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Effects of Multitasking with Music on English-Based Academic Task Accuracy and Completion Speed in High School Students at Eastwood High School: An Experimental Research Study

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ABSTRACT

This research study looked at how multitasking with music affects academic performance of high school students when measuring the speed and accuracy on English-based tasks. Associations between worse academic performance and multitasking exist; however, many current studies are on adults and college students and do not look into real-time performance or self-selected music. To fill this gap, an experimental quantitative research study was done in which 20 students, ages 14-18, completed English-based tasks under two conditions, music and no music. The participants' performance was measured by accuracy and completion time, and then analyzed with a paired sample t-test to compare the results. The data showed that students had slightly increased accuracy and speed in the music condition. The difference between the results was not large enough to be statistically significant. The findings suggest that multitasking with music may not have a major effect on academic performance of time completion or accuracy. This study can add to the field of multitasking through the finding that the effects of multitasking are dependent on habits from the individual participants and environments, instead of purely having a negative effect.

INTRODUCTION

Multitasking is one of the most heavily studied, yet frequently misunderstood behaviors within cognitive psychology. An article on the damage of multitasking by The American Psychological Association (2006) defines multitasking as completing two or more tasks at the same time. An important distinction within this research is the difference between actually completing two tasks at the same time and task switching, which is when a person quickly goes back and forth between tasks and loses efficiency, as defined by the University at Buffalo (2025) in an article about what multitasking is. The type of task this study looks at is the second category: participants completed English-based academic tasks while listening to self-selected music, which means their brains had to split their attention.

Understanding the impact of adolescent multitasking has become increasingly important. Cain et al. (2016), a study on performance when multitasking, found that access to smartphones, social media, and streaming platforms lead to increased multitasking behaviors. Balıkçı et al. (2023), a study on the increase in multitasking behaviors found that behaviors have increased exponentially, especially due to the COVID-19 pandemic lockdown, when the divide between technology and schooling became erased. Cain et al. (2016), also found that on average, Americans aged 8-18 spend 29% of their media time multitasking; a decade ago this rate was only 16% (p. 9). This increase shows the importance of understanding how multitasking affects academics. Because of how common multitasking is, finding out how this habit impacts students is essential to understanding what the implications are for how adolescents learn.

LITERATURE REVIEW

To understand this topic further, this paper will first explore the cognitive foundations of multitasking, including how the brain is impacted and why task switching has mental costs, and then cover the long-term emotional and cognitive impacts of multitasking within adults before narrowing to the immediate effects on academics for college students. It will then examine digital media multitasking and how it affects adolescents and their academic performance. Finally, this paper will focus on background music with cognitive performance and how factors like tempo, lyrics and individual differences impact the effects music has on task performance.

Cognitive Foundations for Multiasking

It is a common misconception that multitasking is a learnable skill which can be improved over time. When splitting attention between two different tasks there are cognitive costs that cannot be subdued purely from habits. The American Psychological Association (2006) found that human brains are not designed for heavy-duty multitasking, which is shown through experiments where participants lost time whenever they switched to a different task otherwise known as switch cost. This can cost a person up to 40% of productive time when trying to complete tasks and makes completing tasks more inefficient (American Psychological Association, 2006). This time loss is supported by Sohn et al. (2000), a study on cognitive control during multitasking, which found that certain types of multitasking need internal (endogenous) mental prep while others need external (exogenous) reaction to stimuli. Endogenous preparation uses the lateral prefrontal cortex and the posterior parietal cortex, but the exogenous adjustment uses the superior prefrontal cortex and the posterior parietal cortex (Sohn et al., 2000). When these different parts of the brain are activated while multitasking, it creates cognitive strain because the activated regions are fighting for cognitive control. A study on selective attention with noise, Ophir et al. (2009), found that high media multitaskers (HMMs) who are people who frequently multitask every day were more easily distracted and performed worse when measured on working memory, efficiency in task switching, and the ability to filter their attention. During this task HMMs had a larger switch cost (+167

ms) and were slower on both trials (p. 12), whereas light media multitaskers (LMMs) in the same tasks were not impacted (Ophir et al., 2009).

Long-term Impact of Multitasking

Research on adults consistently shows that multitasking makes workplace and personal performance worse. In a research study on the unseen impacts of multitasking, Goes et al. (2018) found that the multitasking of customer service agents led to lower satisfaction rates for customers and increased mistakes, even in high-performing employees. Further, a study on healthcare professionals, Weigl et al. (2013) found that physicians who participated in multitasking while they worked reported significantly more strain, fatigue, and stress, despite believing they had improved efficiency. While slight gender differences exist, holistically women and men perform largely the same. Buser & Peter (2025), a research study on choice multitasking, found that both men and women had performance drops within forced multitasking conditions, and the differences by gender were not statistically significant. Multitasking has also been linked to coping and emotional health. Shin et al. (2025) ran a three-part study on connecting media multitasking to coping strategies with emotions and found that heavy media multitasking is linked to negative emotions like depression, anxiety, and cognitive behavioral avoidance. Multitasking creates long-term emotional and cognitive costs in professional and personal spaces.

Immediate Academic Performance Impacts From Multitasking

Immediate academic drawbacks exist for students when they multitask while studying and engaging in academics. Paul (2013), in a study on the impacts of multitasking while studying, found that multitasking while students do schoolwork makes the learning more shallow, impairs memory, and creates more difficulty when transferring learning to new contexts. Students' ability to remain on task also decreased significantly after 10 minutes of the study (Paul, 2013). A University of Denver (2025) article about college students multitasking found that students make up to four times more mistakes when they task switch and can take 50% longer to complete tasks. Uncapher & Wagner (2018), a study that analyzed the brains and cognitive strain of media multitaskers found that high media multitaskers (HMMs) have poorer reasoning and long-term memory when compared to their peers. Music is particularly common for students when multitasking. Moreover, a study on the effects of various types of music on different types of multitasking by Young and Nolan (2015) found that classical music had a negative impact on attention performance; however, attention performance was not affected when listening to popular music with lyrics.

Multitasking has negative impacts on even the most high-achieving students. Mercimek et al. (2020) conducted a study on 214 middle school students, of which 93 were gifted and 121 were non-gifted (p. 995). This study found that concurrent multitasking can weaken learning outcomes even in gifted students. This finding is further reinforced from the research of Cain et al. (2016), which found that common media multitasking was correlated with worse performance on statewide standardized

achievement tests in math and English. Higher media multitasking was connected to worse working memory, executive function, and higher rates of impulsive behavior (Cain et al., 2016). A study done in Spain, which focused on how multitasking impacts grades and homework by Martín-Perpiñá et al. (2019) found that heavy homework multitaskers had a higher likelihood of failing core subjects and reported more technology dependence. While doing homework, 27.5% of adolescents were categorized as heavy media multitaskers in the heavy media multitaskers homework (HMMHW) group (p. 85). Some of the most common multitasking activities were sending mobile messages and listening to music (Martín-Perpiñá et al., 2019). Therefore, multitasking is exacerbated by the many forms it can take within media technology.

Digital Media Multitasking

Modern adolescents are on an increasing trend of multitasking with entertainment apps, like social media and games. Junco and Cotten (2012), a study on the relationship between multitasking and academic performance, found that Facebook multitasking was a negative predictor of GPA. Similarly, Lee (2015), a study about multitasking impacts from Facebook, found that 10% of the sample group had high levels of addiction to Facebook and 11% had high levels of addiction to smartphones (p. 44). A correlation also exists between excessive use of smartphones or Facebook use and multitasking (Lee, 2015). Moreover, Kokoç (2021), a study on attention relationship with academic performance and social media multitasking, found that multitasking with social media was a negative predictor for academic performance; however, attention control was a positive predictor for academic performance. Chang et al. (2017) found in a research study on the online game experience and its relation to ability of multitasking virtually that the multiple online battle arena (MOBA) players showed stronger multitasking skills in virtual environments than other gamers or people who are non-gamers. Furthermore, Salmela-Aro et al. (2016) in a research study on multitasking effects within gaming found that excessive internet use, often tied to gaming, was linked to school burnout and symptoms of depression.

Background Music Impact On Cognitive Performance

Instrumental Music, Lyrics, and Language-based Tasks. Studies about music cognition have found that lyrics are the main source of cognitive interference when completing language-based academic tasks. This relationship is more complex than just the presence of lyrics because personal habits and familiarity with music are also factors that reduce interference. Souza and Barbosa (2023) a study on music and cognitive task interference found that when college students completed a variety of tasks such as verbal memory, visual memory, math problems, and reading comprehension, under the conditions of music with lyrics, instrumental music, and silence, the music with lyrics had the greatest decrease in performance. The instrumental music did not have a significant effect and did not have a strong positive or negative relation (Souza & Barbosa, 2023). The finding that music with lyrics harms performance is further sustained by Sun et al. (2024), a study looking at reading comprehension and lyrics with music multitasking which found that in a study on college students aged 18-21, pop music containing lyrics led to a reduced reading

comprehension when compared to the non-music condition. The negative effects were the most severe when lyrics and text appeared together which suggests that lyrics compete with the same processing resources that are needed for verbal academic tasks therefore impairing the ability to complete them. An important aspect of performance also depends on familiarity with the music. Young and Nolan (2015) found that when looking at the performance of college-aged participants, instrumental classical music had the largest impairment of reading comprehension out of every condition and no music control. The study determined that the participants were unfamiliar with classical music, so it created more distraction, which suggests that familiarity with music impacts the cognitive strain separately from the presence or absence of lyrics (Young & Nolan, 2015). Furthermore, Sun et al. (2024) found that frequent and habitual music listeners had less of a performance drop than participants who did not listen to music often, which is attributed to a strengthened inhibitory control for auditory stimuli that is irrelevant because of continuous exposure to it.

Characteristics of Music and Individual Differences. Past familiarity and lyrics factors like tempo, arousal level, and emotional impact can also change how background music affects cognitive performance. Hofbauer et al. (2024), a study on music tempo and valence with cognition found that when looking at adults' performance, the fast tempo music was linked to better immediate word recall and verbal fluency when compared to slow tempo music, whereas positive emotional impact on its own created better recall and fluency independent of the tempo. The benefits found were not universal among participants, and the results suggested that the same music can benefit some people and harm others depending on their noise sensitivity (Hofbauer et al., 2024). Similarly, Gigliotti et al. (2025), a study on cognitive performance when multitasking with music found that when looking at adults aged 18-40, both the low arousing and high arousing instrumental music caused higher activation psychologically when compared to silence, and this did not have any negative performance effects. High-arousing music also improved the executive control and attention performance, and both of the music conditions helped with verbal fluency for many different tasks compared to silence (Gigliotti et al., 2025). The difference between the positive findings from Gigliotti et al. (2025) and mixed to negative findings from Souza and Barbosa (2023) does not contradict because the former used instrumental excerpts to minimize distraction and the latter used music to compete with verbal processing. These studies cannot be generalized to populations under 18 because they are focused on college students and adults. There are key differences in the cognitive abilities of adolescent populations compared to older populations, which can drastically affect the results.

CURRENT GAP AND APPROACH

While previous research has shown that multitasking leads to worse academic performance and working memory in college students and adults (Cain et al., 2016; Uncapher & Wagner, 2018; Junco & Cotten, 2012), fewer studies look at adolescents and high school students. The multitasking cognition studies that do involve music all recruited adult or college aged participants (Souza & Barbosa, 2023; Sun et al.,

2024; Hofbauer et al., 2024) and Gigliotti et al. (2025) included that their findings should not be applied to people younger than 18 years old. Additionally, past research has used controlled music conditions where certain songs were assigned to the participants which does not accurately reflect study behaviors in adolescence; by self selecting personal music where tempo, lyric presence, and genre vary across participants (Sun et al., 2024; Young & Nolan, 2015). Many studies also use standardized tests and self-reports that are not able to show the real-time impacts of multitasking using modern technology, especially with music entertainment apps (Paul, 2013; Martín-Perpiñá et al., 2019). Despite music multitasking being the most common homework multitasking behavior in high school students (Martín-Perpiñá et al., 2019), past studies have primarily focused on social media, gaming, and phones, which creates a gap in how self selected music impacts the speed and accuracy of English-based academic tasks in high school students. This gap will be further investigated in this paper with the following research question: *In what ways does multitasking with music impact the academic success of Eastwood High School students aged 14-18 when it comes to accuracy and completion speed for English-based academic tasks?*

Hypothesis

Based on the current literature review of background music with lyrics negatively impacting verbal memory and reading comprehension in adults and college students (Souza & Barbosa, 2023; Sun et al., 2024), and that adolescents are a developmentally different population in which these effects have not been measured (Gigliotti et al., 2025). Prior research also indicates that multitasking was linked to worse academic outcomes (Junco & Cotten, 2012), while another study observed that multitasking increased strain and reduced academic performance (Weigl et al., 2013). Thus, it was hypothesized that Eastwood High School students that self-selected music and multitasked when completing academic tasks would have a lower accuracy and speed compared to the condition where students completed the academic tasks without music.

METHODS

Research Design

The purpose of this study was to explain how multitasking with music impacts academic performance among high school students, specifically their accuracy and speed when doing English-based academic tasks. Multitasking can be defined as completing two or more tasks simultaneously or switching between them at a rapid pace (University at Buffalo, 2025). Within this study, English-based academic tasks are defined as the 10-question English-based PSAT Google forms that participants filled out. Conducting this study with controlled experimental conditions aimed to measure how the presence or lack of music impacts the accuracy and speed of academic tasks in students.

This study used an experimental research design and was conducted at Eastwood High School to compare the same students' performance on academic English-based tasks in two conditions: multitasking with and without music. This study included Eastwood High School students aged 14-18 across all four grades to ensure a diverse pool of participants. Eastwood High School is a pseudonym for the school the study was conducted at. The independent variable was if music was present or absent, and the dependent variable was the accuracy and speed of completion. Quantitative data was collected through Google forms (see Appendix H & G) under two conditions, A (without music) and B (with music), and measured the speed of completion and accuracy of English-based academic tasks (see further procedures in Appendix A). The music was self selected by participants and not controlled in order to simulate realistic study environments among adolescents.

According to Leedy and Ormrod (2015), experimental research is a way to determine the relationship between variables and find the cause and effect of them. Experimental research was the best method because participants were randomly assigned to two condition groups to test the variable of music. This method was chosen over a quasi-experimental method because specifically assigning the groups would have bias and not be beneficial for the outcome and findings of this study.

Sampling

The potential participants were the students at Eastwood High School, aged 14-18 who had filled out the interest form. The participants also had to be able to attend two of three study sessions. They also had to have access to and bring a chromebook and headphones to both of their study sessions. After recruitment, 20 participants were found who fit this criteria. This study evaluated these participants because past research has not focused on adolescents or high school students.

Limitations

One limitation of this study is that students may vary in reading and literacy levels so the difficulty of some questions asked under both conditions may differ depending on the participants, which may impact the accuracy. The study attempted to mitigate this limitation by including a mix of easy and medium practice questions and excluding advanced ones so that the questions would be accessible to participants across all four grade levels. A further limitation within the study is for condition B, participants chose their own music. The style of music, including if it has lyrics or is instrumental, can affect the participants in different ways and may exacerbate negative multitasking effects. Another limitation is the sample population was solely from Eastwood High School. This small location focus creates difficulty in obtaining a diverse set of candidates. Additionally, the sample size was 20 participants, which also creates a limitation of having enough representation and quantity to ensure validity and saturation of the results. Therefore, the study and testing conditions were randomized to minimize limitations and provided greater validity.

Ethical Considerations

To make this study as ethical as it could be, all participants filled out an assent form (see below in Appendix C) and had their guardians fill out a consent form (see below in Appendix B). If participants were 18, they filled out their own consent forms. It was well noted within the forms and in person that participation is voluntary and that participants can withdraw at any time. Although names were collected for data purposes, names and personal information was kept confidential. All data was stored in a password-protected Google Drive folder, which was only accessible to me and my teacher. This study has minimal risk to participants and is equal to normal risk when studying or completing classroom activities. A potential for mild academic stress exists when participants are completing the English-based academic task so to reduce this risk, I informed students that their work is not graded and their performance is only for research purposes.

Positionality

As the researcher of this study, I have internal bias and assumptions about multitasking and its impacts due to my personal experience multitasking with music while studying, and having completed my literature review on this subject. This bias could unconsciously impact how I utilize my findings. To reduce this bias, I used only quantitative data, accuracy, and speed of completion times, instead of subjective judgment of the impacts on participants.

Participants could have also had personal bias from their own past study habits. Students who regularly study with music may do better than students who study with no music. To address this bias, I randomized the assignment of the order for the conditions to students and tested them in both scenarios. I also told participants that no right type of result was right or wrong and that being honest in their answers was important to get valid data.

RESULTS

The primary purpose of this study was to explain whether multitasking with music affects academic performance. Therefore, paired samples t-tests were conducted to compare the student performance within the two conditions: completing English-based academic tasks without music (Condition A) and with music (Condition B). The performance was measured through completion time and the number of correct answers.

All twenty participants completed the academic tasks under both conditions. Completion time was recorded in minutes and accuracy was measured by the number of correct answers out of ten questions. Due to the same participants completing the test in both conditions, paired samples t-tests were utilized to find the differences in performance under the no music and music conditions.

Paired sample statistics

Variable and Condtion	Mean	Standard Deviation	T-test t(19)	P-value (one tailed)	Cohen's d
Time B	10.64	2.82	1.69	0.053569	0.38
Time A	11.28	2.58	1.69	0.053569	0.38
Accuracy A	7.35	1.6	-0.78	0.222474	0.17
Accuracy B	7.65	1.6	-0.78	0.222474	0.17

Figure 1: Descriptive statistics and paired sample t-test results for completion time and accuracy in the no music (A) and music (B) conditions. Mean and standard deviation are reported for both variables (N=20).

Time Completion Scores Were Slightly Faster with Music

To examine if multitasking with music impacts the speed of academic task completion, the completion time was compared with the no music and music conditions to determine if the presence of music impacted how fast participants were able to complete the English-based academic task. As represented in (Figure 2), the mean completion time in the no music condition (M = 11.28 minutes, SD = 2.58) was greater than the mean completion time in the music condition (M = 10.64 minutes, SD = 2.82).

A paired samples t-test was completed to ascertain if the difference in completion time under the two conditions was statistically significant. The results showed that the difference in the completion time between the music and no music conditions was not statistically significant, t(19) = 1.69, p = 0.107, d = 0.38.

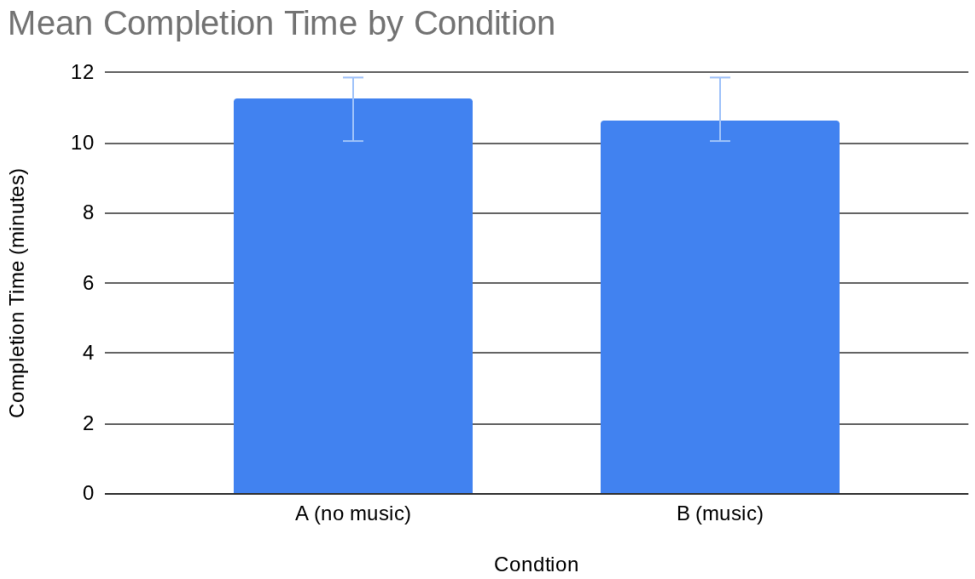

Figure 2: Mean completion time under music and no music conditions. Error bars represent the 95% confidence interval.

Accuracy Scores Were Slightly Faster With Music

Similarly, accuracy was compared with the music and no music conditions to investigate if listening to music impacted the number of correct answers on the academic task. The accuracy was measured as the number of correct answers out of ten questions. As represented in (Figure 3), the mean accuracy score in the no music condition was 7.35 correct responses (SD = 1.60), and the mean accuracy score in the music condition was 7.65 correct responses (SD = 1.60).

A paired samples t-test was run to determine if the difference was statistically significant. The results showed the difference between the two conditions was not statistically significant, $t(19) = -0.78$, $p = 0.445$, $d = 0.17$.

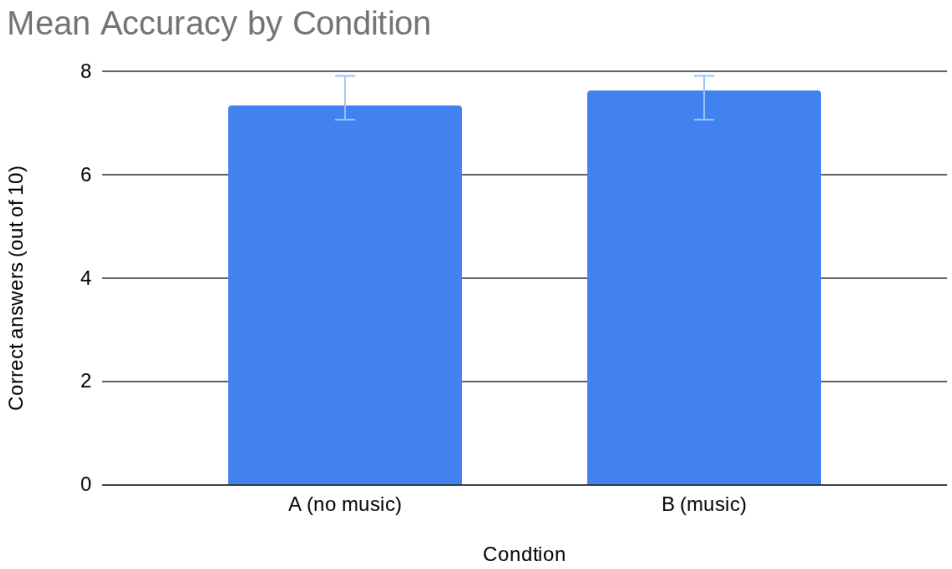

Figure 3: Mean accuracy scores under music and no music conditions. Error bars represent the 95% confidence intervals.

Student Perception of Speed and Accuracy Varied

After completing the experiment, the participants filled out a post-study form that required them to reflect on their performance. They were asked if they thought their performance was faster or more accurate in a specific condition. Participant responses are represented in (Figure 4).

In total, eight participants reported they believed they were faster when listening to music, six participants reported they completed the task faster without music, and six participants reported no difference in speed between the two conditions. Their perceived accuracy represented that nine participants reported believing they performed with a greater accuracy without music, four participants reported higher accuracy with music, and seven participants reported no perceived difference between the two conditions.

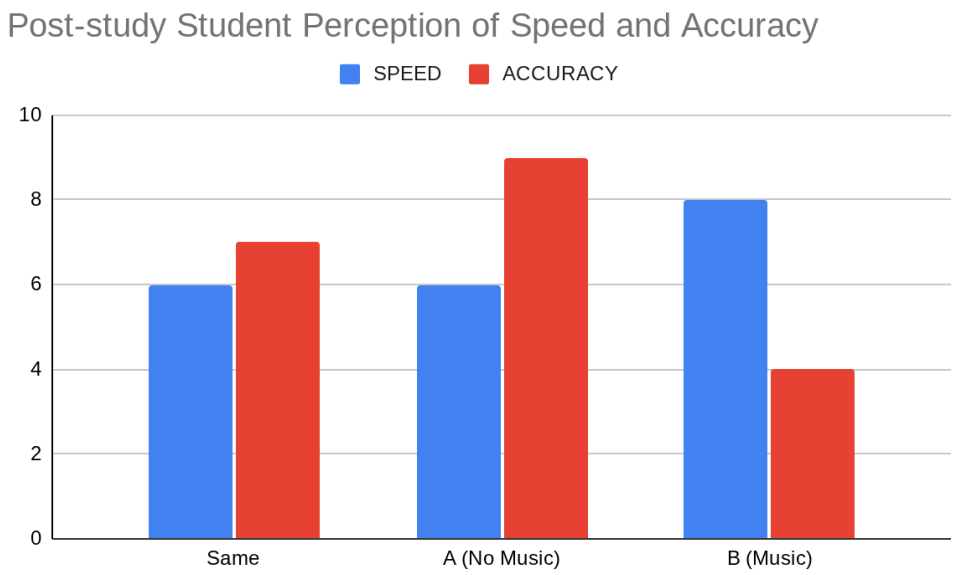

Figure 4: Participants self-reported perceptions of speed and accuracy with the music and no music conditions. The bars represent the number of participants who reported performing better in condition A, condition B, or at the same level in both conditions.

DISCUSSION

The goal of this study was to explain how multitasking with music may impact the academic success of high school students aged 14-18, specifically in the speed and accuracy of English-based academic tasks. The results showed that participants completed the English-based tasks faster and with better accuracy when listening to music; however, the differences were not great enough to be statistically significant. This finding means that in the sample, listening to music while completing English-based tasks did not have a major impact on academic performance.

These findings differ from what past research on multitasking and cognitive performance has found. Studies suggest that multitasking can cause a cognitive divide in attention, which negatively impacts academic outcomes. For instance, Junco and Cotten (2012) found that digital multitasking was linked to lower academic performance in students, which suggests that multitasking reduces focus when completing academic tasks. Furthermore, Ophir et al. (2009) found that people who media multitask frequently had reduced cognitive control when switching between tasks. Other research that looked at

multitasking more broadly also suggested that switching between stimuli can create switching costs, which means attention has to frequently readjust if there are multiple tasks competing with each other (American Psychological Association, 2006).

In contrast, research on background music has found mixed results. Souza and Barbosa (2023) found that when multitasking with music containing lyrics, participants had worse verbal memory and reading comprehension; however, instrumental music did not have a significant positive or negative effect. Similarly, Sun et al. (2024) found that pop music that includes lyrics reduced accuracy for reading comprehension lower than in the non-music conditions. The negative effects were the worst when the lyrics and reading task were in the same language (Sun et al., 2024). These findings suggest that background music and specifically music with lyrics can cause cognitive strain when completing language-based academic tasks. Young and Nolan (2015) further supported this, finding that background music can affect the ability to switch between two tasks depending on the nature of the music and the task.

Conversely, other research suggests that the impact of multitasking and academic performance on each other may be more complex than it seems. Gigliotti et al. (2025) found that low and high-arousing instrumental background music does not lead to worse performance and can improve executive control attention and verbal fluency in some people when compared to the silence condition. This suggests that music is not always harmful. Similarly Horbauer et al. (2024) found that faster tempo music was correlated with improved immediate recall and verbal fluency, though personal differences with aspects like noise sensitivity determined who was able to benefit from the condition. Together, these findings suggest the impact of music on academic performance is dependent on the type of music, task and individual participant differences instead of a universal negative effect for all participants.

Although past research has found that multitasking reduces performance, the results of this study align with this more intricate view of multitasking with music and did not find a significant difference between the music and no music conditions. One possible explanation is that many students are accustomed to listening to music while studying which makes the behavior less distracting in this circumstance. Sun et al. (2024) found that students who listen to music frequently while doing homework have smaller negative performance results than students who do not listen to music. This suggests that frequent exposure to the music condition can create a stronger control ability over blocking out unnecessary auditory stimuli. Because music streaming platforms and headphones are common for high school students (Paul, 2013), participants may have already adapted to doing homework while listening to music, which reduces how disruptive the music stimuli is within the experiment.

The post-study perception form also included collecting feedback from the participants after the experiment to gather insight. Some participants thought they finished tasks faster with music and some thought they did better without music or felt no difference. This variation is consistent with Hofbauer et al. (2024) which found that participants had individual differences in their own sensitivity to auditory

stimuli which impacted who was positively and negatively impacted by the background music. This reinforces the idea that music multitasking is not generalizable as a whole and is specific to the person.

Regardless of these findings, limitations should be considered when looking at these results. This study included a small sample of only twenty participants from one specific high school, which limited the generalizability of the results. Additionally, the study only measured one type of academic task and did not control for any characteristics of music, like genre, tempo, or lyrics. All of these factors can impact how music affects cognitive performance (Souza & Barbosa, 2023; Hofbauer et al., 2024). Furthermore, this controlled study was not able to fully reflect a real-world environment because students would typically have additional stimuli like messaging apps or social media while studying.

Overall, the results may contribute to the discussion of multitasking with music and the impact on adolescent academic performance. The majority of previous research found that multitasking negatively affects attention and learning; however, the findings of this study suggest that listening to self-selected music while completing English-based academic tasks does not significantly influence students' performance with speed or accuracy. These findings show how wide the scope of multitasking behaviors is and suggest that the relationship between music and performance may be shaped by individuals' habits, the type of task or music and the environment. Considering these findings and the limitations of this present study, it is important to include the broader implications of this study and the potential direction for future research.

CONCLUSION & FUTURE DIRECTIONS

This study explored how multitasking with music impacts academic success in high school students aged 14-18 through speed and accuracy when completing English-based academic tasks. The results found that listening to music while doing a shorter academic task did not change performance outcomes significantly. Although participants finished the tasks slightly faster and more accurately with music, the differences were not big enough to be statistically significant. The results show that with this group of participants and task, multitasking with music does not strongly affect the academic task performance.

The findings of this study add to the conversation of how behaviors in learning are impacted by different digital media habits. Past research suggests that multitasking can negatively impact attention and academic outcomes; however, the results of this study found the relationship between music and academic performance could be more complicated than originally thought. For some participants, listening to their music during academic tasks may be neutral instead of distracting. These findings may help contribute to the understanding of how common study habits for adolescents impact their academic productivity.

The limitations of this study may help guide future research. Because this study had a small sample size from one high school, the findings cannot represent a broader population of students. Future research could expand the sample size and take participants from many high schools and grade levels to understand how patterns may shift across different groups. Additionally, in this study, no control existed for the characteristics of the music, like genre, tempo, or the presence or absence of lyrics, which can all influence the impact of music on the cognitive process during an academic task.

These results may also lead future studies to look at how different types of music affect different forms of academic work, including reading comprehension, writing tasks, or problem-solving activities. Further, more in-depth exploration of how music impacts other forms of digital multitasking, like social media or messaging apps, is a possible research path. Continued research may help educators and students understand how study environments can be structured in a way that helps support focus and balance the distractions of modern digital learning habits.

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APPENDIX A

The procedure of the study followed these steps:

(The sampling of the participants is expanded on in the next section)

1. I advertised a flyer with a QR code (Appendix I below) to an Interest form (Appendix E below) collecting contact information from students. I also checked if they meet the criteria of ages 14-18, being a current Eastwood student, and at least sometimes multitasking.
2. Once students filled out the interest form there was a link to the consent and assent forms. I collected the parental consent and student assent if students are under 18 and the consent form for students over 18.
3. If the student has responded by filling out the required consent and assent forms, I randomly assigned them to one of two conditions. Condition A is multitasking with no music and Condition B is multitasking with the music app. I then sent them an email and scheduled a meeting time with them.
4. I met with the students in a quiet environment, either the library or a classroom, and had them complete the first control group form they were assigned which was either condition A or B. I had 3 sessions in total where the students were randomly assigned their condition and told as they

arrived. I had 20 students each come to 2 sessions. To time them I had each student use a timer at their desk to record how long it took to complete the English reading comprehension task Google form (Appendix G &H below) using a digital timer provided by my advisor on an iPhone and the timer on Google Forms to ensure accurate timing. After the participants finished I went around and recorded how long it took each student. The PSAT questions were pulled from One Prep SAT question bank and were the same level of difficulty for condition form A and B.

   a. For condition B (with music), I had participants put on music they use when they study or do homework. If they didn't listen to music while studying typically, I had them put on music they usually listen to. The participants did not have a minimum or maximum time to complete the task and worked at their own pace to show the full impact of music and no music. The volume was set to 5 on any device used, so there is consistency.

5. After one week I repeated steps 4 and 5 and replicated the study with the condition they have not yet completed.
6. Once the participants completed both conditions I had them fill out a Post study reflection Google form.
7. I then compiled my data found in a Google Sheet (Appendix D below) tracking the correct answers, time, completion status and date completed for both conditions of participants.

APPENDIX B

Multitasking Research Study Parent/Guardien **Consent** Form

Please contact us with any questions that arise.

Researche[redacted]
Contact: [redacted]
Adviso[redacted]

Purpose of the study
Your student is invited to participate in a research study being conducted through the AP Research class within Carlmont High School.
The purpose of this s[redacted]king with music apps (such as Spotify, Apple Music, etc.) impacts the accuracy and speed of academic English tasks. This study aims to understand if listening to music while completing tasks helps or hurts performance in high school students.

Procedures
If you and your student agree to participate:

- Participants will complete two reading comprehension tasks on school grounds in a quiet room.
- Each task will be completed in two separate sessions a week apart, once with music and once without music.
- Participants choose their own music and will be timed on how quickly and accurate they can answer the questions. Students dont have a time limit and can take how ever long they need.
- Total participation should take 45 minutes to 1 hour for the whole study including all forms and communication.

Benefit and Risk
Possible risks include being exposed to potentially harmful ads within music apps, explicit music (if the participants choose to listen to this), emotions regarding potential stress or anxiety around compleating the academic tasks.
Possible benifits are learning more about how participants study habits can impact their quality and speed of work.

Confidnetiality

- Participents names will not be reported and all participants will remain anonomous.
- All data will be stored in a folder that is only accessible to the researcher and advisor.
- All information will stay confidential and will only be used for this study.

Voluntary participation and withdrawal
Participation is voluntary. Participants are allowed to withdraw at anytime with no penalty. This will not affect, grades or standing within [redacted]

Consent
By signing below you acknowledge that:

- You have read and understood this consent form.
- You understand that your students' participation is voluntary.
- You give permission for your child to participate in the research study as described above.

Parent / Guardian name (Print):

_____

Parents/Guardian signature:

_____

Date:

_____

Student name (Print):

_____

Student signature:

_____

Date:

_____

Appendix C

Multitasking Research Study Student **Assent** Form

Please contact us with any questions that arise.

Researcher: [redacted]
Contact: [redacted]
Advisor: [redacted]

Purpose of the study
You are invited to participate in a research study being conducted through the AP Research class within Carlmont High School.
The purpose of this study is to explore how multitasking with music apps (such as Spotify, Apple Music, etc.) impacts the accuracy and speed of academic English tasks. This study aims to understand if listening to music while completing tasks helps or hurts performance in high school students.

Procedures
If you agree to participate:

- Participants will complete two reading comprehension tasks on school grounds in a quiet room.
- Each task will be completed in two separate sessions a week apart, once with music and once without music.
- Participants choose their own music and will be timed on how quickly and accurate they can answer the questions. Students dont have a time limit and can take how ever long they need.
- Total participation should take 45 minutes to 1 hour for the whole study including all forms and communication.

Benefit and Risk
Possible risks include being exposed to potentially harmful ads within music apps, explicit music (if the participants choose to listen to this), emotions regarding potential stress or anxiety around compleating the academic tasks.
Possible benifits are learning more about how participants study habits can impact their quality and speed of work.

Confidnetiality

- Participants' names will not be reported, and all participants' scores will remain confidential to everyone except for me and my advisor.
- All data will be stored in a folder that is only accessible to the researcher and advisor.
- All information will stay confidential and will only be used for this study.

Voluntary participation and withdrawal
Participation is voluntary. Participants are allowed to withdraw at anytime with no penalty. This will not affect, grades or standing within [redacted]

By signing below, you acknowledge that:

- You have read and understood this assent form
- You understand that you're participation is voluntary.
- You agree to participate in the research study described above.

Agreement
Please read the statement below and check your choice.

- ☐ Yes, I want to participate in the study.
- ☐ No, I don't want to participate in this study.

Student name (Print):

_____

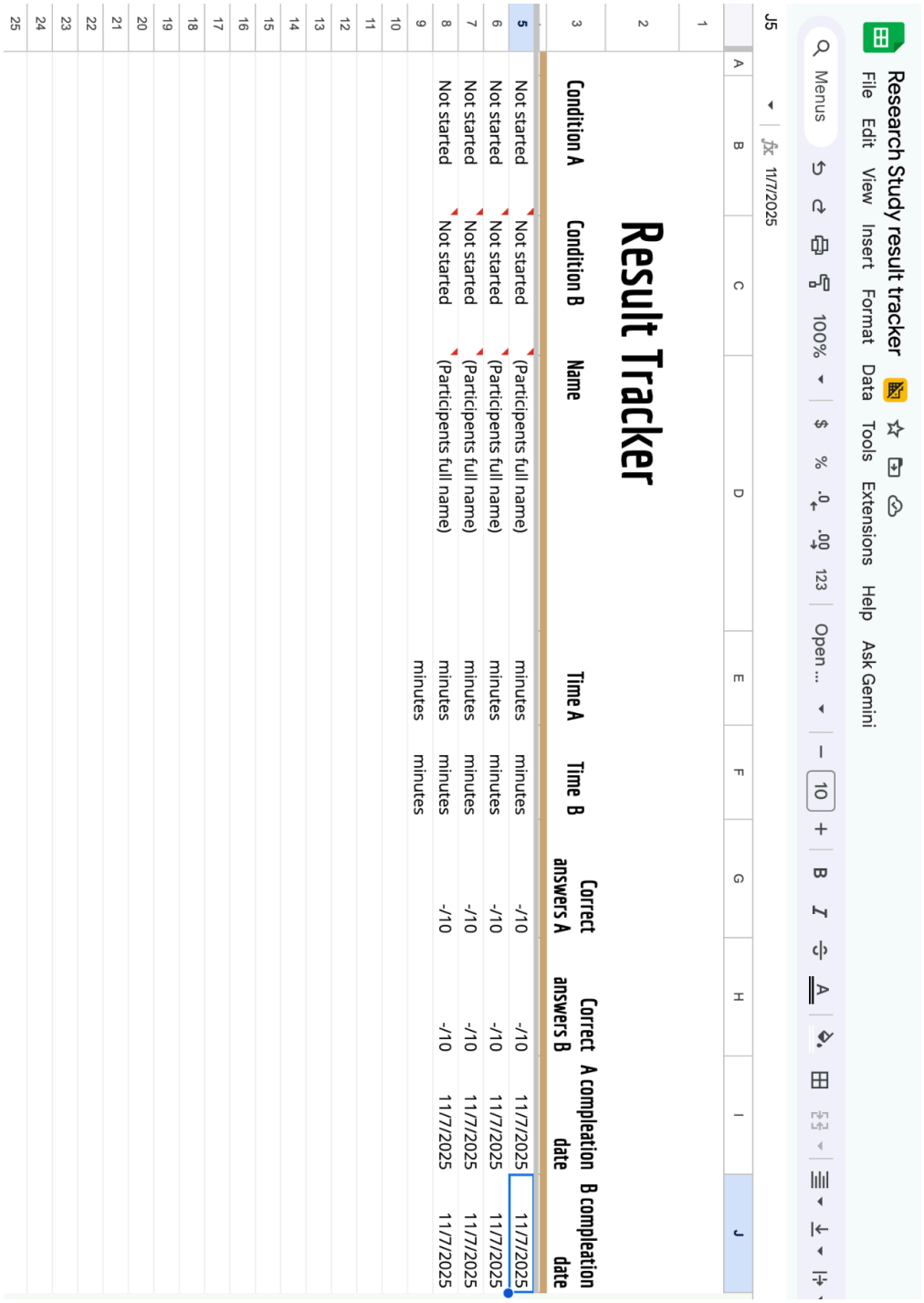
Student signature:

_____

Date:

_____

Appendix D



Research Study result tracker

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J5 | 11/7/2025

Result Tracker

	Condition A	Condition B	Name	Time A	Time B	Correct answers A	Correct answers B	A compleation date	B compleation date
5	Not started	Not started	(Participents full name)	minutes	minutes	-/10	-/10	11/7/2025	11/7/2025
6	Not started	Not started	(Participents full name)	minutes	minutes	-/10	-/10	11/7/2025	11/7/2025
7	Not started	Not started	(Participents full name)	minutes	minutes	-/10	-/10	11/7/2025	11/7/2025
8	Not started	Not started	(Participents full name)	minutes	minutes	-/10	-/10	11/7/2025	11/7/2025
9				minutes	minutes				

Appendix E

Multitasking AP Research project participant interest form

Purpose of Research

You are invited to participate in a research study being conducted through the AP Research class within [redacted]e data collected will be incorporated within my AP Research paper and is advised by [redacted]AP Research teacher. The purpose of this study is to explain how multitasking with music apps (such as Spotify, Apple Music, etc.) impacts the accuracy and speed of academic tasks. This study aims to understand if listening to music while completing tasks helps or hurts performance in high school students. If you wish to participate please continue with this form.

Upon agreement, participants will be sent times to pick from when the forms will be administered. They will complete two forms a week apart from each other under different conditions.

You will be required to meet a total of 2 times

Results will be anonymous. You will be required to put your name and email to be contacted for scheduling purposes however your results will be recorded as an anonymous participant.

Participation is voluntary and participants can opt out at any time.

If you have any further questions you can reach me at [redacted]

* Indicates required question

Email *

☐ Record [redacted]s the email to be included with my response

Email *

Your answer

First name *

Your answer

Last name *

Your answer

Date of birth *

Date

mm/dd/yyyy

What is your age?

- ◯ less than 14
- ◯ 14
- ◯ 15
- ◯ 16
- ◯ 17
- ◯ 18
- ◯ over 18 (or will be in the next 2-3 months)
- ◯ Other: _____

Do you attend Carlmont High School

- ◯ yes
- ◯ no
- ◯ Other: _____

When doing homework after school **do you multitask**? (doing 2 things at once?) This could be listening to music, watching tv, talking to someone else, watching a video. *

- ◯ Always (100% of the time)
- ◯ Often (75% of the time)

- ○ Sometimes (50% of the time)
- ○ Rarely (25% of the time)
- ○ Never (0% of the time)
- ○ Other: _____

*

(If you answered **yes**, often or **sometimes** in the previous question) What **music platforms** do you use when multitasking?

- ☐ Spotify
- ☐ Apple Music
- ☐ YouTube Music
- ☐ Pandora Music
- ☐ Amazon Music
- ☐ Radio
- ☐ Other: _____

Student Participant Assent Form and Parent/Guardian Consent Form: https://docs.google.com/document/d/13RvaisUEEmoFYE6KUlb255sKoN_uehynDPTzz-tOvLw/edit?tab=t.0

If the participant is **under 18** you need to fill out the **Assent** form and you will need to have a parent/guardian fill out a **Consent** form for you before you can participate. For student that are 18 you only need to do the Consent form.

Appendix F

Post study reflection

* Indicates required question

Did you complete both condition A and condition B forms? *

- ◯ yes
- ◯ no
- ◯ Other: _____

For condition B did you use music with lyrics? (this means words like someone singing). *

- ◯ Yes it usually had lyrics
- ◯ It was a 50/50 mix between lyrics and no lyrics
- ◯ No it usually didn't have lyrics
- ◯ Other: _____

Do you feel like you were more productive in condition A (without music) or condition B (with music) *

- ◯ More productive in A
- ◯ More productive in B
- ◯ Same level of productivity in both
- ◯ Other: _____

Do you think you feel like you were faster in condition A (without music) or condition B (with music)? *

- ◯ Faster in condition A
- ◯ Faster in condition B
- ◯ Same speed
- ◯ Other: _____

Do you think you feel like you were more accurate in condition A (without music) or condition B (with music)? *

- ◯ More accurate in condition A
- ◯ More accurate in condition B
- ◯ Same level of accuracy
- ◯ Other: _____

Appendix G

Control A (no music) reading comprehension questions

Locked mode is on. To avoid losing your progress, complete the full quiz before closing.

* Indicates required question

Email *

Record [redacted] as the email to be included with my response

1. Believing that living in an impractical space can heighten awareness and even improve health, conceptual artists Madeline Gins and Shusaku Arakawa designed an apartment building in Japan to be more fanciful than functional. A kitchen counter is chest-high on one side and knee-high on the other; a ceiling has a door to nowhere. The effect is disorienting but invigorating: after four years there, filmmaker Nobu Yamaoka reported significant health benefits. *

Which choice best states the main idea of the text?

- Although inhabiting a home surrounded by fanciful features such as those designed by Gins and Arakawa can be rejuvenating, it is unsustainable.
- Designing disorienting spaces like those in the Gins and Arakawa building is the most effective way to create a physically stimulating environment.

- ○ As a filmmaker, Yamaoka has long supported the designs of conceptual artists such as Gins and Arakawa.
- ○ Although impractical, the design of the apartment building by Gins and Arakawa may improve the well-being of the building's residents.

2. During the World War II era, some Mexican American women adopted a striking * new look called pachuca style. They wore altered men's jackets or zoot suits (wide-legged, long-coated suits) and dramatic makeup, and they combed their hair into high, rounded shapes. Some people criticized pachuca style, saying it was dangerous and women should dress traditionally. But historians see things differently. They see pachuca style as a form of rebellion against the era's rigid social expectations for women. They say that it showed a desire for self-expression and freedom on the part of women who adopted the style.

According to the text, how do historians view pachuca style?

- ○ They think that pachuca style was such a popular trend that it continues to influence fashion in the United States to the present day.
- ○ They think that pachuca style was a way for some Mexican American women to express themselves and resist strict social expectations.
- ○ They think that pachuca style was celebrated because it enabled some Mexican American women to show their support for the United States during World War II.
- ○ They think that pachuca style was similar to other fashion trends that different groups of women adopted in the same period.

3. In her 2021 article "Throwaway History: Towards a Historiography of Ephemera," scholar Anne Garner discusses John Johnson (1882–1956), a devoted collector of items intended to be discarded, including bus tickets and campaign pamphlets. Johnson recognized that scholarly institutions considered his expansive collection of ephemera to be worthless—indeed, it wasn't until 1968, after Johnson's death, that Oxford University's Bodleian Library acquired the collection, having grasped the items' potential value to historians and other researchers. Hence, the example of Johnson serves to _____ *

Which choice most logically completes the text?

- demonstrate the difficulties faced by contemporary historians in conducting research at the Bodleian Library without access to ephemera.
- represent the challenge of incorporating examples of ephemera into the collections of libraries and other scholarly institutions.
- lend support to arguments by historians and other researchers who continue to assert that ephemera holds no value for scholars.
- illustrate both the relatively low scholarly regard in which ephemera was once held and the later recognition of ephemera's possible utility.

4. The following text is from Jane Austen's 1811 novel Sense and Sensibility. Elinor lives with her younger sisters and her mother, Mrs. Dashwood. *

Elinor, this eldest daughter, whose advice was so effectual, possessed a strength of understanding, and coolness of judgment, which qualified her, though only nineteen, to be the counsellor of her mother, and enabled her frequently to counteract, to the advantage of them all, that eagerness of mind in Mrs. Dashwood which must generally have led to imprudence. She had an excellent heart;—her disposition was affectionate, and her feelings were strong; but she knew how to govern them: it was a knowledge which her mother had yet to learn; and which one of her sisters had resolved never to be taught.

According to the text, what is true about Elinor?

- ◯ Elinor often argues with her mother but fails to change her mind.
- ◯ Elinor can be overly sensitive with regard to family matters.
- ◯ Elinor thinks her mother is a bad role model.
- ◯ Elinor is remarkably mature for her age.

5. When fashion designer Lloyd Henri Kiva New opened his store in Scottsdale, Arizona, in 1945, he quickly became known for creating delicately crafted leather goods, like belts and hats. He was perhaps most renowned for his colorful handbags, which he made by hand using a long and painstaking process. As he gained more customers, New began using sewing machines and other tools to help him produce bags more efficiently, though he continued to handcraft the crucial details that made each bag unique. *

Based on the text, what would have been the most likely consequence if New had not begun using sewing machines?

- He would have been unable to ensure that each bag included unique, handcrafted details.
- He would have struggled to meet the increasing demand for his bags.
- He would have had to individually design each bag he produced.
- He would not have been able to generate as much interest in his bags.

6. Ochre sea stars live in tidal pools along the shoreline of the Pacific Ocean. At night, they move to higher shore levels in search of prey. But scientists Corey Garza and Carlos Robles noticed that ochre sea stars stayed at lower levels at night after heavy rains. Garza and Robles hypothesized that a layer of fresh water formed by rainfall was a barrier to the sea stars. To test their hypothesis, the scientists did an experiment. They placed some sea stars in a climbable tank of seawater and other sea stars in a similar tank of seawater with a layer of fresh water on top. Then, the scientists watched the sea stars' behavior at night. *

Which finding from the experiment, if true, would most directly support Garza and Robles's hypothesis?

- None of the sea stars climbed to the tops of the tanks, but sea stars in the tank with only seawater moved around the bottom of the tank more than sea stars in the other tank did.
- Sea stars in the tank with only seawater climbed to the top of the tank, but sea stars in the other tank stopped climbing just below the layer of fresh water.
- Both groups of sea stars climbed to the tops of the tanks, but sea stars in the tank with only seawater climbed more slowly than sea stars in the other tank did.
- Sea stars in the tank with only seawater mostly stayed near the bottom of the tank, but sea stars in the other tank climbed into the layer of fresh water.

7. Male túngara frogs make complex calls to attract mates, but their calls also attract frog-biting midges, insects that feed on the frogs' blood. Researchers Ximena Bernal and Priyanka de Silva wondered if the calls alone are sufficient for midges to locate the frogs or if midges use carbon dioxide emitted by frogs as an additional cue to their prey's whereabouts, like mosquitoes do. In an experiment, the researchers placed two midge traps in a túngara frog breeding area. One trap played recordings of túngara frog calls and the other released carbon dioxide along with playing the calls. Bernal and de Silva concluded that carbon dioxide does not serve as an additional cue to frog-biting midges. *

Which finding from the experiment, if true, would most directly support Bernal and de Silva's conclusion?

- ○ Only a small number of midges were found in the traps, though the majority were found in the trap that played calls and released carbon dioxide.
- ○ Midges entered the trap that released carbon dioxide and played calls only during or immediately after periods of carbon dioxide release.
- ○ More midges were found in the trap that only played calls than in the trap that played calls and released carbon dioxide.
- ○ The trap that released carbon dioxide and played calls attracted few midges when carbon dioxide concentrations were low but attracted many midges when carbon dioxide concentrations were high.

8. "Loon Point" is a 1912 poem by Amy Lowell. In the poem, which presents a nighttime scene on a body of water, Lowell describes an element of nature as an active participant in the experience, writing, _____ *

Which quotation from "Loon Point" most effectively illustrates the claim?

- ○ "Through the water the moon writes her legends / In light, on the smooth, wet sand."

- ○ "Softly the water ripples / Against the canoe's curving side."
- ○ "Or like the snow-white petals / Which drop from an overblown rose."
- ○ "But the moon in her wayward beauty / Is ever and always the same."

9. The following text is adapted from Johanna Spyri's 1881 novel Heidi (translated by Elisabeth Stork in 1915). Eight-year-old Heidi and her friend's grandmother are looking at some illustrated books. *

Heidi had come and was looking with wondering eyes at the splendid pictures in the large books, that Grandmama was showing her. Suddenly she screamed aloud, for there on the picture she saw a peaceful flock grazing on a green pasture. In the middle a shepherd was standing, leaning on his crook. The setting sun was shedding a golden light over everything. With glowing eyes Heidi devoured the scene.

Which choice best states the main idea of the text?

- ○ Heidi is upset until she sees a serene image of a pasture in one of Grandmama's books.
- ○ Heidi is delighted and fascinated by an image she sees in one of Grandmama's books.
- ○ Heidi is initially frightened by an image in one of Grandmama's books but quickly comes to appreciate its beauty.
- ○ Heidi is inspecting an image in one of Grandmama's books because she has never seen a shepherd with his sheep before.

10. O Pioneers! is a 1913 novel by Willa Cather. In the novel, Cather portrays Alexandra Bergson as having a deep emotional connection to her natural surroundings: _____ *

Which quotation from O Pioneers! most effectively illustrates the claim?

- "She had never known before how much the country meant to her. The chirping of the insects down in the long grass had been like the sweetest music. She had felt as if her heart were hiding down there, somewhere, with the quail and the plover and all the little wild things that crooned or buzzed in the sun. Under the long shaggy ridges, she felt the future stirring."
- "Alexandra talked to the men about their crops and to the women about their poultry. She spent a whole day with one young farmer who had been away at school, and who was experimenting with a new kind of clover hay. She learned a great deal."
- "Alexandra drove off alone. The rattle of her wagon was lost in the howling of the wind, but her lantern, held firmly between her feet, made a moving point of light along the highway, going deeper and deeper into the dark country."
- "It was Alexandra who read the papers and followed the markets, and who learned by the mistakes of their neighbors. It was Alexandra who could always tell about what it had cost to fatten each steer, and who could guess the weight of a hog before it went on the scales closer than John Bergson [her father] himself."

Appendix H

Control B (music app) reading comprehension questions

Locked mode is on. To avoid losing your progress, complete the full quiz before closing.

* Indicates required question

Email *

Record [redacted] the email to be included with my response

1. Baltimore, Maryland, has installed engineered structures along 71% of its shoreline to protect infrastructure from wave erosion and other hazards, a practice known as shoreline hardening. To evaluate the responses of waterbirds to two types of hardening structures—riprap and bulkheads—Diann Prosser et al. surveyed waterbird communities consisting of the tundra swan, the great blue heron, and 62 other species at different sites in the Chesapeake Bay on the US East Coast. Utilizing the Index of Waterbird Community Integrity (IWCI), on which a high score corresponds to high community integrity, the researchers found that bulkheads are more strongly negatively correlated with waterbird community integrity than is riprap. *

Which finding, if true, would most directly illustrate the researchers' finding?

- ○ The difference in average IWCI scores for waterbird communities at Stony and Old Road, two sites with a higher percentage of shoreline consisting of bulkheads than of riprap, was statistically insignificant.
- ○ Waterbird communities at Old Road, a site with a relatively high percentage of shoreline consisting of bulkheads, had lower average IWCI scores than did waterbird communities at Miles, a site with a relatively high percentage of shoreline consisting of riprap.
- ○ Waterbird communities at Curtis, a site with a high percentage of shoreline consisting of bulkheads and riprap, had lower average IWCI scores than did waterbird communities at Onancock, a site with a low percentage of shoreline consisting of bulkheads and riprap.
- ○ Waterbird communities at Curtis, a site with equal percentages of shoreline consisting of bulkheads and riprap, had higher average IWCI scores than did waterbird communities at Miles, a site with different percentages of shoreline consisting of bulkheads and riprap.

2. Some businesses believe that when employees are interrupted while doing their work, they experience a decrease in energy and productivity. However, a team led by Harshad Puranik, who studies management, has found that interruptions by colleagues can have a social component that increases employees' sense of belonging, resulting in greater job satisfaction that benefits employees and employers. Therefore, businesses should recognize that _____ *

Which choice most logically completes the text?

- ○ the interpersonal benefits of some interruptions in the workplace may offset the perceived negative effects.
- ○ in order to maximize productivity, employers should be willing to interrupt employees frequently throughout the day.
- ○ most employees avoid interrupting colleagues because they don't appreciate being interrupted themselves.

- ○ in order to cultivate an ideal workplace environment, interruptions of work should be discouraged.

3. Scholars have noted that F. Scott Fitzgerald's writings were likely influenced in part by his marriage to Zelda Fitzgerald, but many don't recognize Zelda as a writer in her own right. Indeed, Zelda authored several works herself, such as the novel Save Me the Waltz and numerous short stories. Thus, those who primarily view Zelda as an inspiration for F. Scott's writings _____ *

Which choice most logically completes the text?

- ○ overlook the many other factors that motivated F. Scott to write.
- ○ risk misrepresenting the full range of Zelda's contributions to literature.
- ○ may draw inaccurate conclusions about how F. Scott and Zelda viewed each other's works.
- ○ tend to read the works of F. Scott and Zelda in an overly autobiographical light.

4. "To You" is an 1856 poem by Walt Whitman. In the poem, Whitman suggests that readers, whom he addresses directly, have not fully understood themselves, writing, _____ *

Which quotation from "To You" most effectively illustrates the claim?

- ○ "You have not known what you are, you have slumber'd upon yourself / all your life, / Your eyelids have been the same as closed most of the time."
- ○ "These immense meadows, these interminable rivers, you are immense / and interminable as they."

- ○ "I should have made my way straight to you long ago, / I should have blabb'd nothing but you, I should have chanted nothing / but you."
- ○ "I will leave all and come and make the hymns of you, / None has understood you, but I understand you."

5. Microbes that live in shallow lakes and ponds produce methane, a harmful greenhouse gas. Ecologist Ralf Aben and his team wanted to see how different types of shallow-water plants might affect the amount of methane that escapes into the atmosphere. Aben's team set up some water tanks with soil and microbes from local ponds. Some tanks had a type of underwater plant that grows in the soil called watermilfoil. Other tanks had either duckweed, a type of plant that floats on the water's surface, or algae. Aben and his team found that tanks with duckweed and algae released higher levels of methane than tanks with watermilfoil did. This finding suggests that _____ *

Which choice most logically completes the text?

- ○ the presence of some kinds of underwater plants like watermilfoil helps prevent methane from escaping shallow lakes and ponds.
- ○ shallow lakes and ponds release more methane than deeper bodies of water because shallow bodies of water usually have more plants than deep bodies of water do.
- ○ shallow lakes and ponds are more likely to contain algae than to contain either watermilfoil or duckweed.
- ○ having a mix of algae, underwater plants, and floating plants is the best way to reduce the amount of methane in shallow lakes and ponds.

6. Roasted green chiles are a popular ingredient in Southwestern cuisine, but the traditional roasting method of burning propane is not environmentally friendly. To see if solar power could provide a better alternative, engineer Kenneth Armijo and his team roasted batches of green chiles using between 38 and 42 heliostats, which are devices that concentrate sunlight. The team was successful in reaching the same roasting temperature used in traditional propane roasting, but they found that propane yielded faster results. While the fastest solar-roasted green chiles took six minutes, batches using propane took only four. Armijo hypothesizes that they can reduce the roasting time for solar-roasted green chiles by using more heliostats. *

Which finding, if true, would most directly support Armijo's hypothesis?

- ○ The temperature inside the roasting drum is distributed more evenly when roasting green chiles with solar power than with propane.
- ○ Attempts to roast green chiles using 50 heliostats yields results in fewer than six minutes.
- ○ Green chile connoisseurs prefer the flavor of solar-roasted green chiles over the flavor of propane-roasted green chiles.
- ○ The skins of solar-roasted green chiles are easier to peel than the skins of propane-roasted green chiles.

7. Paleontologist Alan Tennyson and colleagues studied fossil bones found in New Zealand that are more than 55 million years old. The researchers determined that the fossil bones belonged to two previously unknown species of prehistoric penguins. Moreover, they estimated that one of the two penguin species was more than three times the size of the emperor penguin, which is the largest penguin species that exists today. *

Based on the text, which choice best describes the two previously unknown penguin species?

- ◯ They are frequently studied by paleontologists.
- ◯ They are no longer living species.
- ◯ They were smaller than penguin species that exist today.
- ◯ They spent little of their lives in water.

8. Plants like potatoes, tomatoes, and soybeans are susceptible to bacterial wilt disease caused by the bacteria Ralstonia solanacearum. A multinational team of scientists led by Zhong Wei studied whether other microbes in the soil might influence the degree to which plants are affected by the disease. The team sampled soil surrounding individual tomato plants over time and compared the results of plants that became diseased with those that remained healthy. They concluded that the presence of certain microbes in the soil might explain the difference between healthy and diseased plants. *

Which finding, if true, would most directly support the team's conclusion?

- ◯ The soil surrounding healthy plants contained significantly higher concentrations of microbes known to inhibit Ralstonia solanacearum than the soil surrounding diseased plants did.
- ◯ The soil surrounding the plants contained high concentrations of Ralstonia solanacearum regardless of whether the plants were affected by wilt disease.
- ◯ The soil surrounding healthy plants tended to have significantly higher moisture levels than the soil surrounding diseased plants did.
- ◯ By the end of the experiment, over half the plants had been affected by wilt disease regardless of differences in the types and concentrations of microbes in the surrounding soil

9. Scent is tightly interwoven with our daily lives, often evoking significant memories and important social events. This connection is of growing interest to archaeologists who hope to use it to better understand ancient rituals, trade, social hierarchies, and medicine. Although the speed at which odor molecules dissipate makes identifying ancient scents challenging, advancements in biomolecular technologies show promise in unlocking ancient aromas from preserved artifacts. Archaeological studies making use of these advancements may provide new insights into past societies. *

According to the text, what is one reason some archaeologists are interested in recovering scents from ancient artifacts?

- ○ They are investigating whether people's sense of smell has declined in recent centuries.
- ○ They believe the scents could illuminate important aspects of ancient life.
- ○ They think that ancient scents would be enjoyable to people today.
- ○ They hope to develop new medicines using ancient scent molecules.

10. One aspect of in-person shopping that online shopping can't replicate is the opportunity to touch a product before buying it. Does this difference matter? In an experiment, researchers asked one group of participants to touch a mug and a toy, while another group was prohibited from touching the two items. The participants were then asked how much money they'd pay for the items. People who got to touch the items were willing to pay much more money for them than were people who weren't allowed to touch the items. This finding suggests that _____ *

Which choice most logically completes the text?

- ○ people who mainly shop online probably spend more money every month than people who mainly shop in person do.
- ○ in-person shopping may make products seem more valuable than they seem if only viewed online.
- ○ retailers with in-person and online stores should charge the same price for a given product in both places.
- ○ online retailers may be able to raise the prices they charge for products that are only available online.

Appendix I


PARTICIPATE IN A MULTITASKING RESEARCH STUDY
If you are a [redacted]student ages 14-18 you are elegable to participate!
[redacted]
If interested fill out this form and I will contact you with more info