

Effects of Altering the Valence and Arousal of Music on Short Term Memory Task

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Abstract

Emotion plays an important role in facilitating memory for particular stimuli; however, it is unclear how this is done. Previous studies have looked at valence and arousal, the two dimensions commonly used to describe emotion, and their independent effects on short term memory. However, there are many contradictory findings in the literature. We hoped to gain a better understanding of the effects of valence and arousal by examining the interaction of these two dimensions on word recall. Participants listened to classical music that had varying levels of valence and arousal and were shown lists of words they had to memorize and later recall. We found an interaction between the levels of valence and arousal within music: participants in the positive valence-high arousal music condition remembered more words than participants in the other three music conditions. These results suggest that it is best to listen to happy music, or other positively valenced and arousing music, when studying or performing other cognitive tasks.

Keywords: music, valence, arousal, recall, short-term memory

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Emotions affect many aspects of our everyday lives including decision making, learning, and perceiving the world around us. Previous research on emotion and memory covers a broad spectrum of topics, though a common aim is to explain why and how certain stimuli are better remembered than others. A study by Rubin and Friendly (1986) examined the properties of words that made them memorable and found that a word's emotionality was one of the best indicators of whether or not the word was remembered. Later studies have expanded on the emotional property of stimuli, and have found two distinct elements that make up emotion: valence and arousal (Kensinger & Corkin, 2004). Valence is a continuous measure of how pleasant or unpleasant an emotion is, whereas arousal is a continuous measure that describes how calm or exciting an emotion is (Kensinger, 2004). For example, surprise would be described as having positive valence and high arousal.

Many studies have manipulated the levels of valence and arousal to better understand the effects of emotion on memory. In one study, Bradley, Greenwald, Petry, and Lang (1992) used pictures with varying levels of valence and arousal to examine the effects of these dimensions on immediate recall tasks. They reported that valence and arousal predicted performance on recall equally well. Furthermore, pleasant and arousing pictures were equally more likely to be recalled during the short-term memory task compared to unpleasant and non-arousing pictures. In conjunction with Bradley et al. (1992), Bolls, Lang, and Potter (2001) tested the effects of valence and arousal on short-term memory using auditory stimuli (i.e., radio advertisements). Arousal was found to be a better predictor of memory than valence, but the interaction between valence and arousal was more significant. When the level of arousal was kept constant across different levels of valence, negative messages were better remembered, but when arousal was high for positive messages, positive messages were better remembered.

Although there is a great amount of literature supporting the influence of emotional stimuli on memory, some research indicates that music with varying levels of valence and arousal have no effect on short-term memory. Jancke and Sandmann (2010) systematically manipulated the tempo and consonance of one original song to capture the different levels of valence and arousal, and had participants listen to one of the four variations while studying a series of non-words. They reported that performance on the verbal recognition memory task for these non-words did not vary with the different music conditions. In their discussion, they suggest that the lack of effect of music on verbal learning may be attributed to their use of one single song rather than multiple songs.

Most research has shown that varying the levels of valence and arousal differentially affects memory; however, there are inconsistent findings related to music. Our study aimed to reconcile these conflicting findings by incorporating multiple concepts into our design. We utilized both auditory and visual stimuli (i.e., music and lists of words) to examine how music with different levels of valence and arousal can affect the encoding of words and whether emotional words are remembered more easily than neutral words. Rather than manipulating one song as was done in Jancke and Sandmann (2010), we chose four different songs that were unfamiliar to participants and varied in valence and arousal ratings.

In alignment with past studies (Bradley et al., 1992; Bolls et al., 2001), we predicted that arousing songs, rather than non-arousing songs, would lead to improved performance on the short-term memory task, regardless of valence. Moreover, we believed participants in the positive valence-high arousal music condition would perform the best on word recall, and

participants in the negative valence-low arousal music condition would perform the worst. Finally, it was predicted that emotional words would be remembered more than neutral words.

Method

Design and participants

The present study was a 2 [valence of music: positive and negative] x 2 [arousal of music: high and low] x 3 [valence of words: neutral, positive, and negative] mixed factorial design. Psychology 111B students and friends of the principal investigators were recruited for this experiment. All participants were undergraduate students at the University of California, San Diego. For the pilot study, there were seven participants (four females and three males) between the ages of 21 and 23. For the actual experiment, there were 34 participants (17 females and 17 males) between the ages of 17 and 25. All participants were required to have Internet access, headphones, and normal or corrected to normal vision and hearing.

Materials

The pilot study took place online, through Qualtrics. Participants were required to have Internet access, a computer, and a pair of headphones to listen to 25 classical songs that played for one minute each. Participants used 7-point Likert scales to rate the valence and arousal of the songs. On the valence scale, 1 corresponded to “most unpleasant,” while 7 corresponded to “most pleasant.” On the arousal scale, 1 corresponded to “most calm,” while 7 corresponded to “most arousing.” Participants were also asked to use one of the six universal emotions (happiness, sadness, anger, surprise, disgust, and fear) to best describe the song they just listened to. After each song, participants were asked if they had heard the song before taking the survey.

After data were gathered for all seven participants, averages were taken for each music clip in order to find the best songs that represented the four music conditions: positive valence-high arousal, positive valence-low arousal, negative valence-high arousal, and negative valence-low arousal. Negative valence and low arousal were defined as having averages of 2.5 or below. Positive valence and high arousal were defined as having averages of 5.5 or above. We verified the valence and arousal ratings with the emotions participants used to describe the songs. For example, songs that were categorized as positive valence-high arousal were expected to be described as “happy” or “surprise,” whereas songs that were categorized as negative valence-high arousal were expected to be described as “fear” or “angry.” We analyzed the music ratings and found two songs that fit the criteria for the positive valence-high arousal and positive valence-low arousal music conditions. We did not find any songs that perfectly fit the criteria for negative valence-high arousal or negative valence-low arousal, so we chose two songs with lowest ratings on the valence scale for the negative valence music conditions. To account for the low and high levels of arousal for these negative valenced songs, we looked at the emotional descriptions participants chose for these songs. We found that nearly all participants described the negative valence-low arousal song as “sad,” and the negative valence-high arousal song as “fear.” Although these two songs did not fit into our original criteria, a majority of participants used emotions that fall within the dimensions of the negative valence-low arousal and negative valence-high arousal music conditions to describe the songs. We analyzed participants’ responses on the survey and chose songs that all seven participants had never heard of before participating in the pilot study.¹

For the actual experiment, we compiled a list of positive, negative, and neutral words using the *Affective Norms for English Words* (Bradley & Lang, 1999). Words with average ratings between 1 and 3 on the valence dimension were categorized as negative and words with average ratings between 7 and 9 on the valence dimension were categorized as positive. The

positive and negative words also had average ratings between 4 and 6 on the arousal dimension. Words with averages between 4 and 6 on both dimensions of valence and arousal were categorized as neutral. We used Python software to code a function to randomly generate 12 different lists that included 15 words each: five positive words, five negative words, and five neutral words. No words were repeated. We used four songs from the pilot study that best represented the four combinations of valence and arousal for this experiment.

The experiment also took place online through Qualtrics. In an attempt to control for the effects of different volumes among the participants, we asked participants to adjust their volume to a relative rating of 4. They listened to a random music clip for 10 seconds, and were shown a 7-point Likert scale which ranged from the following: almost silent, quiet, a little quiet, just right, a little loud, loud, maximum. Participants were instructed to adjust their volume to “just right,” which corresponded with the number 4 on the scale.

Procedure

Participants signed a consent form and then filled out demographic information that included name, age, gender, and fluency in English. We made sure participants had normal or corrected to normal vision and hearing before they could begin the experiment. After the demographic questions, participants were instructed to put on their headphones and proceeded to volume control. They were randomly assigned to one of the four music conditions: positive valence-high arousal ($n = 10$), positive valence-low arousal ($n = 7$), negative valence-high arousal ($n = 7$), and negative valence-low arousal ($n = 10$). In order to obtain a baseline of memory for each participant, all participants went through a block without listening to music while shown the lists of words. The silence block was also to ensure that playing music during study time would not distract participants and decrease recall. The silence and music blocks occurred in random order for each participant, and each block contained six trials.

For each trial in the silence block, participants were instructed to focus on a blank page shown on the screen for 40 seconds. Afterward, participants were shown a list that contained 15 words (five positive, five negative, and five neutral words in randomized order), and were instructed to memorize as many as they could. The list appeared in the center of the screen. The list was presented for 30 seconds. When the list disappeared, participants were asked to recall and type out as many words as they could remember in any order. Participants were given 30 seconds to type out the words. When the 30 seconds were over, participants were given 60 seconds to solve two simple addition problems as a distractor task. Participants completed six total trials in the silence block, and each trial contained a different set of 15 words.

Participants listened to the same song during the six trials of the music block. Each trial began with music playing for 40 seconds before participants were shown a list of words. During these 40 seconds, a blank page was presented on the screen. Afterward, participants were shown the list and had 30 seconds to memorize the words while the song continued to play in the background. After the 30 seconds were up, the music stopped and participants were asked to recall and type out as many words as they could remember, in any order. Participants were given 30 seconds to type out the words. Two simple addition problems were presented after the recall task. Participants had up to 60 seconds to solve these problems. The six lists used in the silence block and the six lists used in the music block were different. No words or math problems were repeated.

After participants finished the experiment, they were asked to rate the song to which they listened. They rated the songs according to how unpleasant or pleasant and calm or arousing the song made them feel using 7-point Likert scales. Finally, participants were also asked to describe

the song using one of the six universal emotions in order to verify the song ratings from the pilot study.

Results

The mean numbers of recalled words for each condition are shown in Table 1. A matched pairs t-test did not yield a significant difference in percentage of recalled words between silence and music blocks, $t(27) = 1.51$, $p = 0.143$ (Figure 1). We also separated the distributions of the percentages of words recalled by music condition and used the outlier box plot to identify statistical outliers. We found two outliers in the negative valence-high arousal music condition and excluded them from further analyses. One participant had a very low average ratio of recalled words of 0.167, while the other had a high average ratio of 0.711. After these two data points were excluded (and the six data points from the t-tests were un-excluded), a two between-subject factors with one repeated factor ANOVA was used to analyze the effects music valence and arousal on the percentage and type of words recalled. There was no main effect of music valence, $F(1, 84) = 3.01$, $p = 0.087$ (Figure 2a), and no main effect of music arousal, $F(1, 84) = 0.44$, $p = 0.511$ (Figure 2b) on the percentage of words recalled. There were no differences in the percentage of recalled words among the three types of words (positive, negative, and neutral), $F(2, 84) = 0.29$, $p = 0.751$ (Figure 3a). In addition, a Least Squares Means contrast showed that emotional words (positive and negative) and neutral words were not remembered differently, $F(1, 84) = 0.26$, $p = 0.614$ (Figure 3b). The ANOVA did yield a statistically significant interaction (see Figure 4) between valence and arousal in music such that those in the positive valence-high arousal condition remembered the most number of words, $F(1, 84) = 4.16$, $p = 0.045$.

Discussion

This study addressed the question of why certain stimuli are better remembered than others. In past research, it has been shown that people remember emotional stimuli better than neutral stimuli (Brown & Kulik, 1977; Rubin & Friendly, 1986). Furthermore, arousing stimuli are better remembered than non-arousing stimuli; however, the findings on the effect of valence on memory have been contradictory (Bradley et al., 1992; Newhagen & Reeves, 1992). In an attempt to resolve these inconsistent findings Bolls et al. (2001) studied the interaction between valence and arousal. They found that negatively valenced stimuli were better remembered when the level of arousal was not taken into consideration. However, they found that participants remembered positively valenced stimuli more when the level of arousal was considered. Their study showed that stimuli with positive valence-high arousal were remembered the most. There have also been studies on the effects with music during verbal learning. For example, Jancke and Sandmann (2010) manipulated the valence and arousal levels of one song. They found that there were no significant differences in performance on a verbal recognition memory task between the music conditions.

In contrast to Jancke and Sandmann (2010), we found a significant difference between music conditions on short-term memory, and more importantly, an interaction between music valence and arousal. We found that when music arousal was low, there were no differences in the percentage of words recalled between positively and negatively valenced music. However, when music arousal was high, there was a significant difference between positively and negatively valenced music. Our results partly confirm our hypotheses and replicate the findings of Bolls, Lang, and Potter (2001): participants in the positive valence-high arousal music condition performed the best on word recall, while participants in the negative valence-high arousal music condition performed the worst. These results indicate that it is best to listen to happy music, or other positively valenced-high arousing music, when studying and to stay clear of negatively

valenced-high arousing music. It could be that emotions with negative valence-high arousal invoke a sense of anxiety and stress, thereby decreasing performance on cognitive tasks. This study can have important implications for students who like to listen to music when studying.

Although we found a significant interaction between music valence and arousal, we did not find any independent effects of music valence and arousal on word recall. Participants in the positively valenced and negatively valenced music conditions (ignoring arousal) did not differ in their performance on word recall. Contrary to our predictions, participants in the low arousing and high arousing music conditions (ignoring valence) did not differ in their performance on word recall. The types of words recalled did not vary as a function of silence or music.

In contrast to previous studies, we did not find that emotional words were better remembered than neutral words. Furthermore, the three types of words (positive, negative, neutral) were not remembered differently. Perhaps we are more likely to remember emotional stimuli than neutral stimuli when it is beneficial to us. For example, in the context of previous studies, participants were asked about significant life events or shown threatening pictures of weapons and mutilated bodies. (Brown & Kulik, 1977; Lane, Chua, & Dolan, 1999). In this experimental context, however, participants had to remember as many words as they could, and therefore, may have made an effort to remember all the words presented to them equally.

There were many confounds in our study that potentially limited our results. For example, we were required to carry out our experiment on Qualtrics because of our time constraint and limited resources. Qualtrics did not allow us to make all possible randomizations in our study design, such as the presentation of the words in each list. Another limitation with an online experimental design is the lack of control on a participant's study environment. This certainly can affect a participant's performance on the memory task. Although we instructed participants to complete the experiment in an environment free of distraction, there is no guarantee of their compliance. Even though we chose our words from a standardized source (Bradley & Lang, 1999), we did not control for how frequently each word is used and appears in the English language. It could be that more frequently used words are more accessible in one's mind and therefore better remembered than words that are not commonly used in everyday conversation. Furthermore, two of the four music clips (i.e., negative valence-low arousal and negative valence-high arousal) did not meet the rating criteria. Although all participants from the pilot study used the same emotion word to describe these two songs, the music clips may not have represented their respective emotions to all participants since everyone differs in their opinions and criteria for music. Given that everyone has different opinions about music, future studies can examine people's musical preferences to see whether their musical preferences facilitate learning more than positively valenced-high arousing music. Moreover, there was a trend for participants in the positively valenced music condition (ignoring music arousal) to recall more words. Perhaps this trend will become more evident if the study is repeated with longer musical clips and a larger sample size.

Our results show it is important to examine both dimensions of valence and arousal simultaneously in order to obtain a clearer understanding of how emotion affects memory. Some past studies have only looked at one level of a single dimension (i.e., positive stimuli vs. neutral stimuli) or one single dimension (i.e., main effect of valence); however, the interaction between valence and arousal is critical to understanding the complex relationship between emotion and memory.

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Footnotes

¹ The four songs used in this experiment were: Johannes Brahms's Hungarian Dance No. 5 (positive valence-high arousal), Mussorgsky's Night on Bald Mountain (negative valence-high arousal), Georges Bizet's Carmen Suite No. 1 - Intermezzo (positive valence-low arousal), and Dvorak's New World (negative valence-low arousal).

*Appendix**Example Lists Used in Experiment*

vanity	helpless
syphilis	tank
offend	mystic
massacre	measles
kind	poverty
dinner	muddy
sailboat	disappoint
skyscraper	foul
angel	context
agreement	home
wagon	cake
	book
	king
	fraud
	misery
	tease
	pleasure
	ship
	respectful

Note: Each list contained 5 neutral, 5 positive, and 5 negative words. A limitation of Qualtrics is that we could not randomize the words that appeared in each list for every participant (each list was fixed); however, each participant got different of lists in different order.

Table 1

Contrast of Words Recalled by Music Condition

Music Condition	M	SD	n
Silence	37.67	16.76	34
Positive Valence-High Arousal	48.63	15.73	10
Positive Valence-Low Arousal	39	9.78	7
Negative Valence-High Arousal	37.29	14.41	7
Negative Valence-Low Arousal	35.71	7.54	10

Note: M = mean number of words recalled; SD = standard deviation; n = number of participants in that condition. All participants had a silence condition and were randomly assigned to one of the other four music conditions.

Comparison Between Silence and Music

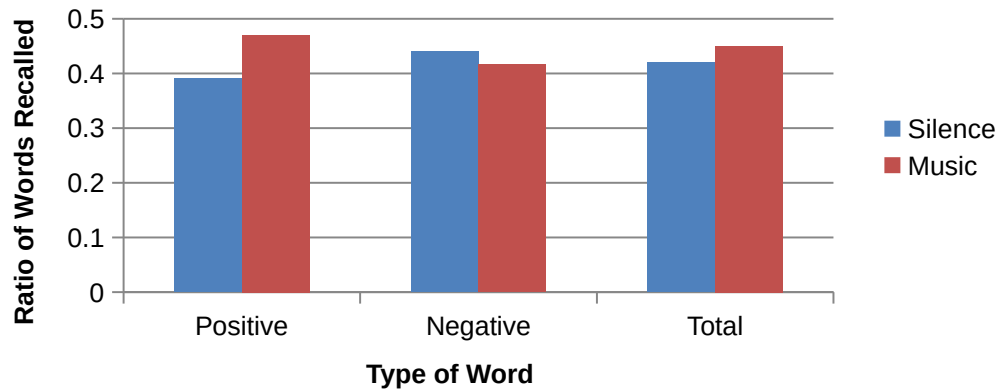


Figure 1. Bar graph showing the comparisons of mean words recalled in silence and music blocks. The word ratios were calculated by comparing the number of words (positive, negative, and overall) each participant recalled to the total number of words (positive, negative, and overall) shown to each participant. For positive words, “music” refers to positively valenced music. For negative words, “music” refers to negatively valenced music. For total words, “music” refers to both positively and negatively valenced music. No significant differences, which suggests that adding music did not distract participants.

Main Effect of Music Valence

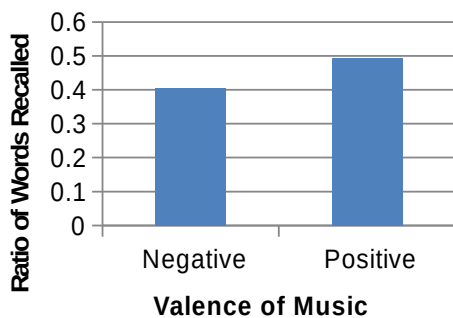


Figure 2a. Mean ratio of words recalled calculated across both levels of music valence, ignoring music arousal. The ratios were calculated by comparing the number of words recalled to the total number of words shown. No significant differences.

Main Effect of Music Arousa

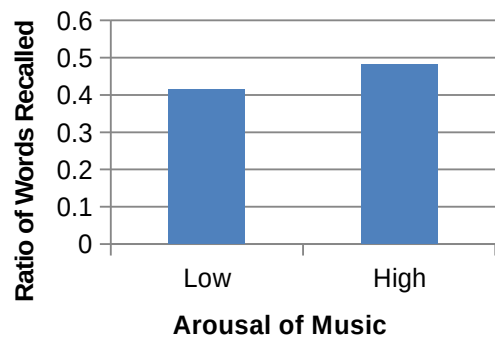
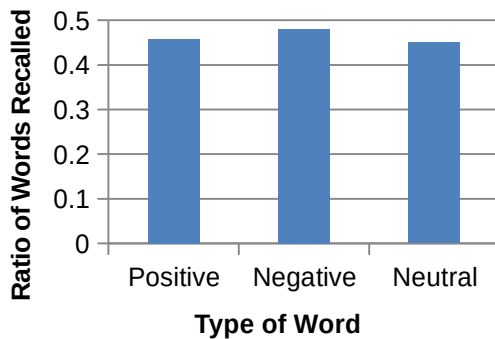


Figure 2b. Mean ratio of words recalled calculated across both levels of music arousal, ignoring music valence. The ratios were calculated by comparing the number of words recalled to the total number of words shown. No significant differences.

Main Effect of Word Valence



Comparison Between Emotional

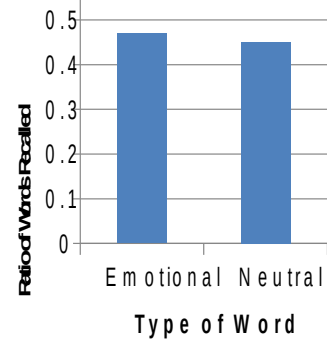


Figure 3a. Mean ratio of words recalled calculated across all levels of word valence. No significant differences.

negative) and neutral words. No significant differences.

Figure 3b. Mean ratio of words recalled
calculated for emotional (positive +

* Interaction Between Music Valence and Music Arousal

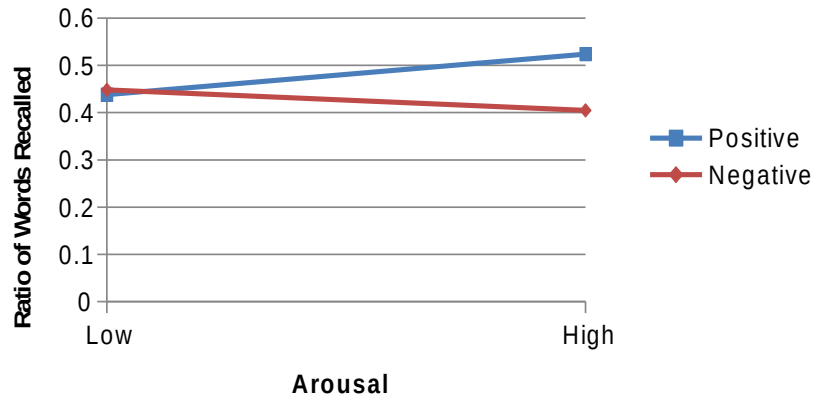


Figure 4a. Statistically significant interaction between music valence and arousal. When arousal is low, the type of valence does not affect the number of words recalled. When arousal is high and valence is positive, participants seemed to remember more words.