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Listeners Remember Music They Like

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Emotions have important and powerful effects on cognitive processes. Although it is well established that memory influences liking, we sought to document whether liking influences memory. A series of 6 experiments examined whether liking is related to recognition memory for novel music excerpts. In the general method, participants listened to a set of music excerpts and rated how much they liked each one. After a delay, they heard the same excerpts plus an equal number of novel excerpts and made recognition judgments, which were then examined in conjunction with liking ratings. Higher liking ratings were associated with improved recognition performance after a 10-min (Experiment 1) or 24-hr (Experiment 2) delay between the exposure and test phases. The findings were similar when participants made liking ratings after recognition judgments (Experiments 3 and 6), when possible confounding effects of similarity and familiarity were held constant (Experiment 4), and when a deeper level of processing was encouraged for all the excerpts (Experiment 5). Recognition did not vary as a function of liking for previously unheard excerpts (Experiment 6). The results implicate a direct association between liking and recognition. Considered jointly with previous findings, it is now clear that listeners tend to like music that they remember and to remember music that they like.

Keywords: memory, liking, emotion, music, exposure

The present investigation sought to determine whether listeners demonstrate enhanced memory for music they like. Experimental psychologists have been interested in associations between emotions and memory for many years. In the early 1900s, researchers reported that pleasant information was remembered better than unpleasant information (Laird, 1923; Tait, 1913; Thomson, 1930; Tolman, 1917) and that word lists were remembered better when followed by a pleasant rather than an unpleasant passage (Tait, 1913). Others of that era reported that temperament, or global mood, was related to memory, with more cheerful participants being slower or less likely to recall unpleasant experiences (Baxter, Yamada, & Washburn, 1917; Morgan, Mull, & Washburn, 1919).

More recent research reports similar findings. For example, memory is enhanced for words deemed to be good or emotional (Rubin & Friendly, 1986). In general, affectively valenced stimuli are remembered better than neutral stimuli (e.g., Dewhurst & Parry, 2000; Ferré, 2003; Kensinger & Corkin, 2003; Schmidt & Saari, 2007), with emotional content enhancing memory for specific visual details (Kensinger, Garoff-Eaton, & Schacter, 2006) as well as for context (e.g., font color; Doerksen & Shimamura, 2001). In line with Tait's (1913) results, children are more likely to identify correctly that they have previously tasted flavors of jellybeans when the flavor is initially presented along with affectively positive information (e.g., "This is Winnie the Pooh's favorite flavor of jellybean"; Lumeng & Cardinal, 2007). Among adults, a high degree of arousal is associated with better memory for pictures (e.g., Bradley, Greenwald, Petry, & Lang, 1992; Kensinger et al., 2006) and for stories accompanied by slides (e.g., Burke, Heuer, & Reisberg, 1992; Cahill & McGaugh, 1995).

Findings from recent studies of mood are also consistent with earlier research. Positive moods are associated with enhanced recall of a narrative (Levine & Burgess, 1997), whereas negative moods are associated with reduced word recall (Ellis, Thomas, & Rodriguez, 1984). Mood also affects the kind of information that is likely to be remembered. Information learned while in a positive or negative mood is more likely to be recalled while in a positive or a negative mood, respectively (Bower, 1981; Bower, Monteiro, & Gilligan, 1978). Similarly, music in major keys (which are happy sounding) is better remembered than music in minor keys (which are sad sounding) when listeners are in a positive mood, but the opposite is true when listeners are in a negative mood (Houston & Haddock, 2007). Thus, memory is influenced by what is being processed and how it is processed.

The association between cognition and emotion is particularly evident in the *mere exposure effect*, the finding that incidental exposure to a neutral stimulus leads to increases in liking when the stimulus is reencountered (e.g., Bornstein, 1989; Zajonc, 2001). For example, Chinese-like characters are rated more positively when they have been seen 25 times previously compared with only once (Zajonc, 1968). In fact, the mere exposure effect is observed even in the absence of explicit recognition. In one study (Kunst-Wilson & Zajonc, 1980), participants were exposed to a number of polygons presented subliminally (i.e., for 1 ms). They were sub-

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sequently presented with pairs of polygons, one previously exposed and one novel, and asked to select the preferred polygon and the one that seemed more familiar. Although the previously exposed polygon was selected as the more preferred shape at greater than chance levels, it was not more familiar. In other words, exposure can lead to enhanced liking in the absence of explicit recognition of the stimulus, which implicates implicit memory. In some instances, the effect is actually stronger when stimuli are presented subliminally rather than supraliminally (e.g., Murphy, Monahan, & Zajonc, 1995).

The perceptual fluency/attribution model (e.g., Bornstein, 1992; Bornstein & D'Agostino, 1994; Jacoby, Kelley, & Dywan, 1989) provides an explanation of the mere exposure effect. Because the perceiver has a memory trace for a previously exposed item, subsequent processing of the same item is facilitated. Contextual information may be used to interpret the improved fluency, such that increased ease of processing is misattributed to some other factor, such as liking (Fazendeiro, Chenier, & Winkielman, 2007). In the absence of explicit recognition, increased fluency is particularly likely to be misattributed as a positive disposition toward a stimulus. As memory for the stimulus increases (i.e., through supraliminal or repeated presentations), participants are more likely to attribute the improved fluency to the actual source (i.e., previous exposure) rather than to an affective response (e.g., liking). From this perspective, increases in recognition accuracy should be associated with decreases in liking.

Although it is clear that previous exposure to a stimulus can lead to positive affective responding in the absence of explicit recognition (e.g., Bornstein, 1992; Bornstein & D'Agostino, 1994; Kunst-Wilson & Zajonc, 1980; Mandler, Nakamura, & Van Zandt, 1987; Peretz, Gaudreau, & Bonnel, 1998; Wilson, 1979; Zajonc, 2001), this absence is not a requirement. For example, Bonanno and Stillings (1986) found that participants could not distinguish between old and new items on the basis of explicit recognition (i.e., remembering having seen an item previously), but they could distinguish between old and new items on the basis of familiarity (i.e., the sense of an item being "old" or "popping out" at them). In fact, when judgments based on familiarity were made, recognition and preference rates were similar. Under the right circumstances, then, fluency can influence recognition as well as liking.

In another experiment (Monin, 2003), participants rated the attractiveness or familiarity of faces selected randomly from an old yearbook. Ratings of attractiveness and familiarity were highly correlated: The more attractive a face, the more likely participants were to say that they had seen the person on campus. In a follow-up experiment, participants studied one of two sets of faces from the first experiment and indicated whether each face was male or female. Participants subsequently saw both sets of faces and indicated whether each face had been seen previously. Attractive faces tended to be recognized as "old" more often than unattractive faces, whether or not they were actually old. Similarly, Phaf and Rotteveel (2005) found that inducing positive affect created more false recognition of words compared with inducing negative affect, whereas other researchers reported correlations between positive affect and accurate judgments of familiarity or recognition (e.g., Brooks & Watkins, 1989; Newell & Shanks, 2007; Wang & Chang, 2004).

The perceptual fluency/attribution model also fails to account for decreases in liking that accompany stimuli that have been encountered many times (cf. Van den Bergh & Vrana, 1998). To explain this phenomenon, Berlyne (1970) and Stang (1974) proposed a two-factor model. The first factor describes the dissipation of novelty through increased exposure. An initial wariness of novelty is adaptive, such that exposure to a novel stimulus coupled with benign consequences leads to the stimulus no longer being viewed as a threat (i.e., learned safety; Kalat & Rozin, 1973) and increases in liking. After multiple exposures, participants become bored with the exposed stimulus (the second factor), leading to a decline in liking ratings. According to this model, the association between exposure and liking forms an inverted U-shaped function, such that stimuli that are too familiar or unfamiliar, or too simple or complex, receive lower liking ratings. This model provides a good account of complex stimuli such as music, for which increases and decreases in liking as a function of exposure have been observed (e.g., Bartlett, 1973; Brentar, Neuendorf, & Armstrong, 1994; Hargreaves, 1984; Heyduk, 1975; Verveer, Barry, & Bousfield, 1933).

More recently, Schellenberg and his colleagues (Schellenberg, Peretz, & Vieillard, 2008; Szpunar, Schellenberg, & Pliner, 2004) examined associations among exposure, liking, and recognition for music. In one condition in the study by Szpunar et al. (2004), participants listened to excerpts from concerti presented at different exposure frequencies. An orienting task required them to identify the lead instrument after each exposure. They subsequently heard the previously exposed excerpts as well as novel stimuli, and rated how much they liked each excerpt and how confident they were that it was presented previously. Liking increased as a function of exposure up to a point (i.e., reaching a maximum at eight exposures), after which it fell to baseline levels (after 32 exposures), whereas recognition improved monotonically. Because the stimuli were randomized separately for each participant, the exposed stimuli for some participants were the novel stimuli for other participants, which ruled out the role of inherent likability or memorability for some excerpts over others. More importantly, increases in explicit memory for complex stimuli were accompanied by increases as well as decreases in liking.

In sum, memory—whether explicit or implicit—and liking often co-occur. Nevertheless, although it is clear that memory influences liking, evidence of a direct influence of liking on memory is much less clear. The most relevant research comes from applied work in advertising, which reveals that how much an ad is liked determines its effect on sales (Haley & Baldinger, 1991). Indeed, a number of studies have found positive associations between liking and memory for ads (e.g., Thorson & Reeves, 1986; Walker & Dubitsky, 1994; Youn, Sun, Wells, & Zhao, 2001). This association between liking and memory for advertised products may represent a different phenomenon than liking for other kinds of stimuli. For example, preexisting attitudes toward a brand influence attitudes toward new products from the same brand (MacInnis & Jaworski, 1989). It is important, therefore, to examine whether associations between liking and memory are evident for other kinds of stimuli that are free of preexisting biases.

Reciprocal influences of liking and memory could be particularly interesting for music because memory for music is associated with both increases and decreases in liking (Hunter & Schellenberg, 2011; Schellenberg et al., 2008; Szpunar et al., 2004). Moreover, despite a general tendency to prefer positively over negatively valenced music (e.g., Hunter, Schellenberg, & Schimmack, 2008, 2010; Ladinig & Schellenberg, 2012), people often enjoy listening to negatively valenced (i.e., sad-sounding) music (Hunter & Schellenberg, 2010). Indeed, the bias favoring happy- over sad-sounding music can be eliminated by inducing fatigue (Schellenberg et al., 2008) or a sad mood (Hunter, Schellenberg, & Griffith, 2011). In one study that was directly related to the present goals, enhanced memory was evident for music that was rated as positively valenced, but there was no measure of actual liking (Eschrich, Münte, & Altenmüller, 2008).

Findings that emotion and memory are integrally linked in a number of complex ways motivated the present set of experiments, which tested whether liking predicts memory for music. Music is a ubiquitous part of human life, with the vast majority of individuals enjoying some kinds of music. Importantly, different people like different types of music (e.g., Rentfrow & Gosling, 2003), which allows for the formation of heterogeneous sets of music stimuli, such that any individual listener is liable to like, dislike, and neither like nor dislike some of the pieces. Such within-individual differences allow for powerful tests of whether liking influences memory for music.

Experiment 1: Does Liking Influence Memory for Music?

In Experiment 1, participants' initial ratings of how much they liked a variety of musical excerpts were examined in conjunction with their subsequent recognition ratings. Although memory for stimuli is known to be associated with increases in liking (e.g., Brooks & Watkins, 1989; Newell & Shanks, 2007; Schellenberg et al., 2008; Szpunar et al., 2004; Wang & Chang, 2004), in some instances improved memory is evident for negatively valenced stimuli (e.g., Ferré, 2003; Kensinger & Corkin, 2003; Schmidt & Saari, 2007). Thus, we had a clear prediction that liking music would influence recognition, but we were agnostic about whether disliking music would have a similar effect. In any event, our method allowed us to tease apart effects of the intensity of the emotional response from effects of positive responding.

Method

Participants. The listeners were 55 undergraduates from an introductory psychology class who received partial course credit for their participation. None had any self-reported hearing difficulties. They were recruited without regard to music training. On average, they had 3.2 years of training (i.e., private, group, or school music lessons; range: 0–10 years), but as in other samples from the same population (e.g., Hunter et al., 2008, 2010; Schellenberg et al., 2008; Weiss, Trehub, & Schellenberg, in press) and the experiments that follow, the distribution was skewed positively, such that the median was 3 years and the mode was 0 years.

Apparatus and stimuli. Testing was conducted in a double-walled sound-attenuating booth (Industrial Acoustics Co.). Stimulus presentation and response recording were controlled with customized software created with PsyScript (Slavin, 2007) installed on a Macintosh computer. The stimuli were presented via computer speakers at a comfortable volume. They comprised 48 music excerpts used initially by Hunter et al. (2008, Appendix) but shortened from 30 to 15 s. These excerpts were taken from instrumental sections of commercial recordings drawn from a wide variety of genres and styles and selected so that they would be unfamiliar to the participants. They varied in tempo and mode, with tempo (fast or slow) and mode (major or minor) counterbalanced. The excerpts were also paired by composer/artist or genre to produce 24 pairs of excerpts. Within each pair, one excerpt had consistent cues to happiness (fast and major) or sadness (slow and minor), whereas the other had inconsistent cues (fast and minor, slow and major).

Two stimulus lists were created, with one excerpt from each composer/artist or genre included on each list. Listeners were assigned randomly to hear excerpts from one of the stimulus lists in the first (liking) phase of the experiment. All listeners were exposed to excerpts from both lists in the second (recognition) phase. To preclude effects of the emotional status of the excerpts on liking and recognition, the number of excerpts containing consistent or inconsistent cues was counterbalanced across the two lists and the exposure and recognition phases, as was the number of happy- and sad-sounding excerpts, and whether excerpts with inconsistent cues were fast and minor or slow and major.

Procedure. In the initial liking phase, listeners made a rating on a scale from 1 to 7 (1 = *dislike a lot*, 7 = *like a lot*) after listening to each of 24 excerpts (all from one of the two lists) presented in random order. In order to ensure that liking ratings were not an artifact of complying with instructions, listeners were not instructed to use the entire liking scale. Trials were self-paced, such that the next excerpt was presented when listeners pressed the space bar. A brief (approximately 10 min) delay followed the liking phase, during which participants completed demographic questionnaires. In the subsequent recognition phase, they heard the complete set of 48 excerpts (i.e., both lists, 24 previously heard, 24 novel) in random order. For each excerpt, they judged whether it was presented in the liking phase (i.e., whether the excerpt was "old" or "new"), and rated how confident they were on a scale from 1 (*not at all sure*) to 5 (*completely sure*). Finally, listeners were asked whether any of the excerpts was familiar to them based on preexperiment exposure.

Results and Discussion

Recognition scores were computed for each listener by combining their responses on the recognition question and confidence rating into a 10-point scale. Excerpts identified as previously heard received scores between 6 and 10 (6 indicating low confidence, 10 indicating high confidence), whereas excerpts identified as novel received scores between 1 and 5 (1 indicating high confidence, 5 indicating low confidence). Thus, recognition scores ranged from 1 (high confidence the excerpt was new) to 10 (high confidence the excerpt was old).

Two overall recognition scores were initially computed for each listener: one for excerpts that were previously heard, another for novel excerpts. Both scores were the average of 24 original scores. Comparing these two scores provided a manipulation check that listeners could indeed remember the excerpts presented in the liking phase, such that it made sense to investigate further whether some excerpts were remembered better than others. Statistical results are provided in Table 1. Recognition scores were higher for old excerpts than for new excerpts.[1]

We next computed recognition scores for previously heard excerpts based on liking ratings. Three recognition scores were computed for each listener: one for excerpts that were initially rated as being liked (i.e., liking ratings of 6 or 7), another for excerpts that were disliked (i.e., ratings of 1 or 2), and a third for excerpts that were neither liked nor disliked (i.e., ratings of 3, 4, or 5). Each score was again an average, but the number of original ratings that were averaged varied from listener to listener depending on his or her liking ratings. Seven listeners had missing values (i.e., no liked or disliked excerpts). In general, however, the range of liking ratings confirmed that the vast majority of participants liked some excerpts, disliked others, and neither liked nor disliked the rest. In other words, the music excerpts were sufficiently diverse for the purposes of this series of experiments.

One additional participant was excluded based on self-reported recognition of some of the music excerpts. Thus, the final sample comprised 47 participants. Because preliminary analyses in this and all subsequent experiments revealed no main effect of the two testing conditions (i.e., the particular list of stimuli that participants heard initially) on recognition and no interaction between condition and the three levels of liking, condition was not considered further.

A repeated measures analysis of variance (ANOVA) revealed a significant difference in recognition scores for previously heard excerpts as a function of how much they were liked. Descriptive and inferential statistics are provided in Figure 1A and Table 2, respectively. Excerpts that were liked were remembered better than excerpts that were disliked, $t(46) = 2.58$, $p = .013$, or neither liked nor disliked, $t(46) = 3.27$, $p = .002$. There was no difference in recognition scores between disliked excerpts and those that were neither liked nor disliked ($p = .939$).

Differences in liking for some excerpts over others could be a consequence of greater familiarity with some genres of music compared to others. If recognition of familiar-sounding excerpts were enhanced in general, we may find higher ratings for familiar-sounding old excerpts but lower ratings for familiar-sounding new excerpts. Because stimuli were initially paired according to genre and only one excerpt from each pair was presented in the initial liking phase, it was possible to examine whether recognition ratings for novel excerpts varied as a function of the degree of liking (and presumed familiarity) of the paired excerpt heard previously. Statistical analyses are reported in Table 3. Recognition ratings for novel excerpts did not differ as a function of the degree of liking of the corresponding excerpt heard in the liking phase. Thus, there was no evidence that listeners provided higher liking ratings solely as a consequence of greater familiarity with some musical genres compared to others.

In short, in the context of a single exposure to unfamiliar musical excerpts, high initial liking ratings were associated positively with subsequent recognition.

Experiment 2: Does the Effect of Liking on Memory Extend Across a Delay?

In Experiment 1, listeners were exposed to the same piece of music twice in less than an hour. Because such rapid repetition is rare in the course of everyday exposure to music (e.g., listening to the radio), in Experiment 2 we introduced a 24-hr delay between the liking and recognition phases, a more ecologically valid time frame. We expected memory to decline across this longer delay, but we had no clear predictions as to what would happen to the effect of liking on memory. One possibility is that the effect of liking on memory could be reduced or eliminated, suggesting that it is transient and not relevant to everyday music listening. A second possibility is that the effect of liking on memory could be maintained across the longer delay. More importantly, the absence of an interaction between liking and the retention interval would justify continued use of the shorter interval in experiments that follow. A final possibility is that the delay could magnify the effect of liking on memory (e.g., Burke et al., 1992; Sharot & Phelps, 2004), resulting in an even larger recognition benefit for liked excerpts.

Method

Participants. The listeners were 54 undergraduates recruited as in Experiment 1. None had participated in Experiment 1. They had an average of 3.2 years of music training (range: 0–11 years; median = 2 years; mode = 0 years).

Apparatus and stimuli. Apparatus and stimuli were identical to those in Experiment 1.

Procedure. The procedure was identical to that of Experiment 1 except there was a 24-hr delay between the liking and recognition phases of the experiment. After making their initial liking ratings and completing the questionnaires, participants left the laboratory and returned at the same time the next day to complete the recognition phase of the experiment.

Results and Discussion

In general, recognition ratings were higher for old than for new excerpts (see Table 1). Thus, even 24 hr after the liking phase, listeners differentiated clearly between excerpts that were previously heard and those that were novel. Eight participants had missing values (i.e., no liked or disliked excerpts), leaving a final sample of 46. Recognition scores for previously heard excerpts varied as a function of liking (see Table 2). Descriptive statistics are illustrated in Figure 1B. Excerpts that were liked were remembered better than excerpts that were disliked, $t(45) = 2.42$, $p = .020$, or neither liked nor disliked, $t(45) = 2.39$, $p = .021$. Once again, there was no difference in recognition scores between disliked excerpts and those that were neither liked nor disliked ($p = .184$). In fact, in absolute terms, recognition scores were lower for disliked excerpts. As in Experiment 1, recognition of novel excerpts did not differ as a function of the degree of liking for the corresponding excerpt heard previously (see Table 3).

We also examined data from Experiment 1 jointly with the present data. A mixed-design ANOVA with liking (disliked, neutral, liked) as a repeated measure and delay (10 min, 24 hr) as a between-participants factor revealed a robust effect of liking, $F(2, 182) = 10.78$, $p < .001$, $\eta_p^2 = .11$, but no main effect of delay and

[1] Across all experiments, the same pattern of results was evident when recognition scores for old and new excerpts were examined after some participants were excluded because of missing data or recognizing the excerpts.

Table 1
Statistical Comparisons of Recognition Ratings for Old and New Excerpts

Experiment	Old *M*	Old *SD*	New *M*	New *SD*	*t*	*df*	η_p^2
1	7.44	0.94	3.01	1.22	20.18*	54	.88
2	7.64	1.12	2.76	0.84	23.77*	53	.91
3	7.33	1.18	3.00	1.09	15.36*	47	.83
4	7.54	1.09	2.99	0.98	22.36*	54	.90
5	7.90	1.07	2.99	0.93	31.56*	85	.92
6	7.40	1.23	3.09	1.27	14.88*	48	.82

* $p < .001$.

no interaction between delay and liking ratings (Fs < 1). Follow-up analyses of the liking effect revealed that even with the additional power provided by the larger sample, there was no difference in recognition ratings between excerpts that were disliked ($M = 7.22$, $SD = 1.87$) and those that were responded to neutrally ($M = 7.39$, $SD = 1.07$; $p = .332$). As before, liked excerpts ($M = 8.13$, $SD = 1.87$) were remembered better than disliked excerpts, $t(92) = 3.53$, $p < .001$, and excerpts that were neither liked nor disliked, $t(92) = 4.03$, $p < .001$.

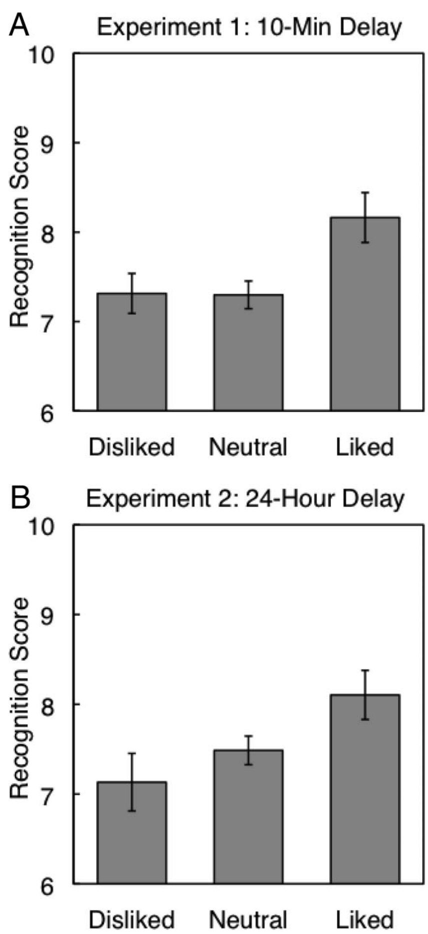

Figure 1. Mean recognition scores and standard errors as a function of liking ratings for previously heard excerpts in Experiment 1 (A) and Experiment 2 (B).

Thus, the effect of liking on memory was apparent even in a more ecologically valid listening context, when the same piece of music was reheard 1 day instead of approximately 20 min later. The lack of a main effect of the delay was surprising and difficult to explain. More importantly, the absence of an interaction between liking and retention interval on recognition justified the use of the shorter interval in subsequent experiments. In contrast to some studies that have observed stronger effects of emotion on memory after a delay (e.g., Burke et al., 1992; Sharot & Phelps, 2004), here the association between liking and memory was similar across both short and long delays.

Experiment 3: Is the Effect of Liking on Memory Dependent on the Exposure Task?

Although listeners exhibited enhanced memory for music they liked in Experiments 1 and 2, it is possible that the effect of liking on memory was a consequence of directing participants' attention to the dimension of liking. The goal of Experiment 3 was to examine whether the association between liking and memory remains evident when initial exposure occurs in the context of a different task: rating stimulus complexity instead of liking. In contrast to Experiments 1 and 2, liking ratings were made in a third phase of the test session, after rather than before the recognition phase. Although liking ratings could increase in general because of the two previous exposures (Szpunar et al., 2004), there was no reason to expect that such increases would differ systematically for some excerpts compared to others.

Method

Participants. The participants were 48 undergraduates recruited as in Experiments 1 and 2. None had participated in Experiments 1 or 2. Participants had an average of 2.8 years of music training (range: 0–14 years; median = 1 year; mode = 0 years).

Apparatus and stimuli. Apparatus and stimuli were identical to those in Experiment 1.

Procedure. The procedure was identical to that of Experiment 1 with two exceptions. Instead of making liking ratings in the first phase, participants rated the perceived complexity of each excerpt on a scale from 1 (*very simple*) to 7 (*very complex*) in order to ensure that they listened attentively on each trial. As in Exper-

Table 2
Statistical Comparisons of Recognition Ratings for Liked, Neutral, and Disliked Excerpts

	Liked		Neutral		Disliked					
Experiment	*M*	*SD*	*M*	*SD*	*M*	*SD*	*F*	*df*	η_p^2	*p*
1	8.16	1.91	7.30	1.06	7.31	1.54	6.50	2, 92	.12	.002
2	8.11	1.86	7.49	1.09	7.13	2.18	4.88	2, 90	.10	.010
3	8.16	1.61	7.25	1.35	7.08	1.66	9.74	2, 70	.22	<.001
4	8.55	1.05	7.46	1.02	7.27	2.45	8.38	2, 88	.16	<.001
5	8.69	1.05	8.01	1.20	7.76	2.28	6.87	2, 110	.11	.002
6 old	8.26	1.39	7.08	1.36	6.39	2.27	15.97	2, 68	.32	<.001
6 new	3.29	1.79	3.08	1.39	2.80	2.12	1.42	2, 74	.04	.249

iment 1, they then completed questionnaires before the recognition phase of the experiment. In the liking phase that followed the recognition phase, listeners rated the same 24 excerpts they heard in the initial phase of the experiment.

Results and Discussion

As in Experiments 1 and 2, mean recognition scores were higher for old excerpts than for new excerpts (see Table 1). One listener claimed to recognize some of the excerpts and was excluded from subsequent analyses. Eleven listeners had missing values when recognition scores were calculated separately as a function of liking ratings (i.e., no liked or disliked excerpts), whereas six had missing values when recognition scores were calculated separately as a function of complexity ratings (i.e., no excerpts deemed to be complex or simple). Thus, sample sizes varied across the different analyses.

As in Experiments 1 and 2, recognition scores for previously heard excerpts varied as a function of how much they were liked (see Table 2). Descriptive statistics are illustrated in Figure 2A. Excerpts that were liked were remembered better than excerpts that were disliked, $t(35) = 3.58$, $p = .001$, or neither liked nor disliked, $t(35) = 3.88$, $p < .001$. There was no difference in recognition scores between excerpts that were disliked and those that were neither liked nor disliked ($p = .514$). In fact, as in Experiment 2, in absolute terms, disliked excerpts received lower recognition ratings. Recognition for novel excerpts did not differ as a function of the degree of liking for the corresponding excerpt heard previously (see Table 3).

Recognition scores were also examined as a function of complexity ratings. Each participant had three recognition scores: one averaged across excerpts deemed to sound complex (complexity ratings of 6 or 7), another averaged across simple excerpts (ratings of 1 or 2), and a third averaged across excerpts that were neither complex nor simple (ratings of 3, 4, or 5). A repeated measures ANOVA revealed a significant difference in recognition scores for previously heard excerpts as a function of complexity, $F(2, 80) = 9.18$, $p < .001$, $\eta_p^2 = .19$. Descriptive statistics are illustrated in Figure 2B. Excerpts rated as complex were remembered better than excerpts that were simple, $t(40) = 3.59$, $p < .001$, or neither complex nor simple, $t(40) = 3.69$, $p < .001$. There was no difference in recognition scores between excerpts that were rated as simple and those that were rated as neutral in complexity ($p = .183$). These response patterns raise the possibility that positive judgments in general—in response to questions about liking or complexity—were driving the observed associations between liking and memory. When liking and complexity ratings were examined separately for each participant, however, the median correlation was very low and not significant ($r = .18$, $N = 24$ excerpts, $p = .226$), which implies that the effect of liking on memory was distinct from the effect of complexity.

To examine whether the orienting question during initial exposure influenced the association between liking and recognition, we considered the data from Experiment 1 jointly with the present data. An ANOVA with liking (disliked, neutral, liked) as a repeated measure and orienting question (liking vs. complexity) as a between-subjects factor revealed a main effect of liking, $F(2, 162) = 15.18$, $p < .001$, $\eta_p^2 = .16$, but no main effect of question and no interaction between question and liking (Fs < 1). Thus, number of previous exposures (i.e., 0 vs. 2) had no effect on overall liking or on the association between liking and recognition. Follow-up analyses revealed that even with the additional power provided by the larger sample, there was no difference in recognition scores between excerpts that were disliked ($M = 7.21$, $SD = 1.58$) and excerpts that were responded to

Table 3
Statistical Comparisons of Recognition Ratings for New Excerpts as a Function of Whether the Paired Old Excerpt Was Liked, Neutral, or Disliked

	Liked		Neutral		Disliked					
Experiment	*M*	*SD*	*M*	*SD*	*M*	*SD*	*F*	*df*	η_p^2	*p*
1	2.96	1.54	2.84	1.24	2.78	1.60	<1	2, 92	.01	.704
2	2.71	1.09	2.87	1.14	2.59	1.43	<1	2, 90	.02	.415
3	3.08	1.42	3.01	1.53	2.86	1.63	<1	2, 70	.01	.663
4	2.83	1.27	2.94	0.94	2.79	1.39	<1	2, 88	.01	.762
5	3.18	1.91	2.94	0.86	2.69	1.72	2.06	2, 110	.04	.132

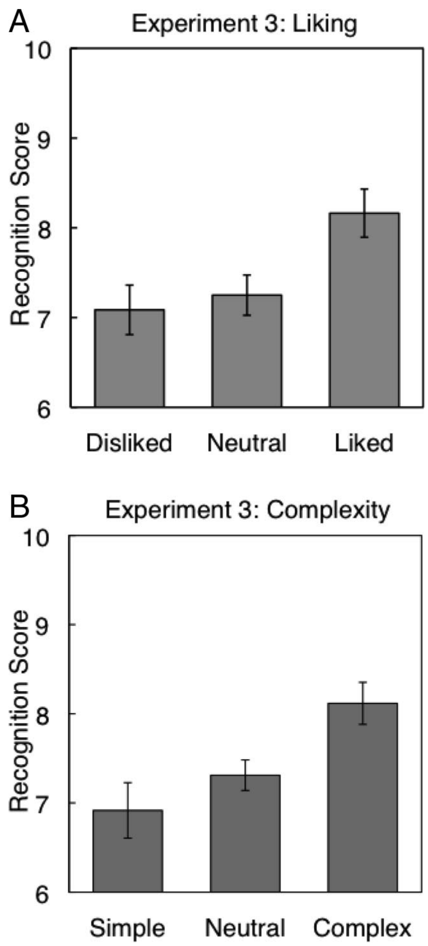

Figure 2. Mean recognition scores and standard errors as a function of liking ratings (A) and complexity ratings (B) for previously heard excerpts in Experiment 3.

neutrally ($M = 7.28$, $SD = 1.19$; $p = .708$). As before, liked excerpts ($M = 8.16$, $SD = 1.78$) were remembered better than disliked excerpts, $t(82) = 4.19$, $p < .001$, and excerpts that were neither liked nor disliked, $t(82) = 4.92$, $p < .001$.

As in Experiments 1 and 2, the present listeners exhibited enhanced recognition for excerpts of music that they liked. Although liking ratings preceded recognition judgments in Experiments 1 and 2, in the present experiment liking ratings followed recognition judgments. If the orienting task used in Experiments 1 and 2 resulted in an effect of liking on memory simply because the task drew participants' attention to the dimension of liking, then the effect should have been eliminated when a different orienting task was used. An association between liking and memory continued to be observed, however, when participants initially provided complexity instead of liking ratings.

Experiment 4: Is the Effect of Liking on Memory Due to Liking, Familiarity, or Similarity?

In Experiments 1–3, enhanced memory for liked excerpts of music did not appear to be a consequence of familiarity rather than liking. If so, excerpts from familiar genres should have been encoded more readily and thoroughly regardless of whether they were presented during the exposure phase, with familiar-sounding foils receiving lower recognition ratings, yet we found no evidence to support this hypothesis. Nevertheless, familiarity was never measured directly, which it was in the present experiment.

It is well established that liking is related to familiarity as well as similarity. For example, people tend to prefer and to interact more with similar people (Berscheid & Reis, 1998; Condon & Crano, 1988). Even when there is no previous contact, familiarity with a person based on proximity or exposure can increase ratings of liking and of similarity (e.g., Insko & Wilson, 1977; Moreland & Beach, 1992; Moreland & Zajonc, 1982). In the case of music, children and adults remember novel pieces of music from their own culture better than novel pieces from a foreign musical culture (Demorest, Morrison, Beken, & Jungbluth, 2008; Wong, Roy, & Margulis, 2009). Native culture pieces would be more similar to music listeners typically hear and thus more familiar sounding as well.

In principle, then, associations between liking and recognition that were evident in Experiments 1–3 may not have been due to liking per se, but rather to how familiar participants were with a particular musical style, or how similar the stimulus excerpts were to music that participants usually hear. Even for different styles of Western music (e.g., jazz, rock, classical), familiar- or similar-sounding music would be consistent with listeners' musical schemas and thus processed more readily, remembered better, and liked more, which could have driven the observed associations between liking and memory. To explore this possibility, in Experiment 4 we examined the relative contributions of liking, familiarity, and similarity to recognition memory for music. We expected that (a) liking, familiarity, and similarity would be associated; (b) recognition would be associated positively with liking, familiarity, and similarity; and (c) the association between liking and memory would remain evident even when ratings of familiarity and similarity were held constant.

Method

Participants. The listeners were 55 undergraduates recruited as in Experiments 1–3. None had participated in the previous experiments. They had an average of 3.4 years of music training (range: 0–17 years; median = 2 years; mode = 0 years).

Apparatus and stimuli. Apparatus and stimuli were identical to those in Experiment 1.

Procedure. The procedure was identical to that of Experiment 1 except that participants made three ratings in the initial phase of the experiment. In addition to rating how much they liked each excerpt, they rated how familiar they were with each style of music on a scale from 1 (*not at all familiar*) to 7 (*very familiar*), and how similar each excerpt was to the music they usually hear, also on a scale from 1 (*I never listen to music like this*) to 7 (*I often listen to music like this*). The order of the three questions was fixed for each participant to avoid confusion, but the six possible orders of the questions were assigned randomly across participants.

Results and Discussion

As in Experiments 1–3, mean recognition scores were higher for old than for new excerpts (see Table 1). Recognition scores based on familiarity or similarity ratings were formed as they were for liking ratings (1–2 = low, 3–5 = medium, 6–7 = high). Ten participants had missing values when recognition scores were calculated separately as a function of liking ratings (i.e., no liked or disliked excerpts), 13 participants had missing values when recognition scores were calculated separately as a function of familiarity ratings (i.e., no low- or high-familiarity excerpts), and 15 participants had missing values when recognition scores were calculated separately as a function of similarity ratings (i.e., no high-similarity excerpts). Thus, sample sizes varied across the different analyses.

As in the previous experiments, recognition scores for previously heard excerpts varied as a function of how much they were liked (see Table 2). Descriptive statistics are illustrated in Figure 3A. Excerpts that were liked were remembered better than excerpts that were disliked, $t(44) = 3.10$, $p = .003$, or neither liked nor disliked, $t(44) = 6.45$, $p < .001$. There was no difference in recognition scores between disliked excerpts and those that were neither liked nor disliked ($p = .613$). Also as in the previous experiments, recognition ratings for novel excerpts did not differ as a function of the degree of liking (and presumed familiarity) of the corresponding excerpt heard previously (see Table 3).

As expected, recognition of previously heard excerpts also varied as a function of familiarity ratings, $F(2, 82) = 16.85$, $p < .001$, $\eta_p^2 = .29$. Descriptive statistics are illustrated in Figure 3B. Excerpts that were familiar ($M = 8.60$, $SD = 1.15$) were remembered better than excerpts that were unfamiliar ($M = 6.96$, $SD = 2.01$), $t(41) = 5.01$, $p < .001$, or rated neutrally ($M = 7.48$ $SD = 1.29$), $t(41) = 5.36$, $p < .001$. There was no difference in recognition scores between excerpts that were rated as being unfamiliar and those that were rated neutrally ($p = .109$).

Also consistent with predictions was the finding that recognition scores for previously heard excerpts varied as a function of similarity, $F(2, 78) = 14.30$, $p < .001$, $\eta_p^2 = .27$. Descriptive statistics are illustrated in Figure 3C. Excerpts that were rated as similar to the music participants usually hear ($M = 9.04$, $SD = 1.26$) were remembered better than excerpts that were dissimilar ($M = 7.80$, $SD = 1.20$), $t(39) = 4.47$, $p < .001$, or rated neutrally ($M = 7.90$ $SD = 1.32$), $t(39) = 4.29$, $p < .001$. There was no difference in recognition scores between excerpts that were rated as dissimilar and those that were rated neutrally ($p = .669$).

Thus, higher degrees of liking, familiarity, and similarity were each associated with better recognition. In fact, comparison of effect sizes ($\eta_p^2 = .16$, .29, and .27 for liking, familiarity, and similarity, respectively) raises the possibility that liking might actually be the least important of the three variables for recognition. When correlations among liking, familiarity, and similarity ratings were examined separately for each listener, the three ratings were highly intercorrelated (liking-familiarity: median $r = .68$; liking-similarity: median $r = .72$; familiarity-similarity: median $r = .73$; Ns = 24 excerpts, ps $< .001$). Of major interest here was whether liking, familiarity, and similarity made independent contributions to recognition memory. To this end, multiple regression was used to predict each participant's recognition scores from his or her liking, similarity, and familiarity ratings. Partial slopes from the regression equations were then analyzed further (as in Ladinig & Schellenberg, 2012; Schellenberg, 1996). (Partial slopes vary monotonically with partial correlations, but unlike correlations, slopes are distributed normally.) These slopes represented the effect of liking on recognition with familiarity and similarity held constant separately for each participant, the effect of familiarity with liking and similarity held constant, and the effect of similarity with liking and familiarity held constant.

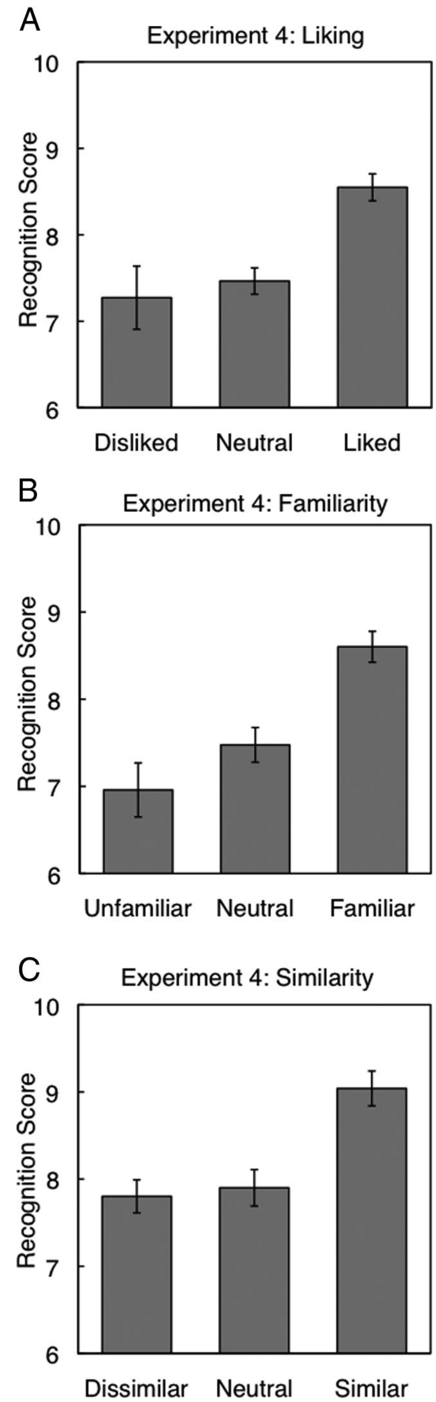

Figure 3. Mean recognition scores and standard errors as a function of liking ratings (A), familiarity ratings (B), and similarity ratings (C) for previously heard excerpts in Experiment 4.

To test whether liking, familiarity, and similarity made independent contributions to recognition, we compared the mean partial

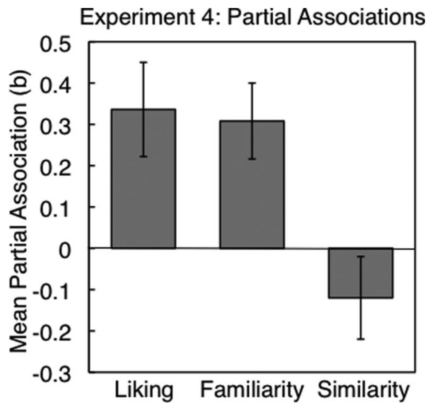

Figure 4. Mean partial slopes and standard errors for previously heard excerpts in Experiment 4. Partial slopes measure the influence of one variable on recognition scores while controlling for the influence of the other two variables.

slope for each variable to 0 (i.e., no effect; see Figure 4). On average, partial slopes for liking ratings (M = .34, SD = .84) were significantly greater than 0, $t(54)$ = 2.95, p = .005, as were partial slopes for familiarity ratings (M = .31, SD = .68), $t(54)$ = 3.34, p = .002. By contrast, partial slopes for similarity ratings (M = −.12, SD = .74) were no different from 0 (p = .236). In fact, the average partial slope for similarity was negative. In other words, excerpts that received higher liking ratings were remembered better than other excerpts when familiarity and similarity were held constant, and excerpts that received higher familiarity ratings were remembered better than other excerpts when liking and similarity were held constant, but excerpts that received higher similarity ratings were not remembered better than other excerpts when liking and familiarity were held constant.

Once again, an association between liking and recognition memory was observed, such that more liked excerpts were remembered better. In addition, associations between familiarity and recognition and between similarity and recognition were evident, such that excerpts from familiar genres of music, and excerpts that were similar to the music participants usually hear, were also associated with improved recognition. Indeed, familiarity, similarity, and liking ratings were highly intercorrelated. These findings are consistent with previously reported associations among liking (or preference), familiarity, and similarity in the context of interpersonal relationships (e.g., Berscheid & Reis, 1998; Condon & Crano, 1988; Insko & Wilson, 1977; Moreland & Beach, 1992; Moreland & Zajonc, 1982), and with associations between familiarity and liking in the context of more traditional mere exposure tasks (e.g., Bonanno & Stillings, 1986; Brooks & Watkins, 1989; Monin, 2003; Newell & Shanks, 2007; Szpunar et al., 2004; Wang & Chang, 2004). In the present experiment, however, we measured familiarity with the genre of music and not with the particular excerpt because the stimulus excerpts were chosen to be unfamiliar.

Even when the contributions of familiarity and similarity were held constant, there was still an effect of liking on memory. Thus, the association between liking and memory is not an artifact in the sense that it is driven by one of these other factors. Rather, increased liking leads to improved recognition. It is particularly interesting that the zero-order effect size for liking on recognition was smaller in absolute terms than effect sizes for similarity and familiarity, yet the partial slope was highest in absolute terms for liking than for the other two variables.

Experiment 5: Does Encouraging Deep Processing Eliminate the Effect of Liking on Memory?

In Experiments 1–4, recognition was enhanced for music excerpts that listeners liked, and the association did not appear to be a consequence of familiarity. It remains unclear, however, why liking was associated with memory. One possibility is that liked excerpts were processed more thoroughly than other excerpts, which led to a stronger memory trace and better recognition.

From the levels-of-processing perspective (Craik & Lockhart, 1972), memory varies as a function of the degree to which the to-be-remembered item is processed semantically or cognitively. For example, semantic encoding tasks (e.g., "Is the word in the category _____?" or "Would the word fit in the sentence _____?") improve memory for words compared with phonemic (e.g., "Does the word rhyme with _____?") or structural (e.g., "Is the word in capital letters?") encoding tasks (Craik & Tulving, 1975). The effect remains evident when participants are informed about the upcoming memory test or when there is a financial incentive for better memory (Craik & Tulving, 1975). Deeper levels of processing serve to enrich the stimulus representation, forming more associations with other mental representations, making the representation more distinctive, and providing a context for later remembering (Craik, 2002).

Participants in Experiments 1–4 may have had more elaborated or distinctive representations of music they liked, which in turn led to enhanced recognition. Because many studies using a levels-of-processing manipulation have required participants to make pleasantness or liking ratings in the deep-processing condition, one might argue that all the music excerpts were processed in a deep manner. Evaluations of music may occur more or less automatically, however, such that they do not reflect a particularly deep level of processing. Moreover, disliked excerpts were unlikely to have been processed deeply when listeners decided that they did not like a particular excerpt based on its genre (e.g., jazz). In short, it is still an open question whether the recognition advantage for liked excerpts stemmed from deeper processing. Thus far in the present investigation, we know that recognition was similar whether listeners made complexity ratings (Experiment 3) or liking ratings (Experiment 1) in the exposure phase.

In the past, levels-of-processing effects on memory for music have been difficult to document. For example, when the exposure phase involved making judgments about timbre (shallow) or familiarity (deep), the encoding task affected subsequent recognition of preexperimentally familiar melodies (Peretz et al., 1998), but it had no effect on recognition of unfamiliar melodies (Halpern & Müllensiefen, 2008; Peretz et al., 1998). In another instance, varying the encoding task for unfamiliar melodies from judgments of rhythmic complexity (shallow) to ratings of pleasantness (deep) had no effect on subsequent recognition (Warker & Halpern, 2005). Consequently, we decided to use a stronger manipulation to inform whether (a) levels-of-processing effects are observable with music stimuli and (b) deep processing could explain the associations between liking and memory observed in Experiments 1–4.

Participants in the present experiment were informed of the upcoming memory test and encouraged to create a unique and detailed visual representation for each excerpt. This particular deep-processing manipulation was selected after consulting with an expert on levels-of-processing and memory (F. I. M. Craik, personal communication, March 4, 2009). The rationale was that if participants were creating more distinctive representations of liked excerpts, and if more distinctive representations were causing improvements in memory, then encouraging participants to create a distinctive representation for each excerpt could reduce or eliminate the effect of liking on memory. We predicted that this deep-processing manipulation would improve recognition (compared to Experiment 1). The robustness of the association between liking and recognition across the previous experiments also motivated us to predict that the association would remain evident even with this new manipulation.

Method

Participants. Listeners were 86 undergraduates recruited as in Experiment 1. None had participated in Experiments 1–4. They had an average of 3.4 years of music training (range: 0–14 years; median = 2 years; mode = 0 years).

Apparatus and stimuli. Apparatus and stimuli were identical to those in Experiment 1.

Procedure. The procedure was identical to that of Experiment 1 except that participants were told at the beginning of the study that they would be listening to music and rating how much they liked each excerpt, and that their memory for the excerpts would be tested later. For each excerpt, participants were encouraged to improve their memories by visualizing themselves in a place where they would be likely to hear that particular kind of music, and to make each location as detailed and unique as possible. In addition to rating how much they liked each excerpt, participants rated how successful they were in forming a mental image for each excerpt on a scale from 1 (*not at all successful*) to 7 (*very successful*). The recognition phase was identical to that of the previous experiments.

Results and Discussion

Once again, mean recognition scores were higher for old excerpts than for new excerpts (see Table 1). Thirty participants had missing values (i.e., no liked or disliked excerpts), yielding a final sample of 56. In comparison to Experiment 1, a significantly greater proportion of participants was lost, $\chi^2(1, N = 141) = 7.05$, $p = .008$, which means that the visualization task decreased the range of liking ratings.

Recognition scores for previously heard excerpts varied as a function of liking (see Table 2). Descriptive statistics are illustrated in Figure 5. Excerpts that were liked were remembered better than excerpts that were disliked, $t(55) = 3.06$, $p = .003$, or neither liked nor disliked, $t(55) = 3.71$, $p < .001$, but there was no difference between disliked excerpts and those that were neither liked nor disliked ($p = .363$). As in the previous experiments, there was no difference in recognition ratings for novel excerpts when they were examined as a function of the degree of liking (and presumed familiarity) of the paired excerpt that was heard previously (see Table 3).

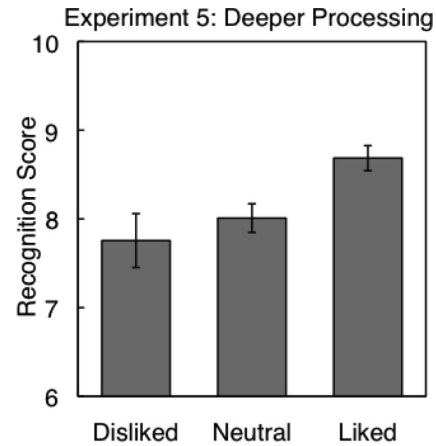

Figure 5. Mean recognition scores and standard errors as a function of liking ratings for previously heard excerpts in Experiment 5.

When these data were considered jointly with data from Experiment 1, a mixed-design ANOVA with liking (disliked, neutral, liked) as a repeated measure and task instructions (liking ratings vs. liking ratings and visualization instructions) as a between-participants factor confirmed that there was a main effect of instructions, $F(1, 101) = 6.31$, $p = .014$, $\eta_p^2 = .06$. As predicted, participants who received the visualization instructions ($M = 8.02$, $SD = 1.09$) had higher recognition scores for previously heard excerpts than participants who received the original instructions ($M = 7.56$, $SD = 0.85$). Although there was also an effect of liking, $F(2, 202) = 13.00$, $p < .001$, $\eta_p^2 = .11$, there was no interaction between instructions and liking ratings ($F < 1$). In other words, although recognition was enhanced by the present encoding manipulation, the effect of liking on recognition was unchanged. Follow-up analyses of the main effect of liking revealed that even with the additional power provided by the larger sample, there was no difference in recognition ratings between excerpts that were disliked ($M = 7.55$, $SD = 1.98$) and those that were responded to neutrally ($M = 7.68$, $SD = 1.19$; $p = .472$). As before, liked excerpts ($M = 8.45$, $SD = 1.52$) were remembered better than disliked excerpts, $t(102) = 4.02$, $p < .001$, and excerpts that were neither liked nor disliked, $t(102) = 4.90$, $p < .001$.

On average, participants reported that they were moderately successful at visualizing a scene to go along with each music excerpt ($M = 4.45$, $SD = 0.93$). There were also marked individual differences in self-reported average success on the visualization task (range: 2.13–6.50). To examine whether perceived success on the visualization task was related to recognition scores or to the effect of liking on recognition, we performed a median split on visualization scores. A mixed-design ANOVA examined overall recognition ratings as a function of exposure (previously exposed or not) as a repeated measure and perceived visualization success (low or high) as a between-subjects factor. In addition to the robust effect of exposure, $F(1, 54) = 846.84$, $p < .001$, $\eta_p^2 = .94$, there was a significant interaction between exposure and visualization success, $F(1, 54) = 10.34$, $p = .002$, $\eta_p^2 = .16$, although the main effect of visualization success was not significant ($F < 1$). Tests of simple effects revealed that participants who were less ($M = 7.86$, $SD = 1.20$) or more ($M = 8.27$, $SD = 0.86$) successful at the visualization task did not differ in their recognition scores for previously heard excerpts ($p = .142$). For novel excerpts, however, participants who were more successful at the visualization task ($M = 2.58$, $SD = 0.76$) had lower recognition scores than participants who were less successful ($M = 3.30$, $SD = 0.87$), $t(54) = 3.28$, $p = .002$. In other words, perceived success on the visualization task predicted more accurate identification of novel excerpts as new.

Finally, we examined whether recognition scores for previously heard excerpts varied as a function of differences in liking and perceived visualization success. A mixed-design ANOVA with one between-subjects factor (visualization success) and one repeated measure (liking) revealed that there was no interaction between visualization success and liking ($p = .356$). Thus, although the visualization manipulation improved recognition memory in general (compared to Experiment 1), and perceived success of the manipulation was associated positively with individual differences in recognition, the effect of liking on memory did not vary as a function of how successful participants thought they were at complying with the visualization instructions.

In sum, recognition memory was better for excerpts that were liked to a greater extent, as it was in Experiments 1–4. This effect of liking on memory was evident even when participants were encouraged to encode all the excerpts deeply. Although a two-way interaction could have suggested that the original effect of liking stemmed from deeper encoding, the lack of an interaction does not rule out this possibility. Indeed, the results can be interpreted as showing that (a) the visualization task encouraged a deep level of processing for the entire encoding episode, (b) liking led to more elaborative processing of some excerpts compared to others, and (c) these two factors were additive rather than interactive.

Experiment 6: Does Liking Influence "Recognition" of Foils?

In Experiments 1–5, we found a consistent association between liking and memory. There are two possible explanations for this association: Liking may enhance recognition accuracy, or liking may lead to a looser criterion for recognition. In other words, listeners may systematically provide higher recognition ratings for excerpts they like solely because they like them, not because they actually remember them better.

In the previous experiments, liking for novel excerpts was assessed indirectly by examining recognition as a function of the degree to which the paired excerpt was liked. In Experiment 6, we assessed the potential effect of liking on recognition ratings for novel excerpts directly by collecting liking ratings for previously heard as well unheard excerpts. The experiment was similar to Experiment 3. In the initial exposure phase, listeners heard half the excerpts and made complexity ratings. In the subsequent recognition phase, they provided ratings for all 48 excerpts. The novel aspect of Experiment 6 was that in the final liking phase, listeners rated all 48 excerpts. This method allowed us to tease apart (a) recognition for previously heard excerpts as a function of how much they were liked and (b) recognition for previously unheard excerpts as a function of how much they were liked.

Method

Participants. The listeners were 49 undergraduates recruited as in Experiments 1–5. None had participated in the previous experiments. They had an average of 4.0 years of music training (range: 0–14 years; median = 3 years; mode = 0 years).

Apparatus and stimuli. Apparatus and stimuli were identical to those in Experiment 1.

Procedure. The procedure was identical to that of Experiment 3 except that in the liking phase that followed the recognition phase, listeners rated the complete set of 48 excerpts.

Results and Discussion

As in Experiments 1–5, mean recognition scores were higher for old excerpts than for new excerpts (see Table 1). One listener claimed to recognize some of the excerpts and was excluded from subsequent analyses. Thirteen and 10 listeners, respectively, had missing values when recognition scores were calculated separately as a function of liking ratings for previously heard and unheard excerpts (i.e., no liked, neither liked nor disliked, or disliked excerpts), and three had missing values when recognition scores were calculated separately as a function of complexity ratings (i.e., no excerpts deemed to be complex or simple). Thus, sample sizes varied across the different analyses.

Recognition scores for previously heard (old) excerpts varied as a function of how much they were liked (see Table 2), as they did in Experiments 1–5. Descriptive statistics are illustrated in Figure 6A. Excerpts that were liked were remembered better than excerpts that were disliked, $t(34) = 4.90$, $p < .001$, or neither liked nor disliked, $t(34) = 4.47$, $p < .001$. There was no difference in recognition scores between excerpts that were disliked and those that were neither liked nor disliked ($p = .055$). In fact, as in all previous experiments except for Experiment 1, in absolute terms disliked excerpts received lower recognition ratings.

By contrast, recognition scores for previously unheard (new) excerpts did not differ as a function of how much they were liked (see Table 2). Descriptive statistics are also illustrated in Figure 6A. Moreover, a two-way repeated measures ANOVA revealed a significant interaction between liking and whether the excerpt was previously heard, $F(2, 64) = 3.47$, $p = .037$, $\eta_p^2 = .10$, which confirmed that the association between liking and recognition varied as a function of whether the excerpt had actually been heard. As shown in Table 2, differences in liking accounted for 32% of the variance in recognition of previously heard excerpts, but for only 4% of the variance in recognition of novel excerpts.

As in Experiment 3, recognition scores were also examined as a function of complexity ratings. Descriptive statistics are illustrated in Figure 6B. A repeated measures ANOVA revealed a significant difference in recognition scores for previously heard excerpts as a function of complexity, $F(2, 88) = 4.97$, $p = .009$, $\eta_p^2 = .10$. Excerpts rated as complex were remembered better than excerpts that were neither complex nor simple, $t(44) = 3.31$, $p = .002$, but the difference between complex and simple excerpts fell short of statistical significance ($p = .084$). As in Experiment 3, there was no difference in recognition between excerpts that were rated as simple and those that were rated as neutral in complexity ($p = .264$). When liking and complexity ratings were examined separately for each participant, the median correlation was low and not

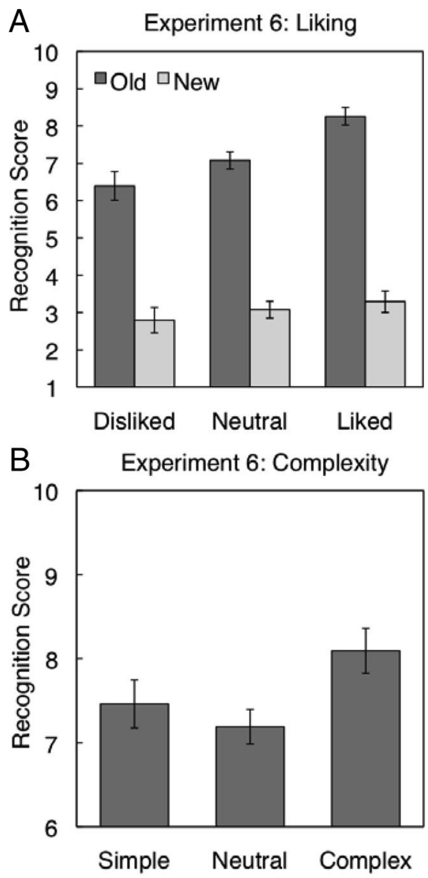

Figure 6. (A) Mean recognition scores and standard errors as a function of liking ratings for previously heard (old) and unheard (new) excerpts in Experiment 6. (B) Mean recognition scores and standard errors for complexity ratings in Experiment 6.

significant ($r = .17$, $N = 24$ excerpts, $p = .427$), which implies that the effect of liking on memory was distinct from the effect of complexity.

Experiments 1–6: Item Analysis

Was the association between liking and memory driven by a few particular music excerpts? In other words, were some excerpts liked and remembered well by most participants across the six experiments? In general, we expected some excerpts to be more likable (and therefore better recognized) than others because of the homogeneity of the samples: first-year university students who would tend to like similar kinds of music. For example, previous studies of samples from the same population tested with the same excerpts revealed general preferences for happy- over sad-sounding music (e.g., Hunter et al., 2008, 2010; Ladinig & Schellenberg, 2012). Nevertheless, if excerpts rather than listeners were treated as the experimental unit, strong positive correlations between likability and recognition across experiments would raise doubts about the validity of our findings.

To examine this possibility, we calculated an aggregate likability rating for each of the 48 excerpts, which was the liking rating averaged across all participants in all six experiments. These likability ratings fell within the range of what was considered a neutral response (range: 2.88–5.49), which confirmed that there were no excerpts that were liked or disliked by all participants. Average recognition scores were also calculated for each excerpt in each experiment. Correlations were then calculated twice for each of the six experiments: once for the listeners who made liking ratings for one list of excerpts, and again for listeners who made liking ratings for the other list. After Bonferroni-correcting for multiple tests, only one of the 12 correlations was significant. For listeners in Experiment 4 who heard one list of the excerpts in the liking phase, general likability ratings were associated positively with subsequent recognition ($r = .58$, $N = 24$ excerpts, $p = .003$). Although the 11 other correlations were positive as expected, they were small and not significant ($.14 < r < .55$).

In other words, in the 11 instances in which the correlation between likability and average recognition was not significant in the item analysis, there was still enhanced recognition for music excerpts that listeners liked in the main analyses. Moreover, the limited variation in likability ratings was not a particularly meaningful comparison with the main analyses, in which enhanced memory was associated with liking ratings of 6 and 7. Thus, the recognition effects observed in Experiments 1–6 appear to be a consequence of individual rather than group differences in liking for particular excerpts.

General Discussion

Across six experiments, recognition of novel music excerpts was enhanced when listeners liked the music. Experiment 1 examined simply whether liking was associated with recognition. Excerpts that were liked were remembered better than other excerpts. Experiment 2 examined whether the effect of liking on memory would remain evident after a 24-hr delay between exposure and test. The effect of liking on memory was unchanged. Experiment 3 examined whether the effect was due to drawing participants' attention to the dimension of liking. Even when participants made liking ratings after recognition judgments, the association between liking and recognition was unchanged. In Experiment 4, when related measures of similarity and familiarity were held constant, the effect of liking on recognition remained evident. Experiment 5 examined whether requiring participants to process all excerpts in an effortful manner would eliminate the effect of liking on recognition. Although the levels-of-processing manipulation improved recognition, it did not influence the association between liking and memory. Finally, the results from Experiment 6 ruled out the possibility that listeners were simply providing higher recognition ratings for excerpts they liked regardless of whether they had actually heard them before. Rather, the association between recognition and liking was evident for previously heard but not for unheard excerpts.

Thus, higher degrees of initial liking for a music excerpt were predictive of improved recognition performance. This result is consistent with positive associations between exposure and liking that have been evident previously with musical (e.g., Schellenberg et al., 2008; Szpunar et al., 2004; Wang & Chang, 2004) and nonmusical (e.g., Brooks & Watkins, 1989; Newell & Shanks, 2007) stimuli. In these studies, although memory was not manipulated directly and the participants sometimes had no explicit memory of prior exposure, their increased liking implicated memory. In other words, memory caused increases in liking.

The present set of experiments were similarly correlational in the sense that liking could not be manipulated directly, just as memory was not manipulated directly in the exposure studies. Rather, participants in the present experiments were exposed to a heterogeneous set of music excerpts, such that most participants liked some excerpts, disliked others, and felt neutral about the rest. Liked excerpts were remembered better than other excerpts. Can we infer, then, that liking caused better memory for music? The time course of the procedure in four of six experiments (all but Experiments 3 and 6) ruled out the possibility that memory caused liking, because all the stimuli were equally novel in the initial liking phase. In principle, better memory in the recognition phase of Experiments 3 and 6 could have led to greater liking in the final phase. Virtually identical response patterns across the six experiments make it more parsimonious to interpret the results of Experiments 3 and 6 identically, with greater (but unmeasured) liking in the first phase leading to better memory in the second phase.

Might there be a third, unmeasured variable that led to better memory and greater liking? The most likely candidates would be variables such as familiarity or similarity. Although the specific excerpts were unfamiliar to listeners, familiar- or similar-sounding genres of music would tend to be liked more, and music from these genres would be more consistent with listeners' musical schemas and thus processed more readily and remembered better. Nevertheless, the possibility that observed associations between liking and memory were due solely to familiarity or similarity was virtually eliminated by the results of Experiment 4. Although positive correlations were observed among ratings of liking, familiarity, and similarity, as one would expect, unique contributions to recognition performance were observed for liking as well as for familiarity. Because the association between liking and memory remained evident when effects of similarity and familiarity were held constant, the case for a causal relation between liking and memory was strengthened.

Moreover, if liking ratings were a consequence of familiarity, better recognition should have been evident for all familiar-sounding excerpts, with higher recognition ratings for familiar-sounding old excerpts but lower ratings for familiar-sounding new excerpts (i.e., foils). Across the first five experiments, recognition of foils did not vary as a function of the degree of liking (and presumed familiarity) for the paired excerpt that was heard previously. These null results also speak against the possibility that familiarity could have led to higher recognition ratings for foils, with listeners misattributing an increased sense of familiarity to having heard the excerpts previously. In either case, ratings would have differed systematically across foils, and no such differences were found. Although both factors could have canceled out each other, it is unlikely that their contributions would have been equal across experiments. Thus, the observed association between liking and memory does not appear to be mediated by familiarity. It remains possible, however, that some other variable or combination of variables accounts for the effect of liking on memory. Addressing this possibility awaits further research. In our view, discovery of additional relevant variables is unlikely to rule out the role of liking, but rather to reveal underlying mechanisms (e.g., arousal) that help to explain the effect of liking on memory.

When considered jointly with previous findings, the present results indicate that the association between liking and memory is not unidirectional, at least not for music. Although memory and familiarity are predictive of increased liking for music, liking is also predictive of increases in recognition. In everyday exposure to music, these two processes are likely to work in tandem, with high degrees of liking associated with enhanced attention, better encoding, and improved memory, and improved memory leading to further enhancements in liking upon repeated presentation, up to the point of overexposure when further increases in memory can lead to decreases in liking. It would be interesting to determine whether initial liking for a piece of music influences the degree to which further exposure influences liking. For example, is satiation reached more quickly for stimuli that are liked at initial exposure, or does a high degree of initial liking provide a protective benefit, making satiation less likely? Are similar mere-exposure effects observed for stimuli that are initially liked or disliked, or are these effects restricted to stimuli that are initially viewed as neutral? And how do individual differences moderate reciprocal associations between liking and memory? In one study (Hunter & Schellenberg, 2011), participants who scored high on one dimension of personality (i.e., openness to experience) had relatively high degrees of liking for novel music and more rapid satiation as a consequence of exposure, but the authors did not measure recognition.

Our findings corroborate observations from 100 years ago showing that emotion does not have to be intrinsic to the stimulus for it to influence memory (Tait, 1913). In the present series of experiments, no music excerpt was liked and remembered better by all participants. Nevertheless, just as affectively valenced stimuli are remembered better, so too are stimuli that elicit a positive evaluation from the participant. In terms of memory, the distinction between affectively valenced stimuli and affective responding appears to be an important one, at least for music. Whereas both positively and negatively valenced stimuli can show a memory benefit compared with neutral stimuli (e.g., Bradley et al., 1992; Dolcos & Cabeza, 2002), the effect can be stronger for negative stimuli in some instances. For example, when sets of emotionally arousing or neutral slides are shown to participants, arousing but negative slides are remembered better than arousing but positive or neutral slides (Kern, Libkuman, Otani, & Holmes, 2005). These findings stand in contrast to the Pollyanna principle, the idea that people tend to remember more positive than negative or neutral information (Boucher & Osgood, 1969), which is consistent with the present results.

The lack of an association between disliking the music excerpts and recognition does not appear to be a consequence of low statistical power, because in five of six experiments (all but Experiment 1), recognition of disliked excerpts was actually lower in absolute terms than recognition of excerpts that were neither liked nor disliked. One possibility is that disliked excerpts were not disliked enough to produce a recognition benefit. For example, if atonal, foreign, or very distorted or dissonant music excerpts were included in the stimulus set, a recognition benefit for strongly disliked excerpts could emerge, at least in principle. As noted earlier, however, memory tends to be poor for music that sounds unfamiliar (Demorest et al., 2008; Wong et al., 2009). Another possibility is that musical experiences are not typically unpleasant in the same way that other kinds of experiences may be unpleasant (e.g., the sound of nails on a chalkboard, the smell of rotting food).

Nevertheless, because participants were not instructed to make use of the entire rating scale, we have no reason to doubt that low liking ratings stemmed from anything other than actual disliking.

Stimuli with intrinsic emotional valence may be processed in a qualitatively different manner than stimuli that evoke actual emotional responses. A memory benefit for negatively valenced stimuli makes evolutionary sense in order for organisms to avoid potentially harmful experiences. By contrast, positively valenced stimuli are not as relevant to survival and consequently have a weaker effect on memory (Ochsner, 2000). Moreover, the emotional valence of the stimulus and the perceiver's response to it (e.g., fear) may jointly influence memory in many instances. Future research in this area could attempt to disentangle the relative contributions of intrinsic valence and emotional responses in order to develop a more complete understanding about how emotion influences cognition.

For stimuli that are not inherently positive or negative, such as a piece of music, there may be more benefit to remembering stimuli that evoke positive rather than negative evaluations. For example, a stimulus eliciting a positive or pleasurable reaction may be remembered better than a stimulus eliciting a negative reaction so that the stimulus can be approached again in the future. This perspective is related to the view that emotional responding to music occurs on two levels, one involving the particular emotion (e.g., happiness, sadness) associated with the music and the other representing an aesthetic evaluation (Hunter & Schellenberg, 2010). It also helps to explain why listeners appreciate sad-sounding music and other art works with negative valence (e.g., Francisco Goya's *Saturn Devouring His Son* and William Blake's *The Great Red Dragon* paintings). In the present experiments, the focus was solely on the evaluative dimension as measured by liking ratings. Associations between liking and memory observed in the present study may be restricted to contexts with a clear distinction between the emotion intrinsic to the stimulus and the perceiver's evaluation. From this view, similar results should be evident for works of visual art but not for stimuli that do not elicit an aesthetic evaluation.

In summary, the present findings highlight three important points. First, there is a direct association between subjective emotional reactions to novel music (i.e., liking) and subsequent recognition memory. This finding, considered jointly with evidence that memory is associated with enhanced liking, suggests a reciprocal relationship between liking and memory, such that increases in liking are associated with enhanced memory and enhancements in memory are associated with increases in liking. Second, memory benefits are restricted to liked music excerpts only and do not extend to disliked excerpts. As such, it is not the strength of the emotional response (i.e., positive or negative vs. neutral) that influences memory, but rather the kind of emotional response (i.e., positive vs. negative or neutral). Third, although it is likely that similar mechanisms are involved in the association between emotion and memory in general and liking and memory in particular, diverging patterns of results suggest that emotional stimuli and emotional reactions to stimuli may be separable processes.

Future work in this area could address questions about the supposedly abstract nature of music, in which the identity of a tune is defined by relations in pitch and time between consecutive tones (Krumhansl, 2000). For example, listeners' mental representations of familiar songs such as "Yankee Doodle" allow them to recognize tunes played at a novel pitch level, at a novel tempo, and in an unfamiliar timbre. Mental representations for music actually contain detailed information about surface characteristics, including pitch level (i.e., key; Schellenberg & Trehub, 2003), tempo (Levitin & Cook, 1996), and timbre (Schellenberg, Iverson, & McKinnon, 1999), much the way that surface characteristics such as a speaker's voice are retained in memory for language (Nygaard & Pisoni, 1998). It would be particularly interesting to examine whether enhanced recognition of liked music would be evident for excerpts that undergo changes in surface characteristics (e.g., shifts in pitch level, tempo, or timbre) from exposure to test. An extension of this work to other classes of stimuli (e.g., photographs, paintings) is also important in order to determine whether associations between liking and memory extend to other domains. In the visual domain, perceivers may show enhanced memory for specific details of images they like, or an enhanced awareness of subtle changes (e.g., a change in color).

Three additional findings from the present set of experiments merit discussion. First, recognition memory for music did not decline across a 24-hr delay (Experiment 2). This finding is surprising because many studies report a decline in performance across a delay. Our null result may reflect long-lasting memory for the particular excerpts used in this experiment, or for music in general. One possibility is that memory for melodies is based more on familiarity than on recollection and that familiarity-based heuristics used for recognizing music may be particularly impervious to the passage of time.

Second, improved recognition memory was associated with higher ratings of complexity (Experiments 3 and 6). In another study that used the same set of music excerpts (Ladinig & Schellenberg, 2012), liking and perceived complexity covaried positively, and both variables were associated positively with increases in tempo. In other words, listeners' perception of musical complexity may be simply a consequence of the number of events per unit of time. There could also be a memory benefit for stimuli that are responded to affirmatively. If this were the case, changing the question at time of encoding could lead to the opposite effect. For example, if participants were asked to rate simplicity rather than complexity, enhanced recognition could be observed for stimuli rated as simple.

Third, although levels-of-processing effects on memory for music are difficult to document (Halpern & Müllensiefen, 2008; Peretz et al., 1998; Warker & Halpern, 2005), the manipulation used here (visualization instructions, Experiment 5) improved recognition compared with the standard method (Experiment 1), such that it could be useful in future research on memory for music. Our stimuli (i.e., excerpts from actual recordings rather than monophonic, expressionless melodies) are also likely to have played a role. Because the manipulation did not eliminate the effect of liking on recognition, we cannot attribute the liking effect unequivocally to differences in levels of processing. Nevertheless, it is reasonable to speculate that increased liking of music was accompanied by deeper processing and that the visualization manipulation was an additional means of increasing processing depth, consequently improving recognition across excerpts.

Although a great deal of progress has been made in understanding the importance of emotion on cognitive processing, we are far from having a comprehensive account of these associations. In particular, similarities and differences between effects of the emotional valence of stimuli and those of emotional evaluations need to be examined more carefully. To date, the bulk of research on emotion and cognition has examined the effect of stimulus valence. The present findings represent an important step in considering the importance of a perceiver's emotional response to the stimulus. Indeed, they point to an important link between memory and positively evaluated stimuli that could ultimately help to explain the intriguing but poorly understood importance of music and art in human experience.

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