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The Role of Selective Attention in Perceptual and Affective Priming

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Two kinds of perceptual priming (word identification and word fragment completion), as well as preference priming (that may rely on special affective mechanisms) were examined after participants either read or named the colors of words and nonwords at study. Participants named the colors of words more slowly than the colors of nonwords, indicating that lexical processing of the words occurred at study. Nonetheless, priming on all three tests was lower after color naming than after reading, despite evidence of lexical processing during color naming shown by slower responses to words than to nonwords. These results indicate that selective attention to (rather than the mere processing of) letter string identity at study is important for subsequent repetition priming.

Priming and divided attention

Repetition priming tasks measure memory as the change in speed, accuracy, or bias in responses to studied relative to baseline items. Repetition priming often is intact in amnesic patients who cannot recollect study episodes (Cermak, Talbot, Chandler, & Wolbarst, 1985; Graf, Shimamura, & Squire, 1985; Graf, Squire, & Mandler, 1984; Shimamura, 1986; Vaidya, Gabrieli, Keane, & Monti, 1995; Verfaellie, Cermak, Letournean, & Zuffante, 1991) and is often independent of recall and recognition (explicit forms of memory) in normal participants (Jacoby & Dallas, 1981; Tulving, Schacter, & Stark, 1982). Thus, repetition priming need not depend on conscious or intentional recollection of study phase episodes at test time.

These findings have led some researchers to propose that repetition priming depends on automatic, unintentional processing and thus should not be susceptible to the division of attention at study (Koriat & Feuerstein, 1976; Parkin, Reid, & Russo, 1990; Parkin & Russo, 1990; Szymanski & MacLeod, 1996). Despite this straightforward proposition, experimental evidence about the role of attention in repetition priming is mixed. Division of attention at study reduces priming in some cases (Eich, 1984; Gabrieli et al., 1998; Mulligan & Hartman, 1996) but not in other cases (Koriat & Feuerstein, 1976; Parkin et al., 1990; Parkin & Russo, 1990).

Mulligan (Mulligan & Hartman, 1996; Mulligan, 1998) used the distinction between conceptual and perceptual tests of memory (Roediger & McDermott, 1996; Roediger, Weldon, & Challis, 1989) to explain inconsistencies in the literature. The distinction between conceptual and

perceptual tests is operationalized in two ways. First, performance on conceptual tests is enhanced by elaborative processing at study, whereas performance on perceptual tests is not affected. Second, changing perceptual features of stimuli (such as modality of presentation) between study and test is detrimental to performance on perceptual tests of memory, whereas performance on conceptual tests is not affected. Mulligan proposed that perceptual priming measures do not demand attentional resources beyond those necessary for stimulus identification. In this view, perceptual repetition priming is intact as long as identity processing at study is intact. However, it is unknown whether identity processing uses substantial attentional resources and, if so, what kind of resources.

Perceptual priming and spatial selective attention

At least one attentional resource, selective spatial attention, was important when priming was measured using a word clarification procedure in which participants saw words obscured by a mask of random dots that were gradually removed until the participant could identify the word. In a study by Johnston and Dark (1985), participants monitored two of four locations on the screen. On each trial, they saw two words presented foveally, one appearing in a designated location and one appearing in a to-be-ignored location, and reported only the words in the designated location. At test, participants were faster to identify attended rather than new or unattended words, and there was no difference in identification of unattended and new words. Hawley and Johnston (1991) briefly presented words flanked by digits during the study phase. Some participants had to report only the words, others reported either words or sums of flanking digits, and others reported only the sums of digits. At test, participants who reported only the words showed priming, whereas participants who reported only the sums of digits showed no priming. Later findings using the flanking digits manipulation (Carrier & Pashler, 1995; Light & Prull, 1995) confirmed that many forms of perceptual repetition priming are sensitive to the manipulations of visual selective attention. The spatial location in which the stimulus is presented must be attended to ensure that normal perceptual repetition priming occurs.

Perceptual priming and lexical processing

Spatial attention to the location of the stimulus may not be enough to yield full priming. Lexical processing, that is, differential processing of a letter string depending on its lexical (word or nonword) status, may be another requirement. Lack of lexical processing (Hayman & Jacoby, 1989) can eliminate word identification priming, a kind of perceptual priming. In a typical word identification experiment, participants are exposed to words in a study phase. In a test phase, studied and baseline (unstudied) words are presented near identification threshold. Priming is measured by how much more accurately studied words are identified than are baseline words (Jacoby & Dallas, 1981). This type of priming is considered perceptual because it is reduced by study-test changes of modality or font (Jacoby & Dallas, 1981; Jacoby & Hayman, 1987; Kelley, Jacoby, & Hollingshead, 1989). Conceptual influences on this test are considered minimal because priming is unaffected by manipulations that vary conceptual encoding (Graf & Ryan, 1990; Jacoby & Dallas, 1981; Roediger & McDermott, 1996, but see Brown & Mitchell, 1994; Thapar & Greene, 1994).

Hayman and Jacoby (1989) used three different study tasks in their experiment: Letter search with target letters presented either before (precue condition) or after (postcue condition) the letter string and lexical decision (deciding whether a string of letters constitutes an English word). To determine whether lexical processing occurred in the two letter search conditions, the speed of letter search in words and nonsense letter strings was compared. The word superiority effect, faster letter search for words than for nonsense letter strings (Reicher, 1969; Wheeler, 1970), was used as evidence of lexical processing. The word superiority effect was obtained in the postcue but

not in the precue condition. These results provided evidence of lexical processing in the postcue but not the precue condition. At test, significant priming was observed after postcue letter search and lexical decision tasks, but no priming was observed after precue letter search tasks. Thus, word identification priming depended on lexical processing at study.

There is also evidence of the importance of lexical processing at study for subsequent word fragment completion priming, another perceptual priming measure. In a typical word fragment completion test, participants are presented with word fragments (e.g., *e ph t* for *elephant)* and are asked to complete the fragment with the first word that comes to mind. Priming is measured by more success in solving fragments for which study words have been seen relative to baseline fragments corresponding to unstudied words. It is a form of perceptual priming because, like word identification priming, it is affected by the changes of modality and surface features of the words between study and test and not enhanced by conceptual processing at study (Roediger et al., 1989; but see Challis & Brodbeck, 1992). Word fragment completion is unaffected by crossmodal divisions of attention as long as participants are required to make some sort of response to the words at study (Mulligan, 1998; Mulligan & Hartman, 1996). Weldon (1991) reported that pronouncing the words at study resulted in greater priming on word fragment completion tests than did passive viewing. Weldon proposed that even perceptual forms of priming benefit from lexical and visual perceptual processing of words, even though they may not benefit from additional semantic processing necessary to produce conceptual priming.

Color naming, identity processing, and priming

Thus, study tasks that divert attention from the spatial location in which the words are presented or eliminate lexical processing would be expected to reduce perceptual repetition priming. However, color naming does neither. First-line evidence of lexical processing during color naming comes from the pattern of reaction times to words, nonwords, and color words. Stroop (1935) observed that naming the color of the ink of a word is slower when the word itself is an incompatible color name (e.g., RED printed in green ink) and faster when the word is a compatible color name (e.g., RED printed in red ink). Also, naming the color of a word is slower than naming the color of a nonsense letter string (Dalrymple-Alford, 1972; Klein, 1964). At the very least, these findings indicate that lexical (i.e., differential processing of letter strings depending on their lexical status) and semantic (i.e., accessing the meaning of color terms) processing of words usually occur during color naming (Henik, 1996; MacLeod, 1991).

Another line of evidence for both lexical and semantic processing during color naming comes from semantic priming studies. Normal or nearly normal semantic priming is observed in lexical decision after participants name the color of the prime word (Bauer & Besner, 1997; Besner & Stolz, 1998; Besner, Stolz, & Boutilier, 1997; Chiappe, Smith, & Besner, 1996) when the prime immediately precedes the target. This is in sharp contrast with other nonsemantic tasks, such as letter search. When participants perform a letter search on the prime, no semantic priming is observed. This combination of results is not easily handled by existing accounts. Neither color naming nor letter search entails conceptual processing of the words, but the consequences of the two tasks for semantic priming are different. Besner and colleagues proposed that lexical processing is controlled by the task context. A letter search task demands resources normally used for later stages of word identification, such as activation of meaning, and thus these later stages of word identification must be blocked, whereas a color-naming task allows word identification to run to completion because it does not use these specific resources.

Several recent studies examined repetition priming after color naming. Szymanski & MacLeod (1996) reported that repetition priming is preserved in a lexical decision task after color naming at study relative to reading at study. Stone, Ladd, Vaidya, and Gabrieli (1998) reported diminished

word identification priming after a color-naming task. These findings suggest that repetition priming may not be uniformly preserved after color naming and that a combination of selective visual attention to the word and lexical processing that occurs during color naming is not sufficient to ensure that all forms of repetition priming will be preserved.

Goals of the present experiment

It is important to establish which of these priming measures are reduced or eliminated by color naming at study to develop better understanding of the mechanisms underlying different forms of repetition priming. In this experiment, we examined two widely used perceptual priming measures: word identification (Jacoby & Dallas, 1981) and word fragment completion (Tulving et al., 1982).

Some of the evidence described earlier suggests that both forms of perceptual priming may depend on visual selective attention or lexical processing at study. However, even if this is the case, a color-naming task does not prevent either selective visual attention (participants attend to word location) or lexical processing (which could be evidenced by word versus nonword effects in color naming). Thus, if the priming on these tests is diminished after color naming, neither principle would describe why.

In addition, we explored another measure of priming: preference for previously seen stimuli (Kunst-Wilson & Zajonc, 1980; Mandler, Nakamura, & Van Zandt, 1987; Zajonc, 1968). Preference for studied over new stimuli may be different from other forms of implicit memory in that it may be based on an emotional response to stimuli that precedes cognitive evaluation (Kunst-Wilson & Zajonc, 1980; Zajonc, 1968). One common way of demonstrating this phenomenon is with a forced-choice procedure. At test, participants see pairs of items and are asked to select one that they like better on every trial. On each trial, a previously seen (studied) and a new (baseline) item are paired. Priming is reflected by greater than chance preference for studied relative to baseline items. This effect was demonstrated to not be sensitive to crossmodal division of attention (Seamon, Brody, & Kauff, 1983). Unlike other forms of repetition priming (Norman, 1993), preference priming is observed with exposure durations that are too short to allow consistent conscious identification of stimuli at study (Bornstein, 1992; Kunst-Wilson & Zajonc, 1980, Mandler et al., 1987; Seamon, Marsh, & Brody, 1984). One possibility, advocated by a number of researchers, is that this kind of priming results from perceptual or other kinds of fluency in the processing of the stimuli that participants attribute to liking the stimulus more (Bornstein, 1992; Bornstein & D'Agustino, 1994; Mandler et al., 1987; Reber, Winkielman, & Schwarz, 1998). These authors believe that the preference for studied stimuli is simply another case of perceptual priming. The question of what kind of fluency in processing would result in such priming effect has been addressed by a recent study in which both visual perceptual fluency and response or phonological fluency was found to contribute to the preferences for studied stimuli (Vrana & Van den Bergh, 1995).

Thus, certain unique features of priming with preference judgments (e.g., its affective properties and the presence of subliminal effects) make it possible that color naming would affect this form of priming differently from other perceptual priming measures. However, if this form of priming behaves like other perceptual priming measures after color naming, it will provide additional evidence in favor of perceptual fluency explanation and indicate some common mechanisms affecting both perceptual priming and priming with preference judgments.

EXPERIMENT

METHOD

Participants

Undergraduate students from West Valley College *(n* = 80) took part in this experiment and received course credit for their participation. All participants were native speakers of English, reported normal color vision, and were 18-35 years old.

Apparatus

The experimental stimuli were presented using a Power Macintosh computer and PsychLab software version 1.092. Reading and color-naming reaction times were collected with voice-activated relay, connected to the computer.

Stimuli

The stimuli were 48 English words, seven to eight letters long, with an average frequency of occurrence of 5.79 per million (Kucera & Francis, 1967) and 48 pronounceable nonwords (Turkish words or pseudowords), all eight letters long, selected from Zajonc (1968). Half of the words and half of the nonwords were randomly assigned to study list A, and the remaining half of the items were assigned to study list B. There were 24 words and 24 nonwords on each list. Each word and each nonword was assigned a color, with six words and six nonwords on each study list assigned one of four possible colors. Within each study list, the items were arranged in pseudorandom order with the constraint that no more than three words or three nonwords and no more than three items of the same color appeared in a row.

Test lists for the word identification test were created by combining words from lists A and B in pseudorandom order with the constraint that no more than two words from the same list or no more than three words of the same color appeared in a row. Thus, for participants who studied list A, list B was baseline, and for participants who studied list B, list A was baseline. Two test forms were created, with half of the words from each study list (A and B) on each form appearing in the same color as in the study list and the remaining half appearing in different color. The assignment of color correspondence condition to the words was counterbalanced across the two test forms. For the fragment completion test, the same test forms were used, but each word was replaced by a four-letter fragment (e.g., *hi b e* for *thimble).* All fragments had unique solutions, represented by target words. Approximately half the letters were missing in each fragment, and no fragment contained more than two adjacent letters.

For the nonword preference test, the nonwords from study lists A and B were paired, with the constraint that both members of the pair were assigned to the same color at study. Two test forms were created, with half of the items on each list assigned to the same color of presentation and half assigned to different color of presentation. Both members of each pair were always presented in the same color at test (either the same as study or different from it). 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 study list A 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 list could appear in the same location (right or left) and no more than three items could appear in the same color in a row.

Design

The design was 2 (attention condition) X 2 (perceptual test condition). At test, 32 participants performed fragment completion and the remaining 48 participants performed word identification at test. All participants performed an affective preference test. Half of the participants in each of the perceptual test conditions read the words at study, and the remaining half named colors. Within each cell of the design, half the participants studied list A (and list B was used as a baseline) and the remaining half studied list B (and list A was used as a baseline). The assignment of test forms (1 or 2) was completely crossed with the assignment of study lists (A or B) within each cell of the design. The order of the perceptual and affective preference tests was counterbalanced within each cell of the design.

Procedure

At study, participants saw a fixation cross for 500 ms, then a word or a nonword for 1,000 ms. They responded by speaking into a microphone. Participants in the color-naming condition named the color of each letter string, and participants in the word-reading condition read each letter string aloud. After the participants responded, the computer advanced to the next trial. Participants were instructed to respond as quickly and as accurately as possible.

The fragment completion test consisted of a presentation of the four letter fragment for each word. Each fragment was preceded by a warning sign (fixation cross for 500 ms). Participants had 10 s to produce the word that completed the fragment. If they did not respond within this interval, the computer advanced to the next trial.

For the word identification test, each trial began with a fixation cross presented for 500 ms. Then a forward mask consisting of a row of 10 Xs was presented for 100 ms, followed by a word for 30 ms. The word was immediately masked by another row of Xs, and this backward mask remained on the screen until response. If no response was given, the experimenter pressed a key to advance to the next trial. The exposure durations were chosen after pilot studies revealed that they produced approximately 50% of correct identifications of baseline (unstudied) items.

For the preference test, each trial began with a fixation cross presented for 500 ms. Then two nonwords were presented side by side, and participants were instructed to select the nonword they liked better by responding right or left (R or L key on the keyboard).

RESULTS

Study phase

Mean reaction times from the study phase are reported in Table 1. Results from the study phase were analyzed in a mixed ANOVA, with study task (reading, color naming) as a between-participants variable and type of item (word, nonword) as a within-participants variable. Color naming produced faster reaction times overall than reading, $F(1, 78) = 6.11$, $MSE = 242623.80$, $p < .02$, and words were responded to faster than nonwords, $F(1, 78) = 20.64$, $MSE = 62879.20$, $p < .0001$. However, the most important finding was study task by type of item interaction, $F(1,78) = 29.46$, MSE=62879.20, $p < .0001$. Participants were slower to name the color for words than for nonwords, $t(39) = 5.52$, $p < .0001$, indicating that lexical processing of the words occurred at study.

Table 1.

Reaction Times (and Standard Deviations) to Respond to Words and Nonwords in the Study Phase

Mean median reaction times (standard deviations)		
Study condition	Word	Nonword
Color naming	852 (365)	817 (365)
Reading	835 (189)	1233 (561)

Word fragment completion test

The mean proportions correct for baseline and studied conditions and standard deviations are presented in Table 2. The fragments at test were of three kinds: corresponding to the target word from nonstudied list, or baseline; corresponding to the target word from studied list and appearing in the same color, or same color studied; and corresponding to the target word from studied list and appearing in a different color, or different color studied. For each participant, proportions of fragments of these three kinds completed correctly were computed. If the fragments were not completed within 10 s they were scored as incorrect.

To determine whether change of color from study to test made a difference, we obtained priming scores for each condition and then performed a mixed-variable ANOVA with color type (same as study, different) as a within-participants variable and study task (reading, color naming) as a between-participants variable. Neither the effect of color type alone, $F < 1$, nor the interaction between study task and color type was observed, $F < 1$. Thus, in all subsequent analyses, we collapsed across color type. To determine whether priming was affected by the study task, we performed a mixed-variable ANOVA with type of test item (baseline, studied) as a within-participants variable and study task (reading, color naming) as a between-participants variable. The effect of study task, $F(1, 30) = 1.08$, MSE= 197.16, $p > .30$, was not significant, indicating that overall there was no difference in the fragment completion accuracy between the color-naming and reading conditions. More fragments were completed correctly for studied than for baseline words, $F(1, 30) = 58.11$, $MSE = 99.50$, $p < .0001$, indicating that priming occurred. An interaction between type of test item and study task, $F(1, 30) = 11.17$, $MSE = 99.5$, $p < .01$, indicated that priming after color naming was lower than priming after reading. Despite being lower, priming was still present after color naming, $t(15) = 2.72$, $p < .02$. Performance with baseline words was lower in the reading than in the color-naming condition, but the difference between baselines was nonsignificant, $t(30) = 1.41$, $p < .17$. Thus, the observed effect resulted from greater correct fragment completion for studied words after reading than after color naming.

Table 2.

Percentage of Target Completions in the Word Fragment Completion Test

Mean percentage accuracy (standard deviations)

Study condition	Studied	Baseline	Priming
Color naming	36.98	26.30	10.68

Reading	(16.24)	(10.06)	27.34
	48.96	21.62 (8.64)	
	(12.41)		

Word identification test

The mean proportions correct for baseline and studied conditions and standard deviations are presented in Table 3. The analysis for this test was the same as the analysis for word fragment completion test described earlier.

As in the word fragment task, changing color from study to test made no difference in word identification priming. Neither the effect of color type alone, $F < 1$, nor the interaction between study task and color type was observed, $F < 1$. Thus, in all subsequent analyses, we collapsed across color type.

To determine whether priming was affected by the study task, we performed a mixed-variable ANOVA with type of test item (baseline, studied) as a within-participants variable and study task (reading, color naming) as a between-participants variable. The effect of study task, $F(1, 46) = 4.50$, $MSE = 732.90$, $p < .04$, indicated that participants were overall more accurate in their identification performance after reading than after color naming. More studied than baseline words were identified, $F(1, 46) = 70.98$, $MSE = 91.01$, $p < .0001$, indicating that priming occurred. An interaction between type of test item and study task, $F(2, 45) = 15.14$, $MSE = 92.09$, $p < .01$, indicated that priming was greater after reading than after color naming. Despite being lower, priming was still significant after color naming, $t(23) = 2.84$, $p < .01$. Baseline words were identified better after reading than after color naming, but the difference was nonsignificant, $t(46) < 1$. Thus, the observed effect resulted from greater correct fragment completion for studied words after reading than after color naming.

Table 3.

Percentage of Correct Identifications in the Word Identification Test

Mean percentage accuracy (standard deviations)

Study condition	Studied	Baseline	Priming
Color naming	47.57	39.06	8.51
Reading	(20.92)	(21.84)	23.91
	67.75	43.84	
	(17.87)	(20.41)	

Preference judgments

The mean proportions of preferences for studied items and standard deviations are presented in Table 4. The analysis for this test differed from the analyses described earlier because items were presented in pairs (one studied and one baseline item on each trial) and a forced-choice procedure was used to collect participants' responses. Thus, participants' responses to baseline and studied items were not independent of each other.

A mixed-variable ANOVA with study condition (reading, color naming) and color type (same, different) revealed an effect of study condition, $F(1, 77) = 4.07$, $MSE = 336.71$, $p < .05$, indicating that preferences were higher after reading than after color naming, but there was no effect of color type, $F < 1$, and no interaction between study condition and color type, $F < 1$. One-sample tests against a null hypothesis of no preference (proportion of studied items selected = .50) revealed a significant preference for studied items after reading, $t(38) = 2.92$, $p < .01$, but not after color naming, $t < 1$.

DISCUSSION

The broader question addressed by this study was about the role of selective attention to letter string identity upon priming on perceptual and preference tests. The experiment examined the effect of color naming at study on three different tests of repetition priming: word fragment completion, word identification, and preference judgments. All three forms of priming were lower for color naming at study than for reading at study.

Color naming was chosen as study task because it does not eliminate visual spatial attention to the location in which the stimulus is presented or lexical processing of the words, but it diverts attention from responding to stimulus identity by requiring a response based on stimulus color. Consistent with standard findings using Stroop task, analysis of study phase response times in our study revealed that participants processed the lexical identity of words because they were slower to name the colors of words than nonwords. Thus, neither selective visual attention to the location at which the string of letters was presented nor lexical processing of words was sufficient for full expression of repetition priming on the tests examined here.

Table 4.

Preference for Studied Nonwords

Study condition	Mean percentage preference (standard deviations)	Priming
Color naming	50.62 (15.95)	.62
Reading	56.58 (17.72)	6.58

Despite the lower priming after color naming than after reading, some priming was observed on word identification and word fragment completion tests. This may reflect small priming effects occurring on every trial for every word or occasional large effects averaged together with no effect on most trials. If the former is the case, a component of perceptual priming may be independent of selective attention to word identity. If the latter is the case, all aspects of perceptual priming may require selective attention, and small priming effect may be explained by an occasional failure of

selective attention. The present paradigm does not allow us to distinguish between these two possibilities.

None of the tests of implicit memory represents pure measures, and it is conceivable that the contribution from explicit memory to test performance was different in the two attention conditions. For example, it is possible that participants' test performance after the reading, but not after the color naming, may have reflected explicit memory contributions. However, this is unlikely because the two perceptual priming measures used in this study have been dissociated from explicit memory in patients with amnesia (Cermak et al., 1985; Vaidya et al., 1995) and normal participants (Jacoby & Dallas, 1981; Tulving et al., 1982). The explicit contribution to the preference effect was also minimal. Even after reading, preference for studied items was only 56% (i.e., only 6% above chance), whereas recognition is likely to have been much higher. Thus, the most plausible interpretation of our findings is that there is a genuine effect of selective attention on both perceptual and affective priming.

Both perceptual priming measures involved identifying words from incomplete (word fragment completion) or very briefly presented (word identification) cues. Identifying words from visual cues involves several major component tasks, such as extracting primitive visual features, determining letter identity, constructing pronunciation, retrieving meaning, and producing response. Any one of these constituent processes can benefit from savings through prior exposure to the same word in the context of the same or a different task. Because neither visual nor lexical processing per se was sufficient for the two forms of perceptual priming, the most likely additional candidate is the process of retrieving pronunciation from the orthographic representation of the word.

This process as a source of savings would be consistent not only with our findings but also with some earlier findings. Weldon (Weldon, 1991; Weldon & Jackson-Barret, 1993) underscored the importance of producing the same response (i.e., naming the word) at study for word fragment completion priming. Hayman and Jacoby (1989) demonstrated the importance of processing the word as a unit at study for subsequent word identification priming.

The preference effect was not statistically significant after color naming. Given the small magnitude of priming after reading, this finding may result from floor effects. The elimination of the preference priming after color naming is even more surprising. One possible explanation is that only words, and not nonwords, were encoded during color naming at study. However, previous studies demonstrate that even more restrictive encoding conditions often are sufficient to produce the priming effect on preference judgments. This effect is the only form of lasting priming that was reported with subliminal presentations, and it does not increase in magnitude if exposure durations are increased beyond 50 ms at study (Bornstein, 1992; Seamon et al., 1984). Our findings are difficult to reconcile with these previous results. Traditionally, such experiments involved no responses of any kind to the stimuli at study (Bornstein, 1992; Kunst-Wilson & Zajonc, 1980; Mandler et al., 1987; Zajonc, 1968). Both our control and our experimental conditions did require a response at study (reading or color naming). One difference between our task and previously used manipulations is the inhibition component potentially present at the time of response selection in color naming. However, it is unclear why unfamiliar nonwords would need to be inhibited in a color-naming task or how this inhibition would affect the affective encoding of the stimulus that presumably happens within first 50 ms of exposure. A recent study by Vrana & Van den Bergh (1995) demonstrated that naming the nonwords at study relative to passive viewing conditions results in greater priming effect on preference judgments. These authors suggested that phonological fluency and perceptual fluency contribute to this kind of priming. Our results are also consistent with the possibility that the fluency of computing pronunciation from orthography is an important component supporting the priming in preference

judgments. Thus, our study adds to the accumulating evidence that priming observed with preference judgments relies on the same mechanisms, at least in part, as other forms of perceptual repetition priming.

None of the priming measures were affected by the color correspondence between study and test. This indicates that the nature of the representation supporting these forms of priming is not a specific color word conjunction. The fact that color correspondence between study and test stimuli did not make a difference for the amount of priming suggests that no savings were accrued at the level of conjoining visual features to form visual letter representations in this case. Generally, task-irrelevant perceptual features rarely make a difference for priming. For example, color match between study and test did not make a difference for picture naming priming in one study (Cave, Bost, & Cobb, 1996), and other studies reported no effect of size change on picture naming (Biederman & Cooper, 1992; Park & Gabrieli, 1995). However, these findings may be very specific to stimulus presentation conditions in each experiment and may not apply to all presentation conditions. One of the more controversial findings is the effect of font correspondence between study and test on perceptual priming measures (Graf & Ryan, 1990; Jacoby & Hayman, 1987; Marsolek, Kosslyn, & Squire, 1992; Roediger & Blaxton, 1987; Vaidya, Gabrieli, Verfaellie, Fleischman, & Askari, 1998). This effect is found sometimes, but not always, and occurs only when the fonts used are unusual (Jacoby & Hayman, 1987) or the study phase task specifically involves paying attention to the font (Graf & Ryan, 1990; Vaidya et al., 1998). Thus, when a specific perceptual feature is made salient or task relevant, savings may be observed. With respect to color correspondence between study and test, perhaps if every letter were presented in different color at test and conjoining shape and color thus became an important aspect of word identification, savings in color-letter correspondence from study to test may have been observed.

It is becoming increasingly clear that attention in some form (e.g., at least visual spatial attention) may be an absolute requirement for any form of memory. Beyond this, each implicit memory test may have its own unique attentional needs not captured by the distinction between conceptual and perceptual measures of implicit memory. Our findings are consistent with the possibility that both perceptual and preference judgment measures of priming depend in part on the fluency in computation of pronunciation from orthography and that study tasks that prevent or interfere with such computation affect these measures of priming, even when they leave both visual and lexical processing intact.

Notes

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