Cardiovascular Change During Encoding Predicts the Nonconscious Mere Exposure Effect

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These studies examined memory encoding to determine whether the mere exposure effect could be categorized as a form of conceptual or perceptual implicit priming and, if it was not conceptual or perceptual, whether cardiovascular psychophysiology could reveal its nature. Experiment 1 examined the effects of study phase level of processing on recognition, the mere exposure effect, and word identification implicit priming. Deep relative to shallow processing improved recognition but did not influence the mere exposure effect for nonwords or word identification implicit priming for words. Experiments 2 and 3 examined the effect of study–test changes in font and orientation, respectively, on the mere exposure effect and word identification implicit priming. Different study–test font and orientation reduced word identification implicit priming but had no influence on the mere exposure effect. Experiments 4 and 5 developed and used, respectively, a cardiovascular psychophysiological implicit priming paradigm to examine whether stimulus-specific cardiovascular reactivity at study predicted the mere exposure effect at test. Blood volume pulse change at study was significantly greater for nonwords that were later preferred than for nonwords that were not preferred at test. There was no difference in blood volume pulse change for words at study that were later either identified or not identified at test. Fluency effects, at encoding or retrieval, are an unlikely explanation for these behavioral and cardiovascular findings. The relation of blood volume pulse to affect suggests that an affective process that is not conceptual or perceptual contributes to the mere exposure effect.

The "mere exposure" of a previously unfamiliar stimulus reliably elicits increased liking toward it. First observed more than a century ago (Fechner, 1876) and investigated most extensively by Zajonc (1968), who named the phenomenon, the mere exposure effect is measured by above-chance affective preference for previously exposed stimuli. The mere exposure effect has been reported in more than 250 publications, studied in diverse cultures and in a variety of settings, and examined across the phylogenetic scale (for reviews see Bornstein, 1989; Butler & Berry, 2004; Harrison, 1977; Hill, 1978; Moreland & Topolinski, 2010).

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Yet whether it shares the same mechanism as other forms of priming or is mediated by a different mechanism that precedes cognitive evaluation remains in dispute (e.g., Harmon-Jones & Allen, 2001; Hicks & King, 2011; Hupbach, Melzer, & Hardt, 2006; Lee, 1994; Topolinski, 2012; Willems, Dedonder, & Van der Linden, 2010; Zebrowitz & Zhang, 2012). As a consequence, there is no widespread consensus with regard to its placement in a theoretical framework (for reviews see Butler & Berry, 2004; Moreland & Topolinski, 2010).

An evolutionary-based affective mechanism was first proposed to explain the increased liking elicited by repetition of a novel, unreinforced stimulus (Zajonc, 1968, p. 19). In order to drive the mere exposure effect, it was posited that the initially exposed stimulus must be unfamiliar or novel (Phase 1), evoke a reflexive fear reaction (Phase 2), and be repeated in the absence of threat (Phase 3). The outcome was the experience of positive affect (Phase 4), a natural consequence of the attenuation of fear. The requirement of stimulus novelty (Butler, Berry, & Helman, 2004), negative to positive emotional sequencing (Zebrowitz & Zhang, 2012), and liking judgments accompanied by positive affect (Harmon-Jones & Allen, 2001) are consistent with the evolutionary approach. The phenomenon was also described as driven by automatic and unintentional processing that was independent from cognitive evaluation. The mere exposure effect can be produced when recognition is at chance, in the presence of dissociations with recognition, and with greater magnitude when exposures are subliminal (for reviews see Butler & Berry, 2004; Moreland & Topolinski, 2010). These findings suggest that the mere exposure effect is a form of implicit memory, specifically priming (e.g., Seamon et al., 1995).

Implicit priming tests measure memory indirectly and implicitly as the change in speed, accuracy, or bias in response to studied relative to baseline items (reviewed in Schacter, 1987). Tests that measure implicit priming have been divided into two categories, perceptual and conceptual (reviewed in Gabrieli, 1998). Perceptual implicit priming is concerned with processing the physical attributes of the stimulus (e.g., identifying words). Conceptual implicit priming is concerned with processing the semantic information associated with the stimulus (e.g., producing category exemplars). Experimental manipulations of encoding and retrieval conditions can reveal the extent to which priming on a task relies on perceptual versus conceptual processes (Roediger, Weldon, & Challis, 1989).

The purpose of this investigation was to examine memory encoding to determine whether the mere exposure effect could be categorized as a form of conceptual or perceptual implicit priming and, if the evidence did not support either, whether cardiovascular psychophysiology, an alternative measure, could reveal its nature. We examined conceptual (Experiment 1) and perceptual (Experiments 2 and 3) influences by applying study–test manipulations and classifying implicit priming as conceptual or perceptual based on study phase semantic level of processing (LOP) and study–test changes in physical form, respectively (Roediger et al., 1989).

Across experiments, there was a constant stimulus exposure duration for once-presented stimuli during study, conditions that have yielded the mere exposure effect for nonwords (Stone, Ladd, & Gabrieli, 2000). Consistent with prior findings about the mere exposure effect and implicit priming in general, participants were not warned at encoding about any upcoming test or that stimuli would be repeated at test. Mere exposure effects are most pronounced when participants are least aware of repeated stimulus exposures (Bornstein, 1989; Murphy, Monahan, & Zajonc, 1995; Zajonc, 1980). Implicit priming is used here to distinguish this outcome measure from conscious decision making that may be referred to as priming or repetition priming in other mere exposure effect protocols (see Experiment 2, Discussion and General Discussion).

An alternative approach to understanding processes underlying priming effects is that of psychophysiological measurement. Such measurements have been used during the retrieval stage of the mere exposure effect, including electromyography and electroencephalography (Harmon-Jones & Allen, 2001). Also, skin conductance responses have been used successfully to differentiate between old and new nonwords during the test phase of a repetition priming paradigm (Topolinski, 2012, Experiment 7A). In the present study, we examined cardiovascular changes at encoding because cardiovascular responses have been used to investigate emotional processing (reviewed in Kreibig, Wilhelm, Roth, &

Gross, 2007), are autonomic responses that can operate outside conscious awareness (Berntson, Quigley, & Lozano, 2007), and have not been previously used with the mere exposure effect.

We examined the encoding stage of the mere exposure effect because most experiments have been conducted almost exclusively on its retrieval stage (for reviews see Butler & Berry, 2004; Moreland & Topolinski, 2010). Research investigating a variety of responses at encoding has advanced our understanding of the neurobiological mechanisms underlying explicit or declarative memory (e.g., Davachi & Dobbins, 2008). This suggests the utility of examining the encoding stage of the mere exposure effect.

Cardiovascular psychophysiology, the recording of cardiovascular responses during behavioral research, is based on the premise that cardiovascular responses differ in direction and magnitude contingent on stimulus characteristics but remain sensitive to the specificity associated with individual response patterns (Cacioppo, Tassinary, & Berntson, 2007). The responses that are typically used with cardiovascular psychophysiological paradigms are heart rate (HR) and blood volume pulse (BVP), a measure of vasodilatation and vasoconstriction; BVP relative amplitude is inversely correlated with HR (Cowings, Kellar, Folen, Toscano, & Burge, 2001; Cowings & Toscano, 2000; Cowings et al., 2007). Distinct cardiovascular changes during encoding are measurable within a few seconds of stimulus onset, allowing precise quantification of event and no event (baseline) conditions within an implicit priming paradigm.

Assessing the feasibility of recording cardiovascular responses as a means of examining stimulus-specific affective preference (Experiment 4) and then developing and implementing a cardiovascular psychophysiological implicit priming paradigm (Experiment 5) was taken as an approach to identifying psychophysiological correlates of processes at encoding that drive the mere exposure effect at retrieval.

EXPERIMENT 1

The goal of Experiment 1 was to examine conceptual influences during the encoding stage of the mere exposure effect. Traditional investigations of conceptual influences during encoding using a verbal protocol have been restricted to semantically relevant stimuli (e.g., words). Semantic knowledge is not inherent to nonwords or pseudowords. This is the item type that is needed to reliably produce the mere exposure effect with a verbal protocol (Butler et al., 2004). As a consequence, previous research has not investigated the influence of experimental manipulations related to conceptual processing. Yet reading a pronounceable nonword causes partial activation of the words in its orthographic neighborhood. Meaningful word associates are activated, and in that sense the processing is similar to what happens when real words are read (Dorffner & Harris, 1997; Gathercole, 2006). If conceptual processing influences the mere exposure effect, then its proposed independence from cognitive evaluation is questionable.

Deep, relative to shallow, study phase LOP improves performance on tests that rely on conceptual processing, such as recognition, but has no effect on performance for tests such as word identification that rely on perceptual processing (Craik & Lockhart, 1972). These empirical findings were used to propose that a test should be classified as a measure of conceptual memory if performance is improved after conceptual elaboration at study (Roediger et al., 1989). Using this criterion, conceptual influences during encoding were investigated by comparing deep ("Read the word.") and shallow ("Does the word contain the letter A?") study phase LOP on recognition and the mere exposure effect. Based on the dissociations reported between recognition and the mere exposure effect for stimulus type, encoding conditions, and number of exposures (Kunst-Wilson & Zajonc, 1980; Seamon et al., 1995), it was hypothesized that recognition with nonwords would be improved after deep relative to shallow study phase LOP, but there would be no influence on the mere exposure effect using the identical nonwords.

To further validate the implicit memory implication of this expected dissociation, the same study phase LOP manipulation was used for word identification implicit priming. Although patients with global amnesia and normal controls exhibit perceptual implicit priming on word identification tests with nonwords (Keane, Gabrieli, Noland, & McNealy, 1995) and with other perceptual implicit priming measures (reviewed in Bowers & Schacter, 1993), a written response is required with this item type. Word identification, in its traditional format that uses words and requires an oral response, is widely accepted as a seminal perceptual implicit priming measure. It has consistently dissociated from recognition in amnesic, neurological, and psychiatric groups (reviewed in Gabrieli, 1989, 1998). It was hypothesized that study phase LOP would produce the standard dissociation between recognition and word identification implicit priming, and there would be no change in this well-documented dissociation when item type was not held constant, nonwords for recognition and words for word identification implicit priming.

METHOD

Participants

All volunteers provided informed consent before participating in this research. Participants were undergraduate students at least 18 years of age and native English speakers. They received course credit as compensation and were randomly assigned to groups of 24 each.

In Experiment 1, 144 participants (67 men, 77 women) were randomly assigned to six groups based on study phase instructions (deep or shallow level of processing) and test type (recognition, mere exposure effect, or word identification implicit priming).

Stimuli

The stimuli for recognition and the mere exposure effect tests were 80 pronounceable nonwords (Turkish words or pseudowords), all eight letters long (Zajonc, 1968). The stimuli for the word identification implicit priming test were 80 English words, seven to eight letters long, with an average frequency of occurrence of 5.79 per million (Kučera & Francis, 1967). Words were rated (5-point scale) on valence and imageability by an independent sample ($n = 30$). Study lists using words were constructed so that there was no mean difference in word length, frequency, valence, or imageability. Half the nonwords selected for recognition or for the mere exposure effect tests were assigned to Study List A_{nw}, and the remaining half of the nonwords were assigned to Study List B_{nw}. Half of the words selected for the word identification implicit priming test were assigned to Study List A_{w}, and the remaining half of the words were assigned to Study List B_{w}. Test lists for recognition and the mere exposure effect consisted of 80 items, combining Study Lists A_{nw} and B_{nw}. Test lists for word identification implicit priming consisted of 80 items, combining Study Lists A_{w} and B_{w}. For participants who studied List A (old items), List B was baseline (new items), and for participants who studied List B (old items), List A was baseline (new items).

Within each study list, the items were arranged in pseudorandom order with the constraint that no more than three nonwords on recognition and the mere exposure effect tests or three words on the word identification implicit priming test appeared in a row. The same pseudorandom order procedure was used for the test lists. For recognition, nonwords from Study Lists A_{nw} and B_{nw} were presented one at a time. For the mere exposure effect test, nonwords from Study Lists A_{nw} and B_{nw} were paired. The position (right or left) was randomly assigned to the nonwords on the first test form and reversed on the second form, with the constraint that half of the nonwords from each study list appeared on the left and the remaining half appeared on the right on each test form. The pairs were arranged in pseudorandom order with the constraint that no more than three items from the same study list appeared in the same location (right or left). For the word identification implicit priming test, a row of 10 Xs was created and served as a mask that was presented before and after each word.

Apparatus

All stimuli were presented using a Macintosh computer and PsychLab software version 1.092. Reading response times (RTs) for stimuli presented during study were collected with a voice-activated relay connected to the computer.

Design

Experiment 1 used a 2 (study phase LOP: deep vs. shallow) × 3 (test type: recognition vs. mere exposure effect vs. word identification implicit priming) between-participant factorial design.

Procedure

STUDY PHASE.

Participants were randomly assigned to either the deep study phase LOP ("Read the word.") or the shallow study phase LOP group ("Say yes if the word contains the letter a; say no if the word does not contain the letter a"). Each participant saw a fixation cross for 500 ms, followed by a 500-ms interstimulus interval (ISI) and then a nonword (recognition and mere exposure effect) or a word (word identification implicit priming) for 2,000 ms. Participants responded by speaking into a microphone that triggered a voice-operated relay to measure RT. After a participant responded, the software advanced to the next trial. Participants were instructed to respond as quickly and as accurately as possible. During study, no reference was made to the test phase of the experiment.

TEST PHASE.

Participants received the recognition, mere exposure effect, or word identification implicit priming test. There were two forms for each test. In all test conditions, each trial began with a fixation cross presented for 500 ms followed by a 500-ms ISI. For the recognition test, a nonword was presented that remained on the monitor until the participant said either “yes” if he or she remembered the nonword from the study phase or “no” if he or she did not remember the nonword from the study phase. The experimenter recorded the participant’s response and initiated the next trial. For the mere exposure effect test, two nonwords were presented side by side, and participants were instructed to select the nonword they liked best by responding “right” or “left.” The experimenter recorded the participant’s response and initiated the next trial. For the word identification implicit priming test, a forward mask consisting of a row of 10 Xs was presented for 100 ms, followed by a word for 16.7 ms. The word was immediately masked by another row of Xs. The backward mask remained on the screen until the participant said the word that appeared before the row of Xs (e.g., identified the word). If no response was given, the experimenter pressed a key to advance to the next trial. The exposure duration of 16.7 ms was chosen after pilot studies revealed that participants produced approximately 50% correct identification of baseline (new) items while only a row of Xs (the mask) remained on the monitor. During the tests, no reference was made to the study phase of the experiment.

RESULTS

Test Phase

TEST COMPARISONS FOR OLD AND NEW ITEMS.

To test whether participants did significantly better with old items than with new items, *t* tests were conducted on each of the six groups created by the interaction of LOP (deep vs. shallow) and test type (recognition vs. mere exposure effect vs. word identification implicit priming). The percentage of new items was set to chance (50%) for the mere exposure effect due to the forced-choice nature of the test. Table 1 presents means and standard deviations for the proportion of old and new items by study phase LOP and test type for recognition and word identification implicit priming, which were compared with a paired-sample *t* test, and the means and standard deviations for the proportion of old items compared to chance (50%) for the mere exposure effect, which were compared using a 1-sample *t* test. The findings reveal that the mean percentage for old items was

TABLE 1. Means (*M*) and Standard Deviations (*SD*) for Percentage of Old and New Items by Study Phase Level of Processing and Test Type, Experiment 1

		% Old items		% New items			
Test	*N*	*M*	*SD*	*M*	*SD*	*t*	*p*
Deep							
REC_{nw}	24	72.60	13.20	23.70	15.29	15.60	<.001
MEE_{nw}	24	53.90	6.38	50.00[a]	—	2.96	.007
WIP_{w}	24	67.60	25.30	57.20	32.72	5.01	<.001
Shallow							
REC_{nw}	24	56.80	10.50	35.70	10.33	12.56	<.001
MEE_{nw}	24	55.00	6.80	50.00[a]	—	3.60	.001
WIP_{w}	24	70.50	14.10	58.90	18.27	7.03	<.001

Note. [a]*For the mere exposure effect (MEE_{nw}) tests, the percentage for old items was compared with chance, or 50.00, using a 1-sample* t *test. For recognition (REC_{nw}) and word identification implicit priming (WIP_{w}), paired* t *tests were computed. The mean percentage for old items was significantly higher than for new items, with a Bonferroni-adjusted α level of .008 per test. nw = nonwords; w = words.*

significantly higher than the mean percentage for new items across all study conditions.

TEST COMPARISONS FOR Z DIFFERENCE SCORES. To compare the amount of difference between old and new items (e.g., test performance) by experiment, raw scores for old and new items were first converted to percentages. Next, difference scores (percentage old–new item) were computed and converted to *z* scores in order to compare distributions where measurement was based on different scales. Although the standardized difference scores showed a slight positive skew, the residuals did not show a significant departure from a normal distribution for the overall data or within cells. Therefore, all analyses were conducted using parametric tests. All factorial analyses were conducted on the standardized difference scores. However, throughout the results, the means and standard deviations of the percentages are also reported to facilitate interpretation of the findings.

The *z* difference scores between old and new items were entered into a 2 (LOP: deep vs. shallow) × 3 (test type: recognition vs. mere exposure effect vs. word identification implicit memory) between-participant ANOVA. Means and standard errors of percentage and *z* difference scores by study phase LOP and test type are presented in Table 2.

In addition to significant main effects for LOP and test type, the results for *z* difference scores (old–new items) revealed a significant interaction between LOP and test type (see Table 2 note). Bivariate follow-up tests were conducted to further explore the interaction. Significant differences in *z* difference scores were obtained between recognition, the mere exposure effect, and word identification implicit priming, for the shallow, $F(2, 71) = 26.03$, $p < .0001$, partial $\eta^2 = .430$, and deep groups, $F(2, 71) = 112.29$, $p < .0001$, partial $\eta^2 = .765$. In both levels of processing, participants had the largest difference between old and new items under the recognition condition and the smallest difference under the word identification implicit priming condition. A one-way ANOVA also revealed a significant difference in *z* difference scores between deep and shallow LOP for recognition, $F(1, 47) = 61.59$, $p < .0001$, partial $\eta^2 = .572$. Deep had significantly higher percentage *z* difference scores than shallow LOP, indicating that there was a larger difference between old and new items for deep LOP compared with shallow LOP for participants in the recognition condition. There was no significant difference in *z* difference scores between deep and shallow LOP for either the mere exposure effect or word identification implicit priming, both *F*s < 1. Figure 1 presents the mean proportion of *z* difference scores (old–new items) by study phase LOP and test type.

TABLE 2. Means (*M*) and Standard Errors (*SEM*) for Percentage and *z* Difference Scores by Study Phase Level of Processing (LOP) and Test Type, Experiment 1

	LOP											
	Deep				Shallow				Total			
	%		*z* Score		%		*z* Score		%		*z* Score	
Test	*M*	*SEM*	*M*	*SEM*	*M*	*SEM*	*M*	*SEM*	*M*	*SEM*	*M*	*SEM*
REC_{nw}	48.96[a,x]	3.14	1.77	0.17	21.04[a,y]	1.68	0.23	0.09	35.00[a]	2.69	1.00	0.15
MEE_{nw}	3.85[b,x]	1.30	−0.71	0.07	5.00[b,x]	1.39	−0.65	0.08	4.43[b]	0.95	−0.68	0.05
WIP_{w}	10.42[c,x]	2.08	−0.35	0.11	11.67[c,x]	1.65	−0.23	0.09	11.04[c]	1.32	−0.32	0.07
Total	21.08[x]	2.70	0.23	0.15	12.57[y]	1.19	−0.23	0.07	16.83	1.51	0.00	0.08

Note. *Although all analyses were conducted on* z *difference scores, superscripts are shown with percentage difference scores to facilitate interpretation of the findings. The results revealed a significant main effect for LOP,* $F(1, 143) = 27.89$, $p < .0001$, *partial* $\eta^2 = .168$, *and a significant main effect for test type,* $F(2, 143) = 132.97$, $p < .0001$, *partial* $\eta^2 = .658$. *A significant interaction,* $F(2, 143) = 36.30$, $p < .0001$, *partial* $\eta^2 = .345$, *between LOP and test type justified planned comparison. Superscripts for Tukey post hoc comparisons between recognition* (REC_{nw}), *mere exposure effect* (MEE_{nw}), *and word identification implicit priming* (WIP_{w}) *are shown using the letters* a, b, *and* c. *Superscripts for comparisons between deep and shallow are shown using the letters* x *and* y. *Means with different superscripts differ significantly,* $p < .05$. *nw = nonwords; w = words.*

Study Phase

Means and standard deviations of median RTs to studied items by LOP and test/item type for Experiment 1 are presented in Table 3.

RT analyses were used to examine the alternative hypothesis that test performance, as depicted in Figure 1, is a function of processing fluency during study (e.g., encoding). For the test findings reported here, the processing fluency hypothesis would predict an interaction between LOP and test/item type for study phase RTs.

RTs were entered into a 2 (study phase LOP: deep vs. shallow) × 3 (test/item type: recognition vs. mere exposure effect vs. word identification implicit priming) between-participant analysis of variance (ANOVA). The results for study phase RTs revealed a significant main effect for LOP. Deep LOP had significantly longer mean RTs than shallow LOP. A significant main effect for study phase RTs was observed for test/item type. No significant interaction for study phase RTs was found between LOP and test/item type (see Table 3 note).

Overall, these findings revealed that nonwords, used subsequently at test for both recognition (REC_{nw}) and the mere exposure (MEE_{nw}), were processed significantly faster (i.e., shorter RTs) than words, used subsequently at test for word identification implicit priming (WIP_w). Shallow was processed significantly faster than deep LOP for both nonwords and words. No significant interaction for study phase RTs between LOP and test/item type was observed. These findings do not support the alternative hypothesis that test performance is influenced by processing fluency.

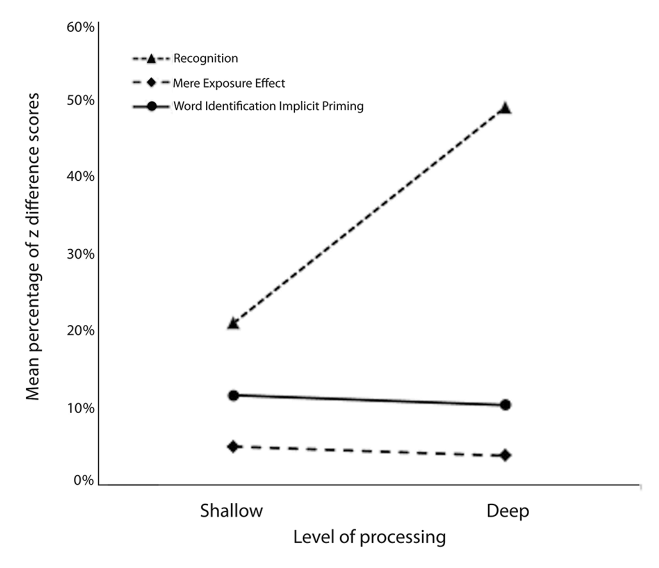

FIGURE 1. Mean proportion of *z* difference scores (old–new items) by study phase level of processing and test type, Experiment 1

DISCUSSION

Deep compared with shallow study phase LOP improved recognition but had no influence on the mere exposure effect. Conceptual processing with nonwords was available for both tests via orthographic

TABLE 3. Means (*M*) and Standard Deviations (*SD*) for Median Response Times (ms) to Studied Items by Level of Processing (LOP) and Test/Item Type, Experiment 1

		LOP					
		Deep		Shallow		Total	
Test/item	***N***	***M***	***SD***	***M***	***SD***	***M***	***SD***
REC_{nw}	48	1,037[a,x]	184	768[a,y]	310	903[a]	287
MEE_{nw}	48	1,086[a,x]	255	850[a,y]	243	968[a]	274
WIP_w	48	1,980[b,x]	498	1,673[b,y]	295	1,826[b]	433
Total	144	1,368[x]	550	1,097[y]	498	1,232	540

Note. *Although no significant interaction between LOP and test/item type,* $F < 1$, *was found for study phase response times, post hoc analyses were examined because of the significant main effects of LOP,* $F(1, 143) = 26.93$, $p < .0001$, *partial* $\eta^2 = .163$, *and test/item type,* $F(2, 143) = 129.87$, $p < .0001$, *partial* $\eta^2 = .653$. *Superscripts for Tukey post hoc comparisons between recognition* (REC_{nw}), *mere exposure effect* (MEE_{nw}), *and word identification implicit priming* (WIP_w) *are shown using the letters* a *and* b. *Because* REC_{nw} *and* MEE_{nw} *were not significantly different from each other, the superscript* a *was used for both tests. Superscripts for comparisons between deep and shallow are shown using the letters* x *and* y. *Means with different superscripts differ significantly,* $p < .05$. *nw = nonwords; w = words.*

similarities to words and their associated meanings. A large performance difference for deep and shallow study phase LOP was obtained with recognition (means of 49% and 21%, respectively). In contrast, deep and shallow study phase LOP was almost identical for the mere exposure effect (means of 4% and 5%, respectively). Unlike recognition, the mere exposure effect is not conceptually driven, a finding that supports its independence from cognitive evaluation.

The well-established observation that word identification implicit priming dissociates from recognition was replicated (for reviews see Roediger & McDermott, 1993; Shimamura, 1986). This finding confirms that the dissociation observed between performance on recognition and the mere exposure effect meets the retrieval intentionality criterion for distinguishing between explicit and implicit memory measures (reviewed in Schacter, Bowers, & Booker, 1989). According to this criterion, if tests use the same nominal cues, vary only in their instructions (testing with and without reference to study), and are dissociated by the same experimental variable, than explicit contamination cannot be used to nullify the implicit memory classification of a test. Also, the same conceptual encoding manipulation did not produce differential test performance for the mere exposure effect and word identification implicit priming, even though the latter test used conceptually meaningful stimuli (words).

Differences in processing time at study for nonwords and words cannot be used to explain these test results. Overall, shorter RTs were obtained for nonwords than for words. However, RTs for study phase LOP did not interact with test type (e.g., recognition and the mere exposure effect with nonwords; word identification implicit priming with words).

EXPERIMENT 2

The goal of Experiment 2 was to examine perceptual influences on the mere exposure effect. To accomplish this goal, a criterion for determining whether a test relies on perceptual processing was used (Roediger et al., 1989): Perceptual processing is demonstrated when changing perceptual features of stimuli between study and test reduces test performance.

To our knowledge, this criterion has not been applied to the nonconscious mere exposure effect when investigated using verbal stimuli. Significant reductions in perceptual implicit priming have been observed in many experiments examining study–test changes in font, an orthographic structure or visual characteristic of a word, with occasional failures to find this effect when the study–test font was not substantial or the study task focused on word meaning (reviewed in Schacter, 1994, pp. 238–239). However, under conditions that forced participants to focus on perceptual features, study–test changes in font reliably produced reductions in word identification implicit priming (Graf & Ryan, 1990). Based on this research, a study–test change consisting of substantially different fonts (type and style) was used to examine perceptual influences on the mere exposure effect using verbal stimuli. For the purpose of validation, word identification implicit priming was again examined using these same manipulations.

Experiment 2 compared the effect of same and different study–test fonts on the mere exposure effect and word identification implicit priming. It was hypothesized that word identification implicit priming, and not the mere exposure effect, would be reduced by a change in study–test font.

METHOD

Participants

In Experiment 2, 48 participants (22 men, 26 women) were randomly assigned to either the same study–test font (Geneva, Geneva) or different study–test font (Monaco, Geneva) group.

Stimuli

All stimuli were the same as those used for the mere exposure effect and word identification implicit priming tests in Experiment 1. However, study lists contained both nonwords and words presented in Geneva font for the same study–test condition and presented in Monaco font for the different study–test condition. A line style and italicized version of Monaco font was used. All test stimuli were presented in Geneva font.

Apparatus

Hardware and software were the same as those used in Experiment 1.

Design

Experiment 2 used a 2 (study–test font: same vs. different, between participants) × 2 (test type: mere exposure effect vs. word identification implicit priming, within participants) mixed factorial design.

Procedure

STUDY PHASE.

Participants were randomly assigned to either the same (word *and* nonword in Geneva font) or different (word *and* nonword in Monaco font) study–test font group. During the study phase, font type (Geneva or Monaco), study list combination (nonwords and words), and reading the stimuli as the only encoding task were the exceptions to the procedure used in Experiment 1.

TEST PHASE.

The procedure was identical to that used for Experiment 1, except that recognition was not examined and each participant received both the mere exposure effect and word identification implicit priming tests, counterbalanced for test order and test form.

RESULTS

Test Phase

TEST COMPARISONS FOR OLD AND NEW ITEMS.

To test whether participants did significantly better with old items than with new items, *t* tests were conducted on each of the four groups created by the interaction of study–test font (same vs. different) and test type (mere exposure effect vs. word identification implicit priming). The percentage of new items was set to chance (50%) for the mere exposure effect because of the forced-choice nature of the test. Table 4 presents means and standard deviations for the proportion of old and new items by study–test font and test type for word identification implicit priming, which were compared with a paired-sample *t* test, and the means and standard deviations for the proportion of old items compared with chance (50%) for the mere exposure effect, which were compared using a 1-sample *t* test. The findings reveal that the mean percentage for old items was significantly higher than the mean percentage for new items across all study conditions.

TEST COMPARISONS FOR Z DIFFERENCE SCORES.

To compare the amount of difference between old and new items (e.g., test performance) by experiment, the *z* difference scores between old and new items were computed and entered into a 2 (study–test font: same vs. different, between participants) × 2 (test type: mere exposure effect vs. word identification implicit priming, within participants) mixed ANOVA. The residuals did not show a significant departure from a normal distribution for the overall data or within cells. Therefore, all analyses were conducted using parametric tests. Throughout the results, the means and standard errors of the percentages are reported to facilitate interpretation of the findings. However, all factorial analyses were conducted on the standardized difference scores.

Means and standard errors of percentage and *z* difference scores by study–test font and test type are presented in Table 5.

TABLE 4. Means (*M*) and Standard Deviations (*SD*) for Percentage Old and New Items by Study–Test Font and Test Type, Experiment 2

		% Old items		% New items			
Test	***N***	***M***	***SD***	***M***	***SD***	***t***	***p***
Same font							
MEE_{nw}	24	58.51	11.29	50.00[a]	—	3.60	.001
WIP_w	24	75.17	23.62	50.87	26.21	10.01	<.001
Different font							
MEE_{nw}	24	59.20	11.33	50.00[a]	—	3.98	.001
WIP_w	24	49.83	26.31	35.24	23.36	5.84	<.001

Note. [a]*For the mere exposure effect (MEE_{nw}) tests, the percentage for old items was compared with chance, or 50.00, using a 1-sample* t *test. For word identification implicit priming (WIP_w), paired* t *tests were computed. The mean percentage for old items was significantly higher than for new items, with a Bonferroni-adjusted α level of .013 per test. nw = nonwords; w = words.*

TABLE 5. Means (*M*) and Standard Errors (*SEM*) for Percentage and *z* Difference Scores by Study–Test Font and Test Type, Experiment 2

	Study-test font											
	Same				Different				Total			
	%		*z* Scores		%		*z* Scores		%		*z* Scores	
Test	*M*	*SEM*	*M*	*SEM*	*M*	*SEM*	*M*	*SEM*	*M*	*SEM*	*M*	*SEM*
MEE_{nw}	8.51[a,x]	2.31	0.02	0.22	9.20[a,x]	2.23	0.08	0.22	8.85[a]	1.62	0.05	0.15
WIP_w	24.31[a,x]	2.43	0.49	0.19	14.58[a,y]	2.50	–0.25	0.19	19.44[a]	1.86	0.12	0.14
Total	16.41[x]	2.02	0.25	0.15	11.89[x]	1.73	–0.08	0.15	—	—	—	—

Note. *There were no significant main effects for the between-participant factor of study–test change in font,* $F < 2.65$, *or for the within-participant factor of test type,* $F < 1$. *There was a significant interaction between study–test change in font and test type,* $F(1, 46) = 4.17$, $p < .05$, *partial* $\eta^2 = .083$. MEE_{nw} *= mere exposure effect; nw = nonwords; w = words;* WIP_w *= word identification implicit priming.*

There were no significant main effects for study–test change in font or test type. However, results revealed a significant interaction between font and test type (see Table 5 note). Mean proportion of *z* difference scores (old–new items) by study–test font and test type are presented in Figure 2.

A one-way ANOVA revealed a significant difference between study–test change in font for word identification implicit priming, $F(1, 47) = 7.80$, $p < .05$, partial $\eta^2 = .145$. As shown in Figure 2, the difference between old and new items was significantly larger when the font was the same than when the font was different for word identification implicit priming. No significant differences were obtained for the mere exposure effect, $F < 1$. In addition, no significant differences were found between the mere exposure effect and word identification implicit priming for same font or for different font, both Fs < 2.8.

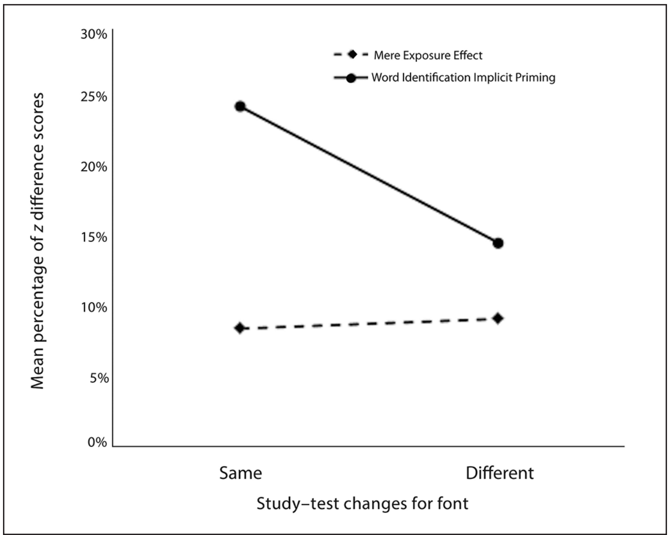

FIGURE 2. Mean proportion of *z* difference scores (old–new items) by study–test change in font and test type, Experiment 2

Study Phase

Means and standard deviations for median RTs to studied items by font and item type are presented in Table 6.

RT analyses were used to examine the alternative hypothesis that test performance, as depicted in Figure 2, is a function of processing fluency during study (encoding). For the test findings reported here, the processing fluency hypothesis would predict an interaction between font and item type for study phase RTs. More specifically, for word identification implicit priming the prediction would be that study phase RTs for words in Geneva font (Geneva–Geneva, same study–test group) would be processed faster (shorter study phase RTs) than words in Monaco font (Monaco–Geneva, different study–test group). For the mere exposure effect, no significant difference in study phase RTs for nonwords by font type (Geneva, Monaco) would be expected (Geneva–Geneva, same study–test group; Monaco–Geneva, different study–test group).

RTs were entered into a 2 (font: Geneva vs. Monaco, between participants) × 2 (item type: nonwords vs. words, within participants) mixed ANOVA. The results for study phase RTs revealed a significant main effect for item type. Nonwords had significantly

TABLE 6. Means (*M*) and Standard Deviations (*SD*) for Median Response Times (ms) to Studied Items by Font and Item Type, Experiment 2

		Font					
		Geneva		Monaco		Total	
Item type	*N*	*M*	*SD*	*M*	*SD*	*M*	*SD*
NW	48	1,080[a,x]	432	1,292[a,x]	679	1,186[a]	573
W	48	827[b,x]	322	981[b,x]	541	904[b]	447
Total	48	954[x]	398	1,136[x]	627	—	—

Note. *No significant main effect was observed for font, or the interaction between font and item type, both* F*s* < 1.5. *Because of the significant main effect of item type,* $F(1, 46) = 78.87$, $p < .0001$, *partial* $\eta^2 = .632$, *post hoc analyses were examined. Superscripts for comparisons between nonwords (NW) and words (W) are shown using the letters* a *and* b. *Superscripts for comparisons between Geneva and Monaco fonts are shown using the letters* x *and* y. *Means with different superscripts differ significantly,* $p < .05$. *The letter* x *is used to denote no differences between Geneva and Monaco fonts.*

longer mean RTs than words for both Geneva and Monaco fonts. No significant main effect was observed for font, or the interaction between font and item type (see Table 6 note). These findings do not support the alternative hypothesis that test performance is influenced by processing fluency.

DISCUSSION

Study–test change in font reduced word identification implicit priming but had no influence on the mere exposure effect. This null finding is consistent with research on visual objects that reported no influence on the mere exposure effect with study–test changes in left–right orientation, size, and color for a three-dimensional shape (Seamon et al., 1997), depth rotation of a solid object (Seamon & Delgado, 1999), and background color that encompassed geometric shapes (Bonanno & Stillings, 1986). Consistent with the method used here, these studies examined the mere exposure effect as a form of implicit priming.

Some studies reported greater priming when perceptual features were held constant, but these studies involved conscious preference judgments. An encoding task that requires participants to rate (on a nominal scale: *good, rather good, rather bad, bad*) how well certain colors fit certain familiar objects (Hupbach et al., 2006) or to make a perceptual decision by rating (on an interval scale: 1 to 9) the complexity of pictures (Lawson, 2004) may activate higher levels of cognitive processing. This may also be the case when decision making interacts with highly complex objects that differ between study and test (Lawson, 2004). Furthermore, the separation between encoding and retrieval may be compromised if the behavioral response is similar for both: A procedure that requires participants to use a mouse click to indicate their preference rating during encoding and also their preference judgment during retrieval provides a behavioral connection between study and test (Hupbach et al., 2006). Some of these possible explicit contaminations were identified in study and test tasks (Hupbach et al., 2006, Experiments 1 and 2, p. 235; Lawson, 2004, Experiment 1). However, the results from the subsequent experiments designed to address them (Hupbach et al., 2006, Experiment 3; Lawson, 2004, Experiment 2) produced inconsistent findings between preference judgments and RTs for a study–test change in color (Hupbach et al., 2006, Experiment 3) and only a trend toward increased preference judgments when same and different object views were compared (Lawson, 2004, Experiment 2).

The study–test change in font examined here produced a significant interaction between font and test type. The mere exposure effect was lower for same (mean of 8.5%), relative to different (mean of 9.2%), study–test change in font. In contrast, word identification implicit priming was higher for same (mean of 24.3%), relative to different (mean of 14.6%), study–test font. The dissociation between these two implicit priming tests suggests that the mere exposure effect is not perceptually driven. However, given that the results for the mere exposure effect are based on null findings, it is possible, although unlikely, that the font manipulation was not robust enough to reveal a perceptual influence on the mere exposure effect.

EXPERIMENT 3

The goal of Experiment 3 was to provide further validation for the findings reported in Experiment 2 by using a more robust study–test change in a stimulus attribute, orientation. The effect of same study–test orientation (horizontal, horizontal) versus different study–test orientation (vertical, horizontal) on the mere exposure effect and word identification implicit priming was examined. It was hypothesized that word identification implicit priming would be reduced by a study–test change in orientation, but no difference would be observed for the mere exposure effect.

METHOD

Participants

In Experiment 3, 48 undergraduate students (25 men, 23 women) were randomly assigned to either the same study–test orientation (horizontal, horizontal) or different study–test orientation (vertical, horizontal) group.

Stimuli

The stimuli were the same as those used in Experiment 2, with the only exceptions being that the stimuli were all presented in Geneva font and study lists were constructed for stimulus presentation in both horizontal (e.g., a row) and vertical orientations (e.g., a column). A depiction of these stimulus orientations is presented in Figure 3.

Apparatus

Hardware and software were the same as those used in the previous experiments.

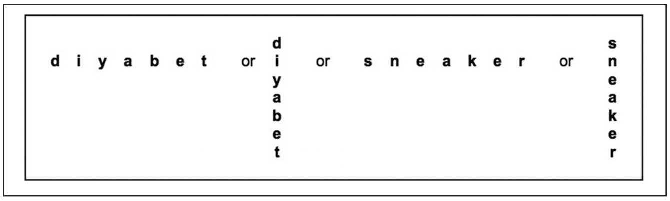

FIGURE 3. Stimulus orientations at study, Experiment 3

Design

Experiment 3 used a 2 (study–test orientation: same vs. different, between participants) × 2 (test type: mere exposure effect vs. word identification implicit priming, within participants) mixed factorial design.

Procedure

STUDY PHASE.

Participants were randomly assigned to either the same or different study–test orientation groups. In the same group, they read each nonword and word presented in a standard horizontal orientation (e.g., row). In the different group, they read each nonword and word presented in a nonstandard vertical orientation (e.g., column). During the study phase, either horizontal or vertical orientation of nonwords and words, each presented in the same font (Geneva), were the only exceptions to the procedure used in Experiment 2.

TEST PHASE.

The procedure was identical to that used for Experiment 2.

RESULTS

Test Phase

TEST COMPARISONS FOR OLD AND NEW ITEMS.

To test whether participants did significantly better with old items than with new items, *t* tests were conducted on each of the four groups created by the interaction of study–test orientation (same vs. different) and test type (mere exposure effect vs. word identification implicit priming). The percentage of new items was set to chance (50%) for the mere exposure effect because of the forced-choice nature of the test. Table 7 presents means and standard deviations for the proportion of old and new items by study–test orientation and test type for word identification implicit priming, which were compared with a paired-sample *t* test, and the means and standard deviations for the proportion of old items compared with chance (50%) for the mere exposure effect, which were compared using a 1-sample *t* test. The findings reveal that the mean percentage for old items was significantly higher than the mean percentage for new items across all study conditions.

TEST COMPARISONS FOR Z DIFFERENCE SCORES.

To compare the amount of difference between old and new items (e.g., test performance) by experi-

TABLE 7. Means (*M*) and Standard Deviations (*SD*) for Percentage Old and New Items by Study–Test Orientation and Test Type, Experiment 3

		% Old items		% New items			
Test type	***N***	***M***	***SD***	***M***	***SD***	***t***	***p***
Same orientation							
MEE_{nw}	24	57.98	10.27	50.00[a]	—	3.81	.001
WIP_{w}	24	68.58	25.45	46.35	23.32	8.13	<.001
Different orientation							
MEE_{nw}	24	57.64	10.03	50.00[a]	—	3.73	.001
WIP_{w}	24	47.22	23.94	36.81	23.94	4.96	<.001

Note. [a]*For the mere exposure effect (MEE_{nw}) tests, the percentage for old items was compared with chance, or 50.00, using a 1-sample* t *test. For the word identification implicit priming (WIP_{w}) tests, paired* t *tests were computed. The mean percentage for old items was significantly higher than for new items, with a Bonferroni-adjusted α level of .013 per test. nw = nonwords; w = words.*

ment, the *z* difference scores were entered into a 2 (study–test orientation: same vs. different, between participants) by 2 (test type: mere exposure effect vs. word identification implicit priming, within participants) mixed ANOVA. The residuals did not show a significant departure from a normal distribution for the overall data or within cells. Therefore, all analyses were conducted using parametric tests. Throughout the results, the means and standard errors of the percentages are reported to facilitate interpretation of the findings. However, all factorial analyses were conducted on the standardized difference scores.

Means and standard errors of percentage and *z* difference scores by study–test orientation and test type are presented in Table 8.

In addition to a significant main effect for study–test change in orientation, the results for *z* difference scores (old–new items) revealed a significant interaction between study-test change for orientation and test type. There was no significant main effect for test

TABLE 8. Means (*M*) and Standard Errors (*SEM*) for Percentage and *z* Difference Scores by Study–Test Orientation and Test Type, Experiment 3

	Study–test orientation											
	Same				Different				Total			
	%		*z* Scores		%		*z* Scores		%		*z* Scores	
Test	***M***	***SEM***	***M***	***SEM***	***M***	***SEM***	***M***	***SEM***	***M***	***SEM***	***M***	***SEM***
MEE_{nw}	7.99[a,x]	2.10	–0.03	0.20	7.64[a,x]	2.05	–0.06	0.19	7.81[a]	1.45	–0.05	0.14
WIP_{w}	22.22[a,x]	2.73	0.33	0.21	10.42[a,y]	2.10	–0.57	0.16	16.32[a]	1.91	–0.12	0.15
Total	15.10[x]	1.99	0.15	0.14	9.03[y]	1.46	–0.32	0.13	—	—	—	—

Note. *Although all analyses were conducted on* z *difference scores, superscripts are shown with percentage difference scores to facilitate interpretation of the findings. There was a significant main effect for study–test change in orientation,* $F(1, 46) = 7.79$, $p < .05$, *partial* $\eta^2 = .145$, *and a significant interaction between study–test change in orientation and test type,* $F(1, 46) = 4.21$, $p < .05$, *partial* $\eta^2 = .084$. *There was no significant main effect for the within-participant factor of test type,* $F < 1$. *Means with different superscripts differ significantly,* $p < .05$. *Comparisons between mere exposure effect (MEE_{nw}) and word identification implicit priming (WIP_{w}) are shown using the letters* a *and* b. *Because MEE_{nw} and WIP_{w} were not significantly different from each other, the superscript* a *was used for both tests. Comparisons between same and different orientation are shown using* x *and* y. *nw = nonwords; w = words.*

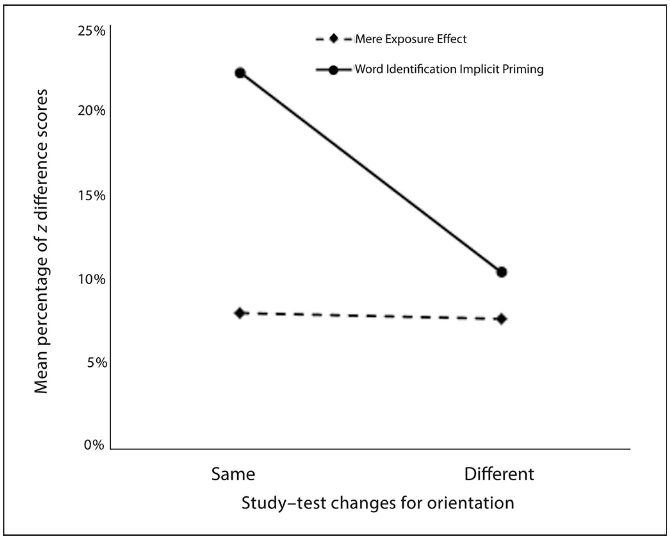

FIGURE 4. Mean proportion of *z* difference scores (old–new items) by study–test change in orientation and test type, Experiment 3

type (see Table 8 note). Mean proportion of *z* difference scores (old–new items) by study–test orientation and test type are presented in Figure 4.

Bivariate follow-up tests were conducted to further explore the interaction. As shown in Figure 4, the *z* difference scores for same orientation were significantly higher than for different orientation for word identification implicit priming. No significant differences were found between same and different orientation for the mere exposure effect, $F < 1$, or between the mere exposure effect and word identification implicit priming for same orientation, $F < 1.5$, or for different orientation, $F < 4.1$ ($p = .055$).

A one-way ANOVA revealed that *z* difference scores for same orientation were significantly greater than for different orientation for word identification implicit priming, $F(1, 46) = 11.74$, $p < .05$, but there was no difference between same and different orientation for the mere exposure effect, $F < 1$.

Study Phase

Means and standard deviations of median RTs to studied items by orientation and item type are presented in Table 9.

RT analyses were used to examine the alternative hypothesis that test performance, as shown in Figure 4, is a function of processing fluency during study (e.g., encoding). For the test findings reported here, the processing fluency hypothesis would predict an interaction between orientation and item type for study phase RTs. The interaction would follow the same pattern as that described for font and item type (see Experiment 2).

RTs were entered into a 2 (orientation: horizontal vs. vertical, between participants) × 2 (item type: nonwords vs. words, within participants) mixed ANOVA. The results for study phase RTs revealed a significant main effect for item type. Nonwords had significantly longer mean RTs relative to words. A significant main effect was also observed for orientation. No significant interaction was found for study phase RTs between orientation and item type. Horizontal orientation and words obtained significantly shorter RTs than vertical orientation and nonwords (see Table 9). These findings do not

TABLE 9. Means (*M*) and Standard Deviations (*SD*) for Median Response Times (ms) to Studied Items by Orientation and Item Type, Experiment 3

		Orientation					
		Horizontal		Vertical		Total	
Item type	*N*	*M*	*SD*	*M*	*SD*	*M*	*SD*
NW	48	1,573[a,x]	796	2,085[a,y]	884	1,829[a]	871
W	48	1,168[b,x]	541	1,594[b,y]	762	1,381[b]	688
Total	48	1,370[x]	703	1,840[y]	853	—	—

Note. *Although no significant interaction was found for study phase RTs between orientation and item type,* $F < 1$, *post hoc analyses were examined because of the significant main effects of orientation,* $F(1, 46) = 4.85$, $p < .05$, *partial* $\eta^2 = .095$, *and item type,* $F(1, 46) = 86.64$, $p < .0001$, *partial* $\eta^2 = .653$. *Superscripts for comparisons between nonwords (NW) and words (W) are shown using the letters* a *and* b. *Superscripts for comparisons between horizontal and vertical orientations are shown using the letters* x *and* y. *Means with different superscripts differ significantly,* $p < .05$.

support the alternative hypothesis that test performance is a function of processing fluency.

DISCUSSION

The main effect for orientation was significant, indicating that the study–test change in orientation was more rigorous than font. Similar to font, there was no main effect for test type, but there was a significant interaction between orientation and test type. A change in study–test orientation reduced word identification implicit priming (12%) but produced almost no influence on the mere exposure effect (less than 1%). The dissociations observed with study–test change in font (Experiment 2) and orientation (Experiment 3) between the mere exposure effect and word identification implicit priming is evidence that perceptual processing does not influence the mere exposure effect.

The results from Experiments 1–3 provided evidence that the mere exposure effect was not a form of conceptual or perceptual implicit priming but may be driven, as originally proposed (Zajonc, 1968), by affective processing. One method of detecting affective processing during encoding is cardiovascular psychophysiology (Berntson et al., 2007). Cardiovascular responses have been used to investigate emotional processing (reviewed in Kreibig et al., 2007). Also, this method provides an opportunity for measurement that is consistent with the prediction that the affective response occurs automatically and outside of awareness (Zajonc, 1980).

EXPERIMENT 4

The goal of Experiment 4 was to assess the feasibility of recording cardiovascular responses as a means of detecting affective preference between stimuli that provide only minimal conceptual and perceptual information. As originally formulated, the evolutionary-based affective mechanism for the mere exposure effect (Zajonc, 1968) predicts affective responses that are positive during retrieval but not necessarily during encoding, a critical distinction that is often overlooked. The first exposure of a novel stimulus was proposed to elicit an instinctive fear reaction (e.g., encoding stage). Furthermore, it was posited that this response would diminish with subsequent exposures and, in the absence of danger, elicit some form of positive affect (e.g., retrieval stage). With distress responses, research with nonhuman animals supports this sequencing of emotional events (Zajonc, Markus, & Wilson, 1974). It was considered, but dismissed, that a novel stimulus might elicit an orienting response (Zajonc, 1998).

With humans it is plausible that the first exposure of a novel stimulus elicits an orienting response that accompanies an increase in attention. The orienting response is defined as a decrease in HR (bradycardia) associated with increased attention toward a novel stimulus, a response that attenuates on repetition (Haroutunian & Campbell, 1981, 1982). Widely considered to serve a survival function (reviewed by Bradley, 2009), the orienting response has been extensively investigated in both human and nonhuman subjects, although not in the context of the mere exposure effect.

Cardiovascular psychophysiology offers a reliable method of detecting the presence or absence of an orienting response (Varner & Rohrbaugh, 1991). There is evidence that decreased HR is related to mild positive affect (Steptoe, Wardle, & Marmot, 2005). Also, decreased HR is a core component of a parasympathetic-dominant pattern called the relaxation response (Benson, 1975, 1983; Benson, Greenwood, & Klemchuk, 1975). These findings suggest that there may be a relationship between decreased HR and affective preference.

Experiment 4 compared cardiovascular reactivity and stimulus affective preference under two stimulus conditions: blank monitor and static visual display. These conditions were selected because they provided minimal conceptual and perceptual content but could be presented continuously, providing more opportunity to examine cardiovascular reactivity than nonwords presented with short-duration ISIs. The behavioral hypothesis was that there would be a difference in affective preference ratings for the monitor relative to the static condition. The cardiovascular hypothesis was that there would be a difference in HR and BVP change scores for the monitor relative to the static condition.

METHOD

Participants

In Experiment 4, 24 undergraduate students (12 men, 12 women) were randomly assigned to a counterbalancing order: monitor–static, static–monitor.

Stimuli

A DVD was constructed with monitor (blank screen) and static (visual stimulus only) 60-s displays, counterbalanced to control for order effects. A 20-point scale (−10 = *strongly not like*; +10 = *strongly like*) was used to rate affective preference for monitor and static conditions.

Apparatus

A DVD player was used to present the monitor and static displays. Cardiovascular data were recorded with the PowerLab 400 System (AD Instruments), an integrated system of hardware and software designed to record, display, and analyze signals from ±10 V down to the microvolt range. The software consisted of the application program for Chart 3.6.3 that ran on a Macintosh computer to which the PowerLab was connected. HR and BVP data were automatically edited for artifact by the low-pass filter (e.g., Fc = 0.3 Hz) that removed component frequencies contingent on the threshold measurement for each participant. PowerLab software computed peak-to-peak time-based calculations in 2-s intervals. Less than 1% of the HR and BVP data for each experiment was omitted from the analyses because of omissions in peak-to-peak detection.

One channel of the PowerLab was devoted to a photosensor that directly converted a photodiode photo current to a voltage for detection by the analog-to-digital converter. The photosensor was positioned at a 45° angle from the center of the computer monitor. Each stimulus on-off-time was detected by a positive followed by a negative signal from the photosensor and recorded on the photosensor channel. HR and BVP were recorded from a photoplethysmograph transducer placed on the distal phalanges of the index finger of each participant's right hand. Data was sampled at 1,000 Hz, with a calibration accuracy of better than 0.1%. The information from the photosensor channel was used to mark the 4 on-off-times for the 60-s intervals involving cardiovascular recording. A 60-s eyes-closed baseline preceded each 60-s monitor and static DVD display.

Design

A simple within-participant design counterbalanced for monitor and static conditions was used. Affective preference ratings, HR, and BVP change scores were the dependent variables.

Procedure

Participants were randomly assigned to a counterbalanced order for viewing either a blank monitor or static (visual stimulus only) display on a DVD. Cardiovascular responses were recorded during the two displays. The monitor and static conditions were preceded by a baseline (eyes closed) period. There were 4 conditions, 60 s each: baseline monitor, monitor, baseline static, static. After the 240-s recording period, participants were asked to rate each condition on a 20-point affective preference scale.

RESULTS

Cardiovascular and Behavioral Data

Software designed by the National Aeronautics and Space Administration (NASA) at Ames Research Center's Psychophysiology Laboratory was used to process the cardiovascular data (Cowings & Toscano, 2006). Both HR and BVP measures were derived from the raw photoplethysmograph waveforms. HR processing included peak detection of raw pulse waveforms, calculating durations between adjacent peaks to derive heart period and its reciprocal HR, and finally averaging contiguous blocks of 10 data points to obtain 0.1-s means. BVP processing involved detecting both peaks and troughs from the raw waveforms, subtracting peak values from trough values to determine relative amplitudes (volume) and block averaging amplitude values to derive 0.1-s means. Means for HR and BVP were computed between the eyes-closed baseline and each stimulus condition: monitor, static. A mean change score was computed (stimulus condition-baseline) for HR and BVP for each participant. Table 10 presents means and standard errors for affective preference ratings and cardiovascular change scores by monitor and static conditions.

Independent sample t tests revealed that mean affective preference ratings, $t(23) = 5.28$, $p < .0001$, $d = 1.558$, and mean BVP change scores, $t(23) = 3.37$, $p < .05$, $d = .950$, were higher for the monitor than for the static condition. A significant difference between the monitor and static condition was not observed for mean HR change scores, $t < 1$. The insignificant findings for HR may result from the lack of variance for this measure within the brief temporal window of measurement. A comparison of the variance for HR change and BVP change by condition is presented in Table 11.

Paired-sample t tests revealed that the mean variance for BVP change was significantly higher than the

TABLE 10. Means (*M*) and Standard Errors (*SEM*) for Affective Preference (AP) Rating, Heart Rate (HR) Change, and Blood Volume Pulse (BVP) Change During Monitor and Static Conditions, Experiment 4

	AP rating		HR change		BVP change	
Condition	*M*	*SEM*	*M*	*SEM*	*M*	*SEM*
Static	–3.42	0.86	–1.11	0.50	–8.63	23.49
Monitor	2.88	0.79	–0.94	0.38	109.26	27.06

TABLE 11. Means (*M*) and Standard Errors (*SEM*) for Variance of Heart Rate (HR) Change and Blood Volume Pulse (BVP) Change During Monitor and Static Conditions, Experiment 4

	Variance			
	HR change		BVP change	
Condition	*M*	*SEM*	*M*	*SEM*
Static	39.23	4.58	14,030.67	5,676.84
Monitor	38.63	6.01	11,631.00	4,708.25

mean variance for HR change in both the monitor, $t(23) = 2.46, p < .05, d = .711$, and static, $t(23) = 2.47, p < .05, d = .712$, conditions.

DISCUSSION

A higher affective preference rating (e.g., liking) was given by 80% of the participants for the monitor relative to the static condition. This behavioral finding was consistent with the means for BVP change but not for HR change. The cardiovascular data suggested that in order to obtain a measurable treatment effect within the constraints of such a short temporal window, a minimum level of cardiovascular variance was required. This proposed requisite minimal variance level was obtained for BVP but not for HR. However, BVP increases are also directly associated with the relaxation response (Rawson, Bhatnagar, & Schneider, 1985) and with relaxation trials during autogenic feedback training (Cowings et al., 2001; Cowings & Toscano, 2000).

One limitation associated with Experiment 4 was the 60-s interval recording time that was too short to allow for HR variability analysis. Nonetheless, because BVP and HR covary in opposition to each other, the results suggested that the development of a cardiovascular psychophysiological implicit priming paradigm with BVP as the outcome measure was feasible for the purpose of examining the encoding stage of the mere exposure effect.

EXPERIMENT 5

The goal of Experiment 5 was to design a cardiovascular psychophysiological implicit priming paradigm and, based on the principle of individual response specificity in psychophysiology (Lacey, Bateman, & Van Lehn, 1953), to test it on the same participants as in Experiment 4. Individual response specificity is defined as the tendency of individuals to show similar physiological patterns of response across a set of diverse conditions during a single test session.

Experiment 5 examined BVP change during encoding as a function of each individual participant's stimulus-specific response at test. The cardiovascular hypothesis was that BVP change at study would be significantly greater for nonwords that were later preferred, relative to nonwords that were not preferred, at test (mere exposure effect). BVP change was not expected to systematically vary for words at study that were later either identified or not identified at test (word identification implicit priming). The behavioral hypothesis was that old items would be preferred more than expected by chance (mere exposure effect) and identified more than new items (word identification implicit priming).

METHOD

Participants

The participants were the same as those in Experiment 4.

Stimuli

The stimuli were the same as those used in Experiments 2 and 3, except that all stimuli were presented in Geneva font and standard horizontal orientation during both study and test.

Apparatus

The same hardware and software as that used for Experiments 1–3 were used to present the stimuli. Cardiovascular recording involved the same hardware and software as in Experiment 4.

Design

Experiment 5 used a simple within-participant design. Participants received the mere exposure effect and word identification implicit priming tests, counterbalanced for test order and test form.

Procedure

The procedure was the same as that used for Experiments 2 and 3, with the following procedural modifications made during study: (a) no encoding manipulation (all participants read the nonwords *and* words), (b) no study–test change in stimuli presentation (all studied items were presented in Geneva font and standard horizontal orientation), (c) an increase in the stimulus on-time from 2,000 ms to 5,000 ms, followed by the insertion of a 2,500-ms black slide used to trigger a photosensor whose deflection precisely marked the stimulus on–off time, and (d) a photoplethysmograph transducer placed on the distal phalanges of the index finger of each participant's right hand to record BVP. The photosensor deflections used to precisely define event and no-event periods for a single participant's raw BVP data are depicted in Figure 5.

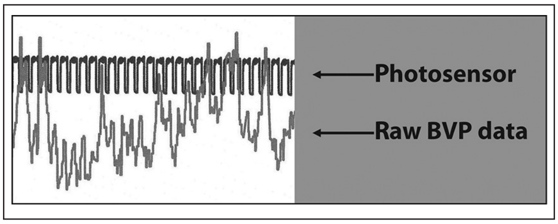

FIGURE 5. Sample of raw blood volume pulse (BVP) data recorded from a single participant during the mere exposure effect and word identification implicit priming tests, Experiment 5. The photosensor was used to precisely mark slide on–off times for stimulus-specific BVP change during study

RESULTS

Test Comparisons for Old and New Items

The percentage difference scores between old and new items were entered into a within-participant (test type: mere exposure effect vs. word identification implicit priming) ANOVA with no between-participant factors. The residuals did not show a significant departure from a normal distribution for the overall data or within cells. Therefore, all analyses were conducted using parametric tests. Consistent with Experiments 1–3, the percentage of new items was set to chance (50%) for the mere exposure effect because of the forced-choice nature of the test. In contrast to Experiments 1–3, the ANOVA was run on the percentage scores because no comparison between *z* difference scores can be computed when no between-participant effects are present (e.g., both mean scores equal 0 and *SD* equal 1).

The results for percentage difference scores (old–new items) revealed a significant effect for test type (mere exposure effect vs. word identification implicit priming), $F(1, 23) = 18.20$, $p < .001$, partial $\eta^2 = .442$. Word identification implicit priming ($M = 11.81$, $SEM = 1.79$) had significantly higher mean percentage difference scores than the mere exposure effect ($M = 3.99$, $SEM = 1.36$). To test whether participants did significantly better with old items than with new items, *t* tests were conducted for the mere exposure effect and word identification implicit priming. Table 12 presents means and standard deviations for percentages of old and new items by test type.

TABLE 12. Means (*M*) and Standard Deviations (*SD*) for Percentage of Old and New Items by Test Type, Experiment 5

		% Old items		% New items			
Test	*N*	*M*	*SD*	*M*	*SD*	*t*	*p*
MEE_{nw}	24	53.99	6.67	50.00[a]	—	2.93	.007
WIP_w	24	64.41	15.44	52.60	12.58	6.61	<.001

Note. [a]*For mere exposure effect (MEE_{nw}) the percentage for old items was compared with chance, or 50.00, using a 1-sample* t *test. For word identification implicit priming (WIP_w), a paired* t *test was computed. The mean percentage for old items was significantly higher than for new items, with a Bonferroni-adjusted α level of .025 per test. nw = nonwords; w = words.*

Cardiovascular and Behavioral Data

Means were calculated for BVP (sampled at 0.1 s) for each trial event and no-event interval. The information from the photosensor channel was used to mark the exact 5,000-ms on-time for each studied item. An event was defined as 6,000 ms: the 5,000 ms on-time of the stimulus plus the 500-ms fixation cross and 500-ms ISI that preceded it. No event was defined as 2,500 ms, the on-time for the black slide that followed each stimulus.

A mean change score for each study trial was computed (event - no event) for BVP. Change score means for each study trial were derived from each participant's cardiovascular chart. Then, BVP change scores were categorized based on that particular participant's stimulus-specific response at test: preferred (P), not preferred (NP), identified (I), and not identified (NI). This coding method formed the basis for the BVP data analyses. Means and standard deviations for cardiovascular data recorded during study based on each individual participant's stimulus-specific responses during test are presented in Table 13.

Paired-sample *t* tests revealed that BVP change scores (event, no event) recorded during study for preferred stimuli (P) during test were significantly higher than for stimuli that were not preferred (NP) during test, $t(23) = 2.90, p < .05, d = .281$. No significant difference was observed for mean BVP change scores (event, no event) recorded during study for stimuli that were either identified (I) or not identified (NI) during the word identification implicit priming test, $t < 1$ for both. Test performance on the mere exposure effect and word identification implicit priming as a function of BVP change at study is presented in Figure 6.

TABLE 13. Means (*M*) and Standard Errors (*SEM*) for Stimulus-Specific Blood Volume Pulse (BVP) Change at Study Based on Stimulus-Specific Responses by Participants at Test, Experiment 5

	MEE_{nw}				WIP_w			
	P		NP		I		NI	
	M	*SEM*	*M*	*SEM*	*M*	*SEM*	*M*	*SEM*
BVP change	11.04	2.58	7.63	2.38	10.96	2.82	11.24	4.06

Note. MEE_{nw} = *mere exposure effect;* WIP_w = *word identification implicit priming; P = preferred; NI = not identified; I = identified; NP = not preferred; nw = nonwords; w = words.*

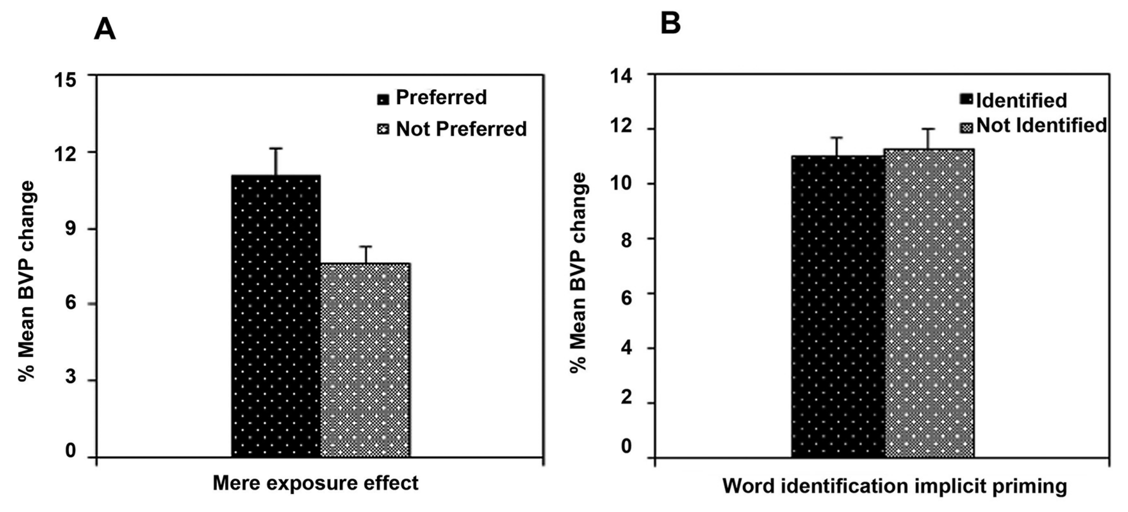

FIGURE 6. Test performance for (a) mere exposure effect and (b) word identification implicit priming as a function of blood volume pulse (BVP) change during study, Experiment 5. Error bars show standard error. Mean BVP change for nonwords preferred was greater than for nonwords not preferred on the mere exposure effect test. No difference was observed for mean BVP change between words identified and words not identified on the word identification implicit priming test

Study Phase RTs and BVP Change

In order to determine whether encoding processing time caused BVP change at study, mean stimulus-specific RTs based on each participant's stimulus-specific response at test were computed. Means and standard deviations for stimulus-specific RTs during study are presented in Table 14.

Stimulus-specific encoding processing time does not explain BVP change at study that predicted the mere exposure effect at test. For combined data, reading RTs were longer for nonwords than for words, $t(23) = 4.28$, $p < .005$, $d = .62$.

DISCUSSION

Our results confirmed both the cardiovascular and behavioral hypotheses. Stimulus-specific BVP change at study predicted the mere exposure effect at test. BVP change at study was significantly greater for nonwords that were later preferred, relative to nonwords that were not preferred, at test (mere exposure effect). There was no difference in BVP change for words at study that were later either identified or not identified at test (word identification implicit priming). As in our previous experiments, affective preference was greater for old items than expected by chance (mere exposure effect), and identification was greater for old than for new items (word identification implicit priming).

Greater BVP change associated with a novel stimulus exposed during encoding suggests that the mere exposure effect may be driven by the orienting response. HR deceleration attenuates (habituation) when the presentation of the stimulus is repeated (Haroutunian & Campbell, 1981, 1982; Richardson & Campbell, 1991). Because decreased HR is a core component of a parasympathetic-dominant pattern called the relaxation response (Benson, 1975, 1983; Benson et al., 1975) and has also been associated with mild positive affect (Steptoe et al., 2005), the orienting response elicited by a novel stimulus of mild to moderate intensity (e.g., encoding stage), and the expected gradual attenuation of it on subsequent exposures (e.g., retrieval stage), may be subjectively experienced as mild positive affect and behaviorally manifested as affective preference.

GENERAL DISCUSSION

These experiments indicate that the mere exposure effect is neither conceptually nor perceptually driven but may reflect a form of implicit priming that is mediated at encoding by affective processing. BVP change at study was significantly greater for nonwords that were later preferred, relative to nonwords that were not preferred, at test (mere exposure effect). There was no difference in BVP change for words at study that were later either identified or not identified at test (word identification implicit priming). Stimulus-specific BVP change at study predicted the mere exposure effect at test.

In these experiments, the number of stimulus exposures at study and test was the same for all memory measures: one exposure for each phase. Also, stimulus on-time during study was held constant across tests. These procedural controls were derived from our finding that a significant mere exposure effect could be obtained with only one stimulus exposure at study and a single repetition at test (Stone et al., 2000). This is important because it allowed us to compare performance across tests while preserv-

TABLE 14. Means (*M*) and Standard Deviations (*SD*) for Stimulus-Specific Response Times ($^{s\text{-}s}$RT) (ms) During Study, Experiment 5

		MEE_{nw}						WIP_w					
		P		NP		Total		I		NI		Total	
	N	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
$^{s\text{-}s}$RT	24	1,179	342	1,189	341	1,184[a]	338	981	273	1,000	299	991[b]	283

Note. *Paired-sample* t *tests revealed no significant differences in stimulus-specific response times for preferred (P) and not preferred (NP) stimuli or for identified (I) and not identified (NI) stimuli,* $t < 1$. *Superscripts for study phase response time comparisons between nonwords used at test for the mere exposure effect (*MEE_{nw}*) and words used at test for word identification implicit priming (*WIP_w*) are shown using the letters* a *and* b. *Means with different superscripts differ significantly,* $p < .005$. *nw = nonwords; w = words.*

ing an essential element at encoding for the mere exposure effect as originally conceptualized (Zajonc, 1968): affective properties (e.g., novel stimuli) combined with subliminal effects (no awareness of stimulus repetition). Our procedure did not include a reference to subsequent repetitions (e.g., Schacter et al., 1989) or coordinated affective tasks between study and test that link these phases. This allowed us to compare the mere exposure effect with other memory measures without decoupling the special and unique processing at encoding (affective properties and subliminal effects) that distinquishes the mere exposure effect from other forms of memory. Exposure effects are more pronounced when obtained under subliminal conditions than when participants are aware of the repeated exposures (Murphy et al., 1995; Zajonc, 1980). No parallel finding has been reported for other implicit priming measures.

Experiment 1 used the Roediger et al. (1989) framework to determine whether the mere exposure effect should be classified as a conceptual implicit priming test. Deep relative to shallow processing improved recognition but did not influence the mere exposure effect for nonwords. The dissociation between recognition and the mere exposure effect was observed with a conceptual study phase manipulation when both tests used the identical meaningless letter strings (e.g., nonwords). The dissociation between recognition and the mere exposure effect was almost identical to that observed with word identification implicit priming for words, semantically meaningful stimuli. This finding suggested that the mere exposure effect is independent from cognitive evaluation and supported classifying the mere exposure effect as a form of implicit priming (e.g., Seamon et al., 1995). However, it did not rule out the possibility that the mere exposure effect is perceptually driven.

Experiments 2 and 3 used the Roediger et al. (1989) framework to determine whether the mere exposure effect should be classified as a perceptual implicit priming test. Different study–test font and orientation reduced word identification implicit priming but had no influence on the mere exposure effect. These implicit memory dissociations between the mere exposure effect and word identification implicit priming do not support the proposal that the mere exposure effect is perceptually driven.

Experiment 4 assessed the utility of using cardiovascular psychophysiology, a peripheral measure, during encoding to observe whether a unique form of processing may be driving the mere exposure effect. A positive relationship between BVP change and affective preference ratings that differentiated between two stimulus conditions, both providing minimal conceptual and perceptual content, was obtained. These results suggested that the development of a cardiovascular psychophysiological implicit priming paradigm was feasible for the purpose of examining the encoding stage of the mere exposure effect.

Experiment 5 examined whether stimulus-specific BVP change at study predicted the mere exposure effect at test. Based on the principle of individual response specificity in psychophysiology (Lacey et al., 1953), the same participants (e.g., Experiment 4) were used for this subsequent examination. BVP change at study was significantly greater for nonwords that were later preferred, relative to nonwords that were not preferred, at test (mere exposure effect). There was no difference in BVP change for words at study that were later identified or not identified at test (word identification implicit priming). These findings suggest that the retrieval demand (e.g., affective preference) may be driven by the initial analysis of a novel stimulus that leads, for unknown reasons, to more or less activation of the parasympathetic nervous system. The outcome of an association between a particular stimulus and parasympathetic nervous system activation (e.g., relaxation) is expressed as affective preference for that stimulus at test. A familiar stimulus under conditions of a neutral valence retrieval demand (e.g., word identification) does not operate the same way. The relation of BVP to affect (reviewed in Kreibig et al., 2007) suggests that an affective process contributes to the mere exposure effect.

Fluency effects cannot be used to explain these cardiovascular findings. Food additives with easy-to-read names have been judged as less harmful than additives with hard-to-read names (Topolinski & Strack, 2010, Experiment 3). This suggests that the individual nonwords that were easier to pronounce may have elicited the greater BVP change during study that later predicted affective preference judgments at test. The RT data (Experiment 5) do not support this speculation: Stimulus-specific RTs during study for preferred nonwords during test, relative to those not preferred, did not differ (see Table 14). Yet it is still possible that preferred nonwords could have been processed easier than those not preferred at test. This alternative retrieval-based hypothesis cannot be directly tested: RTs were collected at study only in the absence of an encoding manipulation (Experiment 5). However, we can examine it indirectly in the previous experiments by comparing processing time for different encoding conditions to test performance. For LOP (Experiment 1), contrary to the typical finding for simply reading nonwords and words (e.g., Taroyan & Nicolson, 2009), RTs for nonwords (recognition, mere exposure effect) were shorter than for words (word identification implicit priming). Yet these differences in processing fluency as measured by reading RTs (see Table 3) did not consistently predict test performance (see Figure 1). For study–test changes in physical features (Experiments 2 and 3, respectively), RTs for nonwords were longer than for words (see Tables 6 and 9). Yet, again, these differences in processing fluency did not consistently predict test performance (Figures 2 and 4). Based on these empirical findings, it is unlikely that either an encoding or a retrieval-based fluency induction can explain the cardiovascular findings (Experiment 5).

Several mechanisms have been proposed that remove genuine emotion as an explanation for the increased liking associated with the mere exposure effect. The centerpiece for these explanations is perceptual fluency: Familiar stimuli are easier to perceive, encode, and process than are unfamiliar stimuli (Jacoby & Whitehouse, 1989). The perceptual fluency and misattribution mechanism proposes that the mere exposure effect, like other forms of repetition priming, increases perceptual fluency for stimuli and that perceptual fluency is misattributed to liking (Bornstein & D'Agostino, 1994). The modified two-factor mechanism proposes that people prefer stimuli that are familiar and predictable and that perceptual fluency reflects learning, in the absence of recognition, that leads to greater liking (Reber, Schwarz, & Winkielman, 2004; Reber, Winkielman, & Schwarz, 1998; Seamon et al., 1995). The motor simulation mechanism proposes that greater motor fluency caused by specific stimulus reenactments drives preferences for repeated stimuli in the mere exposure effect and improves performance for repetition priming and the familiarity, but not recollection, component of recognition (Topolinski, 2012).

The experiments that form the basis for the proposed motor simulation mechanism have not adhered to all the essential elements of the nonconscious mere exposure paradigm (reviewed in Butler & Berry, 2004): (a) stimulus content that is both novel and minimal (e.g., nonsense words and simple geometric forms); (b) the absence of processing demands at encoding, except those that are at the lowest end of the processing continuum (e.g., passive viewing of subliminal stimuli, reading nonwords or identifying letters by case); (c) no reference to stimulus repetition at study (e.g., either given directly within study instructions or indirectly by coordinated study–test affective or preference tasks); (d) no reference to subsequent testing at study; and (e) liking or affective preference judgments at test. Rating stimulus likability during study may engage higher-order decision making at encoding (e.g., Topolinski & Strack, 2009, Experiments 1–3, all groups except one; Topolinski & Strack, 2010, Experiment 3). Also, likability and preference judgments given at study and test, respectively, may connect encoding to retrieval (e.g., Topolinski & Strack, 2009, Experiments 1–3; Topolinski & Strack, 2010, Experiment 3). Informing participants that the stimulus will be repeated removes the nonconscious element from encoding and retrieval (e.g., Topolinski & Strack, 2009, Experiments 1–3). Substituting confidence ratings and RT data for preference judgments in a protocol with similar components to the mere exposure effect does not examine the effect itself (e.g., Topolinski, 2012, Experiments 6 and 7A). From this perspective, the recently proposed motor simulation mechanism (Topolinski & Strack, 2009) is probably a valid explanation for conscious affective preference judgments rather than the nonconscious mere exposure effect. In fact, Topolinski has acknowledged this limitation of the sensorimotor simulation explanation. When discussing the finding that mere exposure effects have been reported when the exposed stimuli are outside a person's awareness (Kunst-Wilson & Zajonc, 1980), Topolinski made this statement: "However, other mere exposure effects are less likely to be based on covert sensorimotor simulations" (Moreland & Topolinski, 2010, p. 336). We suggest that if the outcome measure is conscious decision making, then the phenomenon investigated is not the mere exposure effect, as described by Zajonc (1968).

Our results are most aligned with the evolutionary-based affective mechanism. However, this mechanism would predict that the initially exposed novel stimulus evokes a reflexive fear reaction. Aversive stimuli, such as electric shock or intense auditory stimulation, elicit an increase in HR (tachycardia), a response that, on repetition, does not readily habituate (Chalmers & Levine, 1974). In contrast, a relatively mature sensory system responds to novel stimuli of mild to moderate intensity with a decrease in HR (bradycardia) that habituates on stimulus repetition (Haroutunian & Campbell, 1981, 1982). These findings suggest that the initially exposed novel stimulus (encoding stage) is associated with increased attention, not fear. Attention may be an absolute requirement for any form of memory (Mulligan, 1998). But the absolute level of attention may be more critical for the mere exposure effect than for other forms of implicit priming. Lower implicit priming after color naming than after reading was observed for word identification and word fragment completion, both implicit priming tests, and implicit priming for the mere exposure effect was eradicated (Stone et al., 2000). It may be that multiple mechanisms, both specific and general, contribute to the mere exposure effect and other forms of implicit priming.

Future behavioral neuroscience research that aims to assess the extent to which increased BVP during encoding underlies affective preference during retrieval could examine patient groups known to have an impaired mere exposure effect. Increased BVP change during the encoding stage of the mere exposure effect should be lower for patients with severe depression than for normal controls. Severely depressed patients showed a suppressed mere exposure effect, with intact recognition (Quoniam et al., 2003). Increased BVP change during the encoding stage of the mere exposure effect should also be suppressed for patients with frontal lobe lesions (late traumatic brain injury >28 years), the only other group reported to have deficits in the mere exposure effect (Barker, Andrade, Morton, Romanowski, & Bowles, 2010). The reduction in the mere exposure effect for patients with lesions in the frontal lobe is consistent with the neuroimaging findings on normal participants that showed right lateral frontal activation during preference judgments (Elliott & Dolan, 1998).

Investigations that aim to differentiate the neural substrates for perceptual and affective implicit priming may benefit by using a seminal perceptual implicit priming task and the prototypical protocol for the nonconscious mere exposure effect, respectively. The data collected in Experiment 5 suggest that the vagus nerve plays an important role in mediating the mere exposure effect. This is because HR deceleration is mediated by the parasympathetic nervous system through the vagus nerve (cranial nerve X), a peripheral route thought to modulate central nervous system function (Rutecki, 1990). Because the origin of the vagus nerve is the postolivary sulcus of the medulla (Binder, Sonne, & Fischbein, 2010), future neuroimaging studies on the nonconscious mere exposure effect should focus on subcortical structures within the brain stem and their possible connections with the frontal lobe.

Based on the combined findings from Experiments 1–5, the mere exposure effect may represent a different form of implicit priming that relies on emotional mechanisms that are independent of cognitive evaluation (Kunst-Wilson & Zajonc, 1980; Zajonc, 1968, 1980, 2001). These findings encourage the development of new methods designed to further examine the possibility that there are three forms of implicit priming: conceptual, perceptual, and affective. Within this broader framework, normal levels of positive affective implicit priming may be the mechanism that allows "an organism to distinguish between safe and unsafe objects and habitats, forming the primitive basis for social attachments, social organization and cohesion—the basic sources of psychological and social stability" (Zajonc, 2001, pp. 227–228).

NOTES

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