The Role of Mood, Arousal, and Encoding Strategy in Verbal Memory

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Abstract

The purpose of this study was to induce different moods/arousal levels using positive or negative stimuli (auditory, visual) to determine the impact on the use of specific encoding strategies and verbal memory performance. Despite elevated moods and arousal levels in the positive conditions, there was no memory difference between participants in the positive image over the negative image condition. Furthermore, only those in the positive auditory condition exhibited a memory advantage over those in the negative auditory condition (medium effect size, only marginally significant). Importantly, participants in the positive auditory condition had the highest rates of more effective encoding strategies, while participants in the negative auditory condition had the lowest rates of more effective encoding strategies. Thus, encoding strategy appeared to mediate the effect of mood and arousal on memory. The results imply that it is important to include assessments of encoding strategies when researching the relationship between mood, arousal, and memory.

There is a considerable amount of research on the role of mood in memory, cognition, and learning, with many studies focused on the role of mood (positive, negative, neutral) during encoding and retrieval (for reviews see Mandler, 1992; Revelle & Loftus, 1992). While the literature seems to be in disagreement about the role of positive mood in memory functioning, this discrepancy seems to be a function of the type of memory being tested, with positive moods typically associated with enhanced verbal memory and negative moods associated with enhanced spatial memory (Gray, 2004; Gray, Braver, and Raichle, 2002; for an exception see Palmiero, Nori, Rogolino, D'Amico, & Piccardi, 2015).

In support of the link between positive affect and enhanced verbal working memory, Storbeck and Watson (2014) found that completion of verbal working tasks was also associated with more positive evaluations of stimuli. Similarly, Bar (2009) observed that individuals who engaged in tasks that required broad semantic processing reported higher levels of positive affect. Furthermore, Riediger and colleagues (2011) found that when participants were oriented to seek to maintain or enhance positive affect, or to dampen negative affect (i.e., pro-hedonistic orientation), they exhibited better verbal-numerical working memory compared to when they were more contra-hedonistically oriented. Consistent with this research, others report that depressed mood can produce poorer recall (Ellis, Thomas, & Rodriguez, 1984; Ellis, Thomas, McFarland, & Lane, 1985; Potts, Camp, & Coyne, 1989).

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Because moods have been found to influence individuals' processing strategies (see Schwarz, 2002), different moods might have specific effects on different kinds of memory because of the different strategies people use when processing incoming information. In general, positive moods appear to stimulate more global, flexible, intuitive, and holistic information processing (see Isen, 1999; Isen, 2004 for overviews). In contrast, negative moods appear to stimulate more systematic, narrow, focused, and analytic forms of processing (for review see Schwarz & Clore, 1996). Thus, sad individuals are more likely to spontaneously adopt more vigilant and systematic bottom-up strategies, whereas happy individuals rely on less effortful top-down strategies.

Differences in processing styles as a function of different moods are well established. However, the predictions regarding how these differences in processing style influence attention and memory performance are not so straightforward. On the one hand, one might expect a negative mood to improve learning through the recruitment of more effortful thinking (Forgas, 1995; Forgas, 2013), increase elaborate memory encoding (Bäuml & Kuhbandner, 2007; Forgas, Goldenberg, & Unkelbach, 2009), and improve encoding and attention by "recruiting more accommodative and externally focused processing" (Forgas, 2013, p. 226). On the other hand, negative moods are thought to prompt the activation of irrelevant and ruminative thoughts (Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008) thus depleting resources in working memory (Brose, Schmiedek, Lövdén, & Lindenberger, 2012). Additionally, to alleviate negative moods, sad individuals split attentional resources in working memory between the cognitive task at hand and mood correction processes (Brand, Reimer, & Opwis, 2007; Riediger et al., 2011). Furthermore, there is evidence that negative moods contribute to inhibitory deficits. For example, those in an induced or chronic negative mood have difficulty suppressing mood-congruent material (e.g., Wenzlaff, Wegner, & Roper, 1988). Leight and Ellis (1981) suggest that worry and other task irrelevant cognitive activities associated with depression and negative moods compete for working memory resources, much like anxiety interferes with task performance (e.g., Eysenck, 1979). In support of this memory deficit, there are many reports that depressed individuals complain of memory difficulties (e.g., Beck, 1974) or exhibit deficits in free recall (e.g., Russell & Beekhuis, 1976; Whitehead, 1973). Taken together, these findings suggest that negative mood might have a detrimental impact on memory due to increased interference from activated irrelevant information.

One could also argue that more global, flexible, and holistic processing associated with positive moods could easily accommodate the adoption of more effective relational or associational study strategies. This is because holistic thinking focuses more on context and how objects or items relate to each other (i.e., an associative way of thinking; see Nisbett, Peng, Choi, & Norenzayan, 2001). In fact, induced positive moods increase the activation of remotely related semantic associations (e.g., Bolte, Goschke, & Kuhl, 2003; Corson, 2002; Fredrickson, 2001; Isen, 1999; Storbeck & Clore, 2005). Also, positive material in memory "is more extensive and at the same time better integrated, so that positive affect is able to cue a wide range of thoughts" (Isen, 1987, p. 217). While some argue that this wide range of thoughts activated by positive moods can create cognitive interference and thus limit attentional resources (Mackie & Worth, 1989), others suggest that positive moods broaden and build one's attention span and global processing of external information (Fredrickson & Branigan, 2005), allowing happy individuals to exhibit flexible thinking that allows for more global integration and creative analysis of newly acquired information in order to solve problems (Gasper, 2003).

In support of the beneficial role of holistic or associational processing and memory, Masuda and Nisbett (2001) found that holistic thinkers who focused on relational processing between items and context exhibited better recognition of objects in a scene compared to analytic thinkers who more narrowly focused on discrete objects and their individual attributes. Thus, negative moods may mimic the cognitive strategies of analytic thinkers whose attention is too narrowly focused. This cognitive rigidity associated with negative moods may then interfere with flexible thinking (Gasper, 2003). In fact, there is considerable evidence that positive affect seems to promote cognitive flexibility, while negative moods are associated with more narrowed and focused thinking, especially in problem solving (Dreisbach & Goschke, 2004; Nadler, Rabi, & Minda, 2010).

The inflexible way of thinking associated with negative moods also has an effect on memory functioning, perhaps via a lack of proper study strategies. Certain encoding strategies (e.g., elaborative encoding techniques such as transforming lists into stories or interacting images; Bower, 1970; Paivio, 1971) result in better memory performance than other strategies such as maintenance rehearsal (i.e., repetition) or doing nothing (e.g., simply reading the words with little attention paid to what the items mean). If a particular mindset is more likely to inhibit the utilization of more optimal learning techniques, one would expect diminished retrieval of the learned material. In support of this prediction, "cognitively rigid" individuals exhibit impaired recall as a result of their diminished use of organizational processes in a perceptual grouping task (Cosden, Ellis, & Feeney, 1979). Importantly, others have linked this cognitive rigidity to an encoding strategy and recall deficit in depressed individuals or those in a depressed mood. For example, Hasher and Zacks (1979) suggest that the recall deficits in individuals with depression are the result of the inefficient implementation of effortful study strategies (e.g., organization, imagery, mnemonic or elaborative devices, and rehearsal) related to their inflexible and rigid way of thinking (e.g., Kovacs & Beck, 1978).

In concordance with this study strategy deficit, Leight and Ellis (1981) found that when participants were in an induced depressed mood, they recalled less and were less likely to use organizational study strategies such as chunking, compared to when they were in a neutral mood. Consistent with this finding, Ellis, Thomas, and Rodriguez (1984) found that, compared to a neutral mood, depressed moods were associated with poorer recall, especially when encoding demands were high or in conditions where high effort was needed to engage in the encoding task. In other words, being in a depressed mood might increase one's cognitive rigidity, resulting in poorer implementation of effective study strategies. However, because neither of these studies included a positive mood induction condition, there is no way of telling if more positive mood states would lead to more efficient use of successful encoding strategies. Furthermore, with few exceptions (e.g., Leight & Ellis, 1981), the role of study strategy as a mediator of the relationship between mood and memory has largely been ignored. Combined, however, these studies suggest that the more flexible thinking (associated with more positive moods) might be the type of thinking needed to engage the use of more effective study strategies that involve creating interesting and unique associations among study materials (e.g., connecting verbal materials together in a story). In support of this prediction, Scrimin and Mason (2015) found that the wider activation of information that those in a positive mood experienced encouraged them to perceive connections between concepts.

Another argument for the benefit of positive moods in verbal memory comes from research showing that positive moods induce more cognitive effort and motivation. Although some have shown that negative mood is associated with effort and motivation on some cognitive tasks in order to alter moods to make them more positive (Erber & Erber, 1994; Forgas, 2013), others have shown that positive moods prime individuals to elicit favorable judgments regarding the target stimuli, resulting in enhanced motivation and engagement towards tasks (Isen & Reeve, 2005). Positive mood has also been associated with increased intrinsic motivation in learners within the context of multimedia learning environments (Liew & Tan, 2016; Plass, Heidig, Hayward, Homer, & Um, 2014; Um, Plass, Hayward, & Homer, 2012). Consistent with this finding, sad moods tend to reduce cognitive effort for difficult tasks that potentially further erode mood (see the resource allocation hypothesis, Ellis & Ashbrook, 1988). Given that greater cognitive effort leads to greater recall (Tyler, Hertel, McCallum, & Ellis, 1979) and that effective study strategies (e.g., elaborative processing) require more cognitive effort and result in greater left inferior prefrontal activation (Wagner, Shacter, Rotte, Koutstaal, Maril, Dale, Rosen, & Buckner, 1998), it stands to reason that those in a positive mood will be more motivated to exert the effort needed to engage in the use of more effective encoding strategies.

It is also important to note that, although negative moods are generally associated with more systematic and detailed processing, happy individuals are also able and willing to engage in the detail-oriented processing when information is self-relevant (Das & Fennis, 2008) or when task demands or explicit instructions (e.g., Bless, Bohner, Schwarz, & Strack, 1990) encourage it. For example, happy participants outperformed sad participants on a concentration test that required detailed processing (Bless, Clore, Schwarz, Golisano, Rabe, & Wölk, 1996). In conclusion, it appears that those in a positive mood are motivated and have the cognitive capacity to process details, perhaps because they invest cognitive effort when there is a promise that doing so will maintain or enhance their positive mood (Isen, 1987; Wegener, Petty, & Smith, 1995). In many studies of memory, participants are instructed that their memory will be tested, so perhaps participants in more positive moods will make an effort to effectively encode the learning material because that behavior will be consistent with the task's demands.

Another factor that might contribute to or mediate the beneficial effect of positive moods on tests of concentration and verbal memory is arousal level. Many manipulations of mood and affect are also manipulations of arousal (Revelle & Loftus, 1992). Specifically, negative affect (associated with negative or depressed moods) is typically associated with higher levels of tense arousal (i.e., tension, anxiety, and fearfulness) and lower levels of energetic arousal (i.e., energy, vigor, and peppiness) (Thayer, 1989). Support for this connection between negative mood and lower energetic arousal comes from studies showing that, on assessments of mood and arousal such as the Profile of Moods States (McNair, Lorr, & Droppleman, 1992), there are significant negative correlations between the subscales of vigor-activity (i.e., a measure of energetic arousal) and depression (e.g., Terry, Lane, Lane, & Keohane, 1999; Terry, Lane, & Fogarty 2003, $r = -.28$, $p < .01$). Importantly, energetic arousal, which includes feelings of peppiness and vigor, can be equated to moderate levels of arousal (Thayer, 1989), and moderate levels of arousal are correlated with better memory functioning (for a review of the inverted U-shaped function of memory performance as a function of increasing arousal, see Mandler, 1992). Perhaps inductions of positive mood also induce the moderate levels of arousal needed to create a cognitive readiness for the implementation of effective study strategies.

Taken together, the evidence presented thus far strongly suggests that positive moods induce more motivation, engagement, and concentration, while broadening attention to allow for more associational encoding. There is also evidence that positive moods are associated with moderate levels of energetic arousal, a state well-suited for memory performance. Based on research showing a beneficial effect of positive mood on verbal memory, and that people in a more positive mood have more flexible thinking that may allow for the adoption of more beneficial study strategies, these cognitive improvements from induced positive moods, would be expected on memory tasks that involve verbal or word list recall.

Mood induction has been accomplished using a variety of methods such as inducing hypnosis (e.g., Bower, Gilligan, & Monteiro, 1981), creating success/failure paradigms (e.g., Isen & Means, 1983), listening to a sad story (Johnson & Tversky, 1983), reading self-referent statements of happy and sad experiences (e.g., Das & Fennis, 2008), recalling positive or negative past experiences (Fiedler & Stroehm, 1986; Ruder & Bless, 2003), giving a gift (Yang, Yang, & Isen, 2013), watching a video clip (Scrimin & Mason, 2015; Storbeck, 2012; Wang, 2015), endorsing a picture (Strobeck & Watson, 2014), or reading a list of statements associated with elated or depressed moods (e.g., the Velten Mood Induction Procedure; Riskind, Rholes, & Eggers, 1982). According to de l'Etoile (2002), an important aspect of successful mood induction techniques is that they need to create a mood manipulation that is intense and longer lasting to ensure that the particular mood sustains across study and retrieval. The reason for this is that the effects of mood appear to depend on a match between mood during learning and mood during retrieval (Bower, Monteiro, & Gilligan, 1978; Eich & Metcalfe, 1989). One method that has been successfully used to induce longer lasting and intense moods in both men and woman is a musical mood induction procedure (Clark & Teasdale, 1985; Sutherland, Newman, & Rachman, 1982). Musical mood induction techniques are more successful than other techniques (Gerrarrds-Hesse, Spies, & Hesse, 1994), and because they lack verbal material, they are less susceptible to demand characteristics (Pignatiello, Camp, & Rasar, 1986).

Many researchers have reported a cognitive benefit of positive moods as a result of musical mood induction (de l'Etoile, 2002; Thaut & de l'Etoile, 1993). For example, Thaut and de l'Etoile (1993) and de l'Etoile (2002) found that individuals who were induced to be in a positive mood as a result of listening to classical music (Mozart's *Clarinet Concerto in A*, Opus 107) prior to the encoding phase recalled more words than those not induced to be in any particular mood (exposed to silence)[-1]. These studies provide evidence that positive mood induced by exposure to music is beneficial for recall. However, neither of these studies included an induction of negative moods nor did they include an assessment of the use of encoding strategies or the role of arousal levels. Therefore, we cannot tell from these studies how memory performance might vary as a function of negative mood and lower levels of energetic arousal (compared to positive mood and higher levels of energetic arousal) or if encoding strategy use mediates the effects on memory.

It is important to note that others have been able to manipulate positive and negative moods in a single study using music (e.g., Palmiero et al., 2015; Thompson, Schellenberg, & Husain, 2001). For example, Thompson, Schellenberg, and Husain (2001) successfully induced more negative moods and lower levels of arousal by exposing participants to a slow, melancholy piece of music (Albinoni's *Adagio in G Minor for Organ and Strings*), and they induced more positive moods and elevated arousal by exposing participants to an upbeat, cheerful sonata (Mozart's *Sonata for Two Pianos in D Major, K. 488*). They found that the group that listened to the upbeat, cheerful sonata scored higher on a spatial task compared to silence. Furthermore, the benefit for the cheerful group only emerged when the music increased levels of arousal and mood as measured by the Profile of Mood States (POMS; McNair et al., 1992). They concluded that enhanced cognitive performance is best understood as the result of changes in arousal or positive affect. However, because they did not include tests of memory performance, it is unclear how the differential induction of positive and negative moods influences memory performance.

Additionally, the previously cited studies did not directly compare mood induction techniques that use auditory stimuli to those that employ visual stimuli. According to Bower's (1981) intensity principle, the impact of mood on the recall process depends on the intensity of the mood state. Perhaps certain kinds of stimuli produce more intense moods states. For example, fast tempo music has been shown to increase physiological arousal levels compared to slow tempo music (Krumhansl, 1997; Van der Zwaag, Westerink, & Van den Broek, 2011). There is also evidence that, when processing music, there is bilateral engagement of both hemispheres in the brain (e.g., Breitling, Guenther, & Rondot, 1987). Given these findings, it would be interesting to determine if various types of visual stimuli also impact mood and arousal levels in similar ways as auditory stimuli to encourage the adoption of strategic encoding processes in order to bring about improvements in memory functioning.

To summarize, most of the studies summarized here reported a cognitive and memory benefit of positive mood induced through music. However, very few of these studies examined the role of study strategy as a mediating factor, and the few that did include assessments of encoding strategy only examined the impact of an induced depressed mood on strategy use (or cognitive demand) and recall (Ellis et al., 1984; Leight & Ellis, 1981).

Furthermore, none of them examined the role of arousal in the equation. In addition, many of them did not compare positive to negative moods (only positive to neutral or negative to neutral). Finally, none of the studies compared different types of mood inducing procedures within the same study to determine if specific mood induction procedures were more or less associated with certain arousal levels and uses of more effective study strategies. Therefore, the purpose of this study was to use different methods to induce positive or negative moods in participants to determine the effects on mood and arousal levels and memory for verbal materials in a free recall paradigm. More importantly, we wanted to determine the conditions in which participants were more likely to use optimal encoding strategies. In order to test for the mediating role of study strategy in the link between mood, arousal, and verbal memory, we used the same auditory stimuli employed by Thompson et al. (2001), i.e., upbeat, cheerful classical music to induce positive mood and higher levels of energetic arousal, and slow, melancholy classical music to induce negative and lower levels of energetic arousal. However, we also added additional mood and arousal induction conditions using visual stimuli (i.e., positive images vs. negative images) to also induce differences in mood and arousal. We measured the effect of these mood and arousal induction conditions on participant's mood and arousal prior to studying a list of words and on their free recall performance. After the recall phase, we also assessed which encoding strategies they used. It was hypothesized that exposure to the positive, cheerful conditions would result in elevated mood and energetic arousal, greater use of holistic processing (i.e., use of more associational learning strategies), and better free recall performance.

Method

Design

They study formed a 2 x 2 x 2 x 2 mixed-subjects factorial design with modality of stimuli (visual, auditory) and condition valence (positive/cheerful, negative/melancholy) as the between-subjects factors, baseline and post-tests of mood and arousal as the repeated measures, and probability of correct recall as the dependent measure.

Participants

A total of 92 adults from two universities in the Southeastern United States served as participants in exchange for extra credit towards their introductory psychology course. Participants completed a post-experiment demographics questionnaire that assessed age; gender; ethnicity; number of years of formal music training; number of hours of sleep the night before the experiment; average mood over the last three months, measured on a 5-point Likert scale ranging from 1 (*sad*) to 5 (*happy*); and likability of classical music, measured on a 5-point Likert scale ranging from 1 (*Hate it!*) to 5 (*Love it!*). The participant demographic characteristics as a function of the four conditions are shown in Table 1. There was no significant difference in age, mood over the last three months, number of years of formal music training, hours of sleep the night before, or likability ratings of classical music across the four experimental conditions, *p*'s < .05. Furthermore, the ethnic and gender compositions of the samples were consistent across all conditions, with many more females and White, non-Hispanic individuals in all conditions. The entire sample ranged in age from 18 to 65 years, with an average age of 25.33 years (*SD* = 11.04). The sample was 77.2% female and 22.8% male, and the ethnic make-up was 80.4% White, non-Hispanic, 8.7% African American, 2.2% Hispanic, 3.3% Asian, and 5.5% other. Participants had on average 2.98 (*SD* = 4.26) years of formal music training and had on average 6.55 hours of sleep (*SD* = 1.97) the night before the experiment. Participants' average mood over the last three months was 3.66 (*SD* = .93), as measured on the aforementioned 5-point scale. Participants' average ratings of likability of classical music was 3.38 (*SD* = 1.05), as measured on the aforementioned 5-point scale.

Table 1.
Demographic characteristics as a function of mood induction condition

Valence of Stimuli	Modality of Stimuli	Number of Females, Males	*Mean* Age (*SD*)	*Mean* Mood over last 3 months (*SD*)	*Mean* Yrs. formal music training (*SD*)	*Mean* Hrs. sleep the night before (*SD*)	*Mean* Liking of classical music (*SD*)
Positive/ Cheerful	Visual	18, 5	24.43 (9.98)	3.65 (.89)	2.78 (3.88)	6.96 (2.06)	3.39 (1.03)
	Auditory	20, 3	27.29 (13.28)	3.87 (.87)	2.35 (2.98)	6.91 (1.68)	3.74 (.81)
Negative/ Melancholy	Visual	16, 7	22.35 (7.13)	3.35 (.98)	2.57 (3.99)	6.41 (2.27)	3.17 (1.03)
	Auditory	17, 6	27.13 (12.64)	3.77 (.97)	4.27 (5.78)	5.91 (1.78)	3.23 (1.27)

Note. "Mood over last three months" and "Liking of classical music" is on a 5-point scale, where higher scores indicate more positive, elated moods or greater likability of classical music.

Materials

Study List. The study list consisted of 25 neutral words.[-2] In order to ensure that associations with the pictures would not influence the memorization of the words, we chose 25 neutral words that were not directly associated to each other, to the semantic themes of the pictures, nor to any musical references in any of the mood induction conditions (verified by checking direct, forward, and backward semantic associations via the University of South Florida free association word database; Nelson, McEvoy, & Schreiber, 2004). The list length and composition, including the part of speech, concreteness, and frequency of list items; the number of homographs; and the number of one-, two-, and three-syllable words, was very similar to many other word lists used in several memory studies (e.g., Goodmon & Nelson, 2004; Nelson & Goodmon, 2002; Nelson, Goodmon, & Ceo, 2007; Sahakyan & Goodmon, 2010). Only one list was constructed because of the constraints associated with ensuring minimal direct semantic associations between list items and the pictures. Furthermore, because all participants studied the same list, any differences as a function of word length or other word characteristics would have occurred for all participants. Importantly, we achieved free recall performance similar the previously cited list memory experiments.

Mood and Arousal Induction Conditions. Participants were randomly assigned to one of four between-subjects mood and arousal induction conditions: positive (upbeat, cheerful) music, negative (slow, melancholy) music, positive visual images, negative visual images. The induction conditions involving music consisted of exposure to ten minutes (via a surround sound system) of the same two musical selections utilized by Thompson, Schellenberg, and Husain (2001) to successfully induce different levels of mood and arousal. The positive (upbeat, cheerful) music consisted of *Mozart's Sonata for Two Pianos in D Major*, *K. 488* and was used to induce elated moods and higher levels of energetic arousal, while the negative (slow, melancholy) music consisted of *Albinoni's Adagio in G Minor for Organ and Strings* and was used to induce deflated moods and lower levels of energetic arousal. The induction conditions involving images consisted of exposure to three minutes of 45 pictures (either positive or negative) presented individually at a rate of 4 seconds per picture, for a total presentation time of 180 seconds. The positive images used to induce elated moods and higher levels of energetic arousal were presented in color on a yellow background and consisted of happy faces, smiling babies, etc. The negative images used to induce deflated moods and lower levels of energetic arousal were presented in color on a gray background and consisted of sad faces, funerals, etc. In a pilot study, we determined that three minutes of exposure to the selected 45 images induced levels of mood and arousal similar to listening to 10 minutes of the two musical selections used by Thompson, Schellenberg, and Husain (2001). Longer exposure times (e.g., 10 minutes) actually resulted in decreased mood and arousal in both the positive and negative pictures conditions. Because the purpose of the induction conditions was to induce different levels of arousal and mood between the positive and negative conditions and not between the music and images conditions, we chose to not equate the music and image conditions on exposure time, but instead on the desired comparable levels of mood and arousal. In addition, because of the strong effect of associations on memory performance, it was also important to not expose participants to a large number of images in order to minimize the number of direct associations between image items and study list items. Another added benefit of using a smaller number of images was that it reduced the chance of interference between participants' memory for the images and their memory for the study list items. It is important to note that in the current study, there was a significant difference in mood and arousal levels on the post-exposure test between the positive and negative induction conditions, and there were significant changes from baseline to post-exposure in mood and arousal in both the images and the music conditions. Therefore, although participants in the picture conditions experienced a shorter induction phase, participants in both the music and images conditions exhibited changes in mood and arousal in the desired directions (with no differences in mood and arousal on the post-test between the music and images conditions, and slightly lower levels of mood and arousal on the post-test in the pictures conditions).

Baseline and Post-test of Mood and Arousal. Participants' mood and arousal before and after being exposed to the mood and arousal induction phase was assessed using two subscales (*Depression-Dejection, Vigor-Activity*) from the Profile of Mood States (POMS) – Short Form (McNair et al., 1992). Participants rated how they felt at baseline (i.e., prior to mood induction exposure) and how they felt after exposure to music or images (i.e., post mood induction exposure). They made their ratings on a 5-point scale, 1 (*not at all*) to 5 (*extremely*), for each of 10 emotional descriptors, including five *Depression-Dejection* adjectives (*sad, unworthy, discouraged, lonely,* and *gloomy*) and five *Vigor-Activity* adjectives (*lively, active, energetic, full of pep,* and *vigorous*). In order to maintain the psychometric properties of the POMS-short form, every participant received the items in the same order on both the baseline and the post-test (i.e., we did not counterbalance the order of the subscales between subjects), with the *Depression-Dejection* scale appearing first on the assessment (in the order indicated above). We reversed scored the *Depression-Dejection* items so that lower scores reflected more negative moods and lower levels of energetic arousal, while higher scores reflected more positive moods and higher levels of energetic arousal. The possible range of scores on the entire POMS was 10 to 50, 5 to 25 for each subscale.

Demographic Questionnaire. Following the post-test of mood and arousal, all participants completed a demographic questionnaire designed to assess age, gender, ethnicity, college standing, years of formal music training, number of hours of sleep the night before, general mood over the last three months, and the extent to which they liked classical music in general.

Encoding Strategies Questionnaire. Two final questions assessed whether or not participants used any encoding/study strategies to memorize the study list (yes/no option) and, if yes, which strategies they employed by checking off all of the strategies they used from a list of possible strategies (including sub-vocally reading the word, thinking about how the word sounds or looks, repetition (rehearsal), mnemonics (e.g., method of loci, peg-word method, expression, word, or name mnemonics), association formation, linking words together in a story, or forming a mental image of each item.

Procedure

Upon arrival to the experiment room, the experimenter told the participants that the research study was about visual and auditory perception where participants would complete a questionnaire designed to assess their current mood and then either listen to music or look at some pictures. Then they would be asked some questions about what they experienced and complete some tasks involving words in the English language. After providing informed consent, the participant's mood prior the mood and arousal induction phase was measured by giving all participants one minute to complete the baseline assessment of mood and arousal. The 92 participants were then randomly assigned to one of the four between-subject mood induction conditions: 1. positive visual images, 2. negative visual images, 2. positive (upbeat, cheerful) music or 4. negative (slow, melancholy) music. The random assignment resulted in 23 participants per condition. After exposure to one of the mood and arousal induction conditions, all participants completed the post-test of mood and arousal, designed to assess how the mood/arousal induction conditions made them feel (i.e., if any change in mood/arousal had occurred). Participants then studied a list of 25 neutral words flashed one at a time onto a white projection screen located directly in front of them, at a presentation rate of 4 seconds each, for a total presentation time of 1 minute and 40 seconds. Prior to the list presentation, the participants were instructed to remember as many words as possible. It is important to note that participants were not instructed to use any particular encoding strategy, nor did the experimenter mention anything about encoding strategies (i.e., they were not primed to use a particular encoding strategy and the participants did not make notes about the strategies they used during the study phase). Following the presentation of the list, the participants were instructed to write down as many words as they could (in any order) from the original list of 25 words. They were given one minute to recall as many words as possible. Following completion of the recall phase, the participants then completed the demographics questionnaire and the encoding strategies questionnaire, designed to assess their retrospective self-reports of the study strategies they used during the study phase. All were debriefed, however those in either negative mood/arousal condition (negative images or melancholy music) were also desensitized by briefly listening to the cheerful Mozart Sonata.

Results

Mood Manipulation Check

As in any repeated measure design, it is important to establish baseline equivalencies (see baseline columns of Table 1). A bivariate correlational analysis revealed a significant, positive relationship between the baseline assessments of mood and arousal, $r = .69$, $p < .001$. The results of a MANOVA on the combination of mood and arousal subscale scores at the baseline, revealed no significant effect of either valence condition (positive/cheerful, negative/melancholy), $F(2, 87) = .67$, $p = .51$, *Partial* $\eta^2 = .015$, or type of stimuli (auditory, visual), $F(2, 87) = 1.50$, p = .23, *Partial* $\eta^2 = .033$, or an interaction between the two, $F(2, 87) = .35$, p = .71, *Partial* $\eta^2 = .008$. Follow-up Univariate ANOVAs on each of the POMS subscales revealed no significant effect of either valence, $F(1, 88) = 1.35$, $p = .25$, *Partial* $\eta^2 = .015$, type of stimuli, $F(1, 88) = 2.19$, $p = .14$, *Partial* $\eta^2 = .024$, or an interaction between valence and stimuli type, $F(1, 88) = .36$, $p = .55$, *Partial* $\eta^2 = .004$, on the mood subscale at baseline. There was also no significant effect of either valence, $F(1, 88) = .54$, $p = .47$, *Partial* $\eta^2 = .006$, type of stimuli, $F(1, 88) = 2.81$, $p = .10$, *Partial* $\eta^2 = .031$, or an interaction between valence and stimuli type, $F(1, 88) = .70$, $p = .40$, *Partial* $\eta^2 = .008$, on the arousal subscale at baseline. Follow-up tests confirmed baseline equivalencies on both the mood ($M = 18.92$, $SD = 2.62$) and arousal subscales ($M = 18.67$, $SD = 2.00$) between participants across all four of the between-subject conditions, *ps* > .05.

To determine if the mood and arousal induction conditions produced differences in mood from baseline to post-exposure, we conducted a 2 x 2 x 2 x 2 repeated measures MANOVA with modality of stimuli (visual, auditory) and condition valence (positive/cheerful, negative/melancholy) as the between-subjects factor, and baseline and post-test of mood and arousal as the repeated dependent measures. The three-way interaction between the repeated measures of mood and arousal (baseline, post-test), valence, and stimuli modality on the combination of the dependent measures of mood and arousal was not significant, $F(1, 88) = 3.16$, $p = .079$. Follow-up Univariate ANOVAs on mood and arousal as separate dependent measures are consistent with the lack of a significant three-way interaction in the MANOVA (mood, $F(1, 88) = 3.16$, $p = .079$; arousal, $F(1, 88) = 2.86$, $p = .094$). Subsequent pairwise comparisons confirmed that the lack of three-way interaction is consistent with the predicted pattern of results (see Table 2): the mood and arousal levels were not significantly different from one another at the baseline across the four experimental conditions, *p*'s > .05. Importantly, the mood and arousal induction conditions produced mood and arousal changes in the desired directions; there were significant increases in the mood and arousal from baseline to post-test in the positive conditions (i.e., positive images, cheerful music) and significant decreases in mood and arousal in the negative conditions (i.e., negative images, melancholy music), *p*'s < .001.

To establish if there were differences in mood and arousal on the post-test (Table 2), we performed the same previous MANOVA but with scores on the post-tests as the dependent variables. A bivariate correlational analysis revealed a significant, positive relationship between the post-test assessments of mood and arousal, $r = .95$, $p < .001$. The results of a MANOVA on the combination of mood and arousal subscale scores at the post-test revealed no main effect of stimuli type, $F(2, 87) = 1.82$, $p = .17$, *Partial* $\eta^2 = .04$, nor was there an interaction between valence and stimuli type, $F(2, 87) = 2.55$, $p = .084$, *Partial* $\eta^2 = .084$. However, there was a significant effect of valence condition (positive, negative), $F(2, 87) = 69.14$, $p < .001$, *Partial* $\eta^2 = .61$. Subsequent tests confirmed that those who were exposed to the negative stimuli had lower levels of mood and arousal after that exposure ($M = 12.78$, $SD = 3.92$), compared to those who were exposed to positive stimuli ($M = 20.92$, $SD = 2.74$), *ps*' < .001.

Follow-up Univariate ANOVAs on each of the POMS subscales revealed a significant effect of valence condition on post-test mood, $F(1, 88) = 126.03$, $p < .001$, *Partial* $\eta^2 = .59$, and on post-test arousal, $F(1, 88) = 135.56$, $p < .001$, *Partial* $\eta^2 = .61$. Subsequent tests confirmed that, after exposure to the mood induction conditions, those who were exposed to the negative stimuli had lower levels of mood ($M = 12.91$, $SD = 3.80$) and arousal ($M = 12.65$, $SD = 4.03$) after that exposure, compared to the mood ($M = 20.93$, $SD = 2.94$) and arousal levels ($M = 20.90$, $SD = 2.55$) of those who were exposed to positive stimuli, *p*'s < .001. The effect of type of stimuli on post-test mood only approached significance, $F(1, 88) = 3.67$, $p = .06$, *Partial* $\eta^2 = .04$, indicating no significant different in post-test mood levels between those in the pictures conditions ($M = 16.24$, $SD = 3.42$) and those in the music conditions ($M = 17.61$, $SD = 3.25$). There was no significant effect of stimuli type on post-tests of arousal, $F(1, 88) = 2.65$, $p =$

.11, *Partial* η^2 = .029, indicating no significant difference in post-test arousal levels between those in the pictures conditions (*M* = 16.20, *SD* = 3.31) and those in the music conditions (*M* = 17.35, *SD* = 3.67).

According to follow-up Univariate ANOVAs, there were significant two-way interactions between valence condition and type of stimuli on post-tests of mood, $F(1, 88) = 4.93$, $p = .029$, *Partial* η^2 = .053, and on post-tests of arousal, $F(1, 88) = 4.76$, $p = .032$, *Partial* η^2 = .051. In the positive stimuli conditions, there was no significant difference in post-test mood levels between those exposed to positive pictures (*M* = 21.04, *SD* = 3.50) and those exposed to positive music (*M* = 20.83, *SD* = 2.39), nor was there a significant difference in post-test arousal levels between those exposed to positive pictures (*M* = 21.09, *SD* = 2.95) and those exposed to positive music (*M* = 20.70, *SD* = 2.14), *p*'s > .05. However, in the negative stimuli conditions, those exposed to the pictures stimuli reported significantly lower levels of mood (*M* = 11.43, *SD* = 3.49) and arousal post-exposure (*M* = 11.30, *SD* = 3.67) compared to those who were exposed to the music stimuli (Mood *M* = 14.39, *SD* = 4.11; Arousal *M* = 14.00, *SD* = 4.39).

To summarize, the mood and arousal conditions influenced mood and arousal levels in the desired directions, the positive pictures and positive music conditions were effective in increasing mood and arousal levels from baseline to post-exposure, and both the negative pictures and negative music conditions were effective in decreasing moods and arousal levels. However, the negative pictures were slightly more effective at inducing lower moods and arousal levels than the negative images.

Table 2.
Mood and arousal levels as a function of mood induction condition

Valence of Stimuli	Modality of Stimuli	Baseline Mood *Mean* (*SD*)	Post-test Mood *Mean* (*SD*)	*t*(*23*)	Baseline Arousal *Mean* (*SD*)	Post-test Arousal *Mean* (*SD*)	*t*(*23*)
Positive/	Visual	19.17 (2.25)	21.04 (3.50)	-4.37**	19.04 (1.75)	21.09 (2.95)	-4.99**
Cheerful	Auditory	18.04 (2.82)	20.83 (2.39)	-6.26**	18.00 (1.41)	20.70 (2.14)	-7.01**
Negative/	Visual	19.48 (2.76)	11.43 (3.49)	9.71**	19.00 (2.15)	11.30 (3.67)	8.92**
Melancholy	Auditory	19.00 (2.56)	12.91 (4.05)	6.63**	18.65 (2.48)	14.00 (4.39)	4.80**

Note - * indicates significance at the p < .01 level, ** indicates significance at the p < .001 level. Mood and arousal scales range from 5 to 25, with higher scores reflective of more elated moods or higher levels of energetic arousal.

Effect of Mood and Arousal Induction Condition on Probability of Recall and Extra-list Intrusion Rates

In order to determine any effect of mood and arousal induction prior to learning on memory performance, we conducted a 2 x 2 between-subjects factorial ANOVA with stimuli valence (positive, negative) and stimuli type (pictures, music) as the between-subjects factors and probability of recall as the dependent measure.[3] There was no effect of stimuli valence on memory scores, $F < 1$. However, as shown in Table 3, there was a main effect of stimuli type, $F(1, 88) = 6.86$, $p = .01$, *MSE* = .014, *Partial* η^2 = .07, revealing a memory advantage of exposure to any type of music (*M* = .40, *SD* = .14) over images (*M* = .33, *SD* = .10), $t(44) = -2.57$, $p = .01$, *Cohen's d* = -.58. However, the main effect of stimuli type was qualified by a two-way interaction between stimuli valence and type, $F(1, 88) = 5.15$, $p = .03$, *MSE* = .014, *Partial* η^2 = .06. Subsequent tests revealed that participants who viewed positive images prior to the study phase did not have higher memory scores compared to those in either the negative image condition, $t(44) = -1.56$, $p = .13$, *Cohen's d* = -.55, or those in the negative (slow, melancholy) music condition, $t(44) = -1.45$, $p = .15$, *Cohen's d* = -.41. There was also no memory difference between those in the positive (upbeat, cheerful) music (*M* = .43, *SD* = .14) and negative images condition, $t(44) = -1.45$, $p = .15$. *Cohen's d* = .61. However, the participants who listened to positive music had a memory advantage that approached significance compared to those who listened to negative music prior to the study phase, $t(44) = 1.69$, $p = .09$, *Cohen's d* = .50.

Table 3.
Average probability of list recall and average number of extra-list intrusions as a function of mood induction condition

Valence of Stimuli	Modality of Stimuli	*Mean* Probability of Correct Recall (*SD*)	*Mean* Number of Extra-list Intrusions (*SD*)
Positive/	Visual	31% (10)	0.48 (0.95)
Cheerful	Auditory	44% (14)	0.26 (0.54)
Negative/	Visual	36% (08)	0.43 (0.66)
Melancholy	Auditory	36% (14)	0.26 (0.45)

In order to more directly examine the relationship between mood and arousal on the POMS post-test (prior to the study phase) and memory performance, we conducted a simple correlation between memory probability scores and POMS post-test scores. There was no correlation between total POMS scores prior to the study phase and probability of recall, $r = .000$, $p = 1.00$. Thus, scores on the POMS assessment directly prior to the study phase accounted for 0% of the variance in list recall. There were also no significant correlations between memory performance and the mood subscale of the POMS questionnaire, $r = .01$, $p = .86$, or between memory performance and the arousal subscale of the POMS questionnaire, $r = -.006$, $p = .96$. Memory performance was also not related to self-reported subjective mood over the last three months, $r = -.05$, $p = .63$.

We also examined the effect of mood and arousal induction condition on the number of extra-list intrusions, indicative of poorer memory performance. Higher extra-list intrusion rates may reflect lower working memory capacities (Lecerf & Roulin, 2009), a limited attentional mechanism that coincides with a reduced ability to inhibit non-list items from intruding in the recall episode (Anderson, 2003; Conway & Engle, 1994), or an inability to distinguish between contextually relevant and associatively related, yet non-relevant information (Sahakyan & Delaney, 2010). Results revealed that the overall intrusion rate was very small ($M = 3.50$, $SD = .68$) and did not vary as a function of stimuli valence ($F < 1$), stimuli type ($F(1, 88) = 1.93$, $p = .17$, $MSE = .001$, *Partial* $\eta^2 = .02$), or the interaction between the two ($F < 1$).

Encoding Strategies and Probability Recall

To compare probability of recall as a function of encoding strategies, we created a composite variable of more effective encoding strategies according to the previous literature (e.g., association formation, mnemonics, putting the words together in a story, forming interactive images among the list items) and less effective study strategies (e.g., repetition or doing nothing). Results revealed those who used a more effective encoding strategy exhibited greater recall ($M = .43$, $SD = .12$) compared to those who used less effective study strategies ($M = .30$, $SD = .09$), $t(90) = 5.72$, $p < .001$. The results of a series of chi-square analyses on the number of participants who did and did not engage in more useful memories strategies as a function of each condition is shown in Table 4. The condition with the highest rate of recall (i.e., the positive music condition) had a greater number of participants who engaged in more beneficial study strategies (e.g., story, association, mnemonics, imagery; $n = 16$ or 66%) as opposed to less beneficial strategies (e.g., repetition or doing nothing; $n = 7$ or 34%), and this frequency difference approached significance, $X^2 = 2.79$, $p = .095$. Sixty-six percent of participants ($n = 16$) in the positive (upbeat, cheerful) music condition used effective study strategies, whereas only 47.8% of participants ($n = 33$) in the other three conditions used more beneficial study strategies. Furthermore, the frequency differences in these three conditions were not significant, indicating that participants in the conditions with poorer recall, were not significantly more likely or less likely to use more effective study strategies than less effective study strategies, p's > .05.

Table 4.
Number of participants who used more or less effective encoding strategies as a function of mood induction condition

Valence of Stimuli	Modality of Stimuli	More effective encoding strategies	Less effective encoding strategies	*Chi-Square*	*p*
Positive/	Visual	11	12	0.04	.840
Cheerful	Auditory	16	7	2.79	.095
Negative/	Visual	13	10	0.10	.750
Melancholy	Auditory	9	14	1.09	.300

Discussion

The purpose of this study was to determine if positive mood and arousal induction procedures would result in enhanced verbal memory performance compared to negative mood and arousal induction procedures. Importantly, we also wanted to determine if encoding strategy mediates the effects of certain moods and arousal levels on probability of word recall. Furthermore, we also wanted to directly compare two visual and two auditory mood induction procedures to determine how the different procedures would affect mood and arousal levels as well as the utilization of different encoding strategies. If mood and arousal has a direct impact on memory, then increasing mood and arousal with either visual or auditory stimuli should result in better verbal memory performance, but perhaps only when increases in mood and arousal are also accompanied by the use of more holistic, associational encoding strategies. We assessed participants' mood and arousal before and after exposure to positive (upbeat, cheerful) music, negative (slow, melancholy) music, positive images, or negative images, and then tested their memory for a list of words. Our hypothesis was that those in the positive mood and arousal conditions would exhibit better verbal list recall because they would experience more energetic arousal, and thus engage in more holistic, relational processing than those in the negative mood conditions. It was expected that moderate levels of energetic arousal that coincide with inductions of positive mood would have created a cognitive readiness for the implementation of effective study strategies.

Importantly, we established baseline equivalencies on both the mood and arousal subscales between participants across all four of the between-subject mood and arousal induction conditions. Consistent with the hypothesis**,** the mood and arousal induction conditions produced differences in both the mood and arousal subscales on the post-tests. However, the mood and arousal induction conditions only produced marginally significant effects in memory performance. Participants who listened to the positive (upbeat, cheerful) music or who viewed positive images prior to the study phase reported higher levels of mood and arousal on the POMS post-test compared to those who listened to the negative (slow, melancholy) music or who viewed negative images prior to the study phase. Furthermore, there was no indication that the positive music condition produced greater positive moods or energetic arousal levels than the positive images condition because there was no significant difference in mood and arousal levels between the two positive mood induction conditions. Thus, despite producing mood and arousal changes in the predicted direction, we only observed greater recall in the positive music condition compared to the negative music condition. This difference only approached significance (p = .09).

Despite the lack of significant differences between the positive music and negative music conditions, analysis of effect size revealed a medium-sized memory effect between the positive and negative music conditions. This trending memory benefit of the mood induction conditions that involved exposure to music are consistent with previous research showing that positive moods enhanced recall of verbal materials (Gray, Braver, & Raichle, 2002; Gray, 2004; Storbeck & Watson, 2014). However, it is important to note that the present results should be interpreted with caution because the memory benefit between the music conditions only approached significance. Future researchers should increase the sample size to increase the power to detect significant differences in recall.

An examination of the music conditions alone might lead one to predict that positive moods induced by a variety of different methods should be associated with better recall of verbal materials. However, we did not observe any memory differences between the positive images and the negative images conditions, despite the fact that the positive images condition produced higher self-reported levels of mood and arousal compared to the negative images condition. Thus, the results of the mood induction conditions that involved exposure to images conflict with previous research showing a positive relationship between induced positive moods and better verbal memory performance (Gray et al., 2002; Gray, 2004; Storbeck & Watson, 2014). We argue that this discrepancy may be due to the differential use of optimal encoding strategies. As mentioned in the introduction, there is much evidence in the memory literature that certain encoding strategies (e.g., elaborative encoding techniques such as transforming lists into stories or interacting images; Bower, 1970; Paivio, 1971) result in better memory performance than other strategies such as maintenance rehearsal (i.e., repetition) or doing nothing (e.g., simply reading the words with little attention paid to what the items mean). At the end of the experiment, the participant's indicated, through self-report, the study strategy or strategies they used to encode the study list. Analysis of the memory strategies employed by the participants suggests that the small memory advantage in the positive music condition coincided with greater utilization of more effective study strategies. Specifically, a greater number of participants in positive music condition engaged in optimal study strategies (i.e., elaborative encoding strategies reported in the previous literature, such as association formation, mnemonics, putting the words together in a story, forming interactive images among the list items) as opposed to less beneficial strategies (i.e., maintenance encoding strategies such as repetition or doing nothing). Indeed, approximately 66% of participants in the positive music condition used more effective study strategies, but only 39 to 56% in the other conditions used more optimal study strategies. Furthermore, the condition with the poorest recall performance (the negative music condition) had the smallest proportion of participants (39%) who utilized more effective study strategies. Thus, it appears that the small memory benefit of listening to upbeat, cheerful music might be due to the co-occurrence of more effective learning techniques. Future researchers should test the study strategy hypothesis to determine if listening to upbeat, cheerful music induces participants to use more effective study strategies or if the co-occurrence of more effective study strategies simply occurs by chance.

We also cannot eliminate the possibility that, by chance, the participants in the upbeat, cheerful music condition simply had greater knowledge and practice with optimal encoding strategies, hence why more of those participants used them. Random assignment should have equated our groups on such individual differences. Nevertheless, if more knowledgeable participants had been assigned to any of the other mood and arousal induction conditions, then those other conditions could have easily produced the highest levels of recall. Perhaps future studies could employ a matched design whereby prior knowledge of studies strategies is assessed prior to assignment to condition and then assignment is rendered so that the conditions contain roughly equal amounts of participants with proficient knowledge and practice with those optimal study strategies. If participants who have similar knowledge of optimal strategies utilize more optimal study strategies in the positive mood induction conditions (compared to the negative mood and arousal condition), where there are no specific instructions to use those strategies, one might be able to argue that being in a positive mood and heightened energetic arousal level creates a cognitive environment ready to engage the use of more cognitively taxing relational processing. One could also cross study instructions with mood induction to more directly test the role of encoding strategies. We did not do this in the current experiment because we wanted to mimic the experimental designs of previous studies and determine which conditions spontaneously coincided with various study strategies.

Leight and Ellis (1981) found that participants induced to be in a depressed mood recalled less and were less likely to use organizational study strategies. Because there was only a marginally significant benefit of positive music and no memory benefit associated with exposure to positive images, the current results are at odds with the previous findings that positive moods (perhaps via more flexible ways of thinking) correlate with greater use of study strategies that involve the creation of interesting and unique associations among study materials (e.g., connecting verbal materials together in a story; Scrimin & Mason, 2015). The current results also appear to be inconsistent with research showing that sad moods are associated with less cognitive effort for difficult tasks (see the resource allocation hypothesis, Ellis & Ashbrook, 1988) and the research on how positive moods enhance motivation and engagement towards tasks (Isen & Reeve, 2005). However, because we did not measure cognitive effort, motivation, or engagement, we have no way of determining if a relationship (or lack of relationship) between these factors and mood did or did not mediate the results. Future researchers might include more direct assessments of cognitive effort, motivation, and engagement in task demands in order to determine the role of these variables in the recall and encoding strategy use.

With few exceptions (e.g., Leight & Ellis, 1981), the role of study strategy as a mediator of the relationship between mood and memory has largely been ignored, along with the role of arousal levels. Thus, we attempted to fill these gaps in the research literature. As mentioned previously, moderate levels of arousal are correlated with better memory functioning (see Mandler, 1992), and many manipulations of mood/affect are also manipulations of arousal (Revelle & Loftus, 1992), with significant negative correlations between the two (e.g., Terry et al., 1999; Terry et al., 2003). We expected to find that any increase in energetic arousal would be associated with greater use of more optimal learning strategies and greater recall performance. However, we only found a medium-sized memory effect and greater use of optimal encoding strategies for those in the positive music condition, despite significantly increasing energetic arousal in both the positive music and images conditions.

Perhaps the best evidence against the direct role of mood and energetic arousal in the current experiment is that those who reported higher levels of mood and arousal prior to the study phase in any of the conditions did not have better memory performance, as the correlations between POMS post-test scores and probability of recall was zero. This could be because the recall test itself negatively altered the mood and arousal state of the participants so that the mood and arousal levels during the memory phase did not match their subjective assessments of their mood and arousal prior to the memory phase. Similarly, it is possible that some of the mood and arousal induction stimuli failed to produce longer lasting effects on mood and arousal. Therefore, future researchers might consider adding a mood and arousal assessment during and following the encoding and retrieval phases of the experiment to eliminate this potential problem of interpretation. To summarize, the better predictor of memory performance seemed to be the implementation of more useful encoding strategies and not to mood and arousal levels alone.

One interesting finding was that those in music conditions overall recalled more than those in the pictures conditions. State dependent or mood congruent learning could explain why there was a main effect of stimulus type on free recall of the word list. Specifically, mood congruent recall might explain the enhanced memory of those in either the positive or negative music condition over the images conditions. Numerous studies have shown that the effects of mood depend not on the valence of the mood, but on a match between mood during learning and mood during retrieval (e.g., Bower, Monterio, & Gillian, 1978; Eich & Metcalfe, 1989; Eich, 1995). Perhaps those in the music conditions (compared to those in the visual conditions) experienced greater mood congruency between study and test phases of the experiment. Eich (1980) suggested that state dependent effects are greater when the retrieval cues are weak such as in free recall (as opposed to recognition). Therefore, one could test this mood congruency hypothesis by assessing mood and arousal during the learning and retrieval phases to determine which mood and arousal induction conditions (music vs. images) helped to create greater mood congruence between the learning and testing contexts. In addition, one could contrast recall and recognition memory in a single experiment. If mood congruency between study and test was greater for the auditory conditions compared to the visual conditions, then a memory advantage for the music conditions would be more evident on a more difficult free recall task, but not on an easier test of recognition. We also cannot rule out the possibility that both positive and negative mood conditions benefitted recall (through mood congruency) because we did not include a neutral condition. Future studies should include a neutral condition in order to more accurately assess the role of mood congruency within the current experimental paradigm.

While mood congruency might explain the memory advantage of music over pictures, there is another possible explanation for why those in the images conditions recalled less than those in the music conditions. Studies have shown that we have better free recall with pictures over words (Lieberman & Culpepper, 1965), so perhaps the prior exposure to the images created a situation of proactive interference, whereby the previously shown pictures in the mood induction phase (i.e., the old items) interfered with recall of the subsequently learned words (i.e., the new items). If the pictures interfered with encoding and recall, then one might expect a higher rate of extra-list intrusions in the images condition. However, this was not the case, as the extra-list intrusion rate was low across all of the conditions. Therefore, it is unclear why participants in the pictures conditions exhibited poorer rates of recall.

To summarize, although the upbeat, cheerful music and positive images conditions induced significant increases in mood and arousal from baseline to post-test, only those exposed to upbeat, cheerful music exhibited a marginally significant memory benefit over those exposed to slow, melancholy music. Mood and arousal do not appear to mediate the medium-sized memory effect in the images conditions because there were no memory differences between the positive and negative image conditions despite significant differences in mood and arousal. Due to high variability in memory performance in the music condition, it is difficult to determine whether the mood and arousal induced through music is beneficial for memory, and most of the evidence points to the use of an effective study strategy as a more viable explanation for why participants in that condition exhibited the best memory performance.

Nevertheless, this research sheds light on a factor that might explain why the evidence of the effects of mood on memory are mixed. With very few exceptions (e.g., Leight & Ellis, 1981), research on the link between mood and memory largely ignores the role of encoding strategy. Furthermore, the results are even more obscured because many studies failed to include manipulations of positive and negative moods and arousal levels in the same study. Given that negative affect is not simply the inverse of positive affect, but rather a separate entity (e.g., Watson & Tellegen, 1985), one cannot assume that an absence of a cognitive advantage for one type of mood equates to a cognitive advantage of the other type of mood. Given our results, future researchers should simultaneously include manipulations of positive, negative, and neutral mood inductions; include multiple assessments of mood and arousal; and include assessments of encoding strategy use by participants to determine the valid source of any recall advantage.

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Footnotes

1. Large effect size in de l'Etoile (2002) (*Cohen's d* = .86), and differences in recall that approached significance, $p = .06$.
2. The study list and all materials used in this study are available upon request from the authors.
3. In the recent memory literature, it is common practice to convert raw memory scores to probabilities (or proportions) by dividing by the total number of list items in order to make the range of the dependent measure easier to conceptualize (see Goodmon & Nelson, 2004; Nelson & Goodmon, 2002; Nelson, Goodmon, & Ceo, 2007; Sahakyan & Goodmon, 2010). The results of the inferential statistical analyses are the same regardless of whether one uses raw scores or proportion of list recall as the dependent measure.