Psicológica (2000) 21, 39-59.

Implicit priming of picture naming: A theoretical and methodological note on the implicit priming task

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The recently introduced implicit priming task (Meyer, 1990, 1991) for the study of word production processes has already provided an impressive number of findings which are taken as the main support for the principle of serial encoding in production. However, prior results can as well be explained by an episodic memory retrieval account which does not resource to production processes. In experiment 1, this episodic memory account is tested in a picture naming version of the task, which minimizes episodic memory contributions. The implicit priming effect is replicated and therefore the standard production account is supported. Experiment 2 found a same-sized implicit priming effect in a standard implicit priming task using the same materials as in experiment 1, which was nevertheless statistically non-significant. Between-experiment comparisons showed that the memory components of the standard version of the task introduces noise in the data, and makes the picture naming version more suitable to study implicit priming effects in experimentally naive participants.

Key words: language production, phonological encoding, implicit priming, picture naming.

Classic language production research was mostly based on the analysis of speech errors, transient malfunctions that unintendedly occur in everyday speech as when a speaker says “in the nen text minutes” for “in the next ten minutes” (from Garrett, 1980; Butterworth, 1980). As it turned out, speech errors show striking regularities that allow a quite detailed story to be

* Acknowledgements. I am indebted to Alfonso Palma, Nicolás Gutiérrez and Pat O'Seaghdha for valuable comments and criticisms. The present research has been carried out within the project "Marcos estructurales y su utilización en producción del lenguaje", ref. PB 97-0805, funded by DGESIC, Ministerio de Educación y Cultura, Programa Sectorial de Promoción General del Conocimiento, 1999-2001. Address: Dept. de Psicología Experimental y Fisiología del Comportamiento, Universidad de Granada, Campus de Cartuja s/n, 18071-Granada, Spain. Email: santiago@platon.ugr.es

told about the normal workings of the language production processing component (see, e.g., Dell, 1986; Fromkin, 1971; Stemberger, 1985).

However, the limitations of this naturalistic approach were soon pointed out. For example, the error collector may be influenced by perceptual biases that affect differentially the detectability of some kinds of errors, or the distributional patterns in the language may affect their likelihood (Cutler, 1981). Although it was possible to devise statistical methods which take into account base chance levels (e.g., Dell & Reich, 1981; Stemberger, 1991) as well as experimental technics to elicit speech errors in controlled laboratory settings (see Baars, 1992, for a review), it was soon evident that theories of normal speech production should not be based almost exclusively on very unfrequent malfunctions of the system (Meyer, 1992).

Accordingly, recent years have witnessed a strong trend towards the development of experimental, mostly reaction time, tasks which allow us to test hypotheses using data from error-free trials, and a corresponding shift of interest from speech error to latency data. This is so to such extent that a very influential model of lexical access in speech production has already been developed with the main goal of explaining results from these more on-line tasks (see Levelt, Roelofs, & Meyer, 1999, for a recent review). However, the fast introduction of new research paradigms is a risky business, as there is a lack of well-established task analyses and it is often the case that there are different alternative explanations for a given outcome (for a recent controversy, see Roelofs, Meyer, & Levelt, 1996; Starreveld & La Heij, 1995; Starreveld & La Heij, 1996). My goal in this paper is to help clarifying the underlying mechanisms of one of these tasks, the implicit priming task, first developed by Meyer (1990, 1991).

The implicit priming task

In the implicit priming task (Meyer, 1990, 1991), participants are asked to learn three or four prompt-response word pairs in each block of trials. Each pair is chosen so that the prompt word acts as a strong and unambiguous semantic cue for its associated response word (e.g., fork-KNIFE; see the appendix for further examples). After participants study the pairings, the prompts are presented one at a time in random order several times during the block and response latencies measured. The key manipulation is the relationship that holds among the response words within a block of trials. In homogeneous blocks, the response words share some aspect, say, they all begin with the same syllable. In heterogeneous blocks, the same prompt-response pairings are rearranged so that they do not share their initial syllable. Sometimes sharing parts of the response leads to shorter response latencies in homogeneous than heterogeneous blocks. The standard interpretation assumes that this is due to output preparation: the participants are able to prepare the shared parts in advance of each trial in a homogeneous block and speed up the processing that leads to the production of the response word (Levelt, 1989; Levelt, Roelofs, & Meyer, 1999; Meyer, 1990, 1991; Roelofs, 1997a).

An important result from the implicit priming task is that sharing initial parts of the response words shortens reaction time, while sharing non-initial parts has no effect. Moreover, the priming effect increases linearly with the number of shared initial segments (Meyer, 1990, 1991)[1]. This constituted prime evidence for the seriality of phonological encoding, which is an important principle in Levelt et al's (Levelt, Roelofs, & Meyer, 1999; Roelofs, 1997a) model.

In a number of subsequent papers, Roelofs (1996a, 1996b, 1998) extended these results to morphological encoding. A greater priming effect was found when the initial syllable of a word is also a morpheme than when it is not. As before, shared non-initial morphemes produced no priming (Roelofs, 1996a), even when the initial morpheme is a particle and the non-initial morpheme is the base verb in a particle-verb combination (Roelofs, 1998). The principle of serial encoding therefore seemed to apply also to morpheme planning in production (Levelt, Roelofs, & Meyer, 1999).

Evidence obtained in the implicit priming task has also been taken to support other important assumptions of Levelt et al's model, namely that only minimally specified metrical representations for words are stored in the mental lexicon and retrieved during production (Roelofs & Meyer, 1998). These metrical representations contain only information about the word's total number of syllables and stress pattern, but not about its abstract CV structure. Roelofs & Meyer (1998) showed that the implicit priming effect from shared initial segments could only be obtained when the words also shared the total number of syllables and stress pattern. By contrast, sharing CV structure did not affect the magnitude of the implicit priming effect.

Finally, the implicit priming task has also been used to investigate other aspects of word production, such as the different effects of implicit versus externally presented primes (Roelofs, 1994), aspects of syllabification

[1] Although in the original studies by Meyer there was some indication of non-linearities related to syllable and word structure, subsequent studies have not been able to replicate this aspect of the results (Roelofs, personal communication, 1997; Costa & Sebastián, 1996).

(Roelofs, 1997b) and a number of subsidiary aspects to the issues above which have not as yet been published (see references in Levelt, Roelofs, & Meyer, 1999).

Summarizing, the implicit priming task has been used in a number of important recent studies on the mechanisms of phonological and morphological encoding, and its results are taken to support the principle of serial encoding. However, as it will be argued in the next section, there is one alternative explanation which is able to account for a majority of the details of published results and which does not resource to production processes, but to episodic memory retrieval processes. Because of the importance of ruling out such alternative hypothesis, I set to replicate the implicit priming effect in the present experiments under conditions that minimize episodic memory effects.

Memory-based analyses of the implicit priming task

The standard task analysis of the implicit priming task assumes that participants learn the association between prompt and response words, and when subsequently presented with a prompt, they retrieve its corresponding response word, encode it phonologically and produce it. The effect of homogeneity of initial parts comes about because participants are able to phonologically encode the initial parts of a response word in advance of its presentation in a homogeneous block, and hold them in some kind of output buffer, so that they are already in place when the word is presented. Because of the principle of serial encoding, non-initial parts of a word, although known, cannot be phonologically encoded before initial parts.

Implicitly assumed in this analysis is that homogeneity within a block does not affect any other process intervening between prompt presentation and response generation. As we will see, this assumption might be unwarranted. A key candidate is the process which retrieves from memory the correct response word for a given prompt. Published studies have not discussed which form may take the learning of prompt-response pairs and the prompt-cued retrieval of the response word. However, as it turns out, a likely account of this process is able to predict by itself most observed results in the implicit priming task.

When participants learn the set of three or four word pairs in each block, they may adopt two different mnemonic strategies. A first, *working memory* strategy consists in holding all word pairs in verbal working memory by means of continuous rehearsal (Baddeley, 1986). When a prompt is presented, it is first located in the articulatory buffer and the word following it is then produced. Little phonological encoding of the response word seems necessary under this account, because it is already in phonological form.

Many aspects of published results argue against the use of this working memory strategy in performing the implicit priming task. Firstly, when four word pairs are used, the total number of words exceeds the average short-term memory span of seven words (Miller, 1956) and it is likely to exceed 2 seconds of pronunciation time (Baddeley, Thomson, & Buchanan, 1975). As a consequence, participants are probably discouraged to rely only on their verbal working memory. Secondly, if they did, phonological similarity among words in homogeneous blocks is expected to produce competition, slowed rehearsal and more errors, as it does in inmediate memory tasks (Baddeley, 1966). Instead, as noted above, the typical result in the implicit priming task is facilitation in phonologically similar blocks.

A second *episodic memory* strategy bears more relevance to the obtained results. Under this account, when participants study the word pairs, they rehearse them together and establish an association between prompt and response words which is permanently stored with them in episodic long-term memory. The fact that prompt and response words are highly semantically associated probably fosters participants to attend to their meaning and adopt this strategy (Craik & Lockhart, 1972). When subsequently asked to retrieve a particular response word in a heterogeneous block they are presented with one retrieval cue: the prompt word. They access the meaning of the prompt and follow the episodic association created in the study phase with the meaning of the response, access it, encode it phonologically and produce it. Admitedly, this is the same as it is supposed to happen in the standard account of the implicit priming task. However, this episodic memory retrieval process depends on the number and efectiveness of available cues (Tulving & Osler, 1968; Tulving & Pearlstone, 1966), and this is not held constant across heterogeneous and homogeneous blocks. In homogeneous blocks, two retrieval cues are available to the participant: the prompt word plus the (implicitly informed) first segments of the response word. Put in another way, the participants may guide their retrieval of the response word both by the prompt word, which is a semantic and episodic cue, and by the fact that after a few trials in each block they realize that all response words begin with the same segments. This might produce a faster memory retrieval of the response word from episodic memory in homogeneous blocks.

The other characteristics of the observed implicit priming effects may be derived from the efectiveness of different cues for lexical retrieval from long-term memory. Investigations on the tip-of-the-tongue phenomenon (Brown, 1991; Brown & McNeill, 1966) have shown that when a speaker is unable to access the whole phonological form of a word which he knows (that is, when the word is 'in the tip of his/her tongue'), some partial aspects of its phonology may be preferentially retrieved, namely, the initial and, to a lesser extent, the final phonemes, its total number of syllables and stress pattern. These aspects of phonological form are also usually spared in phonologically-related word substitutions (or malapropisms, see Fay & Cutler, 1977), which has been taken to suggest that the word form lexicon is preferentially organized along these dimensions. These results agree with the initial segments of a word, its number of syllables and stress pattern being particularly good cues to access its phonological form.

Research using the cross-word puzzle paradigm provides compelling confirmation from what looks like a close analog to the implicit priming task (Dolinsky, 1973; Goldblum & Frost, 1988; Horowitz, White, & Atwood, 1968). In the cross-word puzzle paradigm, participants are presented with word fragments in a matrix of spaces, one for each letter, along with a semantic cue, and they are asked to retrieve the word that fits with the presented semantic and orthographic information. Studies using this task have found that the best retrieval cues are the initial letters of the word, followed by the final letters. The worst fragments are medial letters and unclustered letters. Fragments comprising pronounceable syllables seem to be more effective cues than same-sized fragments which are not syllables, and medial morphemes do not facilitate retrieval to a greater extent than medial syllables (Goldblum & Frost, 1988).

If production latencies in the implicit priming task are related to the ease of retrieval of the response word's phonological form, it is expected that initial segments will speed up production to a greater extent than final and medial segments, as it is repeatedly found. Other aspects of the results show similarities or lack a parallel because the studies under comparison did not manipulate the same variables. For example, cross-word puzzle studies have not tested whether the length of the initial fragment increases the speed and likelihood of retrieval, but it is reasonable to assume that it does so. The difference between medial and final fragments found in cross-word puzzle studies have not been systematically examined in implicit priming tasks: only Meyer (1991, exp. 4) included a medial condition, comprising only one segment, and found null priming, as well as she did with final segments in other experiments (see also Meyer, 1990). However, this result is based on a single between-experiment comparison of two null effects and should not be taken as conclusive. Advantages for initial segments comprising a whole syllable over non-syllabic ones were also found in the original studies on implicit priming (Meyer, 1991), although this result was not replicated in later studies (see references in footnote 1). The lack of efectiveness of morphemic units in fragment-guided word retrieval may be due to the fact that the morphemes tested were word-medial. Also untested in this paradigm are the effects of number of syllables and stress pattern as memory cues for words.

There are two main arguments against the analogy between cross-word puzzle and implicit priming tasks. The first argument is that the timing of the retrieval events is very different (e.g., Goldblum & Frost, 1988, found retrieval times in the order of seconds [mean 16.97 s in exp. 1, deadline for responding 30 s], while Meyer, 1990, reported production latencies in the millisecond range [mean 607 ms in exp. 1, deadline for responding 1000 ms]). However, it is possible that the number and effectiveness of retrieval cues carries its influence down to the level of highly automatized and rapid retrieval events. The second argument is that the cross-word puzzle task is based on orthographic information and the implicit priming task is based on phonological information. However, as Goldblum & Frost (1988) argue, given the long reaction times involved in the former and that it may not tap on-line processing, it is possible that both orthographic and phonological lexicons are implicated.

¿Can we use some aspect of already published results to sort out this alternative memory-based explanation of the implicit priming effects? The memory-based hypothesis predicts that the effect of retrieval cues should be greater the more demanding the task is on memory of newly learned associations. In other words, the less effective is the semantic cue, the more effective should be any other retrieval cue available in reducing response time. This leads us to expect an interaction between the implicit priming effect and the level of practice in producing the same prompt-response pairings. Some studies who have repeated the whole set of experimental blocks twice along the experiment have indeed reported effects of repetition (practice) and an interaction of repetition, implicit priming effect and order of homogeneous and heterogeneous blocks, but no one-way interaction between repetition and the implicit priming effect (Costa & Sebastián, 1996; Meyer, 1990, 1991). By contrast, other studies do not find this interaction (Roelofs, 1996a). The interaction reported has to do with the order of homogeneous and heterogeneous blocks having a strong effect in the first half of the experiment (the priming effect is bigger when the heterogeneous blocks come first), whereas it has no effect in the second half of the experiment (Meyer, 1990, 1991). The prediction of the memory-based hypothesis seems to be unsupported by available data. However, the fact that each independent prompt-response association undergoes its own time course of strengthening with practice following a non-linear function (weaker associations increase their strength to a greater extent than stronger associations), and the fact that the initial strength of the semantic cue for each response word is unknown do not let us state conclusively that the implicit priming effect cannot be adscribed to different degrees of retrieval easiness in homogeneous and heterogeneous blocks.

I should make clear from the outset that both explanations are not mutually exclusive. There is always the possibility that both memory retrieval processes and word production processes are making independent contributions to the implicit priming effect. In experiment 1, I set to replicate the implicit priming effect under conditions which minimize demands on episodic memory of prompt-response associations, namely by substituting a picture of a common object for the prompt word and asking participants just to name the picture aloud. Naming a familiar picture is an order of magnitude more automatic a process than producing a word upon presentation of a semantic cue which episodic association to the word has just been established. The memory-based hypothesis of the implicit priming task predicts that a reduced or null effect of implicit priming should be found under these conditions. On the contrary, if the standard explanation of the implicit priming effect is correct and memory retrieval is responsible for no part of its size, we should find a clear implicit priming effect. Experiment 2 was intended to allow a direct comparison of effect sizes by using exactly the same response words in a standard procedure.

EXPERIMENT 1

IMPLICIT PRIMING OF PICTURE NAMING

Experiment 1 was designed so as to maximize the chances of finding implicit priming as well as minimizing episodic memory contributions to production latencies. Only pictures of very high name agreement were used. Participants were also shown the pictures in advance and instructed to name them aloud, so that their tendency to use the expected name would be assured. Picture names in homogeneous blocks shared two initial segments, the first consonant and following vowel. Experimental blocks were repeated twice in order to assess the effect of repetition.

METHOD

Participants. Twelve undergraduate students from the University of Granada took part in the experiment and received course credit for their participation. All of them were native Spanish speakers and had normal or corrected to normal vision.

Materials. Eight response words were selected so that they corresponded to names of easily depictable objects. Four words started with the phonemes /pi/ and four words with /ka/. Pi-words were two syllables long, while ka-words were three syllables long. All of them followed the default penultimate stress pattern of Spanish. Response words were presented in two homogeneous blocks of four words each (one for the /pi/ and one for the /ka/ fragment) and two heterogeneous blocks (each one mixing two pi-words and two ka-words). Therefore, homogeneous blocks also shared total number of syllables and stress position, while heterogeneous blocks contained words differing in number of syllables and stress position counting from the beginning of the word (but not from the end). These conditions are adequate to find implicit priming effects (Roelofs & Meyer, 1998). Also, /p/ and /k/ initial phonemes were chosen because they showed strong implicit priming effects in Meyer (1990, exp. 1). Experimental items are listed in the appendix. Line drawings for the eight experimental words were drawn by hand by the author, and digitized into independent computer files. They were presented to a group of 5 pilot participants in order to assure 100% name agreement. They were also presented to participants in experiment 1 before the experiment itself to make sure that they also tended to use the selected names for these drawings. Four extra pictures where prepared for the practice block, which shared no fragment of their names.

Apparatus. The experiment was written in MicroExperimental (MEL) code (Schneider, 1988) and run in an IBM PS/2 30 286 personal computer. Voice onset latency was detected by means of a microphone Brigmton D-360L connected to a vocal key, and measured to the nearest millisecond.

Design. Reaction time and accuracy data were collected and analyzed as a function of 3 factors: Fragment (/pi/ versus /ka/), Context (homogeneous versus heterogeneous) and Repetition (first versus second).

Procedure. Participants were tested individually in a sound-isolated room. First, the participant read the instructions, which presented the experiment as a standard picture naming task in which the same pictures were to be named repeatedly in blocks of four. Instructions emphasized both speed and accuracy in naming the pictures. There were one practice block with the four practice pictures, and four experimental blocks repeated twice for a total of eight experimental blocks in the session.

The order of blocks was counterbalanced as follows. For the first participant, the two homogeneous blocks were presented first, followed by the two heterogeneous blocks. The order of blocks within each condition was reversed for the second participant. The third participant received the heterogeneous blocks first. Again, the order of blocks within each condition was reversed for the fourth participant. The following participants were assigned to the same four orders in sequence, making up a total of 3 participants in each different order. The second half of the experiment was always an exact repetition of the first part.

At the beginning of each block the participant was informed of the names of the four drawings that were to appear in that block. Within each block, each drawing was presented eight times, in different random orders for each block and participant. No inmediate repetitions of trials were allowed. Within each trial, a fixation point was presented for 500 ms, followed by a drawing for a maximum of 3000 ms. If a response was detected during this period, the drawing remained a further 500 ms after response onset and the screen was cleared. If no response was detected a message in the screen informed the participant about it. Intertrial interval was 500 ms long. The experimenter sat next to the subject facing another computer screen with the same display. Errors were defined as anything but a fluent production of the target word. Therefore, error responses included disfluencies (filled pauses and stutterings), misnamings (producing a wrong name), extraneous noises (lip smacks, coughs). Upon detecting an error, the experimenter stopped the experiment by pressing the space bar in the computer keyboard, notated down the error, and re-established the sequence of trials. This also gave subjects the opportunity to recover from the error.

Data analyses. Latencies below 200 ms and above 1500 ms were considered outlyers and discarded. Latencies of the eight repetitions of each item for each block and participant were averaged. Accuracy and latency data on correct trials were analyzed separately by means of independent ANOVAs both taking participants (F1) and items (F2) as random factors. All three factors (Fragment, Context and Repetition) were within-participant factors in the analysis by participants, while Fragment was a between-item factor and Context and Repetition were within-item factors in the analysis by items.

RESULTS

There were a total of 34 error trials (0,98%), and no response was detected on 4 trials (0,11%). Out of correct trials, 4 data points fell outside the range 200 to 1500 ms (0,11%) and were discarded. Table 1 presents the resulting means per condition.

Table 1. Mean latency and error percentages per condition.

Experiment 1

	Repetition 1		Repetition 2	
	Hom	Het	Hom	Het
pi-words	552 (0,025%)	570 (0,001%)	531 (0,020%)	554 (0,003%)
ka-words	563 (0,008%)	582 (0,005%)	536 (0,001%)	564 (0,005%)
mean	557	576	533	559

Experiment 2

	Repetition 1		Repetition 2	
	Hom	Het	Hom	Het
pi-words	755 (0,036%)	773 (0,026%)	699 (0,020%)	711 (0,013%)
ka-words	729 (0,030%)	755 (0,035%)	704 (0,021%)	711 (0,024%)
mean	742	764	701	711

Latency. I found a significant Context effect ($F1(1,11) = 23,709$; $MSe = 466,989$; $p < 0,001$; $F2(1,6) = 13,292$; $MSe = 283,072$; $p = 0,010$) and a significant effect of Repetition ($F1(1,11) = 10,868$; $MSe = 922,737$; $p = 0,007$; $F2(1,6) = 74,549$; $MSe = 44,822$; $p < 0,001$). There were no differences associated to different initial Fragments ($F1(1,11) = 2,079$; $MSe = 1009,434$; $p = 0,177$; $F2(1,6) = 2,266$; $MSe = 281,989$; $p = 0,182$), nor interactions (all Fs < 1, except for the interaction of Context and Repetition in the analysis by items: $F2(1,6) = 3,274$; $MSe = 24,822$; $p = 0,120$).

Accuracy. The reduced number of errors (less than 1%) renders their analysis by means of ANOVA suspicious, because it is highly possible that the assumptions of the analysis are violated by the data. However, an inspection of error percentages in table 1 shows that the conditions with shorter latencies are also less accurate. Because this may indicate the presence of a speed-accuracy trade-off, it seemed worthwhile to carry out the analysis and rely on the robustness of the ANOVA against violation of assumptions (Keppel, 1982).

Both Context and Fragment showed a trend to affect the accuracy of responses, which approached significance by participants and reached it by items (Context: F1(1,11) = 4,455; MSe = 0,00053; p = 0,058; F2(1,6) = 6,508; MSe = 0,00012; p = 0,043; Fragment: F1(1,11) = 4,400; MSe = 0,00030; p = 0,059; F2(1,6) = 9,391; MSe = 0,00004; p = 0,022). No interactions were detected (all Fs < 1, except for the interaction of Context and Fragment (F1(1,11) = 3,571; MSe = 0,00026; p = 0,085;

F2(1,6) = 2,542; MSe = 0,00012; p = 0,161). Summing up, accuracy was somewhat reduced in the homogeneous versus heterogeneous blocks, as well as for pi-words versus ka-words.

DISCUSSION

Experiment 1 found a clear and highly reliable effect of Context or implicit priming, which was estable across repetitions. An explanation of the implicit priming effect exclusively in terms of the relative easiness of retrieval from episodic memory in homogeneous versus heterogeneous blocks is therefore ruled out by present data.

However, there is a troublesome aspect in experiment 1 which might threaten this conclusion: accuracy was reduced in the homogeneous blocks compared to the heterogeneous blocks, suggesting that there might be speed-accuracy trade-offs in the data. If participants balanced speed of response with accuracy, the obtained implicit priming effect might be only an artifact of the conditions of this experiment. In order to test whether the effects on latency and accuracy arise from a common underlying speed-accuracy trade-off, I correlated the size of the implicit priming effect on latency and accuracy by participants (following Roelofs, 1996a). A speed-accuracy trade-off should manifest itself in a positive correlation between the difference in speed and the difference in accuracy between homogeneous and heterogeneous blocks by participants. By contrast, a non-significant correlation in the opposite direction was found (r = -0,188). It may be concluded that the Context effect on accuracy is not related to its effect on latency, sustaining the conclusion stated above.

Although a clear implicit priming effect was found in a picture naming task, ruling out possible explanations based on memory retrieval processes, experiment 1 does not let us assert that such memory processes are not making a contribution to the implicit priming effect as obtained in the standard version of this task. In other words, because the paired associates version of the implicit priming task places higher demands on episodic long-term memory, it is possible that the number and efectiveness of retrieval cues available in homogeneous versus heterogeneous blocks contributes to certain extent to the size of the effect. This predicts that the size of the implicit priming effect should be greater in the standard version than in the picture naming version. Experiment 2 was aimed to test this prediction.

EXPERIMENT 2

STANDARD IMPLICIT PRIMING

In order to test whether the size of the implicit priming effect changes from the picture naming version to the standard version of the task, experiment 2 used the same response words as experiment 1 and replicated it in all respects, except for the fact that the response words were elicited by prompt words, following the standard implicit priming procedure.

METHOD

Participants. Twelve participants from the same population as in experiment 1 took part and received course credit. None of them took part in experiment 1.

Materials, apparatus, design, and procedure. Experiment 2 was an exact replication of experiment 1. The only difference was that a prompt word was selected for each response word, such that they held a strong semantic relationship and the prompt would serve as an unambiguous cue for the response word. Participants were instructed to learn the prompt-response pairs and produce the response word corresponding to the prompt in each trial. The set of paired associates for each block was presented on the screen at block onset. Participants studied the pairs until they felt they could do the task with no error. The experimenter then started the block.

RESULTS

There were 80 error trials (2,31%) and no response was detected in 12 trials (0,34%). Out of correct trials, there were 44 trials in which the latency was smaller than 200 ms or greater than 1500 ms (1,3%). Outliers were discarded from subsequent analyses. Table 1 shows the resulting means per condition.

Latency. Only the main effect of Repetition was reliable (F1(1,11) = 40,168; MSe = 1289,880; p < 0,001; F2(1,6) = 320,292; MSe = 55,104; p < 0,001). Neither Context (F1(1,11) = 2,086; MSe = 2798,227; p = 0,176; F2(1,6) = 3,258; MSe = 626,101; p = 0,121) nor Fragment (both Fs < 1) approached the 0,05 probability level. There was an interaction between Fragment and Repetition (F1(1,11) = 9,768; MSe = 391,277; p < 0,01; F2(1,6) = 22,961; p < 0,004), such that pi-words benefited more from practice than ka-words.

Accuracy. Only Repetition affected accuracy, and only in the analysis by participants (F1(1,11) = 4,852; MSe = 0'00077; p = 0,049; F2(1,6) = 3,015; MSe = 0,00041; p = 0,13; All other Fs < 1, except for the interaction of Fragment and Context: F1(1,11) = 1,646; MSe = 0,00056; p = 0,225; F2(1,6) = 1,898; MSe = 0,00016; p = 0,217).

DISCUSSION

Surprisingly, experiment 2 failed to replicate the implicit priming effect using the standard version of this task. By contrast, a statistically clear effect was found in experiment 1 with the same materials and procedure, except for the fact that response words were elicited by means of pictures instead of prompt words. As the size of the implicit priming effect was not much smaller in experiment 2 than in experiment 1 (15 versus 21 ms), methodological differences may be introducing noise in the standard version and, therefore, increasing the difficulty of detecting significant implicit priming effects. To substantiate this suggestion, I conducted an overall analysis introducing Experiment as a factor.

In the analysis of latency, the Experiment factor was highly significant (556 ms in experiment 1 versus 729 ms in experiment 2, F1(1,22) = 47,763; MSe = 30051,420; p < 0,001; F2(1,6) = 275,606; MSe = 1741,333; p < 0,001). Clear main effects of Context (F1(1,22) = 10,103; MSe = 1632,610; p = 0,004; F2(1,6) = 14,46; MSe = 392,106; p = 0,008) and Repetition (F1(1,22) = 48,554; MSe = 1106,310; p < 0,001; F2(1,6) = 503,443; MSe = 36,102; p < 0,001) were found as well. The effect of Repetition was stronger in experiment 2 than in experiment 1 (interaction Repetition by Experiment: F1(1,22) = 7,344; MSe = 1106,310; p = 0,012; F2(1,6) = 44,118; MSe = 63,820; p < 0,001) and the effect of Repetition was stronger for pi-words than for ka-words in experiment 2 but equally strong for both types of words in experiment 1 (interaction Experiment by Fragment by Repetition: F1(1,22) = 8,265; MSe = 317,400; p = 0,008; F2(1,6) = 12,975; MSe = 63,825; p = 0,011). Also the one-way interaction between Repetition and Fragment approached significance by subjects (F1(1,22) = 4,131; MSe = 317,400; p = 0,054) and was significant by items (F2(1,6) = 12,836; MSe = 36,102; p = 0,011). No other F value reached a probability level below 0,05. Importantly, there were no traces of an Experiment by Context interaction (both Fs < 1), nor of a two-way interaction between Experiment, Context and Repetition (F1 < 1; F2(1,6) = 3,887; MSe = 112,471; p = 0’096). Summing up, experiment 2 showed overall much greater latencies and a stronger effect of Repetition which was greater for pi-words than for ka-words, but an implicit priming effect which was not significantly smaller than that in experiment 1. These results suggest that memory retrieval factors are playing a greater role in experiment 2 than in experiment 1, probably contributing the added noise that masks the effect of Context or implicit priming.

The analysis of accuracy across experiments, with the reservations presented above because of the small number of errors, supported the suggestion that memory retrieval makes the task more difficult and complex. Overall, there were more errors in experiment 2 than in experiment 1 (F1(1,22) = 5,465; MSe = 0,0019; p = 0,028; F2(1,6) = 19,592; MSe = 0,00016; p = 0,004). There were also some trends, as indicated by significant results in the analysis by participants but not by items (Repetition: F1(1,22) = 5,984; MSe = 0,00045; p = 0,022; F2(1,6) = 2,602; MSe = 0,00034; p = 0,157; Interaction Context by Fragment: F1(1,22) = 4,508; MSe = 0,00041; p = 0,045; F2(1,6) = 3,061; MSe = 0,0002; p = 0,130).

Finally, the suggestion that the standard implicit priming task generates a much noisier data set than the picture naming implicit priming task was directly tested by means of two procedures. I first compared latency standard deviations in both experiments. These were higher in experiment 2 than in experiment 1 (121 ms versus 73 ms; F1(1,22) = 24,876; MSe = 569,528; p < 0,001; F2(1,7) = 95,668; MSe = 95,668; p < 0,001). Second, I conducted a power analysis of the factors in both experiments. Power rised from 0,85 in experiment 1 to a value of 1 in experiment 2 for the Repetition factor, probably because this factor had a greater effect size in the latter. However, power was reduced from 0,26 to 0,11 for the Fragment factor, and dropped from 0,99 to only 0,26 for the Context factor, in spite of the fact that the sizes of these two factors did not differ significantly across experiments. The reasons for these task differences, together with the theoretical implications of present results are taken up in the following general discussion.

GENERAL DISCUSSION

Summarizing present results, a clear implicit priming effect was found in a picture naming version of the implicit priming task (Meyer, 1990, 1991) which minimizes the contribution of episodic learning of prompt-response word associations to production latencies. In a second experiment, a similarly-sized implicit priming effect arose in a standard implicit priming task, but it was undetected by statistical analyses because the higher overall variability arose by using recently established, though strong, episodic associations to elicit the response words.

These results bear two implications, one theoretical, the other methodological. On the theoretical side, present data suggest that the implicit priming effect cannot be attributed to the efectiveness of episodic cues. This hypothesis relies on the fact that there are more word retrieval cues available in homogeneous than heterogeneous blocks in the implicit priming task. As shown in the Introduction, differences in cue effectiveness were able to explain most aspects of the results obtained in prior published studies using this task. However, the memory-based explanation had not been directly tested against the standard explanation up to now. Because the size of the implicit priming effect was unaffected by the use of a picture naming versus a standard version of the implicit priming task, episodic memory retrieval processes can not be its prime cause. Therefore, word production processes remain as the more likely cause of the implicit priming effect observed in the implicit priming task.

On the methodological side, however, episodic memory factors do seem to increase random variance in participants' performance. It was shown that the standard version, making use of word paired associates to elicit response words, produces longer latencies, higher variability, and patterns of change with practice that are idiosyncratic to individual associations. As a result, the statistical power of the procedure is decreased, making more difficult to discriminate experimental effects from noise. I suggest that the picture naming version of the implicit priming task may be a better tool to investigate the detailed workings of the processing mechanisms that give rise to the implicit priming effect.

How can we explain that published studies have been able to find clear effects using the standard version of the task? I suggest that the answer may be related to the type of participants. To my knowledge, all of them have been carried out using participants from the subject pool at the Max Planck Institut für Psycholinguistik at Nijmegen. Although this is a large pool of people, most of them are likely to be quite experienced at the general task of performing reaction time experiments. They are also paid for their services, rising motivation levels. Prior experience in reaction time tasks and high motivation is likely to produce a much higher involvement in the experimental task than when more naive and less motivated participants are used, as it is the case in the present study and in many others in current literature. In the implicit priming task, it means that the episodic associations will be more quickly and firmly established, and attention and quick responding will be more constant along the session, reducing global noise. Only one published study using the standard implicit priming task have been conducted with experimentally more naive participants (Costa & Sebastián, 1996), and they reported a high level of noise and problems in replicating the basic implicit priming effect (they obtained the effect only in 2 out of 10 different conditions differing in degree of overlap from 1 to 2 initial segments).

This account also predicts that Max Planck participants should be faster than more naive participants as those in the present experiments. By way of a cuantitative comparison, Meyer (1990, exp.1) reported a mean production latency of 607 ms, while experiment 2 above found a mean 729 ms (734 ms if we consider only the bisyllabic words to equal number of syllables and stress pattern to Meyer's study), a difference likely to be highly significant. Alternatively, the difference might be due to the strength of the semantic association between prompts and responses being greater in Meyer (1990) than in experiment 2. Although possible, I find this unlikely given the very strong associations used in both studies and the size of the latency difference. The picture naming version of the implicit priming task seems to reduce memory load and effort, and therefore it is better suited to study implicit priming effects in experimentally naive and less motivated participants.

RESUMEN

Potenciación implícita del nombrado de imágenes: Una nota teórica y metodológica sobre la tarea de potenciación implícita. La tarea de potenciación implícita ("implicit priming"), introducida recientemente por Meyer (1990, 1991) para el estudio de los procesos de producción de palabras ha producido ya un impresionante número de hallazgos, que constituyen el apoyo principal para el principio de codificación serial en producción. Sin embargo, los resultados previos se pueden explicar también mediante una hipótesis basada en recuperación de la memoria episódica que no recurre a procesos de producción. En el experimento 1 se pone a prueba esta explicación episódica en una versión de denominación de dibujos de la tarea, la cual minimiza la contribución de los procesos de memoria. El efecto de potenciación implícita se replica, por lo que se apoya la explicación estándar basada en procesos de producción. El experimento 2 encuentra un efecto de potenciación implícita del mismo tamaño en una tarea estándar, utilizando los mismos materiales que en el experimento 1, pero que, sin embargo, no fue estadísticamente significativo. Las comparaciones entre los dos experimentos mostraron que los componentes de memoria de la versión estándar de la tarea introducen ruido en los datos, y hacen la versión de denominación de dibujos más adecuada para el estudio de los efectos de potenciación implícita con participantes sin entrenamiento previo en la realización de experimentos de tiempo de reacción.

Palabras clave: Psicolingüística, producción, implicit priming, denominación de dibujos.

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APPENDIX

Experimental materials used in experiments 1 and 2 (in uppercase), and their associated prompt words in experiment 2 (in lowercase).

Homogeneous, pi-words

colada	-	PINZA
cigarro	-	PIPA
zumo	-	PIÑA
abeto	-	PINO

Homogeneous, ka-words

badajo	-	CAMPANA
desierto	-	CAMELLO
chaqueta	-	CAMISA
llave	-	CANDADO

Heterogeneous blocks

badajo	-	CAMPANA
colada	-	PINZA
chaqueta	-	CAMISA
abeto	-	PINO

cigarro	-	PIPA
desierto	-	CAMELLO
zumo	-	PIÑA
llave	-	CANDADO

(Manuscrito recibido: 20/9/99; Revisión aceptada: 9/12/99)