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Associative priming in a masked perceptual identification task: Evidence for automatic processes

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Two experiments investigated the influence of automatic and strategic processes on associative priming effects in a perceptual identification task in which prime–target pairs are briefly presented and masked. In this paradigm, priming is defined as a higher percentage of correctly identified targets for related pairs than for unrelated pairs. In Experiment 1, priming was obtained for mediated word pairs. This mediated priming effect was affected neither by the presence of direct associations nor by the presentation time of the primes, indicating that automatic priming effects play a role in perceptual identification. Experiment 2 showed that the priming effect was not affected by the proportion (.90 vs. .10) of related pairs if primes were presented briefly to prevent their identification. However, a large proportion effect was found when primes were presented for 1000 ms so that they were clearly visible. These results indicate that priming in a masked perceptual identification task is the result of automatic processes and is not affected by strategies. The present paradigm provides a valuable alternative to more commonly used tasks such as lexical decision.

Since the first observation of priming effects for associated word pairs (Meyer & Schvaneveldt, 1971) and the proposal of the two-process theory of information processing (Posner & Snyder, 1975), researchers have investigated to what extent priming effects result from automatic and strategic processes (Balota & Lorch, 1986; de Groot, Thomassen, & Hudson, 1982, 1986; den Heyer, Briand, & Dannenbring, 1983; Keefe & Neely, 1990; Neely, 1976, 1977; Neely, Keefe, & Ross, 1989; Seidenberg, Waters, Sanders, & Langer, 1984; Shelton & Martin, 1992; Tweedy, Lapinski, & Schvaneveldt, 1977). The different contributions of

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strategic and automatic processes have been investigated primarily in lexical decision and pronunciation. Another task in which priming effects can be observed but one that has not been used very often is the masked perceptual identification task (Evett & Humphreys, 1981). In this task, primes and targets are masked, and therefore the influence of strategies might be eliminated. In the present paper we investigated to what extent priming effects in a masked perceptual identification task are caused by strategic and automatic processes.[1]

Automatic priming is a facilitatory process that results from the relation between words in long-term memory. In word-processing tasks, such as lexical decision, the response to a target word (e.g., *pepper*) is faster and more accurate if the target follows a related prime (e.g., *salt*) than if it follows an unrelated prime (e.g., *boy*). Automatic priming effects are often explained by the spreading activation theory (Anderson, 1983; Collins & Loftus, 1975); however, alternative accounts have been developed (Masson, 1995; Ratcliff & McKoon, 1988).

In addition to automatic processes, two strategies have been proposed that play a role in the occurrence of priming effects. A first strategy that has been proposed is an *expectancy-based* strategy (Becker, 1980; Neely, 1976, 1977; Posner & Snyder, 1975). According to this account, subjects generate an expectancy about the target after identification of the prime. Posner and Snyder suggested that a response is facilitated if the target matches the expectation. If the target does not match the expectation the response is inhibited. Thus, an expectancy-based strategy results in a *benefit* when the expectation is correct and in a *cost* when the expectation is incorrect. Neely (1976) showed that responses to a target preceded by a related prime are faster than responses to a target preceded by a neutral prime (i.e., a row of *X*s). Responses to a target preceded by an unrelated prime were slower than responses preceded by a neutral prime. This pattern of facilitation and inhibition suggests that strategic processes are at least partially responsible for the associative priming effect (however, see Jonides & Mack, 1984, for problems in interpreting performance relative to a neutral condition). As there is a cost to wrong expectations, the expectancy-based strategy will be used more frequently when the proportion of related targets is high. This hypothesis was confirmed by Tweedy, Lapinski, and Schvaneveldt (1977) who found larger priming effects for lists with a high relatedness proportion than for lists with a low relatedness proportion (see also de Groot, 1984; den Heyer, Briand, & Dannenbring, 1983). Further evidence for the use of an expectancy-based strategy was provided by Neely (1977).

A second strategy that has been proposed to play a role in the lexical decision task is a *postlexical relatedness checking* strategy (Balota & Lorch, 1986; de Groot et al., 1982, 1986; Neely et al., 1989; Seidenberg et al., 1984). In a lexical decision task, the subject has to make a binary decision about the lexical status of the target stimulus. An important characteristic of the primed lexical decision task is that there is a correlation between the relatedness of prime and target and the correct response. If the prime and target are semantically related the target must be a word, because nonwords are not semantically related to words. The relatedness checking strategy account assumes that subjects use this correlation in the decision process. Subjects will be biased to give a "word" response if they detect a relation between prime and target. It is further assumed that the absence of a relation will bias subjects to give a "nonword"

[1]The present paper is concerned with strategies that cause priming, not with strategies in general. Strategies play a role in every task. However, the aim of the presented study was to investigate the role of those strategies that affect priming. Thus, all claims in the present paper about the influence of strategies are limited to those strategies that affect priming, such as guessing strategies or postlexical relatedness strategies.

response. This strategy has been called postlexical because it is assumed to operate *after* both the prime and the target have been identified, but *before* a response is produced. Relatedness checking strategies are assumed to play a role in the lexical decision task because the presence/absence of a relation between prime and target gives information about the response. However, in pronunciation the presence or absence of a relation between the prime and the target does not give any information about the response that is to be given. Therefore, relatedness checking is assumed to play no role in pronunciation (Balota & Lorch, 1986; Pecher, Zeelenberg, & Raaijmakers, 1998; Seidenberg et al., 1984).

Priming effects are often investigated to test theories concerning the representation and retrieval of semantic information (e.g., Masson, 1995; McNamara, 1992; McRae & Boisvert, 1998; McKoon & Ratcliff, 1992; Zeelenberg, Pecher, de Kok, & Raaijmakers, 1998). These theories make predictions about *automatic* priming effects. A potential problem in the interpretation of the results of studies that test the predictions of these theories is that priming effects may be contaminated by strategic processes. Because of these strategic processes, priming effects may be obtained that are not the result of automatic processes (Seidenberg et al., 1984; Shelton & Martin, 1992). Alternatively, automatic priming effects may be *obscured* by strategies (Balota & Lorch, 1986; McNamara & Altarriba, 1988; Pecher et al., 1998).

A study by Shelton and Martin (1992) illustrates that strategies may critically determine the presence or absence of priming effects. Shelton and Martin studied nonassociative semantic priming effects (i.e., priming for semantically related word pairs that are not associated according to free association norms, for example *bird–fish*) in lexical decision and claimed that such effects are due to strategies instead of automatic processes. They argued that in the standard paired presentation procedure subjects notice the semantic relation between prime and target for pairs such as *bird–fish*. Because the detection of a relation implies that the target is a word, lexical decisions to related targets will be facilitated. Shelton and Martin supported their claim that nonassociative semantic priming is due to such a strategy by using a procedure that was designed to prevent subjects from noticing the relation between prime and target. They used a single presentation procedure in which the stimuli are presented not as pairs but in a long sequence of stimuli. According to Shelton and Martin this procedure makes the "pairing" of prime-target pairs less obvious, and consequently subjects will not use relatedness checking strategies. Using the single presentation procedure they found that priming was absent for nonassociative semantically related word pairs, but present for associatively related word pairs. Because of these results Shelton and Martin argued that automatic priming effects are caused by spreading activation between nodes at the lexical level of representation and not between nodes at the semantic level of representation. This example clearly shows that priming effects may be contaminated by strategies and, more important, that the elimination of strategies leads to a different theoretical account of automatic priming effects.[2] It is therefore important to develop experimental procedures that eliminate the use of strategies.

[2]Shelton and Martin's (1992) claim that nonassociative semantic priming is not supported by automatic processes has recently been challenged by some authors (Lund, Burgess, & Atchley, 1995; McRae, de Sa, & Seidenberg, 1997). These authors have argued that Shelton and Martin did not obtain nonassociative semantic priming because of the low semantic similarity of the word pairs in their study. These arguments are, however, irrelevant for the point we are making here, which is that incorrect conclusions concerning theories of automatic priming may be drawn if procedures are used that do not eliminate the influence of strategies.

One such procedure was developed by Evett and Humphreys (1981), who studied priming in a masked perceptual identification task. Evett and Humphreys used a four-field paradigm in which a trial consists of the following sequence: MASK–PRIME–TARGET–MASK. In this paradigm, the prime and target were presented very briefly, and subjects were asked to identify any words they perceived. Using this paradigm Evett and Humphreys obtained priming for associated prime–target pairs. The percentage of correctly identified targets was higher for associatively related pairs than for unrelated word pairs. Only a very low percentage of primes was correctly identified, which suggests that subjects could not have used the primes intentionally to respond more accurately to the targets. Therefore, Evett and Humphreys claimed that the priming effect could not have been due to strategies and thus was the result of a purely automatic process. Several other researchers have also argued that it is unlikely that priming effects are affected by strategies if the primes are masked (de Groot, 1983; Perea & Gotor, 1997; Williams, 1996), because expectancy generation and relatedness checking can be used only if the prime is consciously perceived.

The assumption that strategies are eliminated when the prime is masked critically depends on the inability of the subjects to identify the prime. The view that semantic priming may be obtained when conscious identification of the prime is prevented has been challenged by Holender (1986). He argued that priming effects with visually masked primes are more likely to be due to conscious identification of the primes on some proportion of the trials rather than to semantic activation of the prime without conscious prime identification. If indeed subjects identify the prime on a given trial, they may guess the identity of the target. Their guess is more likely to be correct if the prime and target are related, and this may explain the priming effect. The perceptual identification task may be sensitive to such a guessing strategy because the subjects have to make a response on the basis of incomplete stimulus information. The use of such a strategy would go against the assumption that priming effects with masked prime procedures are purely automatic. Given these considerations it is necessary to investigate the influence of strategies on semantic priming in masked prime procedures, instead of merely assuming that they are eliminated.

Let us consider how automatic and strategic processes may play a role in the perceptual identification task. Because the stimuli are presented briefly and masked, performance is based on incomplete stimulus information. Partial information comes from the perceptual input. These may be letter features or individual letters. The subject will try to use this partial information to retrieve the word from memory that is most likely to be the stimulus. Partial information from the prime may be insufficient for conscious prime identification, but may still provide additional information for the target. Therefore, semantic features extracted from the prime may aid the bottom-up identification of the target. This is more likely if prime and target are related, thus a priming effect may be observed.

However, if this bottom-up process of target identification fails, the subject may still try to guess the identity of the target on the basis of other information. In that case, if the prime stimulus has been identified, the subject may produce a strong associate of the prime and give that as a response. This strategy might seem similar to the expectancy-based strategy that may play a role in lexical decision and naming with long stimulus-onset asynchronies (SOAs). However, such a guessing strategy is different from the expectancy-based strategy because in the

Evett and Humphreys (1981) paradigm the SOA between prime and target is very short, around 40 ms. Thus, the subject will not have time to generate an expectancy before the target is presented. As we described earlier, it is more likely that the subject will generate an "expectancy" some time after both prime and target have been presented, and identification on the basis of perceptual information has failed. Note, however, that in the Evett and Humphreys paradigm the prime is rarely identified. Therefore it seems unlikely that such a guessing strategy will be effective.

The guessing strategy is different from the postlexical relatedness checking strategy that plays a role in lexical decision. First of all, postlexical relatedness checking plays a role *after* both prime and target have been identified. If the task is only to identify the stimuli, this strategy cannot affect performance. Second, the relatedness checking strategy plays a role only in binary decision tasks in which relatedness and response are correlated. Because the perceptual identification task that we use is not a binary decision task, performance will not be affected by relatedness checking.

The present series of experiments investigated Evett and Humphreys' (1981) claim that priming effects obtained in the perceptual identification task are the result of automatic processes. This was done by studying two different effects that have been used in previous studies to show the influence of automatic and strategic processes on priming in lexical decision and pronunciation. The first effect that we investigated is the mediated priming effect. Mediated priming refers to priming for word pairs that are related via a mediating association (e.g., lion–[tiger]–stripes). Thus, for mediated word pairs there is no direct association from the prime to the target (or vice versa). Mediated priming effects are presumably the result of automatic processes, because the relation between the prime and target is not obvious to the subject (Balota & Lorch, 1986; McNamara & Altarriba, 1988; Shelton & Martin, 1992). The second effect that we investigated is the relatedness proportion effect. It is usually assumed that under conditions of strategic priming, priming effects are larger when the proportion of related trials is high than when the proportion of related trials is low. Under conditions of automatic priming, however, the proportion of related trials does not affect priming.

The usual dependent variable in the perceptual identification task is the proportion of correctly identified *targets*. In addition, we collected two other measures to cheek for a strategy by which a subject guesses the target based on the identification of the prime. First, error responses were recorded, and we checked whether the errors in the unrelated condition consisted of words that would have been correct responses if the prime had been presented in the related condition. For example, if the prime–target pair *salt–boy* is presented, and the subject responds with *pepper*, this would likely be the result of a guess. This measure will give an estimate of the extent to which priming effects are due to such a guessing strategy. Second, we recorded the number of *trials* on which at least one word of the pair (prime, target, or both) was correctly identified. With this scoring method, if the subject guesses one word of the pair after identification of the other word this will not count as an extra identification. This way the influence of guessing is excluded from the performance measure and hence does not contribute to the priming effect. Note that this is a conservative estimate of the automatic priming effect, because automatic priming also might result in a higher probability of both words being identified in the related than in the unrelated condition.

EXPERIMENTS 1A, 1B, AND 1C
Mediated priming

An effect that may be used to study the contribution of strategic and automatic processes on priming is the so-called mediated priming effect. Mediated priming is priming for prime–target pairs that are *indirectly* associated via a mediator. For example, the words *lion* and *stripes* are not directly associated, according to free association norms, but they are indirectly associated via the mediator *tiger*. Several researchers have argued that mediated priming effects are the result of automatic priming and may even be eliminated if subjects use a postlexical relatedness strategy (Balota & Lorch, 1986; de Groot, 1983; McNamara & Altarriba, 1988; Shelton & Martin, 1992).

Balota and Lorch (1986) studied priming for mediated pairs (e.g., *lion*–[*tiger*]–*stripes*) in both lexical decision and pronunciation. They obtained priming for mediated pairs in pronunciation but not in lexical decision and argued that the priming effect for mediated pairs was masked by a relatedness checking strategy in the lexical decision task. Because subjects did not notice the relation between prime (e.g., *lion*) and target (e.g., *stripes*) the mediated word pairs were considered unrelated. As a result, responses to mediated targets were inhibited by a relatedness checking strategy. Balota and Lorch further argued that in the pronunciation task mediated priming effects occur because subjects do not engage in relatedness checking in this task.

These results indicate that mediated priming depends on automatic processes. Therefore, the observation of mediated priming in perceptual identification would give strong support for the hypothesis that priming effects in perceptual identification are the result of automatic processes. Moreover, it is unlikely that a mediated priming effect is the result of a guessing strategy, because the target is not directly associated to the prime. However, as we argued earlier, the relatedness checking strategy that masks mediated priming in lexical decision does not play a role in perceptual identification. Therefore, the present experiment can be used to show the presence of automatic priming, but not necessarily the absence of strategies. In Experiment 1A we presented only mediated word pairs. In Experiment 1B we presented both mediated and directly associated word pairs. McNamara and Altarriba (1988) observed that mediated priming in lexical decision was absent when directly associated word pairs were presented but present when no directly associated pairs were presented in the experiment. McNamara and Altarriba argued that the presence of directly related pairs in lexical decision leads to strategies that mask mediated priming. According to them, the use of strategies is minimized if no directly associated prime–target pairs are presented in the experiment, because subjects will not notice that on some occasions prime–target pairs are related. In other words, in the lexical decision task, the inclusion of directly associated prime–target pairs modulates the use of strategies that mask mediated priming. In the perceptual identification task, however, we expected no effect of the presence of directly associated word pairs on the mediated priming effect.

In both Experiments 1A and 1B the prime was presented for a short duration, identical to that for the target. This is the procedure that was used by Evett and Humphreys (1981). In Experiment 1C we presented the prime for a longer duration (i.e., 1000 ms). With this procedure, the prime is clearly visible, and the target is masked. Therefore, subjects can identify the prime and use it to guess the identity of the target. We predicted that this might affect priming for directly related pairs but not for mediated pairs.

Method

Subjects

A total of 26 students of the University of Amsterdam participated in each of Experiments 1A and 1B, and 32 students participated in Experiment 1C. All subjects were native Dutch speakers and reported normal or corrected-to-normal vision. Subjects received course credit for their participation.

Stimulus materials

A set of 58 mediated word pairs was created. Some pairs were selected from de Groot (1983), and some additional pairs were selected from published association norms (de Groot, 1980; Lauteslager, Schaap, & Schievels, 1986; van Loon-Vervoorn & Van Bekkum, 1991). The association frequency between prime and target was .00 in both forward and backward direction. The mean association frequency from prime to mediator was .43, and from mediator back to prime was .07. The association frequency from mediator to target was .27, and the association frequency from target back to mediator was .19. An additional set of 58 directly associated word pairs was selected to be used in Experiments 1B and 1C. The mean association frequency of these pairs was .56. The mean word frequency of the mediated targets was 147.6 per million (SD = 194.5). The mean word frequency of the direct targets was 99.5 per million (SD = 108.8). The mean word length of the mediated targets was 4.8 letters (SD = 1.3). The mean word length of the direct targets was 4.8 letters (SD = 1.3). For both sets of prime–target pairs unrelated word pairs were formed by recombining primes and targets from the related pairs. Two counterbalanced lists were constructed so that across subjects each word occurred equally often in the related and unrelated conditions.

An additional set of 20 pairs was selected for practice trials. Of these, 5 pairs were strongly associated, 5 pairs had a mediating relation, and the remaining 10 were unrelated. For the threshold task 60 unrelated pairs were selected (see Procedure). All words appeared only once during the experiment.

All stimuli were presented on a Hewlett Packard digital display module, model 1345A. This display allows variation of presentation duration in steps of 2 ms. Stimulus presentation and response collection were controlled by an IBM personal computer. The display consisted of a row of eight characters (letters and/or pattern mask characters). The primes were presented in lower-case letters and the targets in upper-case letters. Ten pattern mask characters were used, each consisting of seven randomly oriented lines. Each character covered approximately a visual angle of 0.6° horizontally and 0.9° vertically. The spacing between the centres of the characters was 0.3°. The total field subtended about 6.7° of the visual angle.

Procedure

Stimulus presentation was based on the four-field procedure of Evett and Humphreys (1981). A trial consisted of the following sequence: fixation point (700 ms), forward pattern mask (700 ms), prime, target, and backward pattern mask (700 ms). In Experiments 1A and 1B the presentation time for the prime was equal to that of the target and was determined individually for each subject (see later). In Experiment 1C the presentation time for the prime was always 1000 ms, and the presentation time for the target was determined individually for each subject. In all experiments the prime was presented in lower case and the target in upper case.

Stimulus words were centred in a field of eight characters. Word length varied from three to eight letters. When the stimulus word consisted of fewer than eight letters, the remaining positions were occupied by mask characters. These mask characters were selected at random from a set of 10 different mask characters. Within a trial a position was always occupied by the same mask character for each of the four stimuli.

Subjects were tested individually in a normally lit room. The screen was situated about 60 cm in front of the subject. Subjects were told that the experiment was about the perception of words. There was no time pressure, and the subjects were told that on each trial two words would be presented. They were asked to report any word they could identify. The relation between the words of each pair was not mentioned. The experimenter recorded for the prime and target separately whether the response was correct or incorrect (i.e., whether the named word corresponded exactly to the presented prime and target). If the named word was incorrect the experimenter recorded the word in order to be able to identify possible guessing strategies. After the subject made a response, feedback was given by presenting the same word pair again without masks for 1 s during both the practice and the experimental parts of the experiment.

Before the experimental task started the subjects performed 20 practice trials. After the practice trials each subject received a series of 60 threshold trials in order to determine the presentation time for the primes and targets. During this procedure unrelated prime–target pairs were presented. In Experiments 1A and 1B, both prime and target were presented for six different durations (10 trials for each duration): 26, 32, 38, 44, 50, and 56 ms. The different durations were used in random order. During the threshold-setting task no feedback was given about the identity of the prime and target. A logistic function was used to fit the psychometric function for each individual subject.[3] The parameters of the best fit were used to estimate the stimulus duration at which the subject would correctly identify the target in 40% of the presentations. This estimated presentation time was subsequently used during the entire experiment. The threshold-setting task was followed by the experiment proper. The presentation procedure of prime and target in Experiment 1C was identical to that of Experiments 1A and 1B, except that the prime was presented for 1000 ms during all phases of the experiment.

Results

The mean percentages of correctly identified targets are shown in Table 1. The data were analysed using two-tailed t tests.

Experiment 1A. For mediated word pairs more targets were identified in the related condition than in the unrelated condition, $t(25) = 2.66$, $p < .02$. Thus, there was a priming effect for mediated word pairs. We also analysed the percentage of trials on which either prime or target, or both, were correct. With this measure identification of a second word after correct identification of the first word does not count, so guessing the second word on the basis of the first one does not contribute to this measure. In other words, if subjects were able to identify the prime and subsequently guessed the identity of the target, this guess would not contribute to our measure and consequently not affect our estimate of the priming effect. Note that this measure gives a conservative estimate of "true" perception because all second correct responses are excluded, although not all these responses necessarily are guesses. With this scoring method too, the priming effect was significant, $t(25) = 2.16$, $p < .05$. The prime was correctly identified on 4.8% of the trials. In order to identify possible guessing strategies used by the subjects we also looked at the types of error that were made. Most errors were orthographically related to the target or were a "blend" of letters from the prime and target (e.g., *liar* for *lion–near*). None of the errors that were made in the unrelated conditions were the associate

[3]The logistic function is a mathematically convenient function to represent psychometric functions (e.g., Bush, 1963). By relating the proportion of correctly identified targets, P, to presentation time, t, this function is as follows: $P = X/(1 + X)$, with $X = \exp(a + bt)$, where a and b are the parameters. Choosing the logit form for P results in: $\text{logit}(P) = \log[P/(1 - P)] = a + bt$, and a and b are estimated by means of standard least squares fitting.

TABLE 1
Percentage of correctly identified targets in Experiments 1A, 1B, and 1C

			Mediated pairs		*Direct pairs*	
Experiment	*Prime duration*		*M*	*SD*	*M*	*SD*
1A	Short[a]	Related	45.4	11.3		
		Unrelated	40.2	13.5		
		Priming	5.2			
1B	Short	Related	46.4	10.3	44.3	11.4
		Unrelated	41.0	10.6	34.7	9.3
		Priming	5.4		9.6	
1C	Long	Related	45.2	13.4	68.3	15.3
		Unrelated	39.5	13.8	42.1	18.6
		Priming	5.7		26.2	

[a]Mediated pairs only.

of the prime (the "mediator", e.g., *red* for the pair *tomato–blood*) or the mediated target that would have been correct if that prime had been presented in the related condition. The mean target duration was 42.8 ms ($SD = 6.1$).

Experiment 1B. For the mediated pairs more targets were identified in the related condition than in the unrelated condition, $t(25) = 2.98$, $p < .01$. Thus, again there was priming for mediated word pairs. For the direct pairs more targets were identified in the related condition than in the unrelated condition, $t(25) = 3.91$, $p < .001$. Thus, there was also a priming effect for directly related word pairs. Analyses of the percentage of trials on which either prime or target, or both, were correct showed a marginally significant priming effect for mediated pairs, $t(25) = 1.97$, $p = .06$, and a significant priming effect for directly related pairs, $t(25) = 3.57$, $p < .01$. The prime was correctly identified on 8.6% of the trials. No incorrect responses in both the unrelated mediated and unrelated direct conditions would have been correct if that prime had been presented in the related condition. No incorrect responses in the unrelated mediated condition were the direct associate to the prime. The mean target duration was 34.8 ms ($SD = 7.6$).

Experiment 1C. For the mediated pairs more targets were identified in the related condition than in the unrelated condition, $t(31) = 2.29$, $p < .05$. Thus, again there was priming for mediated word pairs. For the direct pairs more targets were identified in the related condition than in the unrelated condition, $t(31) = 7.27$, $p < .001$. Thus, there was also a priming effect for directly related word pairs. Analyses of the errors indicated that subjects were using a guessing strategy in this task. Of all the incorrect responses in the unrelated conditions, 5.5% were directly related targets that would have been correct if the prime had been presented in the related condition. In the mediated condition, 6.9% of the responses were the mediator that was directly associated to the prime (e.g., *tiger* for the pair *lion–stripes*). None of the errors were the mediated target that would have been correct if the prime had been presented in the related condition. These results clearly indicate that subjects used a guessing strategy when they could easily identify the target. This guessing strategy affected direct priming but not mediated priming, as was confirmed by the three-way (Prime Duration × Relatedness × Type of Relation) interaction in the combined data for Experiments 1B and 1C, $F(1, 56) = 7.91$, $p < .01$, $MSE = 123.2$. The mean target duration was 37.1 ms ($SD = 6.1$).

Discussion

Several studies have shown that mediated priming effects are the result of automatic processes (Balota & Lorch, 1986; de Groot, 1983; McNamara & Altarriba, 1988; Shelton & Martin, 1992). Therefore, the finding of mediated priming in the present study indicates that automatic priming effects can be obtained in a masked perceptual identification task. However, Experiment 1 also showed that mediated priming was obtained irrespective of whether subjects were using a guessing strategy. That is, in Experiment 1C subjects were using a guessing strategy, but we still obtained a mediated priming effect. Therefore, the presence of a mediated priming effect cannot be used to argue that strategies are absent. The next experiment used the relatedness proportion effect to investigate whether strategies may affect priming effects in perceptual identification.

EXPERIMENTS 2A AND 2B
The relatedness proportion effect

The earliest studies on the influence of strategies on priming effects manipulated the proportion of related prime–target pairs. Tweedy et al. (1977) observed larger priming effects for stimulus lists with a high proportion (.875) of related prime–target pairs than for a list with a low proportion (.125) of related prime-target pairs. The relatedness proportion effect has been replicated several times (de Groot, 1984; den Heyer et al., 1983; Keefe & Neely, 1990; Neely et al., 1989). It is generally assumed that automatic priming effects are not affected by the proportion of related word pairs. Strategies, on the other hand, are affected by the proportion of related word pairs because they make use of the fact that prime and target are related on some proportion of the trials. The larger the proportion of related word pairs, the more useful it is to employ a strategy. Thus, the higher the relatedness proportion, the more likely it is that a strategy will be used.

The present experiment manipulated the relatedness proportion, in order to study the influence of strategic processes, such as guessing, on priming effects in the perceptual identification task. In Experiment 2 we presented a list of stimuli that had either a high proportion of related pairs (.90) or a low proportion of related pairs (.10). If priming effects in the perceptual identification task are due to strategies a relatedness proportion effect should be observed. In two experiments we manipulated the duration of the prime. In Experiment 2A we presented the prime for a short duration. The target was presented immediately following the prime. Because both prime and target are masked we expected no proportion effect in Experiment 2A. In Experiment 2B we presented the prime for a longer duration (1000 ms). In this procedure, the prime is clearly visible, and the target is masked. In Experiment 2B, subjects can identify the prime and use it to guess the identity of the target. Such a guessing strategy will be more effective with a high proportion of related prime–target pairs than with a low proportion of related prime–target pairs. Therefore, we predicted a relatedness proportion effect in Experiment 2B.

Method

Subjects

In Experiment 2A, 104 students of the University of Amsterdam participated. In Experiment 2B, 60 students participated. Subjects were randomly assigned to either the low or the high proportion condition. All subjects were native Dutch speakers and reported normal or corrected-to-normal vision. They received course credit for their participation. No person participated in more than one experiment of the present study.

Stimulus materials and apparatus

A set of 40 critical related prime–target pairs were selected from published word association norms (de Groot, 1980; Lauteslager et al., 1986; van Loon-Vervoorn & Van Bekkum, 1991). The same critical pairs were used in both the high and low proportion conditions. The mean association frequency from prime to target was .55 (range .23–.94). The mean word frequency of the targets was 102.5 per million ($SD = 155.9$). The mean word length of the targets was 4.5 letters ($SD = 1.2$). Unrelated word pairs were formed by recombining primes and targets from the related pairs. Two counterbalanced lists were constructed, so that across subjects each word occurred equally often in the related and unrelated conditions but no subject saw any target word more than once during the experiment. Each subject saw 20 pairs in each condition.

An additional set of 160 filler pairs that consisted of strong associates (mean association frequency .49, range .13–.93) was selected from published norms. Two versions of the filler list were created. For the high relatedness proportion condition all filler pairs were presented intact. For the low relatedness proportion condition the filler pairs were recombined to form unrelated word pairs. Thus, for the entire set of stimuli, the proportion of related word pairs was .90 in the high proportion condition and .10 in the low proportion condition.

The practice set consisted of 20 pairs. In both conditions the relatedness proportion of the practice list was identical to that of the stimulus list used in the experiment proper. A set of 60 word pairs were selected for threshold trials. These pairs were all unrelated word pairs that were matched with the experimental pairs on word frequency and word length. No word appeared more than once during the entire experiment.

Procedure

The procedure was identical to that of Experiment 1. In Experiment 2A the prime was presented for a very short duration (i.e., the presentation procedure was identical to that of Experiments 1A and 1B). In Experiment 2B the prime was presented for 1000 ms (i.e., the presentation procedure was identical to that of Experiment 1C).

Results

The percent correctly identified targets for the different conditions are shown in Table 2.

Experiment 2A. In both the low and the high relatedness proportion conditions, targets were correctly identified more often in the related than in the unrelated condition. A two-

TABLE 2
Percentage of correctly identified targets in Experiments 2A and 2B

			Relatedness proportion			
			Low		*High*	
Experiment	*Prime duration*		*M*	*SD*	*M*	*SD*
2A	Short	Related	56.1	16.5	52.0	18.6
		Unrelated	49.1	13.7	43.3	13.8
		Priming	7.0		8.7	
2B	Long	Related	69.7	14.1	91.0	8.7
		Unrelated	55.2	17.3	51.2	16.2
		Priming	14.5		39.8	

Note: Low relatedness proportion: 10% related prime–target pairs. High relatedness proportion: 90% related prime–target pairs.

factor analysis of variance (ANOVA) with proportion (low vs. high) as a between-subjects factor and relatedness (related vs. unrelated) as a within-subjects factor showed that the main effect of relatedness was reliable, $F(1, 102) = 24.17, p < .001, MSE = 132.1$. The main effect of relatedness proportion was marginally significant, $F(1, 102) = 3.49$, $p = .06$, $MSE = 365.5$. Identification was slightly better in the low proportion condition than in the high proportion condition. More important, however, relatedness proportion did not interact with prime type, $F < 1$. Thus, the proportion of related word pairs did not affect the size of the priming effect. Simple effects showed that the priming effect was reliable both in the high proportion condition, $F(1, 102) = 15.07, p < .01, MSE = 132.1$, and in the low proportion condition, $F(1, 102) = 9.43$, $p < .01$, $MSE = 132.1$.

In order to identify possible guessing strategies used by the subjects we also looked at the types of error that were made. In the high relatedness proportion condition 0.28% of all the incorrect responses in the unrelated conditions were the associate of the prime that would have been correct if that prime had been presented in the related condition. In the low relatedness proportion condition this was 0%. The small percentage of "would be correct" guesses seems to be coincidental rather than the result of a guessing strategy. But even if it were due to guessing, it is too small to explain the observed priming effect.

Finally, we analysed the percentage of trials on which at least one word of the pairs (i.e., either prime or target, or both) was correctly identified. This analysis showed the same pattern of results as that in which we looked only at the identification of the target. An ANOVA showed a main effect of relatedness, $F(1, 102) = 23.03$, $p < .001$, $MSE = 2632.7$, a marginally reliable effect of proportion, $F(1, 102)$ 3.64, $p = .06$, $MSE = 371.0$, and no interaction, $F(1, 102) < 1$. These results are similar to those of the ANOVA for target identification. The prime was correctly identified on 6.2% of the trials. The mean target duration was 43.1 ms (SD = 7.3) in the low proportion condition and 41.1 ms (SD = 6.7) in the high proportion condition.

Experiment 2B. In both the low and the high proportion related conditions targets were identified correctly more often in the related than in the unrelated condition. A two-factor ANOVA with proportion as a between-subjects factor and relatedness as a within-subjects factor showed that the main effect of relatedness was reliable, $F(1, 58) = 159.1$, $p < .001$, $MSE = 139.2$. The main effect of relatedness proportion was also significant, $F(1, 58) = 8.12$, $p < .01$, $MSE = 277.7$. Identification was better in the high relatedness proportion condition than in the low relatedness proportion condition. More important, relatedness proportion interacted with prime type, $F(1, 58) = 34.6$, $p < .001$, $MSE = 139.2$. Thus, the proportion of related word pairs affected the size of the priming effect in Experiment 2B, which indicates that the priming effect was modified by strategic processing. Simple effects showed that the priming effect was reliable both in the high proportion condition, $F(1, 29) = 225.4$, $p < .001$, $MSE = 105.6$, and in the low proportion condition, $F(1, 29) = 18.3$, $p < .001$, $MSE = 172.7$. The error data showed that in the high relatedness proportion condition 15.4% of the incorrect responses were the associate of the prime that would have been correct if that prime had been presented in the related condition. In the low relatedness proportion condition this was 1.1 %. This further indicates that subjects used a guessing strategy when primes were clearly visible. The mean target duration was 42.3 ms ($SD = 7.0$) in the high proportion condition and 40.8 ms ($SD = 8.3$) in the low proportion condition.

Combined analysis of Experiments 2A and 2B. Finally, the data for Experiments 2A and 2B were combined to investigate the interaction between prime duration, proportion related, and relatedness. This three-way interaction was significant, $F(1, 160) = 19.52$, $p < .001$, $MSE = 134.7$, indicating that the relatedness proportion effect was larger for long presentation times than for short presentation times of the primes. In fact, as our data from Experiment 2A show, there was no relatedness proportion effect at all for short presentation times of the primes.

Discussion

Experiment 2A showed that priming effects are not affected by the relatedness proportion when primes are briefly presented and masked. In both the high and the low proportion conditions a reliable priming effect was obtained, and there was no interaction between relatedness proportion and priming. The lack of a relatedness proportion effect in Experiment 2A cannot be attributed to a weakness of our manipulation of relatedness proportion (.90/.10). In prior studies weaker manipulations (de Groot, 1984: .25/.75; Tweedy et al., 1977: .125/.875) have resulted in rather large relatedness proportion effects. These effects were attributed to strategies. Moreover, in Experiment 2B in which the primes were presented for 1000 ms so that they were clearly visible, a large relatedness proportion effect was observed. The absence of a relatedness proportion effect in the perceptual identification task of Experiment 2A constitutes evidence that when the prime is briefly presented priming in perceptual identification is the result of automatic rather than strategic processes.

GENERAL DISCUSSION

In two experiments we investigated the influence of automatic and strategic processes on priming effects in a masked perceptual identification task. In both experiments we found evidence for automatic priming effects, whereas we found no evidence for strategic priming effects when both prime and target were presented briefly. In Experiment 1 we obtained priming for mediated word pairs. The mediated priming effect was not affected by the presence of direct associates, contrary to what is found in lexical decision (McNamara & Altarriba, 1988). Nor was mediated priming affected by the manipulation of prime duration, although this manipulation clearly affected direct priming. Taken together with other studies that showed that mediated priming is the result of automatic processes, these results show that priming in masked perceptual identification can be the result of automatic processes. In Experiment 2 we showed that the proportion of related pairs does not affect priming effects when the prime is masked. We also showed that if the prime is clearly visible the priming effect is greatly affected by the relatedness proportion. Thus, the proportion manipulation leads to the use of strategies in a paradigm that allows for these strategies to operate. The absence of a proportion effect when primes are masked strongly suggests that priming effects in perceptual identification are not affected by strategies. An analysis of the errors provided additional evidence that subjects did not use a guessing strategy when primes were briefly presented.

Many researchers have taken great pains to adjust their experimental procedures in order to prevent the influence of strategies on priming. One important adjustment has been to present primes only very briefly, followed by a pattern mask or by the target (which is also an effective mask). In these studies the idea is that primes are not available to conscious awareness, thereby preventing the use of strategies (de Groot, 1983; Perea & Gotor, 1997; Sereno, 1991; Williams, 1996). It has usually been *assumed* that the masking prevents the use of strategies. The present study provides experimental evidence that masking eliminates the use of strategies in masked perceptual identification.

The use and development of procedures that eliminate strategies is of primary importance. Many researchers (e.g., Carroll & Kirsner, 1982; McNamara & Altarriba, 1988; Shelton & Martin, 1992) have dismissed the results of other studies on the ground that those results were due to strategic influences. Using procedures that eliminated strategies, these researchers reached conclusions that were often opposite to what had been concluded in previous studies. Recently, there has been an increased interest in testing the predictions of different theories of automatic priming. The spreading activation theory has largely dominated the priming literature since the first observation of priming by Meyer and Schvaneveldt (1971). However, alternative theories of priming have been developed (e.g., Masson, 1995; Ratcliff & McKoon, 1988). Researchers have tried to design experiments to test the predictions of these theories (e.g., Masson, 1995; McNamara, 1992; McRae & Boisvert, 1998; McKoon & Ratcliff, 1992; Zeelenberg et al., 1998) to decide which theory gives the best account of priming. Experiments aimed at testing theories of automatic priming can be successful only to the extent that procedures are used that effectively eliminate the influence of strategies on priming effects.

In attempts to eliminate the influence of strategies there has recently been a lot of interest in tasks other than lexical decision to investigate word processing (Becker, Moscovitch, Behrmann, & Joordens,1997; de Groot, 1990; McRae & Boisvert, 1998; McRae, De Sa, & Seidenberg, 1997; Vriezen, Moscovitch, & Bellos, 1995). The alternative tasks that have been used are various types of semantic classification task such as animacy decision and size decision. These tasks have the advantage that relatedness can be uncorrelated with the yes/no response that has to be made, thereby preventing relatedness checking strategies. However, the presence or absence of strategies in these tasks has not been investigated systematically. Moreover, it has been argued that priming effects may depend on the extent to which a task requires a subject to engage in semantic processing (Becker et al., 1997). Evidently, an animacy decision task requires more semantic processing than a task such as perceptual identification. Therefore, the masked perceptual identification paradigm that was investigated in the present study is a valuable contribution to the paradigms that can be used to investigate the influence of automatic priming on word processing.

Summary and conclusions

The main result of the present experiments is that priming effects in masked perceptual identification are due to automatic processes and are not affected by strategies. Therefore, this paradigm offers a good alternative to other word-processing tasks that are used to study priming effects. It is a good alternative for the lexical decision task, which has been shown to be particularly sensitive to strategies. It also provides a more "perceptual" alternative to semantic classification tasks such as animacy decision. Evett and Humphreys (1981) argued that priming in perceptual identification is automatic because there is no conscious perception of the prime. We now have experimental evidence showing that associative priming in perceptual identification is indeed automatic.

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