Repeated prime–target presentations do not eliminate repetition and phonological priming in naming digits

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Abstract

In a recent article, Ferrand, Grainger and Segui (1994), using the masked priming paradigm with prime exposures brief enough to prevent prime identification, reported that the prior masked visual presentation of the same phonological word prime facilitates picture naming independently of whether the prime was the same word or a pseudohomophone. Moreover, in terms of percent facilitation, this priming effect was similar in size, suggesting that it resulted from the preactivation in memory of the phonological representation corresponding to the picture name. In the present study, we extend these results using (1) a new set of picture stimuli such as digit numbers, (2) a small number of highly trained subjects, and (3) repeated prime–target stimuli. We replicated this phonological priming effect and its similarity in size with the repetition effect: this effect remained robust even after the subjects had become very familiar with the stimuli, suggesting that it is a highly automatized and mandatory effect.

1. Introduction

Articulating the name that corresponds to the picture of a common object is a fast, efficient and relatively effortless cognitive skill. These aspects of performance obscure the complexity of the processes involved and experimental psychologists must therefore devise methods to unveil this obscurity (see, for example, Glaser, 1992; Riddoch and Humphreys, 1987).
1.1. Repetition and phonological priming in picture naming

Our paradigm capitalizes on the observation that the processing of a picture is facilitated when its written name is presented prior to picture presentation. This effect, known as the “repetition effect”, is one of the most robust experimental effects reported in the field of picture naming (e.g., Durso and Johnson, 1979; Wheeldon and Monsell, 1992). Picture naming experiments using long stimulus onset asynchronies, or with other words interfering between prime and target presentation (variable lag), and unmasked primes have consistently shown that the prior presentation of the same word facilitates picture naming in conditions where primes were clearly visible (e.g., Biggs and Marmurek, 1990; Durso and Johnson, 1979; Monsell et al., 1992; Wheeldon and Monsell, 1992). For example, prior experimentation by Durso and Johnson (1979) reported a robust repetition priming effect for picture naming primed by the prior reading aloud of the printed picture name (with variable lags ranging from 3 s to 5 min). Turning to phonological priming effects, a number of recent studies (Bajo and Canas, 1989; Collins and Ellis, 1992; Lupker and Williams, 1989; McEvoy, 1988) have reported that phonologically similar word or nonword primes do facilitate picture naming in conditions where primes are clearly visible or audible. For example, Collins and Ellis (1992), using a paradigm in which subjects repeated aloud auditorily presented primes and then named picture targets, reported that target pictures were named faster when prime and target shared phonemes in the same position (e.g., DOCK–DUCK). They also showed that the size of this phonological priming effect was very similar for word and nonword primes. Other studies using an interference paradigm (see Glaser, 1992) also demonstrated that phonologically similar word (or nonword) primes facilitate picture naming relative to unrelated controls (e.g., Lupker, 1982; Schriefers et al., 1990). In particular, Schriefers et al. (1990), using a paradigm in which the distractor words were presented auditorily, found that phonologically similar words (e.g., FOG when the target picture was DOG) facilitated picture naming latencies compared to unrelated words (e.g., ROOF when picture target was DOG).

However, since in the present study we are primarily interested in the highly automatized processes involved in normal picture naming, it is essential to avoid contamination by strategic and/or episodic factors. To this end we use the masked priming technique whose utility has been clearly demonstrated (see, for example, Ferrand and Grainger, 1992, Ferrand and Grainger, 1993; Forster and Davis, 1984; Sereno, 1991). In particular, Sereno (1991) demonstrated facilitatory effects of repetition (or identity) priming when prime words were masked and unavailable for conscious report in speeded naming.

1.2. Masked priming in picture naming

Recently, Ferrand et al. (1994) reported a series of picture naming experiments using the masked priming paradigm with prime exposures brief enough to prevent identification. A forced-choice “same–different” judgement task (Is the prime
word nominally the same as the target picture?) revealed that subjects' performance was at chance level, suggesting that very little precise information about the prime was available for conscious identification. This absence of awareness was taken as clear evidence for the automaticity of the processes under study. In their masked priming paradigm, the sequence of events was as follows: first a forward pattern mask (presented for 500 ms), followed immediately by presentation of the prime word for 29 ms, which in turn was followed by a backward pattern mask (for 14 ms), which finally was immediately followed by presentation of the target picture (which remained on the screen until subjects responded). The subject's task was to name the pictures as quickly as possible.

Ferrand et al. (1994) showed that picture naming was facilitated by the prior masked visual presentation of the same phonological word form (relative to unrelated controls and to appropriate orthographic controls), whereas a masked orthographic prime failed to facilitate picture naming (relative to unrelated controls). This robust and large facilitation effect was obtained independently of whether the prime was the same word or a pseudohomophone. Furthermore, this priming effect was similar in size (in terms of percent priming relative to unrelated controls) when the prime was the same word or a pseudohomophone. According to Ferrand et al., these results suggest that the representation underlying the masked repetition priming effect in picture naming is a phonological representation. Such a representation would be equally activated by a word or its corresponding pseudohomophone. These authors presented an activation model of picture naming in which the repetition priming effect and the pseudohomophone priming effect both result from the preactivation in memory of the phonological representation corresponding to the picture name. In this model picture targets first undergo some form of perceptual analysis that activates structural representations in memory which in turn provide activation input to an articulatory code. With picture targets, the articulatory output will receive activation from phonological representations. The interpretation that picture naming is principally influenced by the preactivation of phonological representations is strengthened by the fact that these priming effects (1) were measured against unrelated controls and appropriate orthographic controls, and (2) were similar in size when the prime was the same word or a pseudohomophone.

In the following experiments, we attempt to replicate this phonological priming effect using new set of picture stimuli such as digit numbers. Digit numbers can be viewed as graphic symbols: they are markedly more similar to pictures than to words since, as for pictures, there is no physical overlap between a digit number and its corresponding written name. As pictures, digit numbers have visual, phonological as well as semantic representations (e.g., Dehaene, 1992). Furthermore, the purpose of these experiments is to determine if the masked phonological priming effect decreases or remains stable as a function of prime-target repetition. In conventional priming studies, prime-target repetitions are avoided. Indeed, most investigators concerned with (repetition, phonological, orthographic or semantic) priming are careful to avoid target repetition and counterbalance their stimuli across subjects, the assumption being that target repetition may wash out
any facilitation priming effect. By giving subjects experience over ten blocks of 40 trials, we tested whether repetition of target pictures decreased the expected phonological priming effect. To this end, we use a small number of highly trained subjects with many trials. In Experiment 1, primes and targets were either repeated or unrelated. In Experiment 2, the same target pictures were used but primes and targets were either pseudohomophones or unrelated. If the repetition priming effect is indeed due to the automatic preactivation in memory of the corresponding whole-word phonological representation (as suggested by Ferrand et al., 1994), then it should remain regardless of whether the prime is the same word or a pseudohomophone throughout the ten repetition or trial blocks. Thus, the purpose of the present research is (1) to explore the reliability (through repeated sessions) and (2) the generality (using digits as pictures) of the masked phonological priming effect observed in picture naming (Ferrand et al., 1994), and (3) to test the assumption that multiple prime–target repetitions may wash out any facilitation priming effect in the priming paradigm.

2. Experiments 1 and 2

2.1. Method

Subjects
Four well-trained subjects, all members of the Laboratory of Experimental Psychology in Paris, participated in both Experiments 1 and 2 with a separation of several days. One of the well-trained subjects was the author himself. All four subjects were familiar with reaction times experiments in general and with the priming technique in particular. Subject L.F. was aware of the hypothesis, the three others were not. Each subject had served as an observer in a variety of priming experiments for two years or more. All were native speakers of French with normal or corrected-to-normal vision.

Stimuli and design
Twenty simple black-on-white drawings of digit numbers served as experimental pictures (0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 16, 20, 30, 100, 1000). In addition, there were ten practice pictures. The numbers were edited with WORD 4 (geneva font) and were digitized using a HP Scanjet IIc. At a viewing distance of 60 cm the mean angular size of the digit numbers was 2.5° horizontally and vertically. For word and nonword primes (in uppercase), each character covered approximately 0.38° of visual angle, so a four-letter word subtended about 1.53° of visual angle from a viewing distance of 60 cm. In Experiment 1, for each target picture two types of word primes were selected: (1) word primes that were identical to the target picture name (e.g., DEUX–2), (2) word primes that were unrelated to the target picture name (e.g., DIRE–2) but shared the same first phoneme as the target (as in Ferrand et al.’s experiments). As reported by Forster and Davis
(1991), it is important to have all primes begin with the same phoneme as the target, when using the naming task combined with masked priming, otherwise different onsets may produce an interference effect in target production. In Experiment 2, the target pictures were the same as in Experiment 1. However, the word primes from Experiment 1 were replaced by nonword primes that were either (1) homophonic to the target picture name (e.g., DEUT-2), (2) unrelated to the target picture name (e.g., DOIN-2). Subjects were tested repeatedly on ten blocks in each experiment, giving a total 400 trials. Participation in Experiment 1 and 2 was separated by several days. For each experiment, the subjects ran on average two sessions per day.

**Procedure**

Word primes and target pictures were presented on the center of the screen of a personal computer with a 70-Hz refresh rate. They appeared as black on white background. The masked prime procedure with the naming task used in the experiments of Ferrand et al. (1994) was adopted here. Each trial consisted of the following sequence of four stimuli (see Fig. 1): first a forward pattern mask was presented for 500 ms, this was immediately followed by presentation of the prime word for 29 ms, followed immediately by a backward pattern mask for 14 ms, which finally was immediately followed by presentation of the target picture both presented (the prime and the target) in the same screen location as the mask. The target picture remained on the screen until the subjects responded. Word primes were always presented in upper case. Subjects were asked to fixate the middle of the forward mask. They also were instructed to name as rapidly as possible the number depicted and naming latencies were the main dependent variable. The computer recorded the naming times, measured from the target onset to the triggering of the voice key by the subject’s response (Sennheiser MD211N microphone). The next sequence followed after a 2 s delay. Stimulus presentation was randomized, with a different order for each subject and each session.

![Fig. 1. Sequence of events in the masked priming paradigm used in the present experiments. The subject’s task was to name the target number as quickly as possible.](image)
Estimated visibility of the primes

A post-hoc measure of prime visibility was performed using the stimuli of Experiment 1. In order to assess the amount of information available to awareness, subjects were informed of the existence of a prime word. Subjects performed a forced-choice “same—different” judgement task, that is, they had to decide whether the prime was nominally the same as the picture target. Of course, subjects were informed that half the trials would contain prime words that were the same as the target and the remaining half would contain prime words that differed from the target. On twenty trials, two types of pairs were presented. On ten of the trials, word primes were identical to the target picture name; on the remaining ten, word primes were different from the target picture name. The overall percent correct rate was 47%. By chance alone, subjects would have been expected to judge the

![Diagram of naming latency over repetitions for different relatedness types](image)

Fig. 2. Mean naming latencies (in ms) in Experiment 1 for each subject and for the ten repeated sessions as a function of type of prime—target relatedness (identical vs. unrelated). Vertical bars represent standard errors.
stimuli identical correctly on 50% of the trials. Overall performance (47%) did not differ significantly from chance (50%), \( t(3) = 1.41, p = 0.12 \). None of the four subjects exceeded chance performance. In fact, performances were slightly below chance level. This estimate is very similar to those reported by Ferrand et al. (1994). These results show that subjects had very little information available from the prime stimuli.

2.2. Results

Experiment 1: Repetition priming

Mean naming latencies are given in Fig. 2 for each subject throughout the 10 repeated sessions. Relatedness (identical prime and unrelated prime) and repetition (10 sessions) were entered as main factors in an analysis of variance (ANOVA). The main effect of relatedness was statistically significant, \( F(1,3) = 40.67, p < 0.01 \), with shorter latencies for identical primes (435 ms) than for unrelated primes (449 ms). The latencies decreased from the first (483 ms) to the tenth session (419 ms), \( F(9,27) = 13.73, p < 0.001 \). The relatedness \( \times \) repeated sessions interaction failed to reach significance \( (F < 1) \). Because the error rates were consistently too low (less than 1%), no ANOVA was conducted.

Experiment 2: Phonological priming

Mean naming latencies are given in Fig. 3 for each subject throughout the 10 repeated sessions. An ANOVA was performed with relatedness (homophonic nonword prime or unrelated prime) and repetition (10 sessions) entered as the main factors. There was a significant effect of relatedness, \( F(1,3) = 119.26, p < 0.005 \), with shorter latencies for pseudohomophone primes (410 ms) than for unrelated primes (425 ms). The naming latencies decreased from the first (452 ms) to the tenth sessions (410 ms), \( F(9,27) = 16.24, p < 0.001 \). However, the relatedness \( \times \) repeated sessions interaction failed to reach significance \( (F < 1) \). Once again, since the error rates were consistently too low, no ANOVA was performed.

3. General discussion

The important result of the present study is the absence of any interaction between priming and repeated sessions. Thus the decrease in reaction time over repeated sessions is the same for all prime types. It is important to note however that the repetition and phonological priming effects were still robust. In fact, the amount of priming remained constant throughout the procedure and was about the same for both word and nonword primes. The finding that priming and prime-target repetition did not interact may be important from a methodological point of view. As already said in the introduction, most investigators concerned with priming are careful to avoid target repetition, the assumption being that target repetition may wash out any facilitation. The results of the present experiments indicated that priming does not diminish with repeated sessions, at least in the
The present experiments replicate the results of Ferrand et al. (1994) while using a small number of highly trained subjects and a new set of picture stimuli such as digit numbers. The present experiments show that picture naming is facilitated by prior masked presentation of the same phonological word form, thus replicating the results of prior studies using long lags and/or unmasked primes (e.g., Bajo and Canas, 1989; Collins and Ellis, 1992; Durso and Johnson, 1979). This robust and large facilitation effect was obtained independently of whether the prime is the same word or a pseudohomophone (see also Collins and Ellis, 1992). As can be seen from Figs. 2 and 3, the effects of repetition and phonological

masked priming paradigm with brief prime durations. Therefore, materials can be equated within subjects, thereby reducing the need for large sample. It would also be easy to work with stimulus sets that are relatively small by using multiple presentation of such stimuli sets, as done in the present experiments.

Fig. 3. Mean naming latencies (in ms) in Experiment 2 for each subject and for the ten repeated sessions as a function of type of prime–target relatedness (pseudohomophone vs. unrelated). Vertical bars represent standard errors.
Fig. 4. Net repetition priming effects (in ms) measured against unrelated controls in Experiment 1 and net phonological priming effects measured against unrelated controls in Experiment 2. Effects are given separately for each of the four subjects.

Net priming are very stable across subjects, repeated experimental sessions and experiments. Moreover, Fig. 4 shows the net effects of repetition and phonological priming for each of the four subjects tested in Experiment 1 and 2. As can be seen from this figure, the effects of repetition priming as well as the effects of phonological priming are very stable across subjects and experiments. Moreover, in terms of percentage of naming latencies, the magnitude of this facilitation effect was similar both to the repetition priming effect observed in Experiment 1 and the phonological priming effect observed in Experiment 2 (3.1% and 3.6% respectively).

Since this effect was obtained in conditions where prime were not identifiable by subjects, these results suggest that it is subtended by automatic, fast-developing processes. The question that arises is why prime–target repetition does not eliminate the priming effects. The two-process model proposed by Posner and Snyder (1975) is a useful framework to interpret the robustness of these repetition and phonological priming effects. These theorists argue that priming involves both an automatic spreading activation and a limited capacity attentional process which involves the subject's allocation of attention to the primes. Because automatic activation is supposed to be independent of attentional strategic processes, the facilitation priming effect should occur during repeated prime–target stimuli. Since the present results show that these priming effects remained robust even after subjects had become very familiar with the experimental stimuli, it appears that strategic processes play no role in the current procedure. Therefore, these results strengthen our interpretation that these priming effects are highly automatized, mandatory effects.

What these results also demonstrate is automatic phonological activation from a printed word. This result has already been obtained in visual word recognition
tasks such as perceptual identification (Perfetti et al., 1988; Perfetti and Bell, 1991), lexical decision combined with masked priming (Ferrand and Grainger, 1992, 1993) and naming (Lesh and Pollatsek, 1993).

Ferrand et al. (1994) presented a simple activation model of picture naming that capture the results of the present experiments. In this model, picture targets first undergo some form of perceptual analysis (picture processing units) that activates picture representations which in turn activate whole-word phonological representations in memory that then send activation to the articulatory output. According to this model, the phonological priming effect and the repetition effect both result from the preactivation in memory of the phonological representation corresponding to the picture name. This interpretation is strengthened by the fact that the priming effect for picture naming is similar in size (in terms of percent priming) for repetition priming and phonological priming (as in Ferrand et al., 1994). A printed word or its pseudohomophone equivalent (e.g., DEUT-DEUX) will both activate the corresponding whole-word phonological representation in memory and therefore facilitate subsequent picture naming much to the same extent.

From a methodological point of view, the masked priming technique combined with repeated prime–target presentations in picture naming appears to hold some promise for the study of basic higher-level cognitive processes. The present study suggests that this methodology can be usefully combined with a priming paradigm (particularly with short prime exposures) in the study of picture naming. It seems to be a useful complement to more traditional psycholinguistic approaches.

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References


