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Role of phonological and orthographic codes in picture naming and writing: An interference paradigm study

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Abstract. Two experiments using the picture-word interference paradigm were used to investigate the nature of the representations (phonological/orthographic) underlying lexical access, both in picture naming and in picture writing, and their activation time course. Three alternative views of lexical access in naming and in writing were tested. According to the first view, phonological and orthographic codes are activated in parallel both in writing and in naming. According to the second view, phonological codes are only activated in naming and orthographic codes are only activated in writing. Finally, the third view states that phonological codes are activated in naming and mediate writing. The findings did not support one of three tested views on lexical access in naming and in writing. However, they clearly ruled out a strict phonological mediation view of lexical access in writing.

Key words: lexical access, interference paradigm, phonological codes, orthographic codes.

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INTRODUCTION

Naming and writing words from pictures are two activities that involve a complex combination of perceptual and motor skills. However, while speech production research has given rise to a number of models describing the processes and representations that serve as mediators between the formation of an idea and the execution of an utterance with overt speech as a physical consequence, lexical access in writing by normal subjects has never been investigated in a systematic experimental way.

Studies on lexical access in speech production have provided some evidence that picture naming involves several processing levels: a preverbal level (corresponding to the visual processing of the picture and the identification of the concept denoted by it); a lemma retrieval level (prephonological representations according to Kempen & Huijbers, 1983, and Levelt, 1989); a phonological encoding level (lexeme retrieval); and finally, a level corresponding to the retrieval (or computation) of an articulatory plan (Levelt, 1989; Levelt & Wheeldon, 1994). While a number of studies have shown that semantic and phonological information is activated during lexical access, there is still some disagreement among researchers about the relative time course of these processing levels (semantic/phonological levels). Some authors argue for a discrete view of lexical access in speech (Schriefers, Meyer, & Levelt, 1990; Levelt, Schriefers, Vorberg, Meyer, Pechmann, & Havinga, 1991) whereas others favor an interactive activation account of lexical access (Dell & O'Seaghdha, 1991) or a cascading view of lexical access (Vitkovich & Humphreys, 1991).

Concerning lexical access in speech, Levelt et al. say nothing about the role of orthographic codes. In the literature on speech production, however, there is some research dealing with the role of orthographic codes. Lupker (1982) ran experiments designed to investigate the role of phonological and orthographic similarity between primes and picture labels. In one experiment, he showed that orthographically related primes[1] facilitated naming compared to unrelated controls. In another experiment, Lupker (1982) tried to dissociate the phonological similarity

1. The words used as distractors were orthographically identical to the target words with the exception of the first letter. They differed also in the standard pronunciation of the vowels, such as *BEAR-year*, *HAND-wand*.

effect from the orthographic similarity effect on picture naming. His results showed that when the orthographic similarity of the primes was minimal (*PLANE-brain*), the phonological similarity effect was reliable but weak compared to unrelated controls. The effect associated with orthographically and phonologically related primes (*PLANE-crane*) was similar in size to the effect observed with only orthographically related primes (*BEAR-year*). Thus, these experiments suggested that orthographic codes do play an important role in picture naming.

The facilitatory effect associated with orthographic primes may be limited to the very first processing stages. Rayner and Posnansky (1978) showed that an orthographic facilitation effect was found when interfering stimuli (i.e., IS) were presented for a short duration (35 ms). Nonwords that shared orthographic characteristics with the verbal labels (e.g., *leuf-LEAF*) were found to facilitate picture naming compared to the condition where the pictures were presented alone. With longer exposures of the primes, the effect of orthographically related primes turned out to be inhibitory while the facilitatory effect found with phonologically related nonwords increased (see also Rayner & Springer, 1986). Facilitatory effects associated with orthographically related primes have been reported in tasks such as color naming, translating, retrieving words from definitions and reading (Peereman & Content, submitted).

The studies reviewed above have provided evidence suggesting that lexical access in speech could benefit from orthographic information. The involvement of orthographic codes is thought to be related to the learning of the written language (Wheeldon & Monsell, 1992; Tanenhaus, Flanigan, & Seidenberg, 1980). So, orthographic codes would be automatically activated in speech even when they are functionally irrelevant (Wheeldon & Monsell, 1992). However, in these studies, the effects associated with orthographic primes were not pure in the sense that most often the primes also shared some phonological features with their targets. Thus, the interpretation of orthographic prime effects remains unclear.

While the nature and the activation time course of the representations underlying naming have been widely investigated, to our knowledge, no systematic experimental studies on normal subjects have been conducted concerning writing. The studies dealing with the role of phonological information in writing have mainly been conducted in cognitive neuropsychology research (Bub & Kertesz, 1982; Caramazza & Hillis, 1990; Lhermitte & Dérouesné, 1974) and in research on slips of the pen (Ellis, 1984; Hotopf, 1980). Traditionally, it has been assumed that written language skills were entirely dependent upon spoken language knowledge and processes (Aitkinson & Todd, 1982; Luria, 1970). This "phonological mediation hypothesis" (Rapp, Benzing, & Caramazza, 1994) is faced with various problems such as the production of homophones (i.e., *seen* vs. *scene*; Largy, Fayol, & Lemaire, 1996), silent graphemes (i.e., *h* in the French word *harpe*) and double letters (i.e., *tt* in the French word *natte*). Moreover, some cognitive neuropsychology studies strongly oppose such an account (Bub & Kertesz, 1982; Caramazza & Hillis, 1990; Lhermitte & Dérouesné, 1974). For example, it has been shown that some brain-damaged patients perform better at writing than at naming the same items (Lhermitte & Dérouesné, 1974). These clinical studies strongly suggest that orthographic codes are activated without any prior systematic involvement of phonological codes. Such an account is referred to as the "orthographic autonomy hypothesis" (Rapp & Caramazza, 1994).

Figure 1 depicts a simple model of lexical access in picture naming and writing that clarifies the predictions that can be made for our experiments. This model is based on the views provided both by researchers

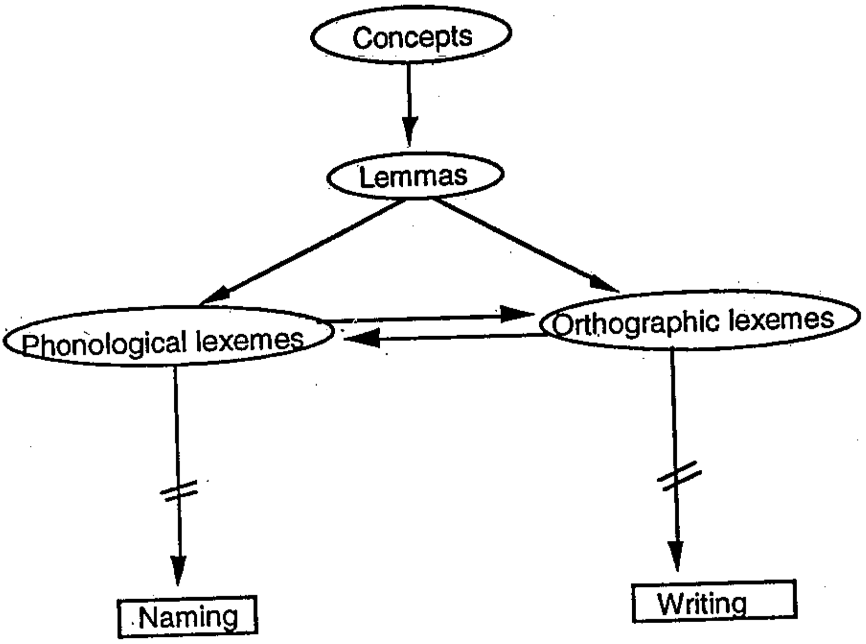

Figure 1. Simple model of lexical access in picture naming and picture writing.

investigating oral production (Bock & Levelt, 1994; Levelt, 1989; Schriefers, 1992) and by cognitive neuropsychologists studying written production (Caramazza & Hillis, 1990; Ellis, 1982, 1988). We assume that the two language production systems share some processing levels.

In this model, written and spoken productions of isolated words from pictures share common conceptual and lemma levels. The first level consists of a visual analysis of a picture and identification of the concept denoted by the picture. The second level corresponds to lemma retrieval. The third level allows the parallel activation of orthographic and phonological codes. Orthographic codes serve as input for the processes involved in the retrieval of a graphic plan in writing, while phonological codes are used by retrieval processes (or computation) of an articulatory plan. Our view implies some hypotheses about the nature of lexical representations and their activation time course. In this model, it is assumed that phonological and orthographic information is activated in writing, as well as in naming, due to connections between lemmas and between both phonological and orthographic lexemes. Furthermore, connections between orthographic and phonological lexemes are included. Such a functional architecture can account for homophonic substitutions in writing (such as the written production *seen* instead of *scene* when the concept to be expressed is *SCENE*). Such errors would result from the activation of the orthographic lexeme *seen* by the phonological lexeme */si:n/*, due to connections between the lemma *SCENE* and the phonological lexeme */si:n/* and between the two orthographic lexemes *seen* and *scene*. Thus, the phonological lexeme */si:n/* could activate both orthographic lexemes *scene* and *seen*. Consequently, the word "*seen*" could be erroneously written because it would have been activated indirectly by the phonological lexeme */si:n/*. However, the correct orthographic word form of a homophone would be written down more often because it would benefit from a higher activation level than its homophonic associates. Thus, this form would receive activation from the lemma and phonological lexeme levels, whereas homophonic associates would receive activation only from the phonological lexeme level.

The view described above can be contrasted to another view favoring greater independence between the processing levels involved in writing and naming. In this view, orthographic codes are not activated in naming, and phonological codes are not activated in writing. Because neither Schriefers, Meyer, and Levelt (1990), nor Levelt, Schriefers, Vorberg, Meyer, Pechmann, and Havinga (1991) discussed the potential role of orthographic codes in lexical access in speech, one could infer that, for these authors, orthographic representations are not activated (or are only so to a lesser degree) in the time course of lexical access in naming.[2] As for writing, Rapp and Caramazza (1994) and Link and Caramazza (in press) consider that the phonological and orthographic lexicons independently receive activation from the semantic system. However, they do not say whether or not phonological codes are systematically activated at the same time as orthographic codes in the written production of isolated words. Thus, it could be possible that orthographic codes are activated without any involvement of phonological codes during lexical access in writing.

Finally, concerning writing, an alternative view is that lexical access in writing always requires the prior retrieval of phonological codes in order for orthographic information to be retrieved or computed (Luria, 1970). Such a view describes writing as a kind of oral production translated into writing, and thus, written production as being dependent upon the oral language production system.

To test these three alternative views, we designed two experiments using the picture-word interference paradigm. This paradigm is one of the most prevalent ones to have been successfully applied to the investigation of lexicalization processes in naming (Jescheniak & Schriefers, submitted). In the two experiments reported in the present paper, participants were required to produce picture labels, either by writing them down or by stating them aloud. Naming and writing latencies were the dependent variables. The pictures were presented with interfering stimuli that had to be ignored by the participants. Visually presented IS were used in the first experiment and auditorily presented IS were used in the second experiment. In Experiment 1, three kinds of visually presented IS were considered. First, we used only orthographically related IS. This was achieved by using French words beginning with a silent *h* (e.g., the French word *harpe*). In this case, an effect associated with the visual presentation of the silent letter would logically be attributable to orthographic similarity alone. Second, orthographically and phonologically related IS were used. The IS involved the visual presentation of the first letter of the picture labels (e.g., *t* for *taupe*). This kind of IS provided phonological and orthographic information. Finally, phonologically but not orthographically related IS were used: the visually

2. However, Meyer and Schriefers (1991), quoting Seidenberg and Tanenhaus (1979), suggested that the auditory presentation of words could activate graphemic information along with phonological information.

presented letter (e.g., *s*) was phonologically related to the picture labels (e.g., *citron*) but had a different graphemic realization (i.e., *s* instead of *c*). This type of IS provided phonological information that was compatible with the initial sound of the label, but also orthographic information that was not compatible with the initial letter in the labels. In addition, we used two control conditions: unrelated and neutral. In the following experiment, for the unrelated IS (U), the pictures were shown with a visually presented letter that was not one of the letters in the picture label. For the neutral stimuli (N), the pictures were presented with nonlinguistic symbols.

The presentation delay of the primes varied: IS were presented either simultaneously or +150 ms after picture onsets. These two SOAs were considered because phonological effects have been found with such delays in speech production studies (Schriefers, Meyer, & Levelt, 1990; Meyer & Schriefers, 1991).

The following predictions derived from the three contrasted views were tested in the following experiment. In accordance with the hypothesis of parallel access to orthographic and phonological information in writing and in naming, facilitatory effects associated with orthographically and phonologically related IS were predicted in writing as well as in naming, at both SOAs. By contrast, the hypothesized direct access to phonological information in naming and to orthographic information in writing led to the following predictions: (i) in oral production, a facilitatory effect was expected with phonologically related IS, orthographically and phonologically related IS, and orthographically unrelated but phonologically related IS. No facilitatory effect was predicted with primes that were orthographically related only; (ii) in written production, a facilitatory effect was predicted with orthographically related IS and with orthographically and phonologically related IS. By contrast, no facilitatory effect was predicted with phonologically related but not orthographically related IS. Finally, in accordance with a systematic phonological mediation view of lexical access in writing, (i) a facilitatory effect with phonologically related IS was predicted at an SOA of 0 ms and little or no facilitatory effect was predicted at a later SOA (+150 ms); (ii) a facilitatory effect was predicted with orthographically related IS at an SOA of +150 ms.

EXPERIMENT 1

Method

Participants. Seventy-two undergraduate students who were native speakers of French participated in the experiment. All had normal or corrected-to-normal vision.

Stimuli. Fifty-four pictures were used. Some of them were selected from children's picture books, others were taken from Snodgrass and Vanderwart's (1980) corpus, and the rest were from a pool of pictures we had used in previous experiments on language production. Nineteen of the labels began with the letter *h*, 18 with the letter *t*, and 18 with the letter *c* and the sound /*s*/. The mean frequency of occurrence in the language was 1403 per 100 million for items beginning with *h*, 1510 for items beginning with *c*, and 1827 for items beginning with *t*. The frequency counts were taken from the Brulex database (Content, Mousty, & Radeau, 1990). For each category of items, the mean number of letters was six and the mean number of syllables was two. ANOVAs on frequency, number of letters, and number of syllables showed that the different item categories did not differ significantly on those dimensions (frequency: $F < 1$; number of letters: $F(2, 21) = 1.702$; number of syllables: $F < 1$). Related IS were created by using the letters *h*, *s*, and *t*. The unrelated distractors were constructed in the following way. For items beginning with *h*, half of the items were associated with the letter *t* and the remaining half with the letter *s*; for the pictures whose labels began with *c*, half were associated with the letter *t* and half with *h*; and finally, for labels beginning with *t*, half were associated with *s* and half with *h*. This procedure was used to make sure that a given unrelated letter did not belong to a given target word. The neutral IS were created by using the nonlinguistic symbols *&* and §. For each category of items, half of the items were associated with *&* and the remaining with §. Nine blocks of 18 picture-IS pairs were created. In each block, six pictures had a label beginning with the letter *c*, six with the letter *h*, and six with the letter *t*. For each type of word (*h, c, t*) there were also two unrelated, two related, and two neutral examplars. In each block (i) no picture was repeated, (ii) a given picture was never followed by a picture whose label began with the same letter, and (iii) a picture and its associated IS were not preceded by the same IS. Care was taken in selecting the pictures inside each block to avoid overlapping between the concepts denoted by the pictures. The presentation of the blocks was rotated across participants. Six training pictures were used: two whose label began with a *c*, two with an *h*, and two with a *t*.

Apparatus. The experiment was developed using PsyScope – version 1.0.1 (Cohen, MacWhinney, Flatt, & Provost, 1993; Vaughan & Yee, 1994) and ran on a Macintosh LC III. A graphic tablet and a contact pen (SP-210) were used to record graphic latencies. A microphone (AIWA stereo; impedance: > 1 kW; -74 dB) was used to record articulatory latencies.

Procedure. The participants were tested individually and were randomly assigned either to the 0 ms SOA condition or to the +150 ms SOA condition. They were randomly instructed either to name or to write. Before the experimental session, the participants were given a booklet showing the pictures with their respective names. They had to learn the names associated with the pictures. They were then told that they had to produce the word for each picture presented on the screen as quickly as possible. They were told that each picture would be presented with a stimulus (in the right center of the picture) that they would try to ignore. Items were presented in blocks of eighteen items. The test trials had the following structure. A ready signal (***) was presented and highlighted for 500 ms, and then followed by a picture. Depending on the SOA condition, the onset of the IS coincided with the target onset, or followed it by 150 ms. The visual primes remained visible for 273 ms. The picture disappeared after the participant initiated writing or naming. The intertrial interval was five seconds. Before running the experiment proper, participants received 18 practice trials.

The written responses were timed as follows. The participants sat with the pen close to the tablet so that the latency would be the time taken to make contact after picture onset. Observations were discarded from the analyses whenever any of the following conditions held: participants did not remember the picture names, words were misspelled, a technical problem occurred, an item other than the expected one was produced, the subject merely touched the tablet and then paused, or the subject wrote a letter or two and then paused. For the spoken responses, the latency was the time between the beginning of the spoken response and the picture onset. Latencies were scored as errors whenever participants did not remember the picture names, a technical problem occurred, participants did not remember the pictures names, used picture names other than the expected ones, stuttered, or produced mouth clicks.

Results

Written latencies. Applying the criteria defined in the procedure section led us to discard 3.2% of the data. Moreover, latencies exceeding two standard deviations above the item and participant means were also excluded (1.6% of the data).

Naming latencies. Applying the criteria defined in the procedure section led us to discard 7.5% of the data. Latencies exceeding two standard deviations above the item and participant means were also excluded (1.7% of the data).

The ANOVA with participants as random factor was a SOA (0 ms vs +150 ms) × Task (naming vs. writing) × IS Type (neutral vs. related vs. unrelated) × Word Type (words beginning with the letter *c* vs. *h* vs. *t*) with independent measures on the SOA and Output Type factors. An ANOVA with items as random factor was performed on the same factors with independent measures on the Word Type factor. Analyses of the simple effects of IS type were conducted for each SOA, Task and Word type combination. Finally, differences between related-neutral (R-N), and related-unrelated (R-U) were tested using planned comparisons (one-tailed *t*-test) following Meyer and Schriefers (1991) and Roelofs (1992).

The main effect of IS Type was significant only for participants, $F1(2, 136) = 13.99$, $p < .0003$, $MSE = 999.37$; $F2 < 1$. The main effect of Task was significant in both analyses, $F1(1, 68) = 66.16$, $p < .00001$, $MSE = 80772.40$; $F2(1, 17) = 2031.58$, $p < .00001$, $MSE = 2591.9$. The main effect of Word Type was significant for participants, $F1(2, 136) = 79.92$, $p < .0001$, $MSE = 2049.61$, and for items, $F2(2, 34) = 9.39$, $p < .0006$, $MSE = 18250.23$. The main effect of SOA was not significant, $F1$ & $F2 < 1$.

The Output Type × Word Type interaction was significant for participants, $F1(2, 136) = 3.77$, $p < .02$, $MSE = 2049.61$, and for items, $F2(2, 34) = 6.77$, $p < .003$, $MSE = 1225.75$. Post hoc comparisons (Newman-Keuls) revealed that the naming latencies were significantly different from each other for each word type. In writing, only the latency for words beginning with *t* was significantly different from the latencies for with words beginning with the letters *h* and *c*.

The Word Type × IS Type interaction was significant for participants only, $F1(4, 72) = 6.88$, $p < .0002$, $MSE = 991.91$; $F2 < 1$. Post hoc comparisons (Newman-Keuls) revealed that (i) for words beginning with the letter *h*, the latencies were significantly different for each IS type; (ii) for words beginning with the letter *c*, only the latencies associated with the related and unrelated conditions and with the neutral and unrelated conditions were significantly different; and (iii) for words beginning with *t*, the latencies associated with the different IS types were not significantly different from each other.

The IS Type × SOA interaction was marginally significant for participants but nonsignificant for items, $F1(2, 136) = 2.94$, $p < .06$, $MSE = 999.37$; $F2(2, 34) = 2.22$.

The mean latencies in naming and in writing for each SOA and for each IS type, as well as the mean differences between the related and unrelated conditions (R-U) and between the related and neutral conditions (R-N) are presented in Table 1. Statistical results for each comparison between R and U and between R and N are included.

Naming

For words beginning with *c*, i.e., the phonologically-related but orthographically-unrelated condition (e.g., *cerf*), the simple effect of IS Type was not significant at an SOA of 0, $F1(2, 34) = 1.98$; $F2 < 1$, or at an SOA of 150 ms, $F1(2, 34) = 2.06$; $F2(2, 34) = 1.22$.

At an SOA of 0, for words beginning with *h*, i.e., the orthographically related condition (e.g., *h* for *harpe*), the simple effect of IS was significant for participants, $F1(2, 34) = 12.67$, $p < .0001$, $MSE = 808.14$, and was marginally significant for items, $F2(2, 34) = 2.46$, $p < .10$, $MSE = 4904.29$. At an SOA of 150 ms, the simple effect of IS Type was significant in both analyses, $F1(2, 34) = 5.73$, $p < .007$, $MSE = 909.47$; $F2(2, 34) = 3.17$, $p < .05$, $MSE = 1797$.

At an SOA of 0 ms, as can be seen from Table 1, planned comparisons revealed a facilitatory effect due to the presentation of a silent letter compared to neutral distractors and to unrelated IS, but this difference was significant only for participants. At an SOA of 150 ms, the R-U difference was marginally significant in the by-participant analysis and nonsignificant in the by-item analysis. The R-N difference was significant for participants and items.

For words beginning with *t*, i.e., the orthographically- and phonologically-related condition, the simple effect of IS Type was not significant at either SOA, all $Fs < 1$.

Table 1
Spoken and written latencies (ms) from Experiment 1 at SOA = 0 and SOA = 150, as a function of Type of word (words beginning with the sound s and the letter c, words beginning with h, words beginning with t) and IS Type (N: neutral; U: unrelated; R: related). The mean differences between the related and unrelated conditions (R-U) and between the related and neutral conditions (R-N) are given with their statistical significance level.

	C			H			T		
	N	U	R	N	U	R	N	U	R
Naming (SOA = 0)	855	847	839	861	841	813	790	871	783
R-U		−8			−28[a]			+2	
R-N		−16			−48[a,b]			−7	
Naming (SOA = 150)	846	866	850	837	816	803	794	792	785
R-U		−16			−13[c]			−7	
R-N		−4			−34[a,b]			−9	
Writing (SOA = 0)	1011	1033	1011	1032	1026	992	983	988	964
R-U		−22			−34[a,d]			−24	
R-N		0			−40[a,b]			−19	
Writing (SOA = 150)	1009	1027	1018	1027	1016	1010	980	965	978
R-U		−9			−6			+13	
R-N		+9			−17			−2	

Notes. a: significant on participants ($p < .05$); b: significant on items ($p < .05$); c: marginally significant on participants ($p < .10$); d: marginally significant on items ($p < .10$).

Writing

For the phonologically-related but orthographically-unrelated condition (i.e., words beginning with *c*), the simple effect was marginally significant at an SOA of 0 for participants, $F1(2, 34) = 3.06$, $p < .06$, $MSE = 974.61$, but not for items, $F2 < 1$. At an SOA of 150 ms, the effect was marginally significant in the by-participant analysis only, $F1(2, 34) = 2.51$, $p < .09$, $MSE = 579.06$; $F2 < 1$.

For the orthographically-related condition (i.e., words beginning with *h*), at an SOA of 0, the simple effect was significant for participants, $F1(2, 34) = 5.92$, $p < .006$, $MSE = 1407$, but not for items, $F2(2, 34) = 2.22$. At an SOA of 150 ms, the effect was nonsignificant, $F1(2, 34) = 1.10$; $F2 < 1$.

As shown by Table 1, at an SOA of 0 ms, a facilitatory effect was observed with the presentation of the silent letter *h* compared with the neutral condition and the unrelated condition. The R-N difference was significant for participants and items and the R-U difference was significant for participants and marginally significant for items.

For the orthographically- and phonologically-related condition (i.e., for words beginning with *t*), at an SOA of 0, the simple effect of IS Type was not significant, $F1 = 1.27$; $F2 = 1.06$, nor was it at an SOA of 150 ms, $F1 = 1.68$; $F2 < 1$.

Discussion

The results of Experiment 1 did not show a facilitatory effect associated with a phonologically- but not orthographically-related prime (i.e., *s* for CIBLE), both in naming and in writing. However, such facilitatory effects have been reported in the literature. Posnansky and Rayner (1978) observed that picture naming (e.g., GIANT) was facilitated to a greater extent when the visual distractor had the same first letter (*gamut*) than when it had only the same initial sound (*jewel*) compared to unrelated distractors (*paint*). Due to the significant facilitatory effect obtained by the presentation of a related silent letter, the present results suggest that orthographic characteristics are activated in naming. However, this effect was not significant for items, either in naming or in writing.

Concerning the above result for naming at an SOA of 0 ms, the item means went in the predicted direction (R < U and R < N) and the magnitudes of these effects for items were close to those observed for participants (R-N: -51 ms; R-U: -33 ms). To account for the variability on items, some descriptive analyses were performed on the neutral, related, and unrelated conditions. A close examination of the item means revealed that 11 items out of 18 showed the predicted R < N trend, which turned out to be nonsignificant, $z(18) = 1.18$. As for the comparison between the unrelated and related conditions, the descriptive analysis revealed that 7 items out of 18 underwent the predicted effect (R < U). To explain why these specific items exhibited the predicted trend (R < U) and not the other items, the frequency and number of syllables and letters were examined. But post hoc analyses failed to give a clear account of this pattern of results.

Concerning writing at an SOA of 0 ms, the predicted trend was observed on the item means (N: 1037 ms; U: 1028 ms; R: 991 ms). Moreover, the magnitudes of these effects (R-N: -46 ms and R-U: -37 ms) were close to those observed on participants. Descriptive analyses for the unrelated, related, and neutral conditions indicated that 11 items out of 18 exhibited the predicted R < N trend, but $z(18) = 1.18$, and that 12 items out of 18 exhibited the predicted R < U trend, but the latter trend was only marginally significant, $z(18) = 1.65$, $p < .09$. An examination of the item frequencies revealed that, as in naming, frequency could not account for the variability observed for items.

One could argue that the variability on items was due to the fact that some words beginning with the silent *h* were "marked" when read aloud with an article. For example, no break occurred between the article "*une*" (/*yn*/) and the noun "*hélice*" (/*elis*/) when the utterance "*une hélice*" (/*ynelis*/) was pronounced, whereas a break occurred between "*une*" (/*yn*/) and "*harpe*" (/'*arp*/) when "*une harpe*" (/*yn'arp*/) was produced. We asked 17 skilled readers to read aloud the words beginning with *h*, preceded by a definite article. Accordingly, two groups of items were distinguished: marked and unmarked items. However, no significant interaction was observed when this factor was entered in the ANOVA. This variable therefore cannot account for the variability observed for items beginning with the letter *h*.

Concerning orthographically- and phonologically-related IS, for naming, an effect was not observed for participants or for items at either SOA. Moreover, no trend was observed on the means: the R-N and R-U differences were nearly null. Concerning writing at an SOA of 0 ms, the analyses did not yield a facilitatory effect associated with the presentation of a phonologically- and orthographically-related letter, even though the means went in the predicted direction (R < N and R < U). However, the trends were not significant in the R < N comparison, $z < 1$, or in the R < U comparison, $z(18) = 1.18$.

The only effect that was consistently observed in Experiment 1 was the fact that a silent letter facilitated picture naming and picture writing. However, this result was only significant for participants. Even though the results provided by the present experiment are difficult to interpret, they nevertheless suggest that orthographic codes may be activated in the naming of isolated words from pictures. The most problematic result obtained in this experiment is the null effect associated with an orthographically- and phonologically-related distractor (the letter *t* for pictures whose labels began with a *t*) because according to the hypothesis of the parallel activation of phonological and orthographic codes in naming and in writing, a significant effect of this kind of IS should have been observed.

EXPERIMENT 2

Experiment 1 did not show any phonological facilitation effect using visually presented distractors either in naming or in writing. Therefore, in the next experiment, IS were presented auditorily to guarantee that the phonological information was derived from the input. The phonologically-related IS involved the auditory presentation of the initial phoneme[3] of picture labels. As in Experiment 1, we considered two control conditions: unrelated and neutral. The unrelated IS were initial phonemes that did not belong to the words, and the neutral condition was achieved using a nonlinguistic sound (a hiss).

Method

Participants. Sixty subjects participated in the experiment. They were undergraduate students at Bourgogne University and were native speakers of French. All had normal or corrected-to-normal vision. None of the subjects had participated in the previous experiment.

3. Strictly speaking, it was not possible to present a phoneme in isolation. Thus, we systematically presented the phoneme followed by the neutral vowel /ə/. This initial linguistic sound was never a syllable in our critical target labels. For the sake of simplicity, the term phoneme will be used.

Stimuli. Thirty pictures were used. As in Experiment 1, some pictures were selected from children's picture books, some were taken from Snodgrass and Vanderwart's (1980) corpus, and other were from the pool of pictures used in the previous experiment. Ten pictures had labels that began with the phoneme */b/*, ten with the phoneme */t/* and ten with the phoneme */k/* and the letter *c*. The mean frequency of occurrence of the items was 2984. The frequency counts were taken from the Brulex database (Content, Mousty, & Radeau, 1990). The mean number of letters was six, and the mean number of syllables was two. The related primes were created by using the sounds */b/*, */k/*, and */t/* for picture labels beginning with such sounds. The unrelated IS were created as follows. For pictures beginning with the phoneme */b/*, half of the items were associated with the sound */t/* and the remaining half, with the sound */k/*; for the pictures beginning with the sound */t/*, half of the items were associated with the sound */b/* and the remaining half, with the sound */k/*; finally for pictures whose labels began with the sound */k/*, half of the pictures were associated with the sound */b/* and the other half, with the sound */t/*. This procedure was used to make sure that no sound belonging to the target picture label was used as an unrelated distractor. Neutral distractors were created using a hiss. Five blocks of nineteen picture-distractor pairs were created. In each block, there were six pictures whose labels began with */b/*, six with */t/*, and six with */k/*. In each block, six pairs were related, six were unrelated, and six were neutral. The pictures inside each block were arranged so that (i) a given picture was presented only once, and (ii) a picture whose label began with a given initial phoneme did not follow a picture whose label began with the same initial phoneme. The semantic overlap between pictures was minimal. Six training pictures were used.

Apparatus. The same apparatus as in Experiment 1 was used.

Procedure. Participants were tested individually. They were randomly assigned to the two SOA conditions (0 ms, +150 ms) and to the two task conditions (naming, writing). Before running the experiment proper, they were given a booklet showing the pictures with the names they would have to use in the experiment. After having learned the pictures, they were given a phoneme discrimination task aimed at verifying whether or not the phonemes used could be discriminated. Participants randomly heard "phonemes" (i.e., */b /*, */t /*, */k /*) through headphones and were required to press a specific button for each "phoneme" recognized, as quickly as possible. They had to use the three fingers of their preferred hand. The phonemes were assigned to the three push buttons using a counterbalancing procedure. There were twenty trials per phoneme. For this task, only errors were recorded. The main experiment followed immediately. Participants were informed that they would have to produce the name of each picture presented on the screen, as quickly as possible, while hearing distractors through the headphones. They were required to pay attention only to the production task. Items were presented in blocks of nineteen. The structure of each trial was identical to that used in Experiment 1. Participants were given 18 practice trials.

Results

Phoneme discrimination task

Error analyses showed that the mean percentage of errors was extremely low (0.09% for /*b*/, 1.6% for /*k*/, and 0.6% for /*t*/). As the main effect of Type of Phoneme was not significant, $F(2, 118) = 2.68$, the phonemes used in the main experiment were clearly discriminated.

Main experiment

Written latencies. Trials in which participants did not remember the picture names, used picture names other than the expected ones, or did not initiate a strong handwriting movement, and trials on which a technical problem occurred, were excluded from further analyses (2.66% of the data). Latencies exceeding two standard deviations above the item and participant means were excluded (1.44% of the data).

Naming latencies. Trials on which a technical problem occurred (0.63%), or on which participants did not remember the picture names, used picture names other than the expected ones, stuttered, or produced mouth clicks (4.48% of the data) were excluded. Latencies exceeding two standard deviations above the item and participant means were excluded (1.48% of the data).

The design of the ANOVA with participants as random factor was SOA (0 ms vs. +150 ms) × Task (naming vs. writing) × IS Type (neutral vs. related vs. unrelated), with independent measures on SOA and Output Type. An ANOVA with items as random factor was performed with the same factors and a repeated measures design. Analyses of the simple effects of IS Type were performed for each SOA and Task combination. Finally, the differences R-N and R-U were tested using planned comparisons (one-tailed *t*-test) following Meyer and Schriefers (1991) and Roelofs (1992).

The main effect of IS Type was significant, $F1(2, 112) = 35.69$, $p < .0001$, $MSE = 432.18$; $F2(2, 58) = 7.066$, $p < .002$, $MSE = 4177.5$, as was the main effect of Task, $F1(1, 56) = 46.63$, $p < .00001$, $MSE = 31722.13$; $F2(1, 29) = 1853.67$, $p < .0001$, $MSE = 1561.67$. The main effect of SOA was not significant, $F1 < 1$; $F2(1, 29) = 1.84$.

The IS Type × Output Type interaction was significant, $F1(2, 112) = 7.14$, $p < .0012$, $MSE = 432.18$; $F2(2, 58) = 7.89$, $p < .001$, $MSE = 803.28$. This interaction showed that (i) in naming, an inhibitory effect associated with related distractors was found (+24 ms) in comparison to the neutral condition, whereas in writing, this effect was nearly null (+3 ms); (ii) the facilitatory effect (compared to the unrelated condition) was greater in magnitude in naming (-22 ms) than in writing (-15 ms). Planned comparisons revealed that the R-N difference between naming and writing was significant, $F1(1, 56) = 6.95$, $p < .01$, $MSE = 427.33$; $F2(1, 29) = 5.13$, $p < .03$, $MSE = 821.16$, while the R-U difference was not, $F1(1, 56) = 1.03$; $F2(1, 29) = 2.93$, $p < .10$, $MSE = 642$.

The Output Type × SOA interaction was significant in the by-item analysis only, $F1 < 1$; $F2(1, 29) = 36.334$, $p < .0001$, $MSE = 1183$. Neither the SOA × IS Type interaction, $F1(2, 112) = 1.49$; $F2(2, 58) = 2.29$, nor the IS Type × SOA × Output Type interaction was significant, $F1(2, 112) = 2.15$; $F2(2, 58) = 1.94$.

Mean latencies in naming and in writing for each SOA and for each IS Type, as well as the mean differences between the related and unrelated conditions (R-U) and between the related and neutral conditions (R-N) are presented in Table 2. Statistical results for each comparison between R and U and between R and N are included.

Naming. At an SOA of 0, the simple effect of IS Type was significant for both participants and items, $F1(2, 28) = 30.56$, $p < .0001$, $MSE = 297.69$; $F2(2, 58) = 10.61$, $p < .0001$, $MSE = 1756.131$. At an SOA of 150 ms, the simple effect of IS Type was significant for participants, $F1(2, 28) = 15.83$, $p < .0002$, $MSE = 434.67$, and for items, $F1(2, 58) = 7.26$, $p < .001$, $MSE = 1703.91$.

As can be seen from Table 2, at an SOA of 0, the R-N as well as the R-U differences were significant for both participants and items. At an

SOA of 150 ms, the R-N difference was significant in the by-participant analysis and marginally significant in the by-item analysis. The R-U difference was significant in both analyses.

Table 2
Spoken and written latencies (ms) from Experiment 2 at SOA = 0 and SOA = 150, as a function IS Type (N: neutral; U: unrelated; R: related). The mean differences between the related and unrelated conditions (R-U) and between the related and neutral conditions (R-N) are given with their statistical significance level.

	Neutral	Unrelated	Related
Naming (SOA = 0)	818	867	840
R-U		–27[a,b]	
R-N		+22[a,b]	
Naming (SOA = 150)	837	879	862
R-U		–17[a,d]	
R-N		+25[a,d]	
Writing (SOA = 0)	1031	1056	1048
R-U		– 8	
R-N		+17[a]	
Writing (SOA = 150)	1019	1029	1009
R-U		–20[a]	
R-N		–10[c]	

Notes. a: significant on participants ($p < .05$); b: significant on items ($p < .05$); c: marginally significant on participants ($p < .10$); d: marginally significant on items ($p < .10$).

Writing. At an SOA of 0, the simple effect of IS Type was significant for participants and marginally significant for items, $F1(2, 28) = 4.39$, $p < .02$, $MSE = 582.96$; $F2(2, 58) = 2.60$, $p < .08$, $MSE =$

1787.23. At an SOA of 150 ms, the simple effect of IS Type was significant for participants, $F1(2, 28) = 3.74$, $p < .03$, $MSE = 413.39$, and was marginally significant for items, $F2(2, 58) = 2.36$, $p < .10$, $MSE = 1367.23$.

As depicted in Table 2, at an SOA of 0, the R-N difference was significant for participants but the R-U difference was not reliable. At an SOA of 150 ms, for participants, the R-N difference was marginally significant whereas the R-U difference was reliable.

Discussion

The results of Experiment 2 show a clear phonological facilitation effect in naming (compared to the unrelated condition) at an SOA of 0 ms. A phonological facilitation effect was also found at a late SOA in naming but the R-N difference was only marginally significant at that SOA in the by-item analysis. However, concerning this last result, the trend (R > N) was significant, $z(30) = 2$, $p < .04$.

For writing, the results indicate that contrary to naming, no facilitation effect was found with the simultaneous presentation of phonologically-related distractors (compared to unrelated IS). Consequently, phonological codes do not seem to play a crucial role in the retrieval of orthographic codes. This finding is the opposite of what would be expected in a phonological mediation account of lexical access in writing. According to such an account, phonological codes are activated to allow orthographic codes to be retrieved. In writing, the only result we observed was that linguistic distractors inhibited latencies compared to nonlinguistic distractors, but at a later SOA, a facilitation effect was found only with related distractors (compared to unrelated ones). However, it is difficult to interpret the latter effects.

GENERAL DISCUSSION

The two experiments reported in this article investigated the nature of the concerned representations and their activation time course in order to test three concurrent views of lexical access, both in picture naming and writing.

According to the first view, the written production of isolated words from pictures necessarily requires the prior activation of phonological information. This view, in which writing is seen as a kind of oral production translated into writing, was proposed by Luria (1970) and by Aitchison and Tood (1982). The second view states that the written production of isolated words involves the activation of orthographic representations without any involvement of phonological representations (and vice versa for oral production) at least in the production of isolated words. Finally, according to the third view, orthographic and phonological representations are activated simultaneously and in parallel, both in writing and in naming. Such parallel activation is thought to be due to connections between lemmas and orthographic lexemes and between lemmas and phonological lexemes. In the two experiments reported here, the interference paradigm was used to test the different views.

Although some of the results are difficult to interpret, there are nevertheless some interesting findings. First, the results of Experiment 2 suggested that phonological codes are not activated early in the time course of lexical access in writing, whereas such codes are activated in naming. Second, the results showed that orthographic representations are activated both in writing and in naming (Exp. 1). In Experiment 1, the results showed that an orthographically-related IS (i.e., the letter *h*) facilitated the naming of words beginning with that letter. This result for naming is far from trivial because studies reported so far in the literature have not convincingly dissociated the effects of phonological and orthographic similarity. However, as already stated, the facilitatory effect associated with the presentation of a silent letter was not robust because it was not significant on items. Concerning the visual presentation of IS, several results are difficult to interpret. For example, it appeared that phonologically- but not orthographically-related IS (i.e., *s* for *CIBLE*) did not facilitate spoken latencies or written latencies. One could conclude from this that a visually presented prime facilitates naming only if orthographic characteristics are retained. However, a phonological facilitation effect associated with the visual presentation of IS has been reported in the literature (see for example, Posnansky & Rayner, 1978). Moreover, no facilitatory effect associated with a phonologically- and orthographically-related distractor (the letter *t*) was observed. Given that access to orthographic and phonological representations in speech and in written production occur in parallel, such a facilitatory effect should have been observed.

One problem that can be raised from these experiments is related to the activation time course of phonological and orthographic information derived from the distractors used. One cannot rule out that the facilitatory effect associated with the orthographically-related condition (i.e., the visual presentation of the initial letter *h*) was due to strategic factors.

An experiment in which the stimulus exposure durations are more carefully manipulated should be conducted. Such a manipulation would be very useful because it has, for example, resolved some discrepancies concerning semantic effects in priming and interference studies (La Heij, Dirkx, & Kramer, 1990). Some recent studies, using the masked form priming paradigm have provided important findings related to the activation time course of orthographic and phonological information in picture naming, and also in the processing of visually presented words (Ferrand & Grainger, 1994; Ferrand, Grainger, & Segui, 1994). Ferrand, Grainger, and Segui (1994) showed that visually masked pseudohomophones (*piez-PIED*) presented for 29 ms before pictures facilitated picture naming compared to orthographically-related nonword primes (*pien-PIED*), whereas the latter primes were not facilitatory compared to unrelated nonword primes (*peul-PIED*). Experiments using this paradigm should be designed to better determine the activation time course of phonological and orthographic information in writing and in naming.

The most important and clearest finding obtained from these two experiments is the fact that lexical access in writing cannot be conceived of as oral production translated into writing, and thus, that *phonological information is not a preliminary and necessary stage for the retrieval of orthographic representations*. This finding argues against a strong phonological mediation account in writing. Such a view implies that phonological codes are retrieved prior to the involvement of orthographic codes. Thus, this view predicts a phonological facilitation effect and no early facilitation effect associated with orthographically related primes.

Moreover, the findings are inconsistent with the view of parallel access to orthographic and phonological information in writing, because the results show only orthographic facilitation effects. Concerning oral production, even if the findings partially support the hypothesis of parallel access to orthographic and phonological representations, the lack of robustness in the effects observed with orthographically-related primes (significant for *F1 and F2*), means that further experiments are needed to better determine the role of phonological and orthographic information in naming and writing. We think, however, that these findings are a first step towards a better understanding of the representations underlying picture naming and picture writing, and more generally, that the relations between spoken and written language production can be investigated in a systematic experimental way.

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RÉSUMÉ

Deux expériences, réalisées à l'aide du paradigme de l'interférence "image-mot", ont été conduites afin d'étudier la nature des représentations (phonologiques/orthographiques) en jeu dans l'accès lexical en dénomination orale et écrite de mots isolés à partir d'images, ainsi que leur décours temporel d'activation. Trois conceptions de l'accès lexical en production verbale orale et écrite ont été testées. Selon la première conception, des codes orthographiques et des codes phonologiques seraient activés en parallèle en production verbale orale comme en production verbale écrite. Selon la deuxième conception, des codes phonologiques seraient activés en production verbale orale tandis que des codes orthographiques seraient activés en production verbale écrite. Enfin, la troisième conception était que des codes phonologiques seraient activés en production verbale orale et médiatiseraient l'accès aux codes orthographiques en production verbale écrite. Les résultats ne s'accordent avec aucune des trois conceptions testées. Toutefois, ils permettent clairement d'écarter la conception selon laquelle l'accès lexical en production écrite de mots isolés est obligatoirement médiatisé par la phonologie.

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APPENDIX
List of experimental item names used in Experiments 1 and 2

Labels used in Experiment 1:

habit, haie, hangar, haricot, harpe, harpon, hélice, herbe, hérisson, hibou, hochet, homard, hôpital, horloge, hotte, hublot, huile, huître, cigogne, cendrier, cible, cintre, cerceau, cigale, cerf, citron, cerise, ciseau, cirque, cierge, cercueil, cigare, ceinture, cellule, cerveau, cercle, tétine, truelle, tracteur, toupie, tomate, taupe, tarte, tigre, tortue, tonneau, tambour, tasse, talon, tronc, taureau, tapis, toit, tableau.

Labels used in Experiment 2:

balai, brique, bougie, botte, bouton, bouteille, billet, banc, bateau, ballon, compas, canard, cochon, cage, camion, couteau, cahier, corde, canon, croix, tomate, tonneau, tasse, talon, tronc, taureau, tapis, toit, tableau, tortue.