Music-Dependent Memory: An Example of Context-Dependent Memory or the Consequence of Distraction?

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Abstract

Music-dependent memory (MDM) is the concept that music can serve as an effective retrieval cue for previously learned information. Both mood and arousal levels have been shown to be important contextual components of MDM; however, the full range of underlying factors that contribute to MDM is still unknown. We manipulated mood, arousal levels, and type (genre) of music to determine the relative contributions of each of these factors to MDM. Participants learned face-name pairs while listening to background music varying in the mood and arousal levels. Participants then performed a recognition task on the previously learned face-name pairs during which the mood and arousal levels were the same as during the learning phase. The type of music, however, was varied. We predicted that the contextual components of music are important causal factors of MDM and that memory performance would be enhanced when the contextual components during learning and testing were similar. Contrary to predictions, the results indicated that the type of music only had an effect on memory performance in the low arousal-negative mood condition: changing the specific musical piece within the same genre impaired memory performance relative to keeping the piece identical or changing the piece and the genre.

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Early investigations of human memory found that the context present at learning and recall can have a significant impact on how well information is remembered, in that information learned in one context is better remembered when the same context is reinstated during recall (Abernethy, 1940; McGeoch, 1932). For example, Abernethy (1940) found that college students performed better on exams when the learning and testing took place in the same classroom, as opposed to different classrooms. This aspect of human memory has been labelled context-dependent memory (CDM). CDM has been shown to be a reliable finding in the literature, and has been extended to a variety of contexts, including: olfactory cues (Cann & Ross, 1989), clothing of the experimenter (Standing, Bobbitt, Boisvert, Dayholos, & Gagnon, 2008), testing environment (Godden & Baddeley, 1975), and alcohol states (Eich, 1980), among many other contexts. CDM follows from what you would expect to find according to the encoding specificity principle (Tulving & Thomson, 1973). As Standing et al. (2008) explains, the encoding specificity principle is the concept that encoding of new information occurs within a variety of surrounding stimuli (e.g., visual cues). Some of the surrounding stimuli then becomes associated with the newly encoded information. If the same surrounding stimuli are present during both encoding and retrieval, the surrounding stimuli can serve as a retrieval cue and aid memory.

Music has been investigated as another potential context under which CDM occurs. Researchers have shown that music does produce CDM effects (Balch, Bowman, & Mohler, 1992; Smith, 1985). For example, Smith (1985) investigated the effect of background music on CDM. Participants learned a list of words under one of three background music conditions: a

Mozart piece, jazz selection, or quiet condition. After the initial learning of the word list, participants completed a free recall test in one of two conditions: same context or different context. Same context conditions had the same background music played during learning and testing; for example, listening to jazz music during learning and testing. Different context conditions had different music played during learning and testing; for example, jazz music played during learning and the Mozart selection played during testing. Smith found that participants recalled significantly more words when the same musical context was reinstated during testing. This research supports the idea that music can serve as an effective retrieval cue and may be another example of CDM.

The subtype of CDM involving music has been referred to as music-dependent memory (MDM). While support for MDM has been found in past research, it is essential to determine the cause of MDM. Currently, at least two possible explanations exist for MDM. One hypothesis is that MDM is the result of music serving as an effective retrieval cue for previously learned information. For example, playing the same music during learning and testing improves memory because similar contextual cues assist memory retrieval. An alternate hypothesis is that MDM occurs not because music serves as an effect retrieval cue, but because changing the music between study and test is distracting and impairs memory performance. The current investigation examined the various contextual components of music in order to determine the hypothesis that best explains MDM. In addition to type of musical genre, mood and physiological arousal have also been proposed as possible contextual components of music.

When mood has been investigated as a possible context for CDM, it has been referred to as mood-dependent memory. As an example, research conducted by Bower (1981) examined the role of mood in memory formation. Participants were induced into either a happy or sad mood by hypnotic suggestion. Memory for word lists, personal experiences, and childhood experiences was examined. Similar to previous CDM findings, Bower found that memory was enhanced when the same mood at learning was reinstated at testing. In other words, participants' memory was significantly better when the same mood was present at learning and testing. Thus, memory was improved when learning and testing occurred during happy-happy or sad-sad conditions rather than incongruent mood conditions (e.g., happy-sad). This finding is important with regard to MDM because music has been shown to be an effective method of inducing emotional states (Blood, Zatorre, Bermudez, & Evans, 1999).

Since mood has been shown to be an effective retrieval cue and music has been shown to influence mood, it follows that mood may be an important aspect of music that leads to MDM. Researchers have recently been examining the role of mood in MDM (e.g., Balch & Lewis, 1996; Balch & Myers, 1999; Mead & Ball, 2007). Mead and Ball (2007) investigated the role of mood in MDM by manipulating the background music played during learning and testing. Participants studied words one at a time while listening to background music in either a minor or major key. Mood ratings of participants indicated that music played in the minor key induced sad moods, whereas music played in the major key induced happier moods. Similar to other investigations examining CDM, Mean and Ball then tested the participants in either mood congruent or mood incongruent states. Thus, four learning-retrieval conditions were examined: two mood congruent conditions (minor-minor and major-major) and two mood incongruent conditions (minor-major and major-minor). Consistent with previous CDM findings, participants recalled significantly more words when the condition at learning and retrieval was the same. In other words, participants recalled more words in the major-major and minor-minor conditions. The results indicate that the mood is at least one contextual component of MDM.

Another type of CDM that has been investigated is arousal-dependent memory. Standing et al. (2008) varied the level of physiological arousal in participants using various levels of physical activity. Participants studied word lists under three arousal conditions: relaxation, moderate arousal, and high arousal. Arousal level was determined by the heart-rate of participants. Similar to other CDM investigations, participants then recalled words in either arousal congruent (e.g., high arousal-high arousal) or arousal incongruent (e.g., low arousal-high arousal) conditions. Standing et al. found no evidence for arousal-dependent memory. That is, participants showed no significant memory improvement for congruent arousal states indicating that arousal levels do not serve as retrieval cues for previously learned information. However, the study did show that there was a linear relationship between memory performance and arousal level. Upon examining congruent arousal states (low-low, moderate-moderate, and high-high), Standing et al. found that memory performance increased as arousal level increased. Thus, although arousal levels do not seem to be an example of CDM, high arousal levels may be important with regard to memory performance. These findings may apply to MDM because, as mentioned previously, music has been shown to be effective at inducing emotional states, including changes in physiological arousal (Blood et al., 1999).

There have been mixed results regarding arousal level and MDM. Balch and Lewis (1996) examined arousal-dependent memory by using music as a means of inducing arousal levels. They first tested to see if arousal could be manipulated by changing the tempo (or speed) of the music. Participants listened to either a fast or slow tempo musical selection and rated their arousal level. They found that fast tempo music induced higher arousal levels and slow tempo music induced low arousal levels. They used these results for the basis of their next experiment that investigated arousal and CDM. Participants were asked to remember word lists while listening to a classical music selection. Half the participants listened to a fast version (i.e., high arousal) of the music selection and the other half listened to a slow version (i.e., low arousal) of the music selection. Critically, during recall participants did not listen to music to induce a particular level of arousal. Instead, participants were asked to imagine themselves in a variety of situations designed to produce arousal levels similar to either the fast or slow tempo music selections. For example, low arousal levels were induced by participants imagining relaxing scenarios (e.g., lounging by a lake) and high arousal levels were induced by participants imagining active scenarios (e.g., driving in traffic). Participants were then asked to recall the words in either an arousal-congruent or arousal-incongruent context. Consistent with previous CDM findings, Balch and Lewis found that memory performance was improved when the same arousal levels were present at learning and testing. In other words, participants recalled more words in the same context conditions (e.g., high arousal-high arousal) than in the different context conditions (e.g., low arousal-high arousal).

As mentioned earlier, however, the results of arousal-dependent memory are inconsistent. Balch, Myers, and Papotto (1999) examined the role of arousal in MDM. Music was used to induce the appropriate arousal conditions. Using a CDM paradigm similar to previous investigations they found that arousal did not show CDM. That is, compared to incongruent arousal conditions (e.g., high arousal-low arousal) participants did not show a marked increase in memory performance when arousal conditions were congruent (e.g., high arousal-high arousal). These results indicate that arousal may not be an important aspect of music when investigating MDM. However, the investigation also showed that the pairing of congruent mood and arousal levels may be important when examining MDM. For example, the researchers found that when participants were induced into a positive mood and high arousal levels that CDM did occur when the same context was reinstated during recall. The same finding was found for negative mood and low arousal conditions. The results indicate that certain combinations of mood and arousal levels may be more beneficial than others with regard to MDM. A recent study by Greene, Bahri, and Soto (2010) extended these findings.

Greene et al. (2010) investigated the interaction between mood and arousal with regard to MDM. Participants in their study listened to short musical selections, and then rated their mood and arousal levels. Mood ratings were categorized as positive or negative and arousal ratings were categorized as alert/energized or relaxed. Participants rated their mood and arousal levels to a variety of musical selections until at least one piece of music was assigned to each of the four emotional states: high arousal-positive mood (HAP), high arousal-negative mood (HAN), low arousal-positive mood (LAP), and low arousal-negative mood (LAN). Before the study phase of the investigation began, participants were asked to indicate their current mood and arousal states. During the study phase, participants were presented with abstract shapes and were told that there would be a subsequent memory task. No music was played during the study phase. Following the study phase, participants listened to music from one of the four musical selections followed by a recognition task of the previously learned abstract shapes. Interestingly, the investigators identified an interaction between mood and arousal on memory performance. MDM occurred only for two of the emotional states: HAP and LAN. MDM did not occur for the LAP and HAN conditions. These findings are important because they indicate that neither mood nor arousal levels on their own are sufficient at producing MDM. In other words, reinstating the same mood or arousal level during the recognition task was not sufficient to produce MDM. MDM was observed only when mood (e.g., positive) was paired with the corresponding arousal level (e.g., high) during learning and testing. These results highlight the importance of the combination of mood and arousal levels with regard to MDM.

There have been two hypotheses put forward that explain the role of mood and arousal in MDM: the mood mediation hypothesis and the mental context hypothesis. The mood mediation hypothesis claims that:

> How well information transfers from one environment to another depends not on how similar the environments look but on how similar they feel. Thus, even when target events are encoded and retrieved in the same physical setting, memory performance suffers if the attending psychological states differ. (Eich, 1995, p. 305)

Support for this hypothesis comes from Eich's (1995) investigations of place-dependent memory and mood. Eich's experiments showed that changing the environmental context from learning to testing had no adverse impact on memory performance unless the mood at learning and testing did not match. In other words, mood is the important mediator when altering environmental contexts, and place-dependent memory occurs because of changes in mood rather than place.

The mental context hypothesis (Smith, 1995), on the other hand, claims that CDM is a function of various contextual changes (e.g., mood, place, mental state, etc.) and any one of these contextual changes can cause CDM. Smith (1995) contends that Eich's (1995) findings indicate that mood is a stronger contextual cue for memory than place, mental states, etc., not that mood is solely responsible for CDM. The Balch and Lewis (1996) study that was mentioned previously supported the mood mediation hypothesis. Balch and Lewis manipulated the tempo of music to induce particular emotional states in participants. They found that this manipulation alone was sufficient to cause MDM. Further, manipulating other contextual aspects of music (e.g., timbre, different music selections) was not associated with MDM effects. Thus, Balch and

Lewis concluded that there was little evidence for the mental context hypothesis with regard to MDM because the other contextual attributes of music produced no MDM effects. Support for the mood mediation hypothesis and previous investigations of mood-dependent and arousal-dependent memory are particularly relevant to the current investigation on MDM.

A couple of potential problems have surfaced with regard to research on MDM. First, the bulk of the research examining MDM has focused on uni-dimensional rather than multi-dimensional approaches. In other words, research has typically focused on one aspect of music at a time (e.g., mood) without regard for the other potential musical cues (e.g., arousal, type of music, etc.). This could be a significant problem since it has been shown CDM effects are strongest when there is a greater degree of contextual change (Eich, Macaulay, & Ryan, 1994; Eich & Metcalfe, 1989). Second, although research has generally confirmed that MDM exists, there are two possible explanations for this phenomenon. The first and most commonly given explanation for MDM is that music serves as an effective retrieval cue. For example, music played during learning induces a particular emotional and musical state. By playing the same music during testing, the same emotional and musical state is reinstated and serves as a retrieval cue for the previously learned material. Therefore, reinstating the learning context increases memory performance because the states are congruent (CDM). The second explanation for MDM is that having the same music played at learning and testing makes no difference at all. That is, music does not act as an effective retrieval cue. The observed improvement on memory performance involving congruent emotional and musical states occurs because having different music played during testing actually worsens performance. It could be that having new music played during testing may be disruptive because of a dual-task effect; for example, having different music played during testing could be distracting (relative to music that has been previously heard) and not allow complete focus on the memory task at hand.

To arbitrate between the two hypotheses, the current investigation examined three contextual components of music including mood, arousal, and type of music. All three contextual components of music were examined because prior research has demonstrated that stronger CDM effects occur with greater contextual change (Eich et al., 1993; Eich & Metcalfe, 1989). Participants learned face-name pairs while listening to one of five background music conditions: no music (control condition), HAP, HAN, LAP, or LAN. A recognition task of the previously learned face-name pairs followed. Critically, background music was played during the recognition task as well. The background music during the recognition task kept the same arousal levels (high or low), and mood (positive or negative) as during learning, but type of music was varied. Therefore, the design controls for mood and arousal levels, but changes the musical context. For type of music, there were three possible variations: same song-(and therefore) same genre, different song-same genre, and different song-different genre. Thus, including a no music control condition, there were thirteen recognition conditions with varying levels of arousal, mood, and type of music.

In line with previous work, it was expected that there would be an effect of context. In particular, there is likely to be a difference between the same song-same genre and different song-different genre conditions. However, if this expected difference occurs, we cannot know if it is because musical context (genre) has changed, or if it is because of new, distracting, musical information (different song), or a combination of both factors. The different song-same genre condition enables these two factors to be teased apart. There are multiple possible outcomes for the different song-same genre condition. One possible outcome is that the memory performance will be worse compared with the same song-same genre music condition, and similar to the different song-different genre condition. The rationale for these results would be that even though the music maintains the same musical context, mood, and arousal, it is still different and prevents full concentration on the memory task because having new musical information during testing is distracting. These results would suggest that mood, arousal, and musical context are not the most important aspects of MDM. Instead, the distraction of new music is responsible for the observed decrease in memory performance from same context to different context conditions. Results in this direction would contradict Eich's (1995) mood-mediation hypothesis and Smith's (1995) mental-context hypothesis, and indicate that the presence of changed information during testing impairs performance, potentially through distraction.

A second possible outcome for the different song-same genre condition is that memory performance in this condition will be similar to memory performance in the same song-same genre condition. If this is the case, then context would appear to be the important factor in MDM improvements. When the musical genre is kept the same (along with mood and arousal) MDM improvements are seen. These results would support Smith's (1995) mental-context hypothesis, and would be consistent with previous research showing the importance of congruent mood and arousal levels between learning and testing (Greene et al., 2010; Balch et al., 1999; Mead & Ball, 2007). Results in this direction would also provide further support for the Eich's (1995) mood-mediation hypothesis indicating that CDM occurs because of how similar environments feel.

Finally, the different song-same genre condition may fall between same song-same genre and different song-different genre. In this case, both context and the presence of new information would appear to influence performance separately, with both factors making a contribution to MDM observed in previous research.

Consistent with previous CDM findings, it was hypothesized that memory performance would be greatest when the context at learning and testing were the most similar. This was hypothesized because of research demonstrating that CDM effects are strongest when there is a greater degree of similarity between contexts (Eich, Macaulay, & Ryan, 1993; Eich & Metcalfe, 1989). Thus, it was predicted that memory performance in the same song-same genre condition would be the greatest, and that memory performance would get worse when new information was introduced even if context was similar (i.e., different song-same genre), and worse again as new information was introduced AND the context changed (e.g., different song-different genre). We also predicted that memory performance would be greatest for the HAP and LAN conditions. As discussed, memory performance improved only under certain combinations of mood and arousal levels (Balch et al., 1999; Greene et al., 2010); specifically, memory performance was improved during HAP and LAN conditions.

Method

Participants

Twenty two participants were recruited from the Psychology Research Participation Pool at the University of Western Ontario. The participant pool included first year male and female undergraduate students enrolled in introductory psychology (14 women, 8 men, M_{age} = 18.5 years, age range: 17-22 years). Each participant was compensated with one research credit for their participation.

Materials and Procedure

A Dell Vostro 3400 laptop computer and the E-Prime (Version 2.0) experimental software program were used for stimuli presentation and data collection. The stimuli presented to participants included background music and face-name pairs.

Background music. The background musical selections for the current experiment were selected from a previously conducted investigation (unpublished data). In the previous investigation, participants listened to a variety of non-lyrical music from numerous musical genres. Participants were asked to rate their mood (positive or negative) and their arousal levels (high or low) for each of the musical selections. The music selections that were chosen for the current investigation were those that were most consistently rated into the following mood and arousal categories: HAP, HAN, LAP, and LAN. A total of 20 musical selections were chosen (see Appendix). Participants listened to the background music at a comfortable listening volume through a pair of Sennheiser headphones.

Face-name pairs. Each face image chosen for the current experiment was from the FERET database of grayscale face images (Philips, Moon, Rizvi, & Rauss, 2000). A total of 316 face images were used, including an equal number of male and female faces. In addition, 316 male and female names were used.

Procedure

Participants first read and signed a letter of information indicating their willingness to take part in the experiment. Following this, participants were asked to indicate their age and gender on the computer. Before the experiment began, participants were read instructions explaining their task for the upcoming experiment. Participants were told that the experiment would consist of a number of study and test phases. During the study phase, participants were instructed that they would be presented with a number of face-name pairs and they would be asked to indicate if the name suited the face for each instance. It was communicated to participants that there was no right or wrong answer for this portion of the experiment. During the test phase, participants were instructed that there would be a recognition task of the previously learned face-name pairs. It was also explained to participants that sometimes music, or no music, would be playing in the background during the study and test phases. They were instructed not to make any decisions regarding the music and that it was just being played in the background. Following the instructions, participants completed a practice study and test phase containing 4 face-name pairs with no music played in the background. The experiment proper began following the answering of any questions regarding the task at hand.

The experiment consisted of 13 study and test phases. Each participant completed all 13 conditions and each condition was presented in randomized order. Music and face-name pair stimuli were presented to the participants using the Dell laptop computer and E-Prime (Version 2.0) experimental software program.

Before each study phase, participants were presented with a white screen prompting them with the instructions, “does the name suit the face?”. The instructions also directed the participants to press 1 if they thought the name suited the face, or press 2 if they thought the name did not suit the face. This was designed to get the participants to think more deeply about the face-name pairs during the study phase in order for them to better remember the face-name pairs for the upcoming recognition task. This screen was presented for 4,000 ms. The study phase immediately followed the instructions. Participants were presented with 24 face-name pairs in randomized order. For each face-name pair, participants indicated on the keyboard if the name suited the face. Each face-name pair was presented for 3,900 ms, regardless of selection, in order to keep the timing consistent for all participants. During each study phase, participants also listened to background music through headphones while learning the face-name pairs. The background music was from one of the following musical categories: HAP, HAN, LAP, or LAN. In addition, there was one silent study phase that served as a control.

Following the presentation of the 24 face-name pairs, the music stopped and participants were prompted with a maroon coloured screen indicating that the test phase of the experiment would follow. The maroon screen appeared for 4,000 ms and prompted participants with the instructions, "does the name match the face?". Participants were instructed to press 1 on the keyboard if they thought the name matched the face from the study phase, or press 2 if they thought the name did not match the face. Each test phase presented participants with the same faces as seen during the study phase. However, only 16 of the names matched the face shown during the study face. The other 8 face-name pairs were re-arranged. Again, face-name pairs were presented for 3,900 ms regardless of selection to keep the timing consistent for all participants. In addition, only the first response for each participant was recorded. Participants also listened to background music during the test phase. The mood and arousal levels of the music played during the test phase always corresponded to the mood and arousal levels of the music played during the study phase. However, the type of music (genre) varied from study to test phase. One possibility was that the music played during the test phase was the same piece of music played during the study phase (i.e., same music-same genre). Alternatively, the music played during the test phase could have been different, but still from the same genre (i.e., different music-same genre). The last possibility was that different music was played and the music was from a different genre (i.e., different music-different genre). There was also one silent test phase that corresponded to the silent study phase.

Concluding each test phase, the music stopped and participants were presented with a white screen asking them to press the SPACE bar when they were ready to complete the next study and test phase of the experiment. Another study and test phase followed until the participant completed all 13 conditions of the experiment.

Results

Three independent variables were manipulated in the current experiment: mood, arousal, and context (type of music). The dependent variable of interest was the corrected hit rate. Corrected hit rate was examined instead of response accuracy in order to account for any response biases. The corrected hit rate was calculated by subtracting the false alarm rate from the hit rate. The hit rate score was the number of correct responses to a re-arranged face-name pair. The false alarm rate was the number of incorrect responses to a face-name pair that was not re-arranged. A difference score was then calculated using the corrected hit rate value from the silent test condition.

These corrected hit rate difference scores were then analysed with a 2 x 2 x 3 (Mood [positive, negative] x Arousal [high, low] x Context [same music-same genre, different music-same genre, different music-different genre]) repeated measures analysis of variance (ANOVA). The ANOVA revealed no main effect of either mood or arousal. There was a significant main effect of context, $F(2, 42) = 8.39$, $p = .001$, as well as two significant interactions: Arousal x Context, $F(2, 42) = 4.82$, $p = .013$, and Arousal x Mood x Context, $F(2, 42) = 4.96$, $p = .012$. A series of follow-up one-way ANOVAs indicated that the effect of context was significant only in the LAN condition, $F(2, 42) = 13.92$, $p < .001$. The HAP [$F(2, 42) = 0.92$, *ns*], HAN [$F(2, 42) = 0.45$, *ns*], and LAP conditions [$F(2, 42) = 2.72$, *ns*] showed no significant main effects of context. One-sample t-tests in the LAN condition indicated that only performance in the different song-same genre condition was significantly worse than silence, $t(21) = -3.86$, $p = .001$. Performance in the same song-same genre [$t(21) = 1.12$, *ns*] and the different song-different genre [$t(21) = 2.00$, *ns*] conditions were not significantly different from silence.

The results indicated that context had a significant effect on memory performance only in the LAN condition, with memory performance in the different song-same genre condition being significantly worse than the silent baseline condition. The same song-same genre and different song-different genre condition did not differ significantly from the silent condition. Memory performance between the HAP, HAN, and LAP conditions did not significantly differ from the silent condition. In addition, the context (type of music) did not have a significant effect in any of these conditions. Please see Figure 1 for a graphical representation of the results.

Discussion

As outlined previously, CDM is the theory that information learned in one context is better remembered when the same context is reinstated during recall (Abernethy, 1940; McGeoch, 1932). The encoding specificity principle explains this phenomenon (Tulving & Thomson, 1973; Standing et al., 2008). Encoding of new information occurs within a variety of surrounding stimuli (e.g., visual cues). The surrounding stimuli or cues become associated with the newly encoded information and can aid memory if the same stimuli are present at retrieval. As mentioned, a variety of contexts have been investigated with regard to CDM (Cann & Ross, 1989; Eich, 1980; Godden & Baddeley, 1975). It was hypothesized that music would also serve as an effective retrieval cue for previously learned information. In other words, the prediction was that memory performance would be greatest when the musical context at learning and testing was the most similar. This was predicted because larger CDM effects have been found when the degree of similarity between learning and testing are most similar (Eich, Macaulay, & Ryan, 1993; Eich & Metcalfe, 1989). Thus, memory performance in the same song-same genre condition should be the greatest. In addition, it was predicted that memory performance would

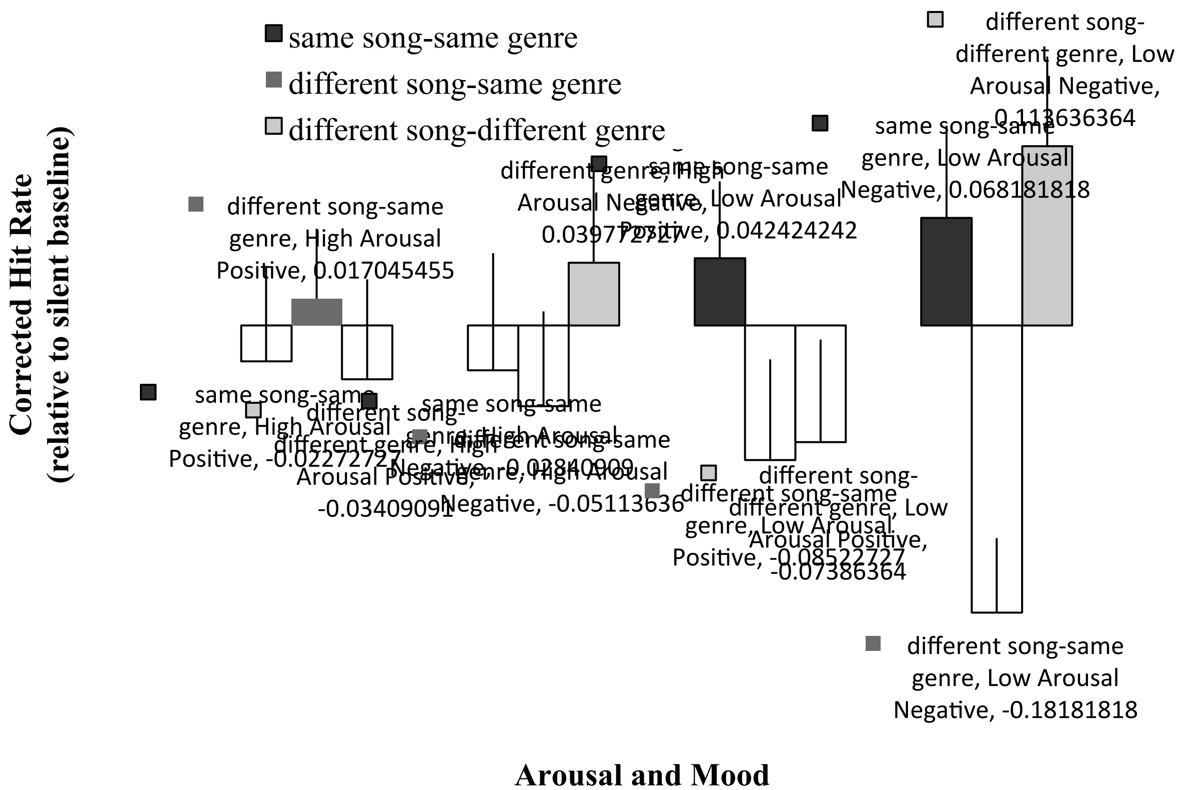

Figure 1. Memory performance represented by the corrected hit rate relative to the silent baseline condition. There was no effect of context for three of the conditions: high arousal-positive, high arousal-negative, and low arousal-positive. There was a significant effect of context for the low arousal-negative mood condition; specifically, memory performance in the different song-same genre condition was significantly worse than the silent baseline condition.

get progressively worse as the context changed more dramatically (e.g., in the different song-different genre condition). Consistent with previous research indicating the importance of a match between mood and arousal levels (Balch et al., 1999; Greene et al., 2010), a second prediction was that memory performance would be greatest in the HAP and LAP conditions.

The results were in contrast to expectations. First, both mood and arousal levels did not affect memory performance; however, there was a significant effect of context (type of music) on memory performance. This was examined through a three-way interaction between mood, arousal, and type of music. The results indicated that for three of the conditions there was no effect of type of music on memory performance: HAP, HAN, and LAP. In other words, it did not matter if the type of music remained the same or changed between learning and testing because memory performance for these three conditions did not differ from the silent baseline condition. Type of music did have a significant effect on memory performance in the LAN condition; specifically, memory performance was significantly worse from silence in the different song-same genre condition. The memory performance of participants in the same song-same genre and different song-different genre did not differ significantly from the silent baseline condition. Thus, musical context had an effect on memory performance, but only in the LAN condition. More specifically, there was a decrease in memory performance during the different song-same genre condition.

As mentioned in the overview of MDM research, there are two possible explanations for MDM. The first explanation for MDM is that music serves as an effect retrieval cue for previously learned information. By playing the same music during testing, the same emotional and musical state is reinstated and serves as a retrieval cue for previously learned information. In other words, musical context is another variety of CDM. The other possible explanation was that music does not serve as an effective retrieval cue; instead, having the same music played at learning and testing makes no difference at all. This explanation proposes that the observed relative increase in memory performance when the same song is played during testing is the result of a decrease in memory performance when a different song is played during testing. It could be that having different music played during testing could be distracting and not allow complete focus on the memory task at hand.

It is difficult to incorporate the current findings into these two explanations of MDM. First of all, musical context had no effect on memory performance in three of the conditions (i.e., HAP, HAN, and LAP). This finding does not support that music serves as an effect retrieval cue or that having different music played during testing is distracting and worsens memory performance. For the LAN condition, there was a decrease in memory performance in the different song-same genre musical context. Relative to the silent condition, the same song-same genre and different song-different genre conditions participants showed no improvement or reduction in memory performance. This does not support the explanation that music serves as an effective retrieval cue either as one would expect to find a linear decrease in memory performance if this was the case. For example, it would be expected that memory performance would be the greatest in the same song-same genre condition, and then get progressively worse as the context changed more dramatically (e.g., in the different song-different genre condition). The significant decrease in memory performance in the LAN different song-same genre may be explained by the distraction hypothesis. Perhaps playing music during testing that is very similar, but still different from the music played during learning, is distracting and impairs memory performance.

I also previously discussed two possible theories of MDM: the mood mediation hypothesis (Eich, 1995) and the mental context hypothesis (Smith, 1995). Eich's (1995) mood mediation hypothesis proposed that CDM is the result of physiological states (e.g., mood) being similar between learning and testing. Smith (1995), on the other hand, proposed that CDM is a function of various contextual changes (e.g., mood, place, mental state, etc.) and any one of these contextual changes can cause CDM. In relation to the current investigation on MDM, Eich's mood mediation hypothesis supports the results that were found for three of the arousal-mood conditions; for example, changing musical context in the HAP, HAN, and LAP conditions did not have an effect on memory performance. These results support the mood mediation hypothesis, suggesting that MDM is the result of the physiological states being similar between learning and testing. There was no improvement or decrease in memory performance because the physiological states during learning and testing were similar.

In contrast, the results for the LAN condition cannot be explained by the mood mediation hypothesis. The mood mediation hypothesis would predict that regardless of the change in musical context, the memory performance during each of the LAN conditions would be similar because of the physiological states being the same. This was not the case, as memory performance during the LAN different music-same genre condition was significantly worse compared to the silent baseline condition. Perhaps these findings are best explained in terms of the mental context hypothesis. The mental context hypothesis would predict that any change in context would decrease memory performance since CDM is the result of a variety of contextual components. As found in the LAN condition, changing the music slightly (different song-same genre) between the study and test phases was sufficient to decrease memory during the different songs-same genre condition. It is important to note, however, that memory performance for the different song-different genre condition was not significantly worse than the silent condition. The mental context hypothesis would predict that memory performance in this condition would be reduced the most because of an even more dramatic change in musical context.

As can be seen, the preceding results and discussion lead to a complicated interpretation of the current findings. Given these findings, some future considerations should be kept in mind with regard to future research on MDM. First of all, the current investigation utilized a within-subjects design to examine MDM. Thus, each of the participants completed all of the conditions in randomized order. Although utilizing a within-subjects design generally increases statistical power, there are some inherent problems with using this design for the current paradigm. The major problem with utilizing a within-subjects design for the current paradigm is that participants were constantly alternating between contrasting physiological states; for example, participants could be listening to HAP music and the next condition could be LAN. Stabilized mood and arousal levels were probably unlikely. This problem could be remedied with a between-subjects design, having one group of participants for each of the arousal-mood conditions: HAP, HAN, LAP, and LAN. Alternatively, a within-subjects design could still be implemented with some modification. For this design, the musical context could vary while keeping the arousal and mood levels constant. However, participants could also given some sort of distractor task before proceeding to the next arousal-mood conditions. In the future, these changes should provide more stabilized mood and arousal levels within participants.

Another future consideration to bear in mind when examining MDM concerns the music that is chosen. The musical selections that were chosen for the current investigation were selected from a previous study (unpublished data, see Appendix). The chosen music was the music that was most consistently and strongly rated by participants into the HAP, HAN, LAP, and LAN categories. The possible complication of selecting the music in this way is that music influences everyone differently. Thus, having each participant rate their mood and arousal levels to the musical selections prior to testing may be beneficial in future MDM research. In addition, the music that was chosen for the current investigation may have influenced the results, especially the LAN findings. Remember that memory performance in the LAN different song-same genre was significantly worse compared to the silent baseline condition. It is important not to over exaggerate these findings, as it may have been something peculiar about that particular song that led to poor memory performance in this condition. Upon listening, it was not clear what the distinguishing feature for that particular song might have been, but I would suggest a replication of the current study with different musical selections in order to confirm the results.

The cause of MDM is still unclear. The current findings could not differentiate between the two possible explanations of MDM. Thus, it is still not known whether music serves as an effective retrieval cue for previously learned information or that hearing new music played during testing impairs memory performance in some way. The current study probably lends the most support for the mood mediation hypothesis, rather than the mental context hypothesis. According to this theory, there was no change in memory performance for three of the arousal-mood conditions (i.e., HAP, HAN, and LAP) because the physiological states were the same. However, the mood mediation hypothesis does not explain the findings for the LAN different song-different genre condition. The results for this condition may be best explained by something particular about the song chosen for this condition. As discussed, future research on MDM would probably benefit from a between-subjects design or an alteration of the within-subjects design that was utilized. In addition, a replication of the current findings with different musical selections would be beneficial to the understanding of MDM.

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Appendix

Note: Below are the names of the songs used with the arousal and mood of each song in parentheses. Arousal ratings were rated on a 5-point scale (1 to 5), with 5 representing the high arousal and 1 representing low arousal. Mood ratings were rated on a 5 point scale as well (-2 to +2), with -2 representing sad and +2 representing happy.

Song	Arousal Rating (*M*)	Mood Rating (*M*)
Thefuzz1.wav (HAP)	3.75	1.50
CliffsofDover1.wav (HAP)	4.25	1.38
Hideaway1.wav (HAP)	3.75	1.25
DietoLive1.wav(HAP)	3.78	1.11
ThunderLightningPolka1.wav (HAP)	3.56	1.11
SymphonyinG1.wav (LAP)	2.38	1.38
Resurrectionii1.wav (LAP)	2.13	1.38
SceneAuxChamps1.wav (LAP)	1.56	1.00
KolNidrei2.wav (LAP)	1.89	0.89
Signe1.wav (LAP)	2.44	1.56
TheSpecialist1.wav (HAN)	4.25	-1.00
Sfx1.wav (HAN)	5.00	-1.75
Transition1.wav (HAN)	3.75	-1.13
ProblemReaction1.wav (HAN)	4.13	-1.25
OrbitalElements1.wav (HAN)	4.56	-1.33
QuasiAdagio1.wav (LAN)	1.44	-1.22
Reveries1.wav (LAN)	1.63	-1.00
AdagioSostenutoAssai1.wav (LAN)	1.22	-0.89
Adagio1.wav (LAN)	1.56	-0.67
Gevurah1.wav (LAN)	1.63	-0.63