DURMS
Durham Undergraduate Research in Music & Science

The Effects of Instrumentation and Musicianship on Working Memory while Listening to Background Music

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ABSTRACT

This study builds upon previous research concerning the factors which effect working memory while listening to background music. Within the scope of this study, the effects of instrumentation and musicianship on performance in a memory test are investigated, with the effects of familiarity being investigated as a secondary factor. The study involved participants memorising word lists while listening to three different versions of the same song as background music. Although not statistically significant, this study suggests that background music with popular music instrumentations was more beneficial to working memory compared to classical music instrumentations. In addition, the results suggest that background music without lyrics was more beneficial to working memory than music with lyrics present. As far as musicianship is concerned, musicians performed better in the memory test across all instrumentations compared to non-musicians. Finally, the results suggest that participants who were not familiar with the background music tended to perform better in the memory test compared to participants who were familiar with the background music. It should be noted that none of these differences found were statistically significant, so further experiments would be required to confirm these trends.

1. INTRODUCTION

This study investigates the effects of instrumentation and musicianship on the recall of words from word lists while listening to background music, and thus the effect of instrumentation and musicianship on working memory while listening to background music.

There have been numerous past studies which have investigated the effects of background music features on working memory. In a study conducted by Bugter and Carden, which examined 'the effect of music genre on a memory task', the effect of two different genres of background music on performance in a memory test was investigated, with the two genres being used as stimuli being rap and classical (Bugter & Carden, 2012). The 60 undergraduate students who acted as participants in this study were placed into one of three groups. The first group was exposed to silence while they completed the memory test, the second group listened to classical background music and the third group listened to rap background music. The memory task was in the form of a game of 'Concentration', where the dependent variable was 'the number of cards "flipped"' in order to complete the game (Bugter & Carden, 2012). It was found that there was a significant difference between groups, with the group in which participants were exposed to classical background music performing better in the memory test than the group exposed to rap (Bugter & Carden, 2012).

Waters also conducted a study that investigated the effects of background music features on working memory. In contrast to the study by Bugter and Carden, Waters specifically investigated the effect of the presence and absence of lyrics in background music on working memory performance (Waters, 2013). In this study, 36 undergraduate students who acted as participants were placed into one of three groups. The first group were exposed to vocal music whereas the second group were exposed to an instrumental version of the same song, whilst the third was exposed to silence. Although the results were not significant, it was found that participants who were exposed to the instrumental version of the background music performed better in the memory test than those exposed to vocal music (Waters, 2013)

Considering the results of the studies conducted by Bugter and Carden and by Waters, a feature both these studies have in common is that they both contain one stimulus with lyrics and another stimulus without lyrics, and both found that the stimuli which contained no lyrics proved the most beneficial for working memory performance. However, a limitation of the study by Bugter and Carden is that the only explanation given for the differences found is that the results were likely caused due to the 'calming' nature of the classical background music, whereas the rap background music was more 'aggressive' (Bugter & Carden, 2012). In relation to this, I argue that another feature of the differing genres could have caused the results, namely instrumentation. This is because classical and rap music tend to have very different instrumentations, so it is possible that these differing instrumentation may have contributed to the results found. With regards to the differences caused by classical music instrumentations compared to popular music instrumentations, in a meta-analysis on the topic of the effects of different features of background music on working memory performance, there is no mention of

specifically the effects of different instrumentations on working memory (de la Mora Velasco & Hirumi, 2020). However, in the same meta-analysis, it was found that classical was the genre where participants tended to perform best in memory tests, whereas pop was the genre which produced the least positive effects in memory tests (de la Mora Velasco & Hirumi, 2020). Therefore, although the effects of different instrumentations were not mentioned specifically within this meta-analysis, I argue that it is likely that classical instrumentations will produce the most positive effects with regards to performance in a memory test compared to popular music instrumentations. This is because the genres of classical and pop tend to contain highly contrasting instrumentations.

Other factors which the studies by Bugter and Carden, and Waters did not consider are the effects of the participants' familiarity with the background music and their musicianship, so these may also be factors contributing to the differences found in memory test performance with the different stimuli. With regards to musicianship, a previous study by Patston and Tippett investigated 'the effect of background music on cognitive performance in musicians and non-musicians.' Within this study, 36 musicians and 36 non-musicians were asked to complete a language comprehension task and a visuospatial task while listening to either silence, piano music played correctly, or piano music played incorrectly (Patston & Tippett, 2011). However, in contrast to the studies by Bugter and Carden, and Waters, this study did not consider the effects of the instrumentation of the background music and did not involve memory tests. Instead, cognitive tests were used (Bugter & Carden, 2012; Waters, 2013). Patston and Tippett found that 'musicians outperformed non-musicians on both tasks', suggesting that musicians have a 'cognitive advantage' compared to non-musicians (Patston & Tippett, 2011). More broadly, specifically with regards to the effect of musicianship on working memory while listening to background music, in the meta-analysis by de la Mora Velasco and Hirumi, it was found that more research is required to determine the impact of musicianship on the effect of background music on working memory, as the majority of previous research did not report on the effects of musicianship, showing that further investigating the effects of musicianship within this study would help to fill a gap in previous research (de la Mora Velasco & Hirumi, 2020). With regards to familiarity, according to a meta-analysis by Kämpfe et al. on the effects of background music on working memory, the overall effect of the participants' familiarity with the background music is largely inconclusive due to how in previous studies, there is 'no clear standard of comparison' for different familiarities, showing that further research on this topic would also be beneficial (Kämpfe et al., 2010).

Considering what has been found in previous research on the topic of background music, this study will address three main research aims, the first of which being to investigate what effect the instrumentation of background music has on working memory, which includes the effect of the presence or absence of lyrics. I hypothesise that, similar to what has been suggested by previous research by Bugter and Carden, and in the meta-analysis by de la Mora Velasco and Hirumi, background music with classical instrumentations will be more beneficial to working memory than background music with popular music instrumentations (Bugter & Carden, 2012; de la Mora Velasco & Hirumi, 2020). In addition to this, regarding instrumentation, I hypothesise that as was found in previous research, background music which contains lyrics will be less beneficial to working memory than music without lyrics (Bugter & Carden, 2012; Waters, 2013). I hypothesise this due to how within the working memory model, the phonological loop is 'responsible for maintaining speech-based information' (Baddeley, 1992), so when participants memorise a list of words, the phonological loop will be used. Because the phonological loop is used to maintain verbal and speech-based information, I argue that it is possible that the presence of lyrics within the background music may affect working memory to some extent, due to the lyrics giving the phonological loop extra verbal information to maintain. Previous research suggests that working memory has a limited capacity (Buchsbaum, 2013), thus, it is likely that background music which contains lyrics will limit the number of words participants are able to memorise. Secondly, this study aims to investigate the extent to which the participant's musicianship affects working memory while listening to background music. Regarding musicianship, I hypothesise that musicians will perform better in the memory tests than non-musicians across all instrumentations, due to how previous research suggests that musicians have a cognitive advantage over non-musicians which is highlighted by the fact that musicians performed better in the cognitive tasks listening to silence, correctly played piano music, and incorrectly played piano music (Patston & Tippett, 2011). The final aim of this study will be to investigate the extent to which the participant's familiarity with the background music affects working memory as a secondary factor. Investigating the effects of musicianship and familiarity will help to further understanding of these under-researched aspects of this topic.

2. METHOD

Design. This research takes the form of a quantitative study, with a within participants design, which involved participants completing an online questionnaire via Qualtrics. The independent variables within this study where the instrumentation of the background music presented to the participant, including the presence or lack of lyrics, the participant's musicianship, and the participant's familiarity with the given background music. The dependent variable within this study was the number of words from a word list each participant correctly memorised for each stimulus.

Participants. The study had a total of 27 participants (7 male, 18 female, 1 non-binary, 1 prefer not to say) who fully completed the survey. The responses from other participants who did not fully complete the survey were discarded. All participants were recruited via social media, in order to target as large a demographic range as possible, with a large range of ages and musicianship levels. Convenience sampling was therefore used. Of the 27 participants who submitted complete survey responses the average age was 24.28 with a range of 18-71 and a standard deviation of 12.81. With regards to musicianship, 17 participants self-described as musicians whereas 10 self-described as non-musicians. The mean average musician age was 21 whereas the mean average non-musician age was 32.8.

Materials/Stimuli. For the stimuli within this study, three different versions of the first minute of *Under the Bridge* by Red Hot Chili Peppers were used. These versions included the original vocal version, a karaoke version which contained the same popular music instrumentation as the vocal version but with the vocals removed, and a string quartet version of the song which had a classical music instrumentation with no vocals. Therefore, by using different versions of the same song, other features of the music were controlled, such as tempo and melody, to ensure that the effects of instrumentation could be investigated without other musical features impacting the results. Furthermore, it was important to use different versions of the same song within this study because it allows for comparison in pairs. In other words, the effect of whether the background music contains a popular music instrumentation, or a classical instrumentation can be observed by comparing the results for the karaoke and string quartet versions. Likewise, the effect of the presence or absence of lyrics can be observed by comparing the results for the vocal version to the karaoke version.

Under the Bridge by Red Hot Chili Peppers was used as background music in this study in order to target as large a range of familiarities as possible. In addition, this song was also used as the stimulus in the study conducted by Waters (Waters, 2013), thus meaning that by also using this song, the results of this study can be compared more directly with what was found in Waters' study.

The words for the word lists to be memorised by participants while listening to background music were selected with reference to the Affective Norms for English Words Database, to ensure that no words in particular would be easier for participants to memorise than others (Bradley and Lang, 1999). More specifically, words to be included in the word lists each had a similar 'valence means (SD)', 'arousal means (SD)' and 'dominance means (SD)' in the range of 4.00-4.99 (Bradley and Lang, 1999). Words from the Affective Norms for English Words Database which met this criteria were then compiled into a single list. There was a total of 27 words within the database which met this criteria to be included in this list. The order of words on this word list was then randomised via an online randomiser and from this, the words were distributed evenly into 3 smaller lists. Each of the 3 lists to be memorised by participants therefore contained 9 randomly selected words which would be a similar difficulty to memorise. However, the words in the word lists were not matched on any other features such as the number of letters each word contains or the reading level.

Musicianship was measured using the OMSI scale for measuring musical sophistication (Zhang & Schubert, 2019). Musicianship was therefore self-reported.

Procedure. In a Qualtrics survey, after informed consent was given, participants answered a series of simple demographic questions. These questions included age, gender, musicianship, and whether English is the participant's first language. After, participants were randomly presented with a version of the background music and were instructed to listen to it while memorising a word list, comprising 9 words. Participants had 1 minute to memorise as many words as possible from the list before Qualtrics automatically advanced to the next page of the survey. On this next page, participants were given 2 minutes to recall all the words they had memorised. This process was repeated until all participants had been exposed to each version of the background music in a random order. It is essential that the order in which the stimuli appear is randomised for each participant because it ensures that differences in memory test performance are due to the independent variables, and not as a consequence of participants performing better in the memory test due to becoming more comfortable with the memorisation process as the survey progresses. Participants were finally asked to rate how familiar they were with the background music on a 5-point Likert scale.

3. RESULTS

Firstly, it is important to acknowledge that the average number of words correctly memorised out of a total of 9 words for each instrumentation was $M = 6.46$, and the number of words correctly memorised ranged from 0 to 9. This shows that the difficulty of the memory test was appropriate, since the mean average number of words correctly memorised does not fall close to the maximum possible score of 9.

Instrumentation. As far as instrumentation is concerned, which includes the presence or lack of lyrics, looking at the results broadly (Figure 1), participants performed the best in the memory test listening to the karaoke version of the background music. However, participants performed the worst while listening to the string quartet version of the background music. When comparing the average number of words correctly memorised for the karaoke

and string quartet versions, where the lack of lyrics is controlled, the results show that participants performed better listening to a popular music instrumentation compared to listening to a classical music instrumentation. In addition, when comparing the vocal version to the karaoke version of the background music, where the popular music instrumentation is controlled, the results show that participants performed the best in the memory test listening to the karaoke version.

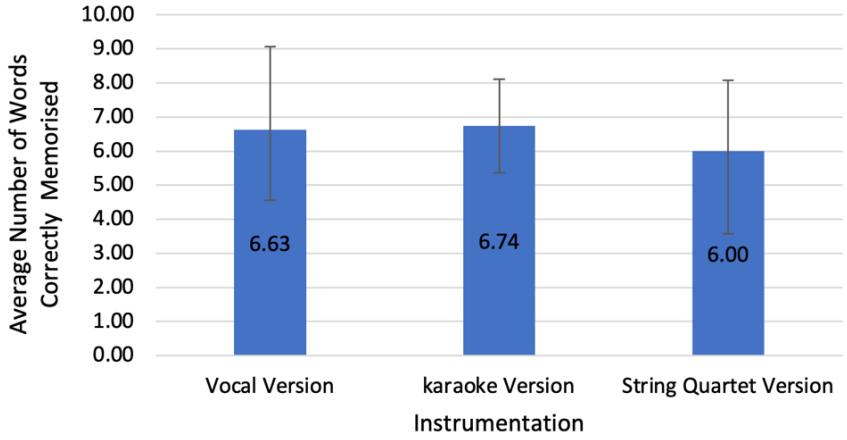

Figure 1. A graph to show the effect of instrumentation on the average number of words correctly memorised.

Musicianship. There was a spread of different levels of musicianship among the participants (Table 1).

Table 1. A table to show the frequency of participants for each category on the OMSI scale for measuring musical sophistication.

Musicianship (OMSI Scale for Measuring Musical Sophistication)	**Frequency of Participants**
Non-musician	3
Music-loving non-musician	7
Amateur musician	5
Serious amateur musician	5
Semi-professional musician	6
Professional musician	1

Because there were very few participants at each extreme of the OMSI scale for measuring musical sophistication ('non-musician' and 'professional musician'), in order to obtain the most representative results possible, participants were then distributed between the categories of 'non-musician' (which included participants who were non-musicians and music-loving non-musicians) and 'musician' (which included amateur musicians, serious amateur musicians, semi-professional musicians and professional musicians). This is demonstrated in Table 2.

Table 2. A table to show the frequency of non-musicians and musicians.

Musicianship	**Frequency of Participants**
Non-musician	10
Musician	17

Regarding Figure 2, when examining the effect of musicianship on performance in the memory test, the results show that musicians performed better in the memory test than non-musicians with all three instrumentations. This therefore suggests that musicianship affects working memory with all three instrumentations when listening to background music. However, the differences between instrumentations nor musicianship produced statistically significant results ($p > .05$) when an ANOVA test was run (*Musicianship*: $F(1,25) = 0.981$, $p = 0.331$, *Instrumentation*: $F(2,52) = 1.816$, $p = 0.17$), showing that further research would be required to confirm the trends seen in Figure 2.

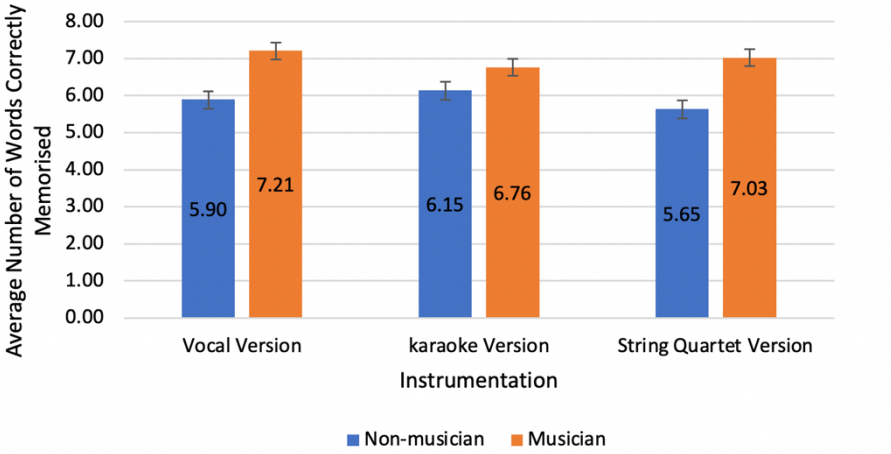

Figure 2. A graph to show the effect of instrumentation and musicianship on the average number of words correctly memorised.

Familiarity. With regards to the distribution of the participants' familiarity with the background music presented to them, Table 3 shows that participants reported a range of familiarities.

Table 3. A table to show the frequency of participants who reported different familiarities on the 5-point Likert scale.

Familiarity rating on a 5 -point Likert scale	**Frequency of Participants**
1 (not familiar at all)	14
2 (slightly familiar)	2
3 (moderately familiar)	4
4 (very familiar)	2
5 (extremely familiar)	5

The frequencies shown in Table 3 were then distributed into binary categories of either 'not familiar' or 'familiar.' Participants who answered 'not familiar at all' were placed into the 'not familiar category' whilst all other participants were placed into the 'familiar' category. Table 4 shows that there is a roughly even distribution of participants who are not familiar and familiar with the background music. This demonstrates that the selected stimuli were successful in targeting a range of participant familiarities.

Table 4. A table to show the frequency of participants who were not familiar and familiar with the background music.

Familiarity	**Frequency of Participants**
Not familiar	14
Familiar	13

As far as the effect of familiarity on the average number of words correctly memorised is concerned, participants who were not familiar with the background music tended to perform better in the memory test compared to those who were familiar with the background music (Figure 3). However, an anomaly to this trend is with the karaoke version of the background music, where participants who were familiar with the background music performed marginally better in the memory test compared to those who were not familiar with the background music. Familiarity nor instrumentation was found to be statistically significant ($p > .05$), when an ANOVA test was run with the results in Figure 3 (*Familiarity:* $F(1,25) = 0.636$, $p = 0.43$, *Instrumentation*: $F(2,52) = 1.816$, $p = 0.17$).

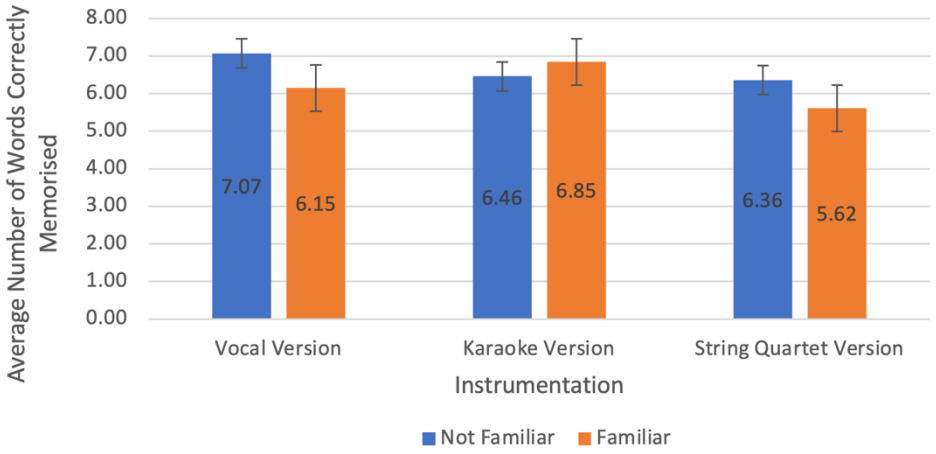

Figure 3. A graph to show the effects of familiarity on the average number of words correctly memorised for each instrumentation.

4. DISCUSSION

Looking at the results obtained broadly, participants performed best in the memory test listening to the karaoke version of the background music and worst listening to the string quartet version. However, when comparing the vocal version to the karaoke version of the song, where the popular music instrumentation is controlled, the results show that participants performed better in the memory test listening to the karaoke version compared to the vocal version. This suggests that participants perform better listening to background music without lyrics. This concurs with the hypothesis and what has been found in previous research, where background music which does not contain lyrics was found to be better for working memory performance (Bugter & Carden, 2012; Waters, 2013). However, the differences found were not statistically significant ($p > .05$), so this hypothesis cannot be accepted. Next, when comparing the karaoke version to the string quartet version of the background music, where the lack of lyrics is controlled, the results show that participants performed better in the memory test listening to music with a popular music instrumentation compared to a classical music instrumentation. This suggests that listening to background music with popular music instrumentations is more beneficial for working memory performance, although these results were not statistically significant ($p > .05$). It was hypothesised that classical instrumentations would be more beneficial for working memory performance, so this hypothesis is rejected. As far as musicianship is concerned, the results show that musicians performed better in the memory test compared to non-musicians, across all three instrumentations. This reflects the hypothesis and what has been found in previous research, which suggests that musicians have a cognitive advantage over non-musicians, including in the presence of background music (Patston & Tippett, 2011). However, the differences found were not statistically significant ($p > .05$), so this hypothesis cannot be accepted. Furthermore, the results show that participants who were not familiar with the background music tended to perform better in the memory test compared to those who were familiar with the background music, suggesting that listening to background music which you may not be familiar with is more beneficial to working memory than listening to familiar background music, although these differences were not found to be statistically significant ($p > .05$).

It should be noted that none of the differences found within this study are statistically significant ($p > .05$), which is likely due to the small sample size ($n = 27$). Due to this, future studies would be required with a larger sample size, with as large a demographic range as possible, to confirm the trends found in this study. Another limitation relating to the sample of participants is the method of recruitment used, namely convenience sampling via various social media platforms. A limitation associated with this method of sampling is that it disproportionately targets 'WEIRD' participants (Western, educated, industrialised, rich, and democratic), meaning that only a small amount of the population is represented within the results found (Henrich et al.,

2010). Therefore, it would be beneficial to use more inclusive methods of sampling in future studies to ensure that a more diverse proportion of the population is represented within the results (Richardson, 2022). In addition, it should be noted that different versions of only a single song were used within this study, so it would be beneficial in future experiments to use different versions of multiple songs in order to obtain a greater range of results. This would involve using songs or pieces from a range of different genres, and similar to this study, including different versions of the same music to compare the effects of instrumentation, in order to see if the trends found within this study are consistent with a wider range of background music.

Another limitation of this study which may have led to obtaining results which were not statistically significant is that certain variables were not controlled. Firstly, inherent in the online nature of this survey, the environment in which participants completed the memorisation tests was not controlled. This would be beneficial to control in future studies because, for example, in this survey, a participant scored zero in one of the memory tasks. I argue that scoring zero could indicate a lack of attention from the participant on the given task, which could be caused due to the environment they are taking the survey in, which may contain distractions. Therefore, it would be beneficial for future studies on this topic to take place in person, so that the environment in which the survey is taken can be better controlled to minimise possible distractions. In addition, controlling factors such as the word lengths and reading level of the words in the word lists may lead to obtaining statistically significant results in future studies on this topic ($p > .05$).

A limitation which may help to explain why participants performed the worse in the memory test while listening to the string quartet version compared to the karaoke version is that of varying loudness. When the waveforms of the stimuli were compared, it was found that the string quartet version of the background music was louder overall for a greater duration of the excerpt compared to the karaoke version, due to how the waveform of the string quartet version has a consistently large amplitude compared to the karaoke version, which tends to be quieter overall and has more variation in loudness (*figure 4* and *5)*. This difference in loudness is significant because previous research suggests that louder background music could hinder working memory performance (de la Mora Velasco & Hirumi, 2020). Due to this, it is possible the fact that the string quartet version was consistently louder could explain why it was found to be the least beneficial to working memory performance, especially since this result is contrary to what previous research suggests, where classical music instrumentations are more beneficial to working memory than popular music instrumentations (Bugter & Carden, 2012; de la Mora Velasco & Hirumi, 2020). Therefore, in future studies on this topic, it should be ensured that the loudness of each stimulus is controlled.

Figure 4. The waveform of the karaoke version of the background music

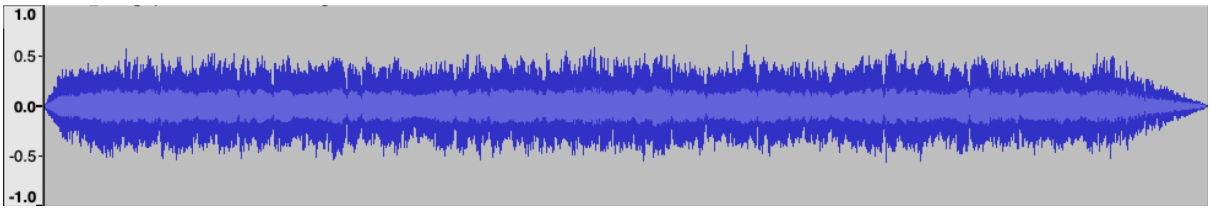

Figure 5. The waveform for the string quartet version of the background music

The final limitation of this study which is essential to address is the fact that there was a large difference between the average age of the musician group ($M = 21$) and of the non-musician group ($M = 32.8$). This 11.8-year average age difference likely impacted the results comparing musicians and non-musicians since the average age of the non-musician group was higher than the average age of the musician group, meaning that it is possible that age may be a factor which reduced the non-musicians' performance in the memory test as opposed to their lack of musicianship. This is because previous research suggests that 'working memory functioning declines with advancing age' (Verhaeghen et al., 2019). Therefore, a greater sample size would be beneficial in future research on this topic to represent a larger range of ages for both musicianship groups, in order to better examine the effects of musicianship.

In conclusion, this study contributes to our scientific knowledge on this topic as it reinforces trends found in previous research with regards to background music without lyrics being more beneficial for working memory performance (Bugter & Carden, 2012; Waters 2013). In addition, the results regarding the effects of popular music instrumentations compared to classical instrumentations make a contribution to knowledge on the topic due to how this study suggests that popular music instrumentations may be more beneficial for working memory, which is contrary to what previous research suggests (Bugter & Carden, 2012; de la Mora Velasco & Hirumi, 2020), showing that further research would be necessary to confirm the trend found within this study, especially since these differences were not statistically significant. Finally, regarding the effects of musicianship and familiarity, this study contributes to an under researched aspect of factors which affect working memory while listening to background music, finding that both differences in familiarity and musicianship appear to have an effect on working memory performance while listening to background music. Again, more research would be required to confirm these trends as the differences found were not statistically significant.

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APPENDIX

Word lists used in the Qualtrics survey.

List 1

1. Hammer
2. Tamper
3. Cellar
4. Obey
5. Derelict
6. Excuse
7. Listless
8. Fur
9. stool

List 2

1. fall
2. pungent
3. contents
4. kerosene
5. aloof
6. vanity
7. shadow
8. absurd
9. dark

List 3

1. bereavement
2. sceptical
3. hazard
4. odd
5. insect
6. lump
7. muddy
8. knot
9. nonsense