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Unconscious semantic priming from pictures

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Abstract

Three experiments examined the effects of unconsciously presented picture primes on semantic categorization and naming responses to both word and picture targets. Picture naming and word categorization responses to targets were faster and more accurate when the picture primes belonged to the same semantic category as the targets, so called priming effect. No priming was found when subjects performed a word reading task. When priming was evident, no difference was found between responses to targets that were nominally identical to primes (e.g. the picture of a lion followed by either the word LION or the picture of a lion) compared with nominally different targets from the same semantic category as the primes (e.g. the picture of an ELEPHANT followed by either the word LION or the picture of a lion). Responding did not differ significantly from chance when subjects were asked to categorize the primes as natural objects vs. artifacts or as meaningful vs. meaningless objects in three distinct forced-choice unspeeded tasks. © 1999 Elsevier Science B.V. All rights reserved.

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1. Introduction

Can semantic information be extracted from unconsciously presented stimuli and subsequently influence overt behavior? This question has attracted attention from scientists for well over a century and the debate continues to rage to this day (e.g. Draine & Greenwald, 1998). The reason why no clear cut answer has yet been provided, is mainly because the question hides two difficult methodological problems. What is the appropriate operational definition of the term unconscious? What is the appropriate measure of the influence of semantic information on overt behavior? Concerning the first question, the problem is that too conservative a defini-

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tion will tend to hide true subliminal effects (see Debner & Jacoby, 1994; Reingold & Merikle, 1988 for arguments to this end), while too lax a definition will encourage erroneous report of such effects, as argued by Holender (1986) among others. Concerning the second question, the problem is to find a measure of semantic influence on subjects' performance that is sensitive enough to avoid committing a Type II statistical error (accepting the null hypothesis when in fact it should be rejected).

The present work follows the tradition of providing evidence for a dissociation between direct and indirect effects of unconsciously presented stimuli (Greenwald, Klinger & Schuh, 1995; Draine & Greenwald, 1998). More specifically, null effects are sought in direct measures (i.e. where subjects respond directly to the unconsciously presented stimuli) accompanied by non-null indirect effects (i.e. priming effects). Although criticized by some (see e.g. Reingold & Merikle, 1988; Debner & Jacoby, 1994; Merikle & Reingold, 1998), as noted by Greenwald et al., 1995 (see also Draine & Greenwald, 1998) it is theoretically important to know whether such a pattern can indeed be reliably observed.

The present study applies a conservative measure of prime non-detectability while testing for priming effects in three different tasks. This is done by combining the use of unconsciously presented picture primes with both a word categorization task, a word naming task, and a picture naming task. A specific point of interest in the present work is that, since Holender's, (1986) in-depth criticisms of the seminal paradigm proposed by McCauley, Parmelee, Sperber and Carr (1980) and extended by Carr, McCauley, Parmelee & Sperber (1982), the use of unconscious picture primes has not yet been reported in the context of studies that employed short (i.e. less than 1 s) prime-target intervals (see Bar & Biederman, 1998, 1999, for recent studies using long, i.e. 10–15 min, intervals, and Boucart, Grainger & Ferrand, 1995 for an analysis of visual priming effects with masked pictures). In the present experiments, a method was devised aimed at responding to those specific criticisms. In order to prevent changes in light adaptation, a direct measure of prime recognizability was established in conditions of constant environmental illumination and after a priming phase of testing in which stimuli were exposed on high-luminance backgrounds. Exposure duration of the prime stimuli and subjects' performance in the recognition test were independent, with prime stimuli constantly exposed for the minimal duration allowed by modern video devices. Prime recognizability was established in two conditions. In one condition (Experiment 1, Section 2 and 3), subjects were required to perform the same semantic categorization task (i.e. living thing vs. artifact) in the direct and the indirect measures. In the other condition (Experiments 2 and 3, Sections 4–7), subjects were required to categorize the primes as meaningful vs. meaningless objects.

2. Experiment 1A: priming

2.1. Method

2.1.1. Subjects

Eighteen undergraduate students (ten females) at the University of Provence volunteered to participate in this experiment for course credit. Their age ranged from 20–27 years. All were naive to the purpose of the experiment and all had normal or corrected-to-normal vision.

2.1.2. Stimuli

The picture stimuli consisted of the line drawings of 84 concrete concepts. Half of the stimuli depicted concepts belonging to artifactual categories (hereafter, artifactual subcategories: utensils, vehicles, etc.), and half of the stimuli depicted concepts belonging to natural categories (hereafter, natural subcategories: mammals, vegetables, etc.). Word stimuli were composed of the names of the picture stimuli. These two sets of stimuli were matched for name agreement and familiarity for the pictures, and length (in letters and syllables) and frequency for the words.

2.1.3. Procedure and design

The stimuli were displayed in black on a white background, on a 15-inch SVGA color computer screen (cathode ray tube; resolution 640×480 pixels) controlled by a 586 CPU. At a viewing distance of 80 cm, the dimensions of the picture stimuli ranged from 3.86–5.43° of visual angle (height), and from 3.72–4.50° of visual angle (width). Each letter subtended 0.35° (width) × 0.75° (height) of visual angle, and the space between adjacent letters was 0.1° of visual angle. Ten different masking patterns were generated by filling a square portion of the screen that subtended $6.0 \times 6.0°$ of visual angle with a blurred background. Each masking pattern was created so that no picture stimulus could be recognized (in free-viewing conditions) when the stimulus and the mask overlapped on the screen. Background, priming stimuli, words, and masks had a luminance of about 28, 25, 25 and 8 cd/m^2, respectively.

The sequence of the events on each trial is schematized in Fig. 1. On each trial, a fixation point (a black cross of 0.6°) was displayed in the center of the screen for 400 ms. At the fixation point offset, a randomly chosen masking pattern was displayed for 100 ms. Following the mask, a picture prime was exposed for 17 ms, followed by a blank screen for 17 ms[1]. At the offset of the blank screen, the same masking pattern as that exposed before the prime was displayed for 100 ms. Following the mask, a blank screen was presented until the onset of the target word. The exposure duration of the blank screen was set in order to obtain a prime-target stimulus-onset asynchrony (SOA) of 340 ms. The target remained in view until the subject's response was recorded (see below).

Subjects were instructed to decide as fast and accurately as possible whether the target word referred to a concept that was either an artifact or a natural thing by pressing one of two keys of a response box. Response times (RTs) were recorded

[1] The expedient of inserting a 17 ms blank interval between the prime and the post-prime mask, as well as setting the luminance parameters in the way described in this section of the article, was adopted in order to increase the probability to obtain central instead of energy masking of the prime (see Delord, 1998 and personal communication).

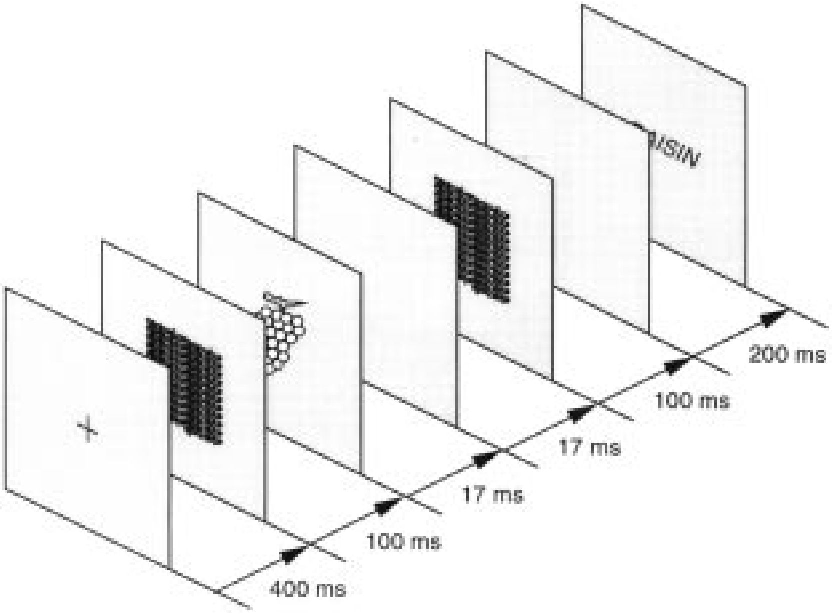

Fig. 1. Sequence of the events on each trial of Experiments 1A and 2A (Sections 2 and 4). In Experiment 3A (Section 6), the target word was replaced with a meaningful picture. In all recognition tests (Experiments 1B, 2B, and 3B, Sections 3, 5 and 7), the target word was replaced with string of 6 'Xs'.

from target onset until the subject's manual response. After the execution of the manual response, an intertrial interval of 2 s elapsed before the presentation of the fixation point for the following trial.

Two factors were independently manipulated within the present experimental design. The first factor was the Response Category of the target stimuli (i.e. natural thing vs. artifact). The second factor was the Priming Condition. Each target was presented in an 'identity' priming condition, i.e. preceded by the picture of the same concept as the target (for instance, the word DOG preceded by the picture of a dog); in a 'same-category' condition, i.e. preceded by a picture of a concept belonging to the same semantic subcategory (for instance, the word DOG preceded by the picture of a cat, i.e. both were domestic mammals); and in a 'different-category' priming condition, i.e. preceded by the picture of a concept belonging to the opposite Response Category (for instance, the word DOG preceded by the picture of a bike). The total set of 252 stimuli was presented in 6 different blocks of 42 stimuli each, with a short rest between the blocks. In each block, Priming Condition and Response Category levels were fully randomized within the constraint of having no more than four consecutive repetitions of the same response on successive trials. Hand-response pairings were counterbalanced across subjects. Before the beginning of the experimental session, each subject performed eight practice trials with stimuli that were not included in the experimental list.

2.2. Results

The analyses concentrated on correct RTs and error rates. Correct RTs were first screened for outliers using the procedure described by Van Selst and Jolicoeur (1994). This procedure resulted in a total loss of 2.8% of the correct trials, that were uniformly distributed across the cells of the present experimental design. Correct RTs and error rates were then submitted to ANOVA, with both subjects (F1) and items (F2) as random factors. Both Response Category (artifact vs. natural object) and Priming Condition (identity vs. same-category vs. different-category) factors were treated as within in the by-subjects analysis. Response Category was treated as between in the by-items analysis. The significance level chosen was $P < 0.05$.

2.2.1. RT analysis

A summary of the results is shown in Fig. 2 (left top panel). The overall mean RT was 641 ms. The main effect of Priming Condition was significant ($F1(2, 34) = 5.0$, MSe $= 1734$, $P < 0.015$ and $F2(2, 164) = 4.9$, MSe $= 4347$, $P < 0.01$), indicating slower responses in the different-category condition (658 ms) than in the identity and same-category conditions (635 and 628 ms, respectively). Mean comparisons indicated that identity and same-category conditions did not differ significantly ($F1(1, 17) = 1.38$, MSe $= 708$, $P > 0.26$), and both differed from the different-category condition (identity vs. different-category, $F1(1, 17) = 5.0$, MSe $= 1822$, $P < 0.04$; same-category vs. different-category, $F1(1, 17) = 6.0$, MSe $= 2674$, $P < 0.03$). The main effect of Response Category was significant ($F1(1, 17) = 30.5$, MSe $= 1163$, $P < 0.001$ and $F2(1, 82) = 10.3$, MSe $= 8164$, $P < 0.005$), reflecting faster responses to concepts belonging to natural categories (623 ms) than to concepts belonging to artifactual categories (658 ms). The interaction between Priming Condition and Category was not significant (all $F < 1$, $P > 0.90$). A further analysis examined priming effects conditionalized on prior trial type, namely, whether an identity or a same-category trial (collapsed) was preceded by an identity/same-category trial or by a different-category trial. The results are shown in Fig. 2 (right top panel). There was no difference in the amount of priming between these two conditions (all $F < 1$, $P > 0.6$). Greenwald, Sean and Abrams (1996) have shown that this pattern can be taken as a marker for unconscious prime-mediated activation. Indeed, in condition of conscious prime presentation, modulations of the amount of priming by prior trial type are often observed, in the form of reduced priming with a prior incongruent trial with respect to priming with a prior congruent trial.

2.2.2. Error rate analysis

The overall mean error rate was 3.0%. Mean error rates were analyzed as a function of the same factors as those considered for the RTs analysis. No factor reached the significance level ($F1 < 2$, $F2 < 1$, $P > 0.12$). In general, null effects of priming on accuracy performance with the low error rates observed in the present and all subsequent experiments are not problematic, and suggest that the subjects performed the

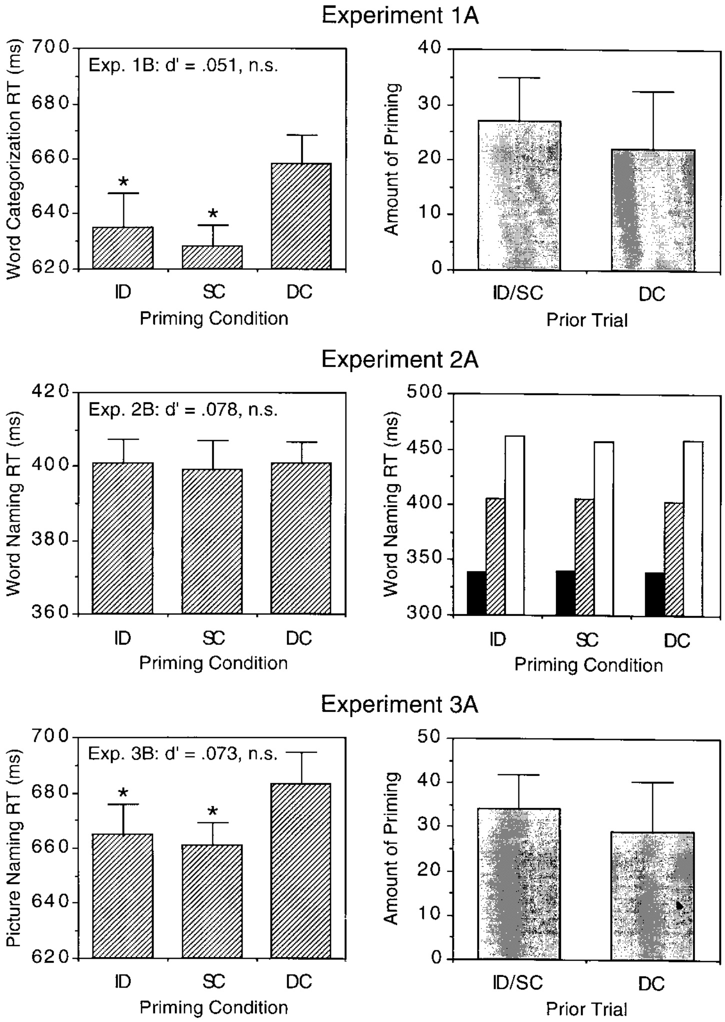

Fig. 2. Top panel (left): Mean RTs and 95% confidence intervals (Loftus and Masson, 1994) as a function of Priming Condition in Experiment 1A (Section 2) (in all graphs: ID, identity condition; SC, same-category condition; DC, different-category conditions). Top panel (right): Amount of priming as a function of prior trial type. Middle panel (left): Mean RTs and confidence intervals as a function of Priming Condition in Experiment 2A (Section 4). Middle panel (right): Mean RTs in Experiment 2A (Section 4) as a function of the three bins (black bars, short RT; shaded bar, medium RT; white bars, long RT) generated after a tertile-based split of the RT distribution. Bottom panel (left): Mean RTs and confidence intervals as a function of Priming Condition in Experiment 3A (Section 6). Bottom panel (right): Amount of priming as a function of prior trial type. In the left top and bottom panels, the asterisks indicate a statistically significant difference ($P < 0.05$) against the baseline provided by the different-category condition.

present tasks by withholding their responses until target information exceeded a self-imposed high-accuracy criterion (Grice et al., 1977).

3. Experiment 1B: recognition test

3.1. Method

3.1.1. Subjects

The same subjects who participated in Experiment 1A (see Section 2.1.1).

3.1.2. Stimuli

The picture stimuli consisted of the 84 line drawings used in Experiment 1A (see Section 2.1.2).

3.1.3. Procedure

The sequence of the events and experimental settings were the same as those employed in Experiment 1A (see Section 2.1.3) (Fig. 1). In the recognition test, each target was replaced with a string of six 'X'[2]. Subjects were informed that, on each trial of the experiment they had just carried out (i.e. Experiment 1A), a picture had been displayed before the onset of the target word. Before the recognition test, subjects were invited to focus on the stimuli presented before the fake target, and to try to decide whether the masked picture depicted a concept belonging to either an artifactual or a natural category. Subjects were invited to make each forced-choice response with no speed pressure using the same response box used in Experiment 1 (see Section 2.1.3), and the same hand-response mapping. The total set of 84 stimuli was presented in a single block. The stimuli were fully randomized within the constraint of having no more than four consecutive repetitions of pictures belonging to the same Response Category on successive trials.

3.2. Results

A direct measure of prime recognizability was computed for each subject in the form of the standard d' measures obtained by treating one level of the Response Category factor (i.e. natural) as signal, and the other level (i.e. artifact) as noise.

[2] It could long be argued about whether the replacement of the target word with a meaningless string of letters was correct in all the recognition tests reported in the present article. On the one hand, a possible objection would be that (1) we did not test prime recognizability in exactly the same presentation condition as in the 'priming phase', and (2) with this paradigm, possible effects of the context of presentation may dangerously vanish (e.g., backward effects of target presentation on prime recognizability; see Bernstein, Bissonnette, Vyas & Barclay, 1989). On the other hand, we chose not to present meaningful stimuli after the primes based on the bulk of evidence showing robust effects of conceptual masking when to-be-recognized pictures are followed by subsequent meaningful visual events (e.g. Potter, 1976; Intraub, 1984).

Mean d' was 0.051. A *t*-test against the null mean indicated that the mean observed d' was not significantly different from 0 ($t(17) = -1.33$, $P > 0.2$)[3].

4. Experiment 2A: priming

The results of Experiment 1A,B were clear-cut. A positive indirect effect in the form of priming was observed in the absence of any conscious perception of the prime stimuli as measured by the recognition test. In the spirit of investigating what type of information can be unconsciously activated following prime presentation, however, it must be noted that the present results are ambiguous. On the one hand, the null difference in the amount of priming for identity and same-category trials would lead one to suggest that activation from the primes is restricted to semantic category information. On the other hand, one alternative explanation may also be viable. Specifically, on the hypothesis that the priming effect observed in Experiment 1A was due to prime-mediated response facilitation/inhibition effects (e.g. Dehaene et al., 1998; see also Eimer & Schlaghecken, 1998), identity and semantic category were confounded in Experiment 1A because both types of information were associated with the same motor response. In order to overcome this confound and investigate this issue in more details, a word naming task was employed in Experiment 2A.

4.1. Method

4.1.1. Subjects

Twenty-one undergraduate students (12 females) at the University of Padova volunteered to participate in this experiment for course credit. The age of the subjects ranged from 19–30 years. All were naive to the purpose of the experiment and all had normal or corrected-to-normal vision. None had previously participated in Experiment 1.

4.1.2. Stimuli

The stimuli were selected from the material employed in Experiment 1A,B (see Section 2.1.2). Because of the different nationality of the subjects, in order to match the stimuli for frequency of the names, length in letters and syllables and familiarity, the set of stimuli was reduced to 72 pictures, 36 belonging to natural subcategories, and 36 belonging to artifactual subcategories.

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[3] On the basis of the results from Experiment 1B and 3B (see Sections 3.2 and 5.2) (i.e. the recognition tests associated with the experiments in which priming effects were evident), additional by-subjects analyses were carried out on RTs after excluding meaningful items that were correctly categorized on more than 50% of the cases in the recognition tests. There were three such items in Experiment 1B (Section 3), and four such items in Experiment 3B (Section 5). After exclusion of these items, the effect of Priming Condition was still significant for both Experiment 1A ($F(2, 34) = 4.3$, MSe = 1822, $P < 0.02$) and Experiment 3A ($F(2, 36) = 5.1$, MSe = 1899, $P < 0.01$). The pattern of results did not change.

4.1.3. Procedure and design

The sequence of the events, experimental settings and design were the same as those in Experiment 1A (see Section 2.1.3). Subjects were required to name each target word as fast and accurately as possible. Naming responses were recorded through a cardioid microphone, and naming RTs were measured from target word onset to the naming response. An intertrial interval of 3 s elapsed between a response on a given trial and the beginning of the next trial. Before the beginning of the experimental session, each subject performed eight practice trials with stimuli that were not included in the experimental list.

4.2. Results

The analyses concentrated on correct RTs and error rates. Elimination of the outliers resulted in a total loss of 2.3% of the correct trials, that were uniformly distributed across the cells of the present experimental design. The factors involved in the ANOVA were Category (artifact vs. natural object), and Priming Condition (identity vs. same-category vs. different-category).

4.2.1. RT analysis

A summary of the results is shown in Fig. 2 (left middle panel). The overall mean RT was 400 ms. The main effect of Category was significant ($F1(1,20) = 8.8$, MSe = 153, $P < 0.001$ and $F2(1,70) = 3.8$, MSe = 1094, $P < 0.06$), indicating slower responses to concepts belonging to natural categories (404 ms) than to concepts belonging to artifactual categories (396 ms). No other factor reached the significance level (all $F < 1$, $P > 0.5$). Given the overall faster RTs in the present experiment compared to RTs in Experiment 1A (see Section 2.2.1), a further analysis was carried out in order to test whether the amount of priming could depend on the speed in performing the word naming task. The RTs in each cell of the present design, for each subject, were divided into long, medium and short RTs following a tertile-based split of the total RT distribution. The results are reported in Fig. 2 (right middle panel). There was no hint of priming effect in any portions of the RT distribution (all $F < 1$, $P > 0.6$).

4.2.2. Error rate analysis

The overall mean error rate was 2.0%. Mean error rates were analyzed as a function of the same factors as those considered for the analyses carried out on RTs. The main effect of Category was significant ($F1(1,20) = 5.8$, MSe = 0.002, $P < 0.03$ and $F2(1,70) = 4.6$, MSe = 0.0042, $P < 0.04$), reflecting a higher error rate for concepts belonging to natural categories (3.0%) than for concepts belonging to artifactual categories (1.0%). No other factor reached the significance level (all $F < 1$, $P > 0.44$).

5. Experiment 2B: recognition test

5.1. Method

5.1.1. Subjects

The same subjects who participated in Experiment 2A (see Section 4.1.1) participated in the present recognition test.

5.1.2. Stimuli

The picture stimuli consisted of the 72 line drawings used in Experiment 2A (see Section 4.1.2) and 20 meaningless shapes selected from Dell'Acqua and Job's study (Dell'Acqua and Job, 1998) (see Fig. 3, for a sample).

5.1.3. Procedure

The sequence of the events and experimental settings were the same as those employed in Experiment 1A (see Section 2.1.3) (see Fig. 1). In the recognition test, each target word was replaced with a string of six 'X'. In a forced-choice test, subjects were invited to classify, with no speed pressure, the picture embedded in the sequence of masks as that of a meaningful object or a meaningless shape. The set of 20 different meaningless shapes was printed on a single sheet of paper, and shown to each subject before the beginning of the recognition test. The stimuli were fully randomized within the constraint of having no more than four consecutive repetitions of meaningful objects or meaningless shapes on successive trials.

5.2. Results

A direct measure of prime recognizability was computed for each subject in the

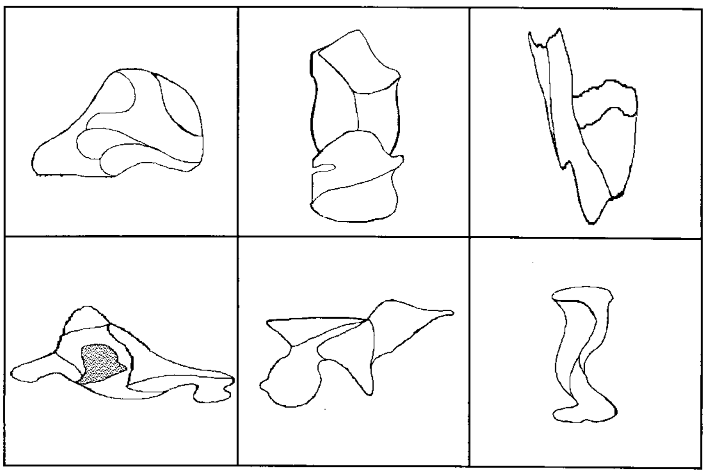

Fig. 3. Examples of meaningless shapes employed in Experiments 2B and 3B (Sections 5 and 7).

form of the standard d$'$ measures obtained by treating the meaningful objects as signal, and the meaningless shapes as noise. Mean d' was 0.078. A t-test against the null mean indicated that the mean observed d$'$ was not significantly different from 0 ($t(20) = 1.062$, $P > 0.3$).

6. Experiment 3A: priming

The results of Experiment 2A (see Section 4.2) showed no influence of semantically related picture primes in a word naming task. This result is in line with the general consensus that word naming is not semantically mediated in languages with relatively consistent spelling-to-sound mappings, such as Italian. On the assumption that semantic processing is mandatorily involved in naming pictures (see Johnson et al., 1996, for a review), we expect to reinstate effects of semantic priming in the picture naming task tested in Experiment 3.

6.1. Method

6.1.1. Subjects

Nineteen undergraduate students (9 females) at the University of Padova volunteered to participate in this experiment for course credit. The age of the subjects ranged from 20–33 years. All were naive to the purpose of the experiment and all reported normal or corrected-to-normal vision. None had previously participated in Experiment 1 or 2.

6.1.2. Stimuli

The stimuli were the pictures used in Experiment 2A,B (see Sections 4.1.2 and 5.1.2).

6.1.3. Procedure and design

The sequence of the events and experimental settings were the same as those in Experiments 1A and 2A (see Sections 2.1.3 and 4.1.3). In Experiment 3A, the target words of Experiments 1A and 2A (see Sections 2.1.3 and 4.1.3) were replaced with pictures. In order to avoid the possible influence of form overlap between prime pictures and target pictures, on each trial prime pictures were displayed randomly moved 2° of visual angle either to the left or to the right with respect to the central position. Target pictures were always displayed in the center of the screen.

The experimental design was the same as that used in Experiments 1A and 2A (see Sections 2.1.3 and 4.1.3). Subjects were required to name each target picture as fast and accurately as possible. Naming responses were recorded through a cardioid microphone, and naming RTs were measured from target onset to the naming response. An intertrial interval of 3 s elapsed between a response on a given trial and the beginning of the next trial. Before the beginning of the experimental session, each subject performed eight practice trials with stimuli that were not included in the experimental list.

6.2. Results

The analyses concentrated on correct RTs and error rates. Outliers elimination resulted in a total loss of 3.1% of the correct trials, that were uniformly distributed across the cells of the present experimental design. Correct RTs and error rates were then submitted to ANOVA, with both subjects ($F1$) and items ($F2$) as random factors. As in Experiment 1A, the factors involved in the ANOVA were Category (artifact vs. natural thing), and Priming Condition (identity vs. different-category vs. same-category).

6.2.1. RT analysis

A summary of the results is shown in Fig. 2 (left bottom panel). The overall mean RT was 679 ms. The main effect of Priming Condition was significant ($F1(2,36) = 6.4$, MSe $= 1759$, $P < 0.005$ and $F2(2,140) = 3.7$, MSe $= 2804$, $P < 0.03$), indicating slower responses in the different-category condition (683 ms) than in the identity and same-category conditions (665 and 661 ms, respectively). Mean comparisons indicated that identity and same-category conditions did not differ significantly ($F1(1,18) = 2.0$, MSe $= 1836$, $P > 0.20$), and both differed from the different-category condition (identity vs. different-category, $F1(1,18) = 6.0$, MSe $= 1086$, $P < 0.03$; same-category vs. different-category, $F1(1,18) = 9.5$, MSe $= 2353$, $P < 0.007$). The main effect of Category was significant ($F1(1,18) = 124.3$, MSe $= 1618$, $P < 0.001$ and $F2(1,70) = 14.3$, MSe $= 27352$, $P < 0.001$), reflecting slower responses to concepts belonging to natural categories (697 ms) than to concepts belonging to artifactual categories (613 ms). The interaction between Priming Condition and Category was not significant ($F1(2,36) = 2.3$, $P > 0.2$ and $F2 < 1$, $P > 0.68$). A further analysis examined priming effects conditionalized on prior trial type, namely, whether an identity or a same-category trial (collapsed) was preceded by an identity/same-category trial or by a different-category trial. The results are shown in Fig. 2 (right bottom panel). There was no difference between these two conditions (all $F < 1$, $P > 0.6$).

6.2.2. Error rate analysis

The overall mean error rate was 7.0%. Mean error rates were analyzed as a function of the same factors as those considered for the analyses carried out on RTs. The main effect of Category was significant ($F1(1,18) = 44.0$, MSe $= 0.0021$, $P < 0.001$ and $F2(1,70) = 8.8$, MSe $= 0.0208$, $P < 0.005$), reflecting a higher error rate for concepts belonging to natural categories (10.1%) than for concepts belonging to artifactual categories (4.5%). No other factor reached the significance level (all $F1 < 1.2$, $F2 < 1$, $P > 0.30$).

7. Experiment 3B: recognition test

7.1. Method

7.1.1. Subjects

The same subjects who participated in Experiment 3A (see Section 6.1.1) participated in the present recognition test.

7.1.2. Stimuli

The picture stimuli consisted of the 72 line drawings used in Experiments 2A and 3A (see Sections 4.1.2 and 6.1.2), and of the meaningless shapes described in Experiment 2B (see Section 5.1.2).

7.1.3. Procedure

The sequence of the events and experimental settings were the same as those employed in Experiments 1B and 2B (see Sections 3.1.3 and 5.1.3). In the recognition test, each target picture was replaced with a string of six 'X'. In a forced-choice test, subjects were invited to classify, with no speed pressure, the picture embedded in the sequence of masks as that of a meaningful object or a meaningless shape. The meaningless shapes were printed on a single sheet of paper, and shown to each subject before the beginning of the recognition test.

7.2. Results

As in Experiment 2B, meaningful objects were treated as signal, and the meaningless shapes as noise. Mean d′ was 0.073. A *t*-test against the null mean indicated that the mean observed d′ was not significantly different from 0 ($t(18) = 0.98$, $P > 0.3$).

8. General discussion

In the present experiments the influence of very briefly presented, pattern-masked, picture primes was investigated in three experiments involving semantic categorization of word targets, word naming, and picture naming. When targets belonged to the same semantic category as prime stimuli (living things or artifacts) responses were faster compared to different category primes when subjects had to categorize word targets as belonging to one of these categories (Experiment 1A, Section 2). Given that the same subjects performed at chance level when asked to directly categorize the prime stimuli (Experiment 1B, Section 3), this is clear evidence for unconscious activation of semantic information from picture stimuli. Furthermore, the fact that performance in the identity prime condition did not differ from the same category condition suggests that only gross semantic information, or task-relevant semantic information, can be extracted in such extreme conditions. In Experiment 2A (Section 4), the speeded naming aloud of word targets was not influenced by picture primes. This absence of picture-word priming can be explained as the result of two distinct properties of object and word naming: object naming is necessarily semantically mediated (i.e. the phonological form cannot be derived directly from a structural representation of the object), and word naming is not necessarily semantically mediated, at least in languages with relatively consistent spelling-to sound correspondences. Thus, a picture prime can generate semantic information that will not be used in word naming. On the other hand, this same information is used in picture naming, as demonstrated by the results of Experiment 3A (Section 6).

The finding of no identity prime advantage over same-category prime in the picture naming task of Experiment 3A (Section 6) (i.e. in the condition of maximal prime-target structural similarity), in line with the results obtained in the word categorization task of Experiment 1A (Section 2), concurs to support the idea that only gross semantic information was extracted from picture primes in the present testing conditions. This result points to a functional dissociation in the time-course of information activation following the presentation of masked visual stimuli. Bar and Biederman (1998) (see also Bar & Biederman, 1999) have shown priming effects for identical pictures but not for same-name different-shaped pictures in a paradigm in which subjects had to name subliminally presented pictures over intervals of 10–15 min, thus providing evidence for a long-lasting priming component that was completely visual. On the other hand, Greenwald et al. (1996) have provided results seemingly more compatible to the present results, by showing purely semantic priming effects restricted to conditions in which unconsciously presented prime-words were followed by to-be-categorized words at intervals of less than 100 ms. Future applications of the paradigm used in the present study should help specify the accumulation and decay functions of visual and semantic information extracted from picture stimuli.

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