (Anderson & Fuller, 2012; Gonzalez & Aiello, 2019; Perham & Sykora, 2012), whereas outright there are few studies that show that music alone may lead to better performance than no music. However, two studies show a bit of light in this path; one by showing that arousing factors may play a role in motivating better performance when those sources of arousal do not directly interfere with the cognitive requirements of the task (Yerkes & Dodson, 1908) and another study demonstrating that, for tasks with low cognitive and attentional demands, arousing music may facilitate task performance relative to silence and low arousal music (Gonzalez & Aiello, 2019). The current study wished to build roots in this diverse research field by testing whether music may be beneficial in motivating participant endurance during a challenging task. Therefore, broadening the ideas from Yerkes and Dodson (1908), by viewing the impact and arousing factor like music can have on persistence and performance. The current study evaluated the hypothesis that when music is coupled with a mentally challenging / draining task, participants will spend longer on the task than participants completing the same task without music.

Cognitive Performance

Performance is the measure of a person's ability to perform a task to the best of their ability. Cognitive performance is generally considered to be the ability to achieve fast and accurate outcomes during a mentally challenging task. This can include any task with a transparent cognitive portion of mental decision-making that occurs before action, such as memory recall or decision-making. Cognitive performance has many practical uses and can be measured in countless ways, as several different types of mental operations are considered cognitive, including those involved in perception, attention, memory, language, and decision processes. Gonzalez and Aiello (2019), for instance, measured cognitive performance through a memory recall and focused attention task. Whereas Anderson and Fuller (2010) measured cognitive performance on a reading comprehension task. The first step with trying to calculate cognitive performance is to find a measure to quantify performance. There are many aspects to quantification such as scientists focusing on testing one specific aspect of cognition within an experiment, as understanding the individual components is necessary to understand how specific aspects of cognition contribute to general cognitive performance. However, cognitive performance must also be evaluated in everyday situations to be more practical (and utilizable) to the average human being. This relatability enables any significant results following the experiment to be applied directly to similar everyday situations. Furthermore, testing participants in everyday situations, such as a reading comprehension task for a student, is essential to understanding how different cognitive skill sets function together (Anderson & Fuller, 2010). There are many ways to measure cognitive performance, and these measures can be used to assess a person's ability to function in different circumstances, ranging from ideal performance conditions to those that involve external distractions, such as noise or background music.

Arousal

Unsurprisingly, many different factors can significantly impact cognitive performance. One example of this factor is arousal. Arousal is a physiological reaction to a stimulus that involves the autonomic nervous system, and arousal reactions can vary based on the strength and influence of the stimulus. Arousal plays an important role in motivating action. Acting as both a calming force like a mom comforting caress to calm a child to sleep, or a motivating rapid beat change in a hip hop song while working out. For instance, arousal plays an essential role in explaining the results of experiments that study the impact of external stimuli on cognitive performance. In these performance tasks, arousal may facilitate focus and high performance. Interestingly, Yerkes and Dodson (1908) attempted to measure the impacts of various arousal levels on performance. In their classic study, the researchers attempted to motivate the performance of mice in a maze task by using various levels of electrocution as reinforcement. The focus of this study was to evaluate whether variations in electricity strength would cause mice to perform faster in mazes. Electricity in this regard was conceptualized as an arousal element, as when the mouse went into the wrong box, it received a mild, medium, or hard shock. Yerkes and Dodson concluded that when the mice were motivated with low to medium levels of shock their performance improved, but when the shock became too strong the mice ran the maze erratically. This study concluded that a certain amount of arousal might help improve performance, but too much arousal can worsen overall performance. An explanation for this interesting result may be stimuli that influence arousal, such as music, may motivate people enough to focus on a task, leading to better overall performance. Whereas, if the arousal is too stimulating, it may make a participant too heightened, leading to the arousal factor becoming a distraction, as shown in the Yerkes and Dodson study. Yet in foresight it is important to note, that this study created a scenario where not only arousal was a motivating factor but so was fear and anxiety. Therefore, arousal alone cannot be visualized as the pain induced by the mice coupled with the repetitive nature of the experiment limits the reliability that external factors may not be a stronger influence than arousal. In the century since the original study was published, countless scientists have replicated the reported relationship between arousal and performance, using many approaches to manipulate arousal along with many different measures of performance.

Therefore, the next step in studying arousal is finding a way to quantify it and compare its impacts in unique scenarios. Husain et al. (2002) attempted to measure arousal with a questionnaire and correlated variations in music to arousal emotion and cognitive performance. A unique aspect of this study was that music was played prior to the cognitive task, as to not play a role in interfering with the task. In their study, Husain et al. (2002) detailed the interesting impact music that varies in tempo and mode can have on arousal. Their findings demonstrated that arousal could be increased or decreased by modulating tempo. Furthermore, building off the study by Yerkes and Dodson (1908), the results of Husain et al.'s (2002) study demonstrated that increasing arousal (with music) led to better performance on a spatial cognition task. Unsurprisingly, arousal levels increased with a higher tempo song and decreased with a slow tempo song (Husain et al., 2002). Therefore, it can be articulated that complex music with faster beat changes does in fact have a strong impact on a participants arousal state.

What is motivation? How do researchers quantify it?

Motivation is any factor that may be internal or external that encourages a particular action for human beings. Motivation, in general, tends to be a positive factor in enabling people to push themselves or increase the duration of a task. It is also a critical factor in the research regarding cognitive performance or general performance. Performance research always discusses how participants' results vary based on controlled factors. Therefore, motivation (whether internal or external) is pivotal, as it can help encourage participants to work, focus, and perform to the best of their abilities. Therefore, how do researchers quantify and label motivation in cognitive performance research? Quantifying motivation can be difficult, as to explain motivation requires a person to reveal whether a motivating factor has an impact on them. This can be evaluated with direct and indirect modes of measurement. An indirect path would be to run a questionnaire / survey of scenarios in daily life coupled with factors like music to ask participants to self-report hypothetically the influence these factors have on their motivation. Comparatively, the direct method would be to run a study which takes the previously stated scenarios in real life and compare whether participants self-report variations in motivation following a real study.

Multitasking

A common feature in previous research about measuring cognitive performance with music is testing participants performance while actively listening to music. This arrangement results in multitasking, as a participant is evaluated while external stimuli play. Therefore, since this is commonplace in most of the previous research, it is pivotal to define and explain this term, to move forward. Multitasking results from sharing one's attention between two mediums either simultaneously or one at a time in sequence. It is not just limited to devices but anything in life that requires dual attention. Therefore, focusing on two tasks rather than one creates a slower response and worse performance overall (Chen & Yan, 2016).

Another essential term when explaining multitasking is mind-wandering. Mind-wandering is a type of multitasking that results in undivided attention being slowly broken by internal distractions (Wong & Lim, 2021). Researchers had participants complete a matching task involving words with or without a video in the background. A self-report was interwoven into the experiment to measure mind-wandering (Ralph et al., 2020). These researchers then used the results to compare mind wandering with and without a distraction caused by an external stimulus.

Johannes et al. (2019) similarly used the performance measure of task completion while multitasking. Participants took part in a task where they would disclose the location of an arrow while their phone was either present or in airplane mode. These researchers concluded based on a self-report that participants still felt angst about missing notifications even when a phone was in airplane mode (Johannes et al., 2019). This desire to not miss notifications can create mind wandering. These scenarios are similar in their focal point: measures of performance while multitasking. However, variations in the methods embrace the importance of task switching, whereas the other focuses on external distractions.

In a similar experiment focused on multitasking, researchers had participants take classes and, after every week, filled out a questionnaire regarding how often they used their cell phones during class (Bjornsen & Archer, 2015). To evaluate for performance within this scenario, like in school, participants took exams. These exams were then correlated with cellphone usage times. Bjornsen and Archer (2015) concluded that cellphone use within class tended to leave students with worse grades. Therefore, it can be articulated that external stimuli coupled with a mentally challenging task can lead to negative performance.

The impact of experience in multitasking

However, another important factor that must be examined with multitasking is whether those who practice multitasking regularly experience decreased negative impacts of multitasking on their performance, relative to those who do not multitask as often. In one experiment (Alzahabi & Becker, 2013), researchers administered a questionnaire for participants to self-report their personal experience with multitasking daily. Therefore, participants' performance in a task was correlated their experience or preference to multitask on a daily schedule. Following their reports, participants took part in a dual-task experiment where they categorized numbers into even or odd numbers and letters into consonants or vowels simultaneously (Alzahabi & Becker, 2013). The number of correct or incorrect categorizations was used as the measure of performance. The study found that amongst participants in both the switch and repeated trials, those with more experience multitasking had faster reaction times. Also, the amount of time wasted switching between tasks decreased depending on the amount and variety of media multitasking a participant takes part in (Alzahabi & Becker, 2013). Therefore, these results point to the important role that experience with multitasking has on performance while multitasking.

Testing for the impact of music on performance

A common ground in cognition research, is testing participants in common scenarios, like schools and work. Furthermore, when combining cognition and multitasking, an important facet is to evaluate participants in scenarios which are common to the participants they are assessing. Therefore, the results are influential, useful and practical to the average reader. Building off this common ground for how research is focused, now the process for testing music and performance will be explained. Gonzalez and Aiello (2019) evaluated the effect of music on performance on tasks that vary in cognitive demands. In this study, cognition was measured through two tasks that varied in complexity. The high-complexity task was completed on a computer and was a memory recall task. First, the participants were shown a list of matched words and asked to memorize the pairs to the best of their ability. Then, following a short rest period, participants were shown the first term and asked to type in the second term from the pair. Comparatively the simple task was a visual search task; participants were presented with a list of words on a piece of paper and were instructed to cross off any words that started with a specific letter. The researchers hypothesized that the presence and complexity of music would lead to differences in results on the two cognitive tasks. The complex and simple tasks were timed, which the participants were told. In the simple task, there were no significant differences in performance when comparing the conditions with music (collapsed across simple and complex music) to the condition without. However, when comparing directly across all three conditions, it was revealed that the complexity of the music influenced performance on the simple task; performance was significantly higher in the complex music condition than in the simple music and no music conditions. For the complex task, the presence of music hindered performance scores significantly relative to when there was no music, regardless of the complexity of the music. When these results are framed according to the Yerkes and Dodson (1908) arousal-performance hypothesis, it appears that pairing a simple visual search task with an arousing stimulus (complex music) may enhance performance relative to conditions that are associated with lower levels of arousal. However, performance on a complex task may be impaired by the presence of music; the high cognitive load of the task may be incompatible with the high perceptual load introduced by music, which may mitigate any potential arousal benefits that music could otherwise introduce.

Anderson and Fuller (2010) created a study to measure the influence of music on a high reading comprehension through a test like an *SAT* exam. Each participant (high-school students) took two comprehension tests on two days, one day with music and one without it. This reading comprehension task was timed for thirty-five minutes. Cognitive performance was measured through scores on the reading comprehension task, comparing music and no music. This study concluded that when music is coupled with a reading task, performance overall tends to worsen. The authors also reported that most students in this sample reported that they extensively use music while studying, yet they worry that it may negatively impact their cognitive ability (performance). The result of this experiment demonstrated that these worries were warranted; when comparing scores on reading comprehension, participants did significantly better when there was a quiet environment than one with music.

Goltz and Sadakata (2021) similarly used a questionnaire to measure self-reported preferences for using music while studying, also examining the motivational impact of music during tasks such as reading and memory. The results demonstrated that, although most participants also agreed that music helps them improve their moods and motivates their performance in doing tasks like reading or memory tasks, many participants preferred not to use music when doing complex tasks.

The results of Gonzalez and Aiello (2019) suggest that if a task demand is low, stimulating music may improve performance as it may stimulate arousal or become a motivator. When task demands are high, music may become a hindrance. The self-reported preferences of students reflect their use of music for motivation and modulation of mood and arousal (Goltz &

Sadakata; 2021; Kononova & Yuan, 2017), as well as their awareness that music may have a negative impact on high-demand tasks (Anderson & Fuller, 2010; Goltz & Sadakata; 2021). At the same time, a low-demand task, such as a familiar task, a low-attention task, or a task that relies on motor procedures (such as bike riding) may benefit from the mood and arousal effects of music.

A great example of a study that highlights the importance of cognitive load and task demands can be seen in the memory recall test from Perham and Sykora (2012). In this study, the researchers ran a serial recall task involving eight items. Participants were presented with a series of eight letters and were instructed to recall the letters in the order that they had been presented. They completed thirty trials of this task, 10 trials while listening to liked music, 10 while listening to disliked music, and 10 while no music played in the background. The liked music was a popular song, and the disliked music was from the Thrash Metal genre. Preference ratings confirmed that the "liked" music was more pleasant and likable than the "disliked" music; the "disliked" music condition was also rated as less pleasant and less likable than the "silent" condition and as more offensive than the other two conditions. Both music conditions were rated as more distracting than the silent condition. Although the results of the serial recall task showed that the no music condition resulted in the best overall performance, performance in the disliked music condition was significantly better than in the liked music condition. The authors proposed two possible explanations: 1) there may have been differences in the perceptual load for each song, and 2) the liked song may have been more engaging for the participants than the disliked song, and consequently more distracting. Pertaining to the differences in perceptual load, the disliked music fits was from the Thrash metal genre; it was repetitive and had limited variations in beat. These low-beat variations coupled with a high-demand task may have led to lower levels of interference with the memory task than the liked music, which was rhythmically more complex. This explanation underscores the importance of task demands, as a strong external force for future research on performance in multitasking tasks.

Why do we use music?

Research on cognitive performance often focuses on the impact of external factors such as music for improvement or regression in performance. However, most previous research has revealed that performance on tasks varies from person to person and based on the current scenario. So, the question arises: why do we as students, teachers, or people still use music in these scenarios? Goltz and Sadakata (2021) sent out a questionnaire to university students before their study to measure their preference for music usage while studying. This questionnaire revealed that most students preferred not to use music as they perceived it as too distracting. However, most participants said they use music to improve their overall mood or motivation. Also, worth pointing out this self-report supports the results of the previously mentioned study run by Anderson and Fuller (2010), as they concluded music presence leads to worse performance, where the self-report revealed participants knew the distracting nature of music.

Cognitive Performance Results Summarized

The biggest takeaway from these multitudes of studies is that there is no shortage of research on the impact music (and other factors) has on performance and mood. The results from this multitude of studies are dependent on how the study was run, alongside, the participant's preference and experience in the task. Therefore, when discussing the results rather than using a blanket statement, it is better to go from study to study to find common ground. At first, there is a good majority of studies that demonstrated that music has a negative impact on cognitive performance, for example, as previously stated when students were compared on their performance on a reading comprehension task with and without music (Anderson & Fuller, 2010). When the students were compared with and without music, participants significantly did better when there was no music during their test. Similarly, when researchers studied the impact of variations in task demands, they also concluded that in the complex task, the presence of music had a negative impact on performance, relative to the silent condition (Gonzalez & Aiello, 2019).

Amongst all these results that show the presence of music stands as a hindrance to better performance, it is worth stating that some research had some variability in results of music and performance. Perham and Sykora (2012) had participants take a memory recall task while liked, disliked, or no music was played in the background. The biggest takeaway from this study was that music led to significantly worse scores than the no-music condition, like the previous studies. However, music preference may have a minor impact on cognitive performance, as seen by the higher scores in the disliked music condition vs. the liked music condition. It is also worth stating the previous study run by Gonzalez and Aiello (2019) also revealed that in the simple task participants did significantly better when this task was paired with a complex song than with a simple song or with no music. Among the multitudes of studies where music and performance are evaluated, there are no studies that suggest that music is beneficial for every cognitive task, though there is evidence that low demand cognitive tasks may benefit from background music. Interestingly a common ground between these studies, is that music nature from complex fast beats to slow beats had a larger influence on performance than the complexity of the task. Therefore, future studies in this niche should focus on these unique scenarios of music and build on them, rather than performance alone.

Music is not simply a distraction but can also serve as a motivating factor during tasks with a low cognitive load, to potentially improve focus and performance over time if the benefits of the motivation outweigh the costs of the distraction. In summation, it is essential to detail that the presence of music or any form of external stimuli during a high demand task tends to lead to worse task performance. However, it must be stated amongst previous research that it is common ground to have all performance measures timed. Therefore, time consumption as an added level of stress can add to the distracting nature of music, and furthermore influence performance. However, these past experiments do not consider music's impact on the ability to sustain motivation over time, since most previous research measures cognitive performance during timed tasks that are short in duration. For long tasks, it is possible that the arousal benefits of music outweigh the distraction.

The Present Study

The current study will compare whether the presence of music has an impact on participants' desire to persist with a mentally challenging task. Although some research demonstrates that music may interfere with attention and therefore performance, people still use music while studying or completing other challenging cognitive tasks. However, most of the prior research has evaluated task performance under time constraints. People use music because it makes the task more enjoyable and enables them to persist longer than they otherwise would. The present study will examine whether music can play a role in motivating participants to endure challenging tasks for more time than they would if music were not playing. The current experiment was designed to assess the question: Can music help motivate participants to persist longer at a challenging task than if no music is present during the same task? The present researchers hypothesize that when music is coupled with a mentally challenging / draining task, participants will spend longer on the task than participants completing the same task without music.

Method

Participants

Twenty-three participants were recruited through the introduction to the psychology participant pool. Of these, 52% identified as female, and 48% identified as male. Their ages varied from 18 to 20 years old ($M = 18.6$, $SD = 0.79$). The twenty-three participants also varied in current enrollment grade (13% Junior, 22% Sophomore, 65% Freshman). The participants were given course credit as compensation for their time.

Materials

Participants completed trials from two types of cognitive tasks, each described individually below. One of the task was free writing with added prompts to show continuation, alongside multiple-choice logic puzzles. All tasks were presented through Qualtrics on a desktop computer. Half of the participants were provided with a Spotify portal during the experiment and were asked to select music to listen to during their testing session. Each participant in the music group had the opportunity to pick their own music through a playlist or an artist-based radio station. Participants in this regard were given free rein, to pick any genre or whether there were lyrics or not. In case a participant did not have a preference, they were given two playlist to choose from, one with lofi music and another with music that is both throwbacks and modern music. The other half of the participants completed the session in silence. Spotify premium was necessary, to prevent ads as an interruption to the study.

Creative writing task

Each participant was presented with a creative story prompt instructing them to begin writing a fictional narrative about a specific topic (topic was specified in the story prompt) and enter their written response to the prompt into a text box on Qualtrics. After they received the story prompt and entered text into the box, participants were provided with a continuation prompt to help them continue their story (such as, "Incorporate a unicorn sighting into your story"). Participants were instructed to complete up to six creative writing trials. A total of six story prompts and continuation prompts are listed in Appendix A. The amount of time spent responding to each prompt was measured, along with the number of words written in response to each prompt.

Spatial logic task

Spatial logic questions from the book *Mensa: The Genius Test* were used for this task. These questions involve identifying patterns that were presented in a series of images (mostly shapes and composite line drawings) and choosing (from a set of provided options) the next shape that would continue the pattern. Participants completed up to six spatial logic trials. The six questions are listed in Appendix B. Grading these responses were measured based on the amount attempted alongside how many were correct as a measure for performance.

Questionnaire

The questionnaire included basic demographic questions (age, gender, and race), alongside questions asking the participants about their study habits and their preference for using music while studying or performing complex tasks (see Appendix C).

Design

This experiment used a between-subjects design, with the independent variable being the music or no music condition, which participants were randomly assigned to prior to the experiment. The dependent variables include performance measures from the logic task (number of questions attempted, number correct, total time spent on the logic questions, and average time per question) and measures from the creative writing task (number of story prompts attempted, number of continuation prompts attempted, average words for each story prompt, total number of words produced for the prompts alone, total number of words produced in the prompts with additives, average time spent responding to each story prompt, and total time spent responding to story prompts).

Procedure

All participants were recruited through the Psychology Participant Pool Moodle page. There was a sign up for an in-person testing session. Once participants selected a time for their first session, they came to a lab in the Natural Sciences building at their designated time for an individual testing session. Before starting the study, each participant reviewed and signed a consent form (see Appendix D). Participants were seated alone in a small, private testing room for the study. They were randomly assigned to the music or no-music condition, prior to appointment. The experimenter instructed half of the participants to select a playlist they enjoy listening to while studying (if they are in the music condition), and the participant had set the volume to a comfortable listening level. For further demographic research, participants choice in music was kept as either no music, lofi or throwback or self-chosen. However, if a participant did not have access to Spotify or did not prefer music, then the primary researcher gave the participant a choice between two preset music playlists. The music was played on a device controlled by the experimenter (so that the participant cannot turn the music off during the testing session). There were two playlists, one was a “Lofi” playlist and another that contained songs from the past and present. The experimenter explained that the participant can spend up to an hour doing the tasks but that they can stop at any point and were awarded one credit for 30 minutes of participation and two credits if they spend more than 30 minutes on the experiment. The researcher also told participants that a timer was set for 40 minutes in case the participant forgets about the time. Then the experimenter explained the various tasks to the participant. The trials from the two tasks were randomized rather than presented in task-specific blocks, so the participants were able to switch between tasks after completing each trial. So, each participant started after confirming consent a free writing task which continued into an additive. This would be a miniature prompt that asked the participant to add a premade story element into their free writing. Then the participant was transitioned to a logic puzzle with multiple choices, they were told they can spend how much or little time they wanted per prompt and puzzle. Each trial had clear instructions on the screen so that randomization of the task trials will not create confusion. After submitting responses, the participants were asked if they would like to continue to another trial or end the testing session. Those who ended the experiment were instructed to leave the testing room, and those who continued were presented with another trial. Participants continued until they decided to end the testing session or until 40 minutes had passed, whichever happens first. When the participants either quit the study or stopped they were transferred a questionnaire about demographic and study preferences/music use. After completing this, participants were debriefed, thanked, and compensated for their participation.

Results

Descriptive Analyses

This experiment followed a between-subjects format, where every participant completed either condition which was chosen before the experiment. Following the completion of the study, participants took part in a questionnaire that attempted to decipher personal beliefs about music in a participant's daily life. The results of the questionnaire can be seen in Figures 1 through 5. A major takeaway from this study is that a large majority of participants self-reported that they use music quite often in tandem with assignments (26% Always, 26% Most of the time, 22% About half of the time, 22% Sometimes, 4% Never) (see Figure 1). Also, a large majority of participants felt confident in their ability to complete work with music playing in tandem (13% Extremely confident, 40% Very confident, 26% Moderately confident, 17% Somewhat confident, 4% Not confident at all) (see Figure 2). Also, a large majority of participants perceived that the presence of music would be a major motivator for persistence during a challenging task (see Figure 3). However, participants self-reported they felt comfortable using music in scenarios like studying for exams or doing math homework. There was also a disparity amongst participants chosen music playlist with three participants choosing Lofi, seven participants chose their own artist and only one participant using the premade throwback playlist.

Inferential Analyses

The overarching question postulated the impacts of music on task persistence and duration. The hypothesis postulated that when comparing participants who ran the same study with and without music, the participants who ran the study with music will lead to longer duration and more correctly solved logic puzzles. To assess this, the data were analyzed in Jasp, and multiple independent sample t-tests were used to evaluate whether there were differences between conditions on a multitude of measures. The independent samples t-test compared the following factors: the number of spatial questions attempted; the number of spatial questions correct; total time spent on spatial questions; average time per spatial question; the number of story prompts attempted; total time on prompts; average time per prompt; the number of continuation prompts attempted; word sum for prompts; word average for each prompt; and word total (see Table 1). All factors were compared by the two comparison groups of the music and no music categories.

A series of independent samples t-tests was used to compare performance measures between conditions on the logic task. There was no significant difference between the number of spatial questions attempted in the music group (M = 2.58, SD = 1.08) versus the number of spatial questions attempted in the no music group (M = 2.00, SD = 1.48), $t(21)$ = 1.08, p = 0.29, d = 0.45. There was no significant difference regarding the number of spatial questions answered correctly when comparing the music (M = 1.00, SD = 0.45) and the no music group (M = 1.09, SD = 0.70), $t(20)$ = -0.36, p = 0.72, d = -0.16. There was no significant difference in the average time spent per spatial question in the music group (M = 59.78, SD = 33.78) and the no music group (M = 39.39, SD = 20.44), $t(20)$ = 1.71, p = 0.10, d = 0.73. However, the total amount of time spent on the spatial questions was significantly longer in the music condition (M = 165.83, SD = 97.95) than in the no music condition (M = 86.24, SD = 70.19), $t(20)$ = 2.19, p = 0.04, d = 0.93. These results represent that on average participants performed similarly regarding spatial tasks regardless of if they were listening to music or not. However, there was an interesting finding that on average participants who listened to music tended to spend significantly longer solving a logic puzzle as compared to the no-music group. However, the number of correct responses did not differ significantly between conditions, so the longer time spent did not lead to better performance in this regard (see Table 1).

A series of independent samples t-tests was used to compare performance measures between conditions on the creative writing task. There was no significant difference in the number of primary prompts attempted between the music group (M = 3.25, SD = 1.06) and the no music group (M = 2.73, SD = 1.01), $t(21)$ = 1.21, p = 0.24, d = 0.51. There was no significant difference in the total time spent on primary tasks between the music group (*M* = 1283.99, *SD* = 328.36) and no music group (*M* = 1478.85, *SD* = 234.63), *t*(21) = -1.62, *p* = 0.12, *d* = -0.68. There was no significant difference in the number of continuation prompts (additives) attempted for the music group (*M* = 3.00, *SD* = 1.28) and the no music group (*M* = 2.09, *SD* = 1.38), *t*(21) = 1.64, *p* = 0.12, *d* = 0.69. However, the average time spent per prompt was significantly higher for the no music group (*M* = 606.24, *SD* = 220.73) than the music group (*M* = 416.07, *SD* = 92.03), *t*(21) = -2.74, *p* = 0.01, *d* = -1.14. The total number of words produced in response to the prompts (without additives) was not significantly different between the music group (*M* = 485.17, *SD* = 186.58) and the no music group (*M* = 458.55, *SD* = 187.75), *t*(21) = 0.34, *p* = 0.74, *d* = 0.14. The total number of words produced in response to the prompts *with* additives was not significantly different between the music group (*M* = 776.17, *SD* = 316.83) and the no music group (*M* = 666.18, *SD* = 264.78), *t*(21) = 0.89, *p* = 0.38, *d* = 0.38. The average word count per prompt (without additives) was not significantly different between the music group (*M* = 249.93, *SD* = 84.94) and the no music group (*M* = 273.67, *SD* = 142.78), *t*(21) = -0.49, *p* = 0.63, *d* = -0.20. The average word count per prompt *with* additives was not significantly different between the music group (*M* = 151.79, *SD* = 42.21) and the no music group (*M* = 151.79, *SD* = 42.21), *t*(21) = -1.61, *p* = 0.26, *d* = -0.49.

Discussion

Summary of Findings / Implications

The experiment described above was designed to evaluate the influence that music may have on participant performance, alongside persistence. Persistence in this study was operationalized as the duration of time spent working on a mentally challenging task, with performance and persistence being operationalized both as the quantity of work produced, measured through word count during free writing, and the accuracy of the work, measured through the number of correct responses to logic puzzles. The current researcher believed that when comparing participants who complete the same study with and without music, on average and overall participants who listened to music would stay for longer and persist with the experiment as compared to participants who did not listen to music. The results from this experiment reveal that on average participants regardless of their group decided to continue task progression at similar levels, and on average had a remarkably similar amount of total time doing the writing prompts (see Table 1). However, there was a significant result that contradicts the primary hypothesis, where on average participants in the no-music group spent longer responding to each writing prompt as compared to the music group, revealing that the lack of external arousal may have led to more attention being placed solely on the writing task. Furthermore, these results reveal that with regards to word count with and without additives the quantity of work did not vary significantly between participants. Taken together with the significant differences showing that the no music group significantly spent more time per prompt than the music group, the lack of significant difference between the number of words produced by each group shows that those in the music group were able to type just as many words as those in the no music group but did so faster. This may suggest that those in the music group worked more efficiently than those in the no music group, although it is possible that there are differences in the quality of their work that are not captured by word count.

However, these results as a total neither support nor disprove the hypothesis that music may be beneficial in motivating longer duration. The quantity of words did not vary significantly when comparing the two groups, therefore revealing a context where music is comparable to no music, and therefore not harming performance.

Although the null findings may be regarded as inconclusive due to small sample size, this study can stand as a representation of a niche in research where the presence of music did not negatively impact performance.

One of the significant results of the study came from the comparison of participants' average time spent per spatial question. Participants in the music group spent significantly more time on average per spatial logic puzzle. Although this one is interesting, in the context of the rest of the results reveal its tone. Although the music group spent significantly more time on average per logic puzzle, the number of correct responses did not differ significantly across the music and no music conditions. Therefore, regarding performance, longer duration did not lead to better performance, regardless of music or not. The music group took longer to achieve the same level of accuracy as the no music group on the spatial questions.

Strengths and Limitations

This study had multiple strengths. Firstly, a strength of this experiment was the simplicity and ease of access. Most people admitted into college are proficient in typing. Furthermore, with Qualtrics, all participants read instructions and press links to complete the experiment fully. Building off the simplicity aspect, another strength is the limited number of restrictions in this experiment. In this experiment, the only requirements were the age of consent and not being visually or auditorily impaired. This enables a wider variety of participants and enables limiting external factors that could impact the experiment. Another strength of this study was the ease of recruiting participants through the introduction to the psychology pool. Rather than having to go from person to person, everything was virtual, and participants signed up for times that worked for them.

Like strengths, there were a multitude of limitations. The first limitation of this study was the time-consuming nature of data collection. Each participant took one full hour to run, as on average participants stayed for thirty-nine minutes. Even with a study this long in duration, overall differences in perseverance (i.e., the time they spent completing the study) did not emerge between the two conditions. It is unknown whether a study that uses a longer set of tasks would allow for differences in level of motivation to emerge between the music and no music conditions.

Another major limiting factor was external motivation. Regardless of external motivation, people still hate writing and even more hate puzzles, as such no matter how much motivation can be provided this can lead to change in results. People may enjoy the task or stare at the clock the entire time to get their participation credit. Therefore, the focus changes from whether music may be beneficial to performance, to whether a participants persistence and motivation to get the most credits comes first.

The small sample size is a major limitation of this study. When using a between-subjects design, twenty-three participants is a small sample. A larger sample would be necessary to evaluate whether the null results obtained for many of the measures in the current study should be interpreted to mean that there are truly no differences to be found between the groups or if these null results indicate a Type II error–a failure to detect a real effect due to small sample size. It is also possible that the results of this study may not generalize beyond college students, who may be used to studying with music in the background.

Future Research Directions

The current study built new roots in an already diverse research pool on music and performance. The uniqueness came from the usage of persistence and time as a measure of performance. Although a conclusive result is difficult to decipher from this study there is a lot in this study that can become a motivator for future research. At first, if this study were going to be rerun, there would be a few details that should be changed for overall better results. The first major change that would be implemented would be to switch this study from between-subjects to within-subjects. One major takeaway from this study and one of its limitations is the influence of each person's personality and interest on motivation to persist. Therefore, rather than comparing two different groups of people, it would be beneficial to increase the number of participants and have a two-day study where each participant was able to run the study with and without music. Therefore, the impact of personal preference can be removed, and external motivators can be minimized. It would also be interesting to see whether there would be a change in results if the study were run through pen and paper as compared to a computer. Furthermore, another interesting detail to include within a rerun, would be to see how delaying music to certain time periods may impact performance. For example, an experiment that measures the impact that music timing has on performance before, during and after the test would be interesting. Finally, would the results of this study be changed if the two studies were changed to one extremely easy task, and another task that is extremely difficult. Therefore, researchers could visualize the impact of swapping between task and whether music may play a beneficial role in adapting, persisting and performing to the best of persons ability.

With regards to applications in daily life, this study shines with regards to finding items, and scenarios that may provide motivation. Genre, words, beats, and rhythm are all factors that contribute to whether a person finds a song enjoyable or not. Yet a large variety of research shows that music when coupled with a challenging task leads to worse performance. However, when participants are questioned, a large majority admit they find it motivating, and still use music daily, regardless of adverse effects (See Figures 1, 2 and 3). Therefore, this type of research is necessary to decipher why people feel this way and to combat this stigma that music is purely a negative additive to performance. Although in many regards, music may be negatively impacting performance, larger-scale research can prove pivotal in finding scenarios where music influence can change from merely a distraction to the sole motivator to endure, while performing at one is best.

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Figure 1. *How often do you listen to music while working on academic assignments?*

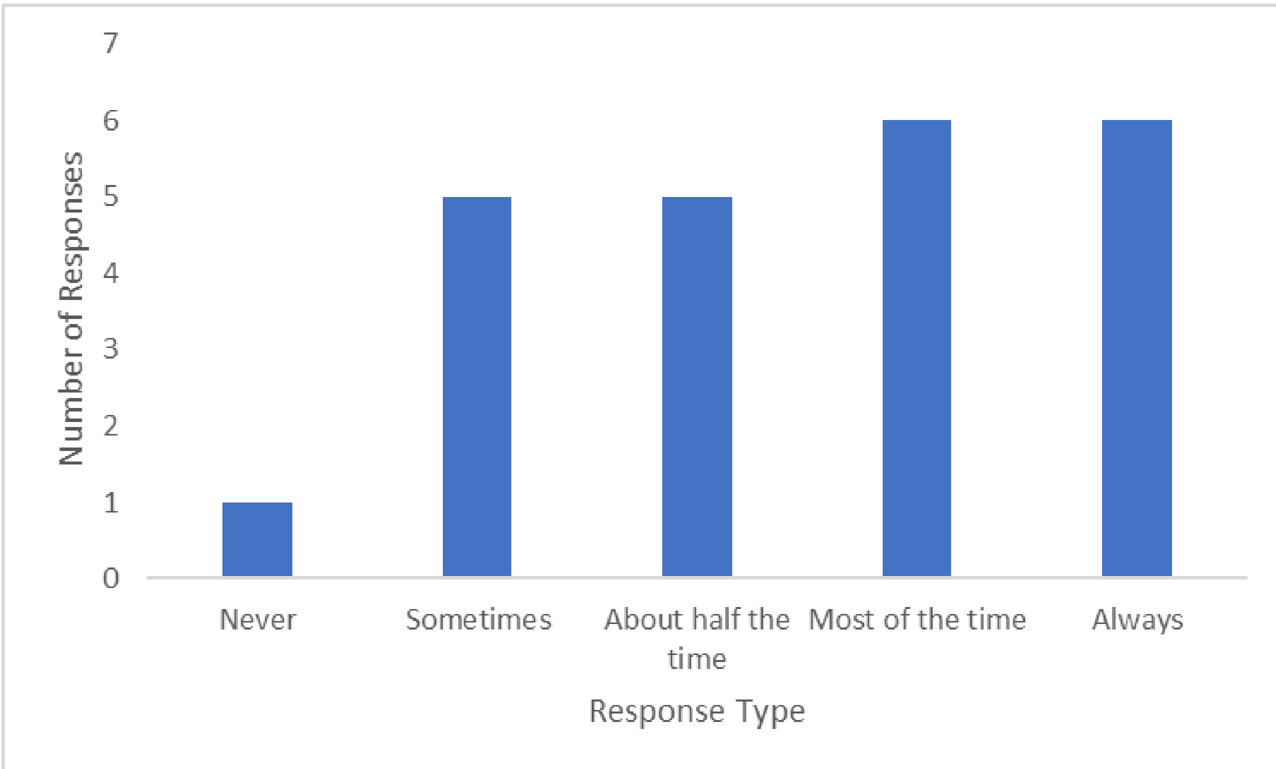


Figure 2. *Confidence in completing work while listening to music*

Figure 3. *Does music motivate you to perform longer during a challenging task?*

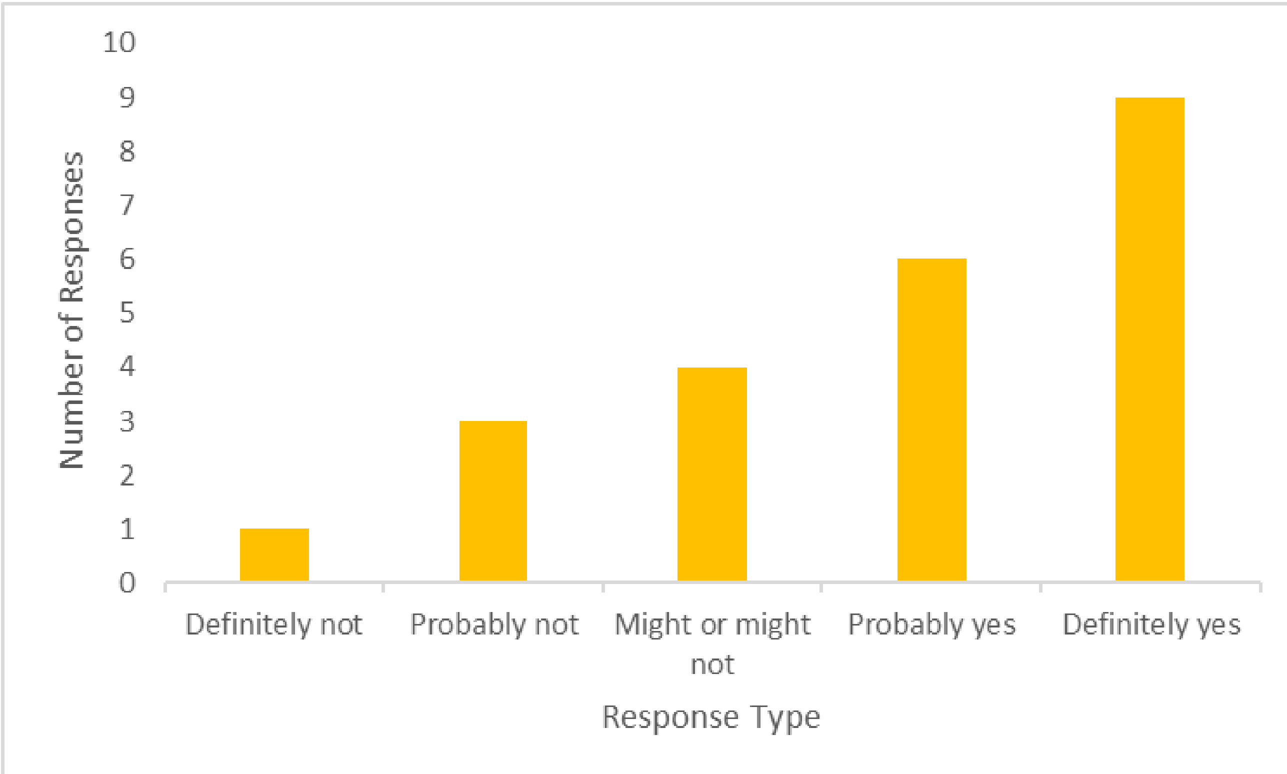


Table 1. *Results Classified*

Result	Music *M*	Music *SD*	No Music *M*	No Music *SD*
Number of spatial questions attempted	2.58	1.08	2.00	1.48
Number correct	1.00	0.45	1.09	0.70
Total time spent on spatial questions (in seconds)	165.83	97.95	86.24	70.19
Average time per spatial question (in seconds)	59.78	33.78	39.39	20.44
Number of primary prompts attempted	3.25	1.06	2.73	1.01
Total time writing (in seconds)	1283.99	328.36	1478.85	234.63
Average time per prompt (in seconds)	416.07	92.03	606.24	220.73
Number of prompts continued	3	1.28	2.09	1.38
Total words without additives	485.17	186.58	458.55	187.75
Total words with additives	776.17	316.83	666.18	264.78
Word average without additives	151.79	42.21	190.62	107.32

Word average with additives	249.93	84.94	273.67	142.78

Appendix A: Story Prompts and Additives

Prompts:

Choose one of these six prompts below as a starting point for your creative writing. The only stipulation to these prompts is that we request you write it as a fictional piece. Along the way, I will call out talking points that you must somehow intertwine into your writing.

1. Please write a short story about the time you went on a trip to the wilderness, what the smells were, who was there, and how it ended. Was it enjoyable, and would you do it again?
2. Write your story about you and your family taking a trip to space for the first time. What did you see, where did you go, and how much did it cost? What year is it, and when you land on the new planet, where did you land, and what did you do during your trip?
3. Write your story about how you gained a superpower (anything you can think of) and how it changed your life. Did you keep your identity a secret, help people, or use your abilities to your benefit?
4. Write yourself into your favorite book or movie. Are you the main character? How does your role in the story change the ending of the book? Do your actions in the book change the entire story?
5. Write your story about your life during a famous historical time (such as the medieval ages, the roaring ’90s, or the Italian renaissance). Was it peaceful, and what did you do for work?
6. Write your story about your dream vacation, how were you able to go there, was it dangerous, and would you go again?

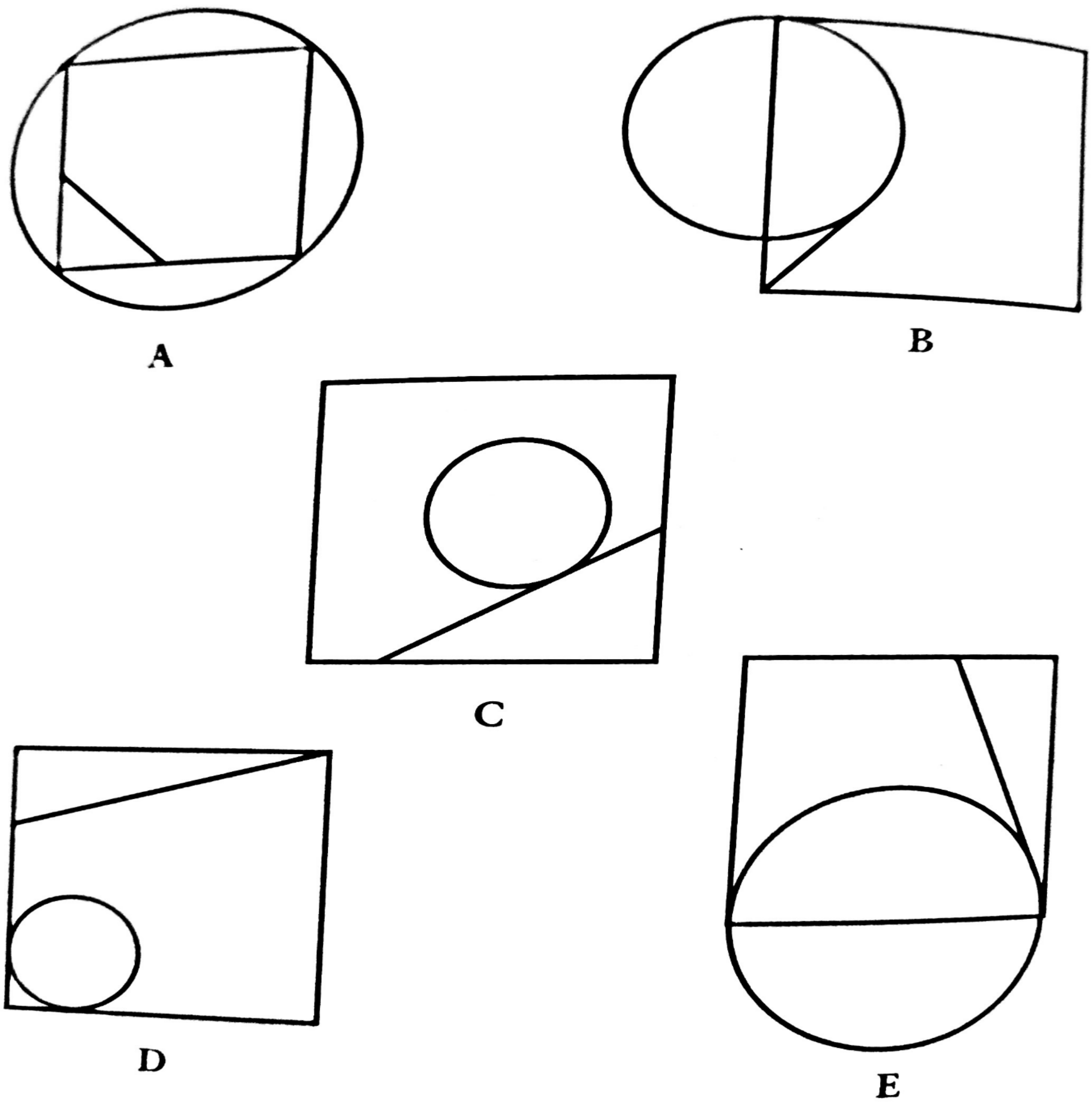
Additives:

1. In your story, add a plot where a stray dog enters and becomes a permanent companion.
2. In your story, add a plot where you make a new friend with a random person along the way.
3. In your story, include a plot about a volcanic explosion somewhere else or near you and how that changes your entire story.
4. In your story, add a plot about how you hear the roar of a lion in the background and how it makes you change your plans.
5. In your story, add a plot where you learn a new ability (mystical or scientific) that helps you along the way.
6. Finally, end your story with a plot about you waking up and finding out everything you have just written was a dream.

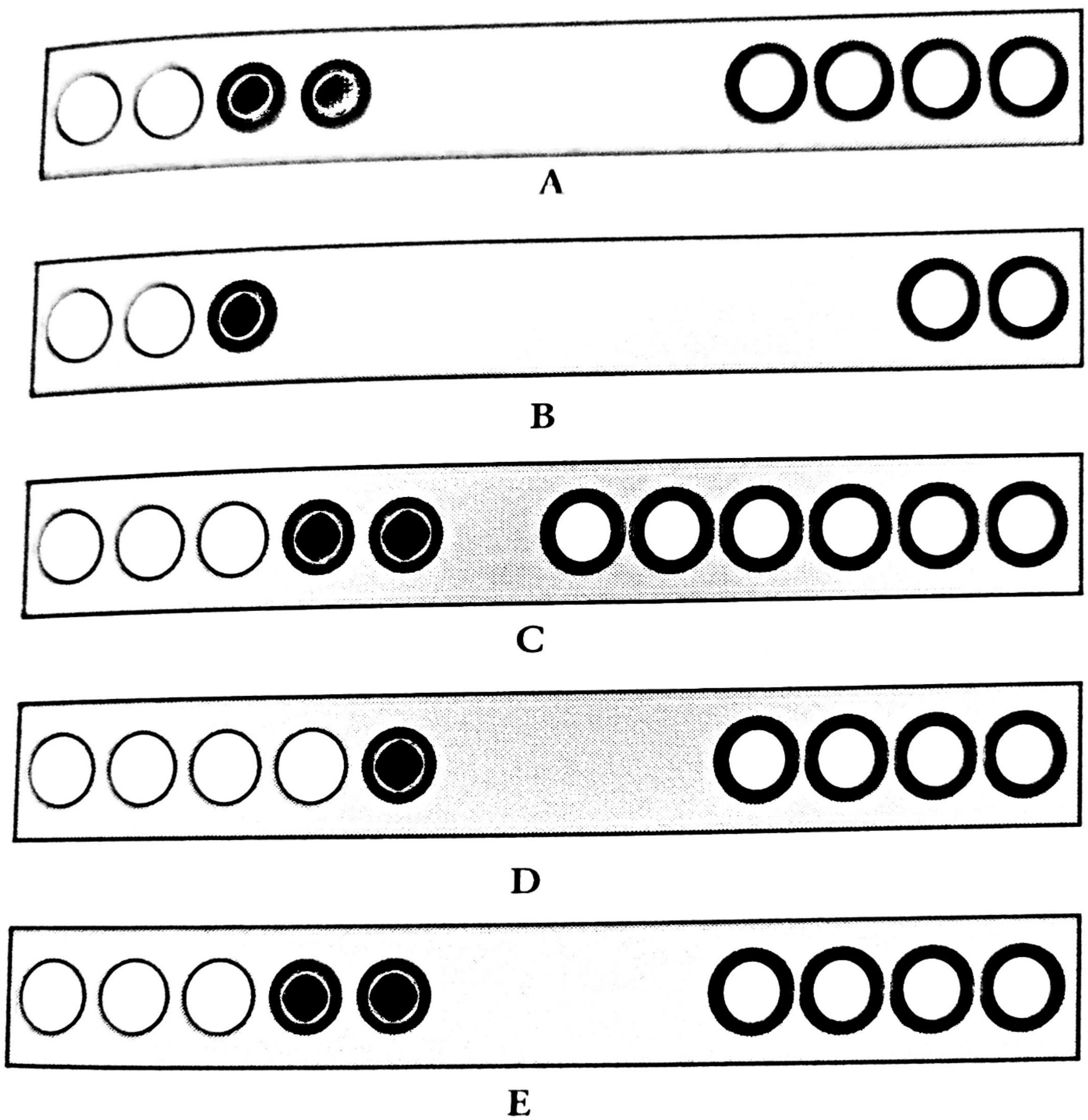
Appendix B: Spatial Logic Puzzles and Answers

44

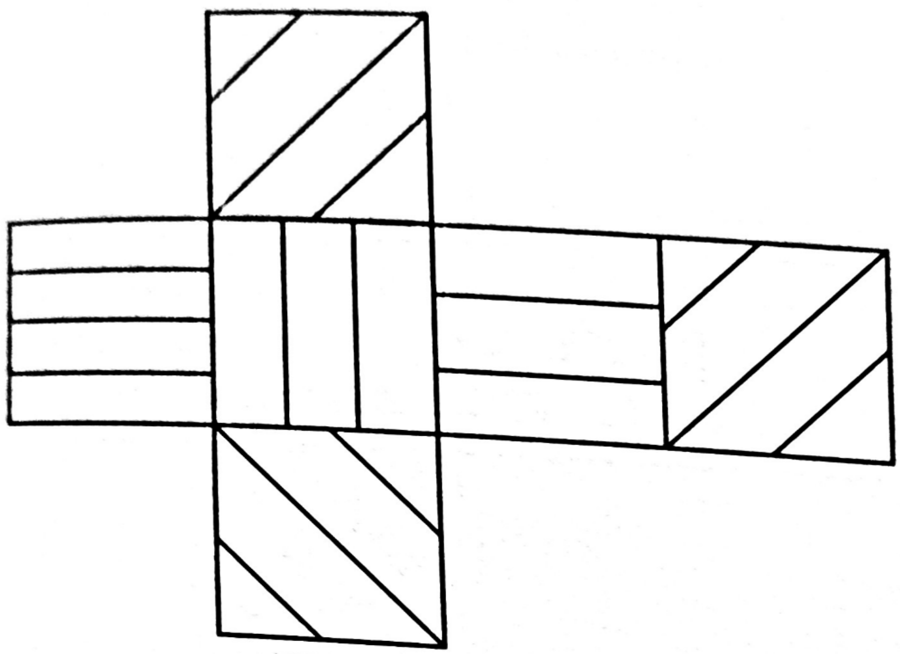
Q1 Which of these is the odd one out? Think triangles.

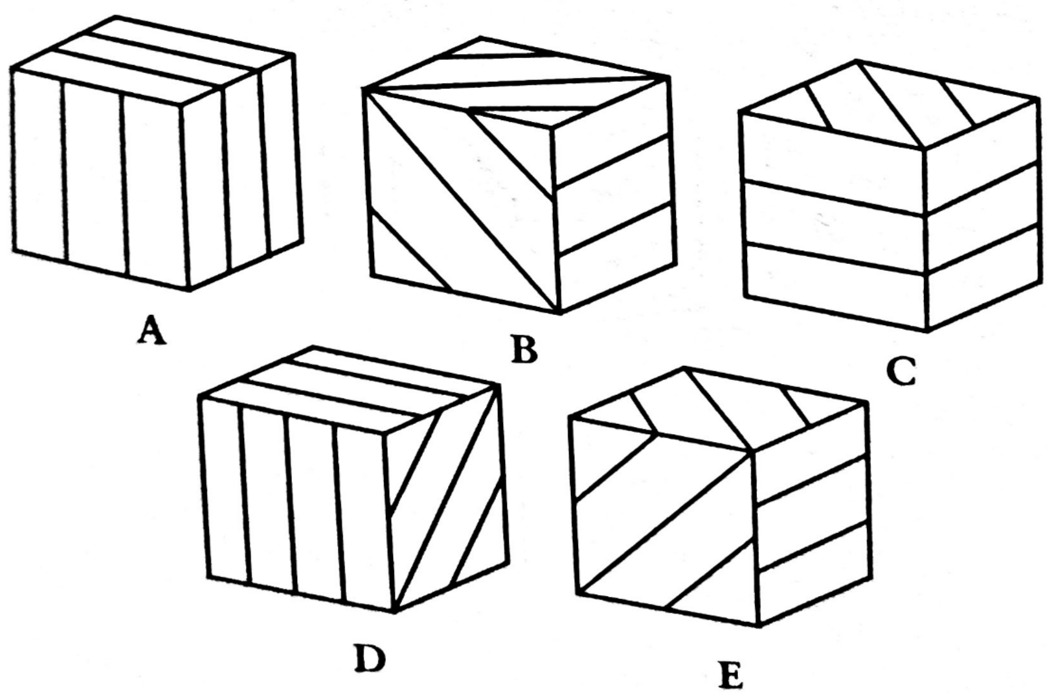


Q4 Which of these is the odd one out?



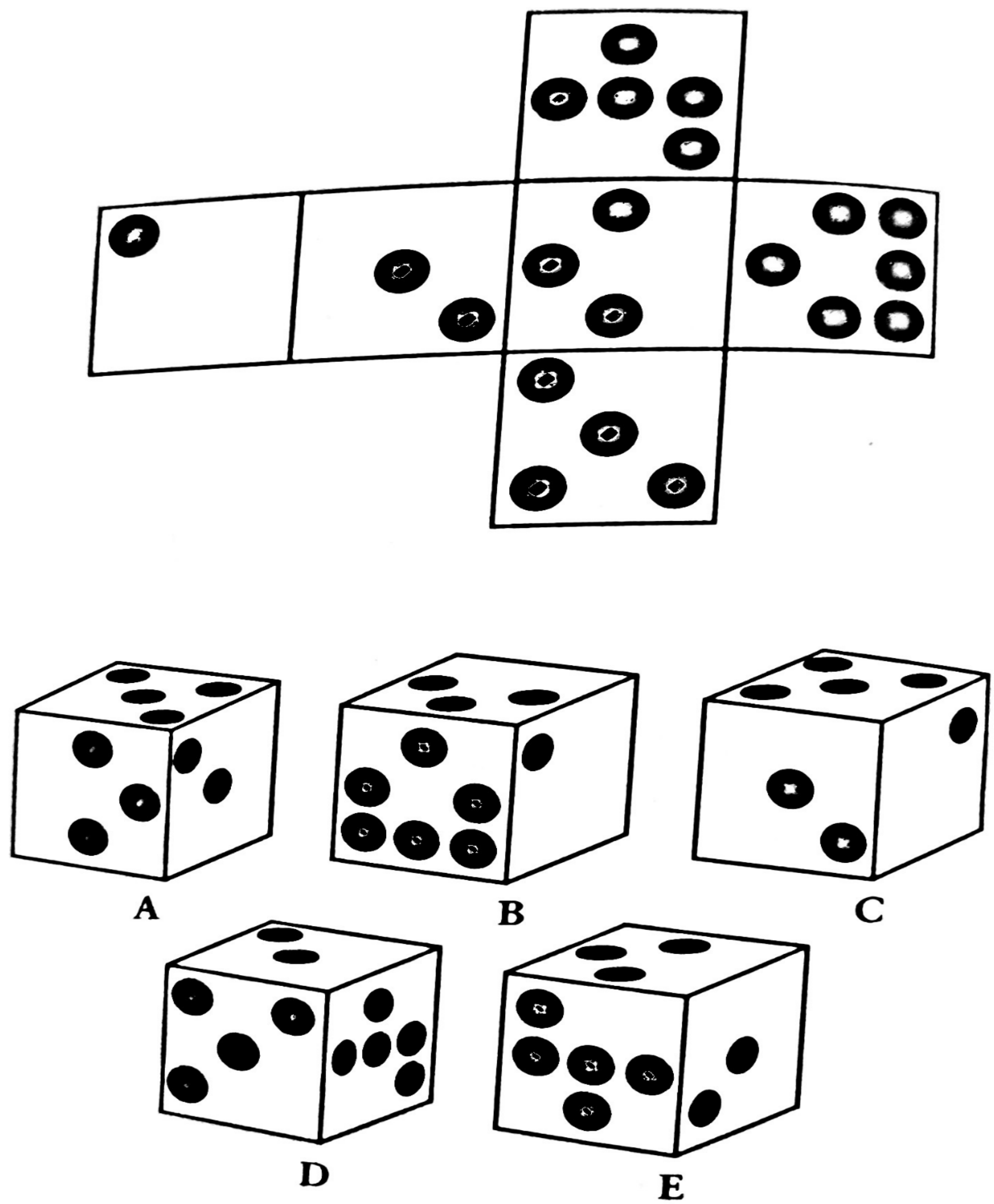
Q16 Which cube can be formed from this?



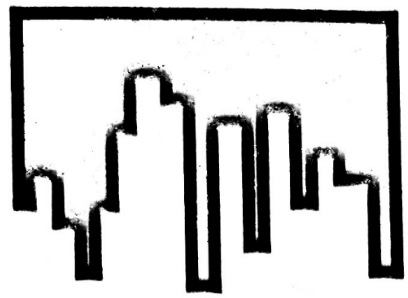


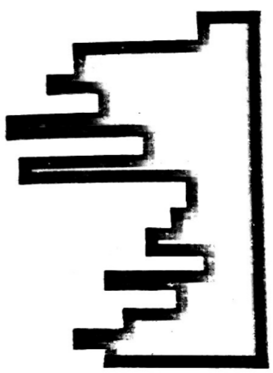
60

Q17 Which cube can be formed from this?

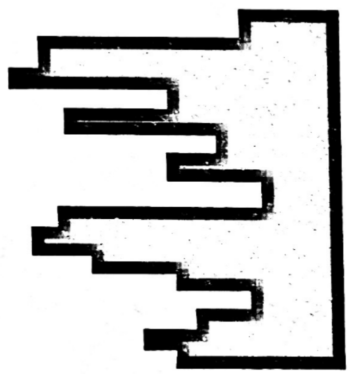


Q18 Which of the following fits together with A to complete the square?

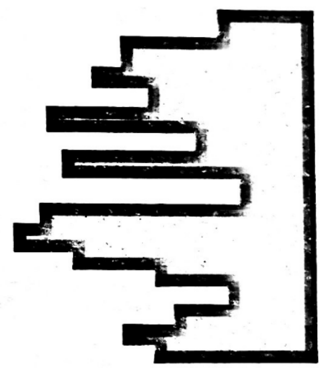




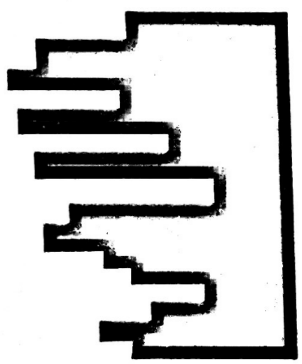
A



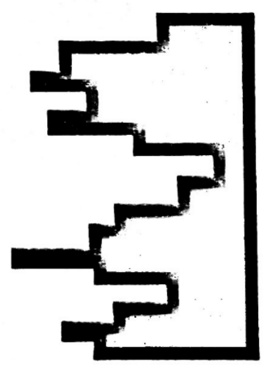
B



C

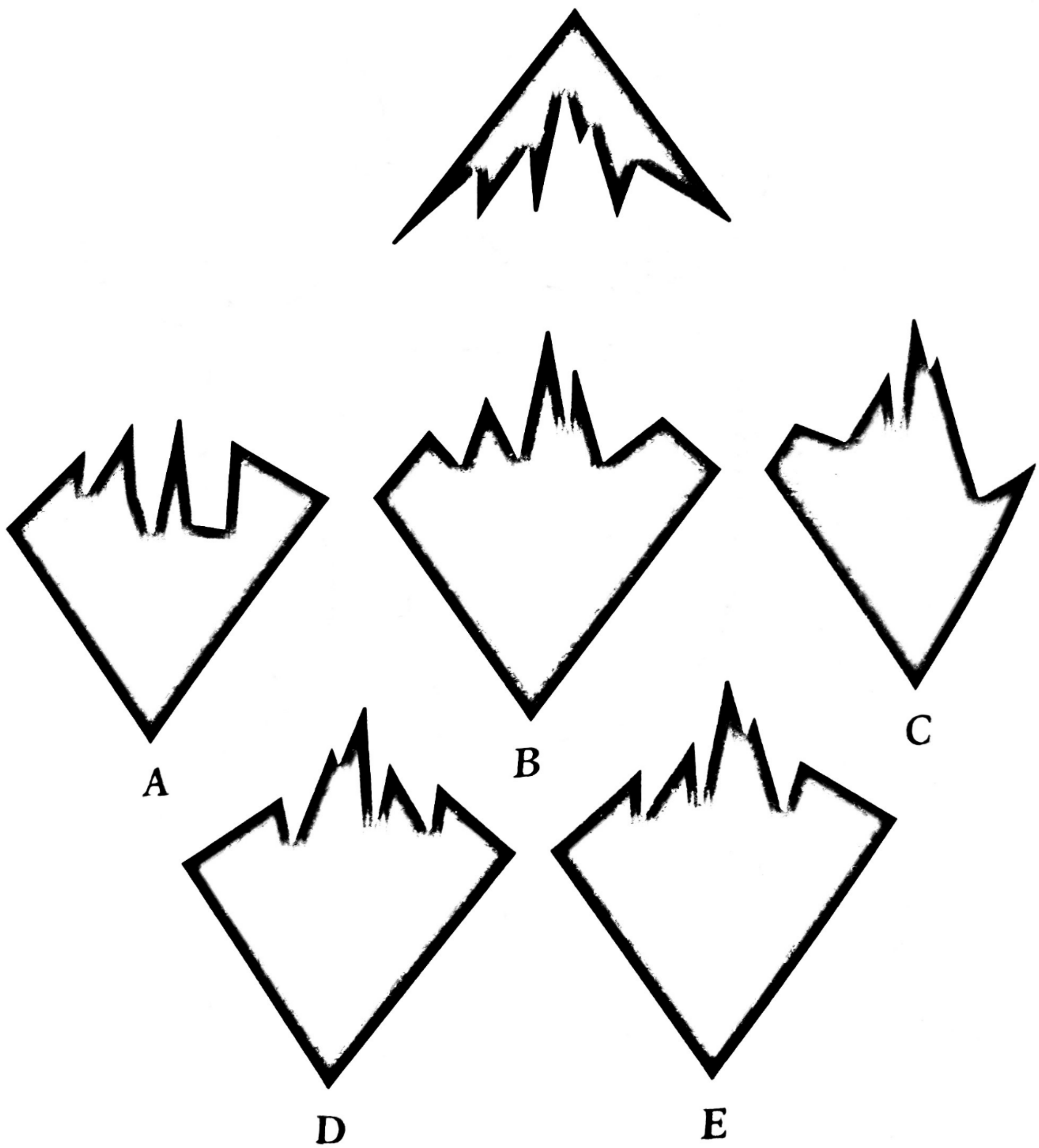


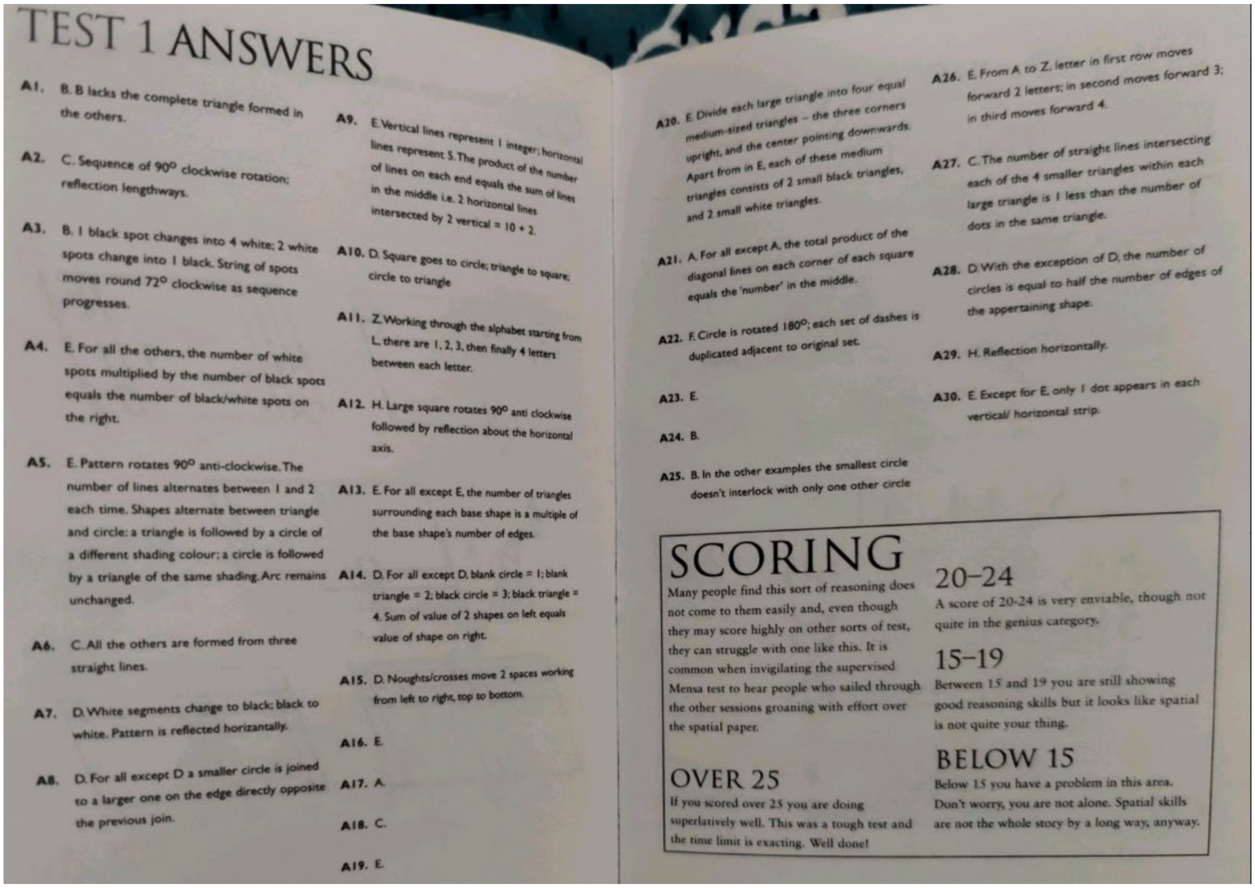
D



E

Q23 Which of the following completes the diamond?





TEST 1 ANSWERS

A1. B. B lacks the complete triangle formed in the others.

A2. C. Sequence of 90° clockwise rotation; reflection lengthways.

A3. B. 1 black spot changes into 4 white; 2 white spots change into 1 black. String of spots moves round 72° clockwise as sequence progresses.

A4. E. For all the others, the number of white spots multiplied by the number of black spots equals the number of black/white spots on the right.

A5. E. Pattern rotates 90° anti-clockwise. The number of lines alternates between 1 and 2 each time. Shapes alternate between triangle and circle: a triangle is followed by a circle of a different shading colour; a circle is followed by a triangle of the same shading. Arc remains unchanged.

A6. C. All the others are formed from three straight lines.

A7. D. White segments change to black; black to white. Pattern is reflected horizantally.

A8. D. For all except D a smaller circle is joined to a larger one on the edge directly opposite the previous join.

A9. E. Vertical lines represent 1 integer; horizontal lines represent 5. The product of the number of lines on each end equals the sum of lines in the middle i.e. 2 horizontal lines intersected by 2 vertical = 10 + 2.

A10. D. Square goes to circle; triangle to square; circle to triangle

A11. Z. Working through the alphabet starting from L, there are 1, 2, 3, then finally 4 letters between each letter.

A12. H. Large square rotates 90° anti clockwise followed by reflection about the horizontal axis.

A13. E. For all except E, the number of triangles surrounding each base shape is a multiple of the base shape's number of edges.

A14. D. For all except D, blank circle = 1; blank triangle = 2; black circle = 3; black triangle = 4. Sum of value of 2 shapes on left equals value of shape on right.

A15. D. Noughts/crosses move 2 spaces working from left to right, top to bottom.

A16. E.

A17. A.

A18. C.

A19. E.

A20. E. Divide each large triangle into four equal medium-sized triangles – the three corners upright, and the center pointing downwards. Apart from in E, each of these medium triangles consists of 2 small black triangles, and 2 small white triangles.

A21. A. For all except A, the total product of the diagonal lines on each corner of each square equals the 'number' in the middle.

A22. F. Circle is rotated 180°; each set of dashes is duplicated adjacent to original set.

A23. E.

A24. B.

A25. B. In the other examples the smallest circle doesn't interlock with only one other circle

A26. E. From A to Z, letter in first row moves forward 2 letters; in second moves forward 3; in third moves forward 4.

A27. C. The number of straight lines intersecting each of the 4 smaller triangles within each large triangle is 1 less than the number of dots in the same triangle.

A28. D. With the exception of D, the number of circles is equal to half the number of edges of the appertaining shape.

A29. H. Reflection horizontally.

A30. E. Except for E, only 1 dot appears in each vertical/ horizontal strip.

SCORING

Many people find this sort of reasoning does not come to them easily and, even though they may score highly on other sorts of test, they can struggle with one like this. It is common when invigilating the supervised Mensa test to hear people who sailed through the other sessions groaning with effort over the spatial paper.

OVER 25

If you scored over 25 you are doing superlatively well. This was a tough test and the time limit is exacting. Well done!

20–24

A score of 20-24 is very enviable, though not quite in the genius category.

15–19

Between 15 and 19 you are still showing good reasoning skills but it looks like spatial is not quite your thing.

BELOW 15

Below 15 you have a problem in this area. Don't worry, you are not alone. Spatial skills are not the whole story by a long way, anyway.

Appendix C: Questionnaire

1) Age_______________

2) Gender_______________

3) Race or ethnicity__________________

4) Current level of education:

o Freshman (1)

o Sophomore (2)

o Junior (3)

o Senior (4)

5) What is your college major?________________________

6) How often do you listen to music while studying or working on academic assignments (such as homework or projects)?

	Never (1)	Sometimes (2)	About half the time (3)	Most of the time (4)	Always (5)

Please choose from choices: (1)	o	o	o	o	o

7) Rate your level of agreement with the following statements:

I find music while doing my academic work to be:

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
Motivating (1)	o	o	o	o	o
Distracting (2)	o	o	o	o	o

8) When you listen to music while working on academic work, how confident do you feel about your ability to finish your work?

	Not confident at all (1)	Somewhat confident (2)	Moderately confident (3)	Very confident (4)	Extremely confident (5)
Please choose from choices: (1)	o	o	o	o	o

9) When you pair music with a challenging task, do you feel that you are more likely to keep working for a longer period than if you didn't have the music?

	Definitely not (1)	Probably not (2)	Might or might not (3)	Probably yes (4)	Definitely yes (5)
Please choose form choices: (1)	o	o	o	o	o

10) Think about your level of comfort listening to music during various types of academic work. Rate each assignment type with how comfortable you would feel listening to music while completing each activity.

	Extremely uncomfortable (1)	Somewhat uncomfortable (2)	Neither comfortable nor uncomfortable (3)	Somewhat comfortable (4)	Extremely comfortable (5)
Studying for an exam (1)	o	o	o	o	o
Taking an exam (2)	o	o	o	o	o
Doing math homework (3)	o	o	o	o	o
Doing writing	o	o	o	o	o

homework (4)	