An Experimental Study of Lexical Access in the Writing and Naming of Isolated Words

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Unlike speech production, lexical access in written production has not systematically been investigated experimentally. Four experiments were run on literate adults to support the view that although the spoken and written language production systems may obviously share some processing levels, they also both have some specific processing components. The general findings provide evidence for such a view and are discussed in the framework of studies in verbal production conducted on normals and on brain-damaged patients.

Contrairement à la production verbale orale, l'accès lexical en production verbale écrite n'a pas été étudié expérimentalement de façon systématique. Quatre expériences ont été conduites sur des adultes cultivés afin d'étayer la conception selon laquelle les systèmes de production du langage partagent des composantes de traitement mais possèdent également des composantes de traitement spécifiques. Les principaux résultats s'accordent avec une telle conception et sont discutés dans le cadre des études sur la production verbale réalisées auprès d'adultes normaux et cérébrolésés.

INTRODUCTION

Written production has traditionally been a step-child of psycholinguistic research, whereas a substantial number of studies have dealt with speech production. Consequently, the study of speech production is far more advanced than that of written production (for speech production, see Bock, 1982, 1987; Dell, 1986; Garrett, 1980, 1982; Levelt, 1989; Levelt & Maassen, 1981; Levelt et al., 1991a; Schriefers, 1992; and for written production, see Hayes & Flower, 1980; Martlew, 1983; Scardamalia & Bereiter, 1986).

Although a number of studies have focused on the problem of lexical access in naming, for writing, there are to our knowledge no systematic experimental approaches conducted on normal subjects. In fact, most studies in written production have investigated higher processing levels involved in writing, such as planning or revising (Bourdin & Fayol, 1994; Fayol, 1997).

There is a general agreement among researchers that lexical access in speech production entails the following processing levels: a conceptual level, a semantico-syntactic level (this level corresponds to the retrieval of lemmas, i.e., prephonological forms; for an extensive discussion about lemma retrieval in speaking, see Roelofs, 1992), a phonological level (referred to as the lexeme level), and an articulatory level (Dell, 1986; Kempen & Huijbers, 1983; Levelt, 1989; for a brief review on lexical access in speech, see Ferrand, 1994). The distinction between the semantic and phonological levels has received empirical support from analyses of access failures (TOT states; see Brown & McNeill, 1966; Meyer & Bock, 1992), speech errors (Fay & Cutler, 1977; Garrett, 1980, 1982), and from experimental studies (Levelt &

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Maassen, 1981; Levelt et al., 1991a; Schriefers, 1992; Schriefers, Meyer, & Levelt, 1990). However, the problem of how these representations are retrieved during lexical access is still being widely debated (Dell & O'Seaghdha, 1991; Harley, 1993; Levelt et al., 1991b).

As for writing, one problem concerns the role of phonological information. This issue has undergone a parallel debate in the literature about reading processes (Coltheart, 1978; Ferrand & Grainger, 1994; Shulman, Hornak, & Sanders, 1978; Van Orden, 1987). There is some evidence to support the view that phonological information is activated during written production. For example, analyses of "slips of the pen" (Ellis, 1979; Hotopf, 1980) have revealed that writers sometimes produce homophonic substitutions. In other words, they produce a word that is similar in sound to the intended one but not related in meaning (e.g. *there* for *their*)[1]. However, there is also some evidence, as shown by cognitive neuropsychologists, that in a number of cases of brain-damaged patients, written performance is more or less spared relative to spoken production (Rapp & Caramazza, 1994). For example, Lhermitte and Dérouesné (1974) described a patient who was 74% correct in written production but only 8% correct in oral production. Such cases are problematic for the phonological mediation claim, since it makes it difficult to argue that spoken neologistic responses form the basis for the retrieval of correct written responses. Besides, in French (as in English) there are many silent letters in words but people are still able to spell the words correctly (Fayol, Largy, & Lemaire, 1994; Largy, Fayol, & Lemaire, 1996). For example, in French, some silent graphemes have no obvious phonological correspondence, e.g. *h* in *harpe* (*harp*) (Véronis, 1986). Also problematic for a phonological mediation account of writing is the selection of the correct spelling for homophones (Ellis, 1984). It has been suggested that phonological information is not necessary to retrieve orthographic representations. Orthographic information may be retrieved directly and would not be systematically mediated by phonological information (the Orthographic Autonomy Hypothesis; Rapp & Caramazza, 1994).

The purpose of our study was to investigate lexical access in written production. Our main concern was to get experimental evidence to support the view that, although the spoken and written language production systems may obviously share some processing levels, they also both have *some specific processing components*. To this end, we studied oral and written productions together. Likewise, it was possible to determine some of differences and similarities between the spoken and the written production of isolated words in reference to some well-known findings observed in spoken production (and more specifically frequency effects). To this end, four experiments and a norming study were conducted on literate adults.

A simple working view is proposed on the basis of speech production psycholinguistic and cognitive neuropsychological studies. In our view, two procedures are available to write or to name visually presented words: a lexical and a nonlexical procedure respectively. For naming and writing words from their auditory presentation, lexical and nonlexical routes are also available. However, the lexical route would be preferred over the nonlexical route for writing familiar words from their auditory presentation (this latter assumption is justified later). For picture naming and writing (that is, naming aloud or writing down the name of a pictured object), a structural level and a semantic level are included. These levels are thought to be common to naming and writing (Caramazza & Hillis, 1990; Ellis, 1982, 1988). The processing levels are thought to differ beyond the semantic level: there may be a phonological lexeme level in naming and an orthographic lexeme level in writing. Connections are postulated between phonological and orthographic lexemes (Ellis, 1988; Patterson, 1988). This kind of connection gives a parsimonious account of homophonic substitution errors in writing (Hotopf, 1980). Phonological information may serve as input for articulatory processes in speech production and orthographic information may serve as input for graphic output processes in mwritten production (allograph selection, retrieval of graphic motor patterns, execution).

In our main experiment (Experiment 1), some participants were asked to write down words while others had to say the words aloud. Different kinds of input were used to elicit the responses:

[1] Homophone substitutions are different from spelling mistakes (or spelling errors) because the latter correspond to the violation of spelling conventions whereas the former correspond to the written production of a word which is correctly spelled and similar in sound to the intended word but whose spelling and meaning are different from the intended word.

pictures, auditorily presented words, and visually presented words. The words varied in frequency. Written and spoken response latencies were recorded. In accordance with the general purpose of this study, the following hypotheses were tested.

1. It is commonly argued that after a visual stimulus, such as a picture, is analyzed, structural representations are contacted and a more abstract processing step involving semantic access takes effect (Vitkowitch & Humphreys, 1991). According to Levelt (1989), in order to retrieve a verbal label, speakers can bypass neither conceptual identification nor lemma retrieval (see also Roelofs, 1992). The assumption that names associated with pictures are retrieved indirectly and that word representations can be accessed directly from the lexicon has been supported by interference studies (Glaser & Glaser, 1989; Smith & Magee, 1980). Our hypothesis was that pictures, unlike linguistic input, have no direct connection with orthographic and phonological representations within the lexicon. Thus, latencies should be longer with pictures than with words whether presented either auditorily or visually. Moreover, we predicted that writing down words from their auditory presentation (dictation) as well as speaking aloud words from their written form presentation (reading aloud), would take longer to initiate than would writing down words from their visual presentation (copying) as well as speaking aloud words from their auditory presentation (shadowing). We expected such a latency difference because in the last two cases, the input may activate certain forms of the corresponding lexical representations directly in the mental lexicon.

2. With words produced from pictures, frequency effects were predicted in spoken as well as in written production (for frequency effects in speech production, see Beattie & Butterworth, 1979; Huttenlocher & Kubicek, 1983; Jescheniak & Levelt, 1994; Levelt, 1983; Oldfield & Wingfield, 1965; Wingfield, 1968). Based on the assumption that pictures cannot be encoded *directly* in linguistic format, our hypothesis was that lexical representations necessitate the previous activation of the mental lexicon. Because the lexicon is accessed, a frequency effect should be observed in naming and in writing words from pictures. A frequency effect was also predicted with words presented auditorily and then produced in the written modality. This hypothesis was in line with Véronis's (1988) assumption. In a simulation with French words, Véronis showed that an assembly process that converted heard words into written words would result in almost one word out of two being misspelled. Thus, an addressed process would be necessary, and so a frequency effect should occur. The classical frequency effect for reading words aloud was also predicted. In contrast, no prediction was made concerning the pronunciation of words presented auditorily and the written production of words presented visually. We simply assumed that frequency effects should be observed whenever some form of lexical representation is retrieved from the mental lexicon.

NORMING STUDY

The experimental procedure required careful preparation of the materials. We had to select low- and high-frequency words. As the words had to be depicted by a drawing, abstract words could not be selected. Moreover, to be selected (1) the words had to be correctly spelled by most participants and (2) the drawings associated with the words had to be considered as easily identified and named in the same way by most participants. More precisely, to be selected as experimental items, the "objects" depicted by the drawings had to be considered as easy or very easy to recognize by 85% of the participants. Ease of recognition was evaluated on a five-level scale (1: very easy; 2: easy; 3: not very easy; 4: not easy at all; 5: not recognized). Similarly, the drawings had to be given the same name by at least 85% of the participants. Finally, the names had to be spelled correctly by at least 85% of the participants.

Method

Participants

Twenty-eight subjects recruited from the University of Bourgogne participated in the norming study. They were undergraduates in pyschology and were native speakers of French.

Stimuli

Two hundred and two black-on-white drawings of concrete objects were selected from children's picture books and from the Snodgrass and Vanderwart's (1980) corpus. The frequency of the words associated with the pictures ranged from 5 to 89,209 (out of 100 million). The frequency

counts were taken from the Brulex database (Content, Mousty, & Radeau, 1990). These words differed as to the number of syllables (monosyllabic and bisyllabic words) and word length, which varied from four to six letters. The pictures were presented in a booklet. Below each picture there was a blank line for writing down the name, and below that, a five-level scale for indicating estimated recognition ease.

Procedure

Participants were tested collectively. They were required to (1) write down the name (without the article) for each picture, and (2) check the level on the scale to indicate whether they identified the depicted object very easily, easily, not very easily, not easily, or not at all.

Results

Forty drawings were selected on the basis of these criteria. The verbal labels corresponding to the selected drawings were 20 monosyllabic and 20 bisyllabic 5-letter words. These two sets of items varied in frequency. Likewise, for each set, high-frequency (HF) and low-frequency (LF) words were distinguished. For the monosyllabic words, the mean frequency was 3659.7 for HF and 303.2 for LF words, and for the bisyllabic words the mean frequency was 3961.2 and 226.2 for HF and LF words respectively. Frequency counts were taken from the Brulex database (Content et al., 1990). Although a perfect match of word onset was not possible, we were careful, following Jescheniak and Levelt (1994), to ensure that there were no systematic differences in the onset segments between LF and HF items (there were 18 word-initial consonants and 2 word-initial vocalic segments in each category of items). Finally, item frequency and initial bigram frequency were not correlated, $r = .02$.

EXPERIMENT 1: ORAL AND WRITTEN PRODUCTION OF ISOLATED WORDS

Method

Participants

Twenty-four adults participated in the experiment. They were undergraduates in psychology at the University of Bourgogne and were all native speakers of French. They were randomly assigned either to the writing group or to the naming group. There were 12 subjects in the naming group and only 9 in the writing group as, for technical reasons, 3 subjects were discarded.

Stimuli

Spoken/Written Production of Words from Pictures. The 40 pictures selected during the pre-experiment were used.

Spoken/Written Production of Words from Words Presented Auditorily. Forty items corresponding to the most common label given for each picture. The items were recorded using Mac Recorder software.

Spoken/Written Production from Words Presented Visually. The 40 experimental words were used.

Apparatus

The experiment was run on a Macintosh computer (LC III). A graphic tablet and a contact pen (SP-210) were used to record written latencies. A microphone (AIWA stereo; impedance: >1kW; −74dB) was used to record spoken latencies.

Procedure

Participants were tested individually in 3 different sessions that took place within 1 week. Each session lasted about 50 minutes. The testing order of the experimental tasks was rotated across participants, that is to say the participants received the tasks in the same cyclical sequence but began at different points in that sequence.

Producing Words from Pictures. A trial consisted of a 500msec presentation of a centred ready signal (a black point) followed by a 1000msec blank and then by a picture. Participants were required either to pronounce quickly or to write down the name associated with the picture (in this experiment as well as in subsequent experiments, participants were never told what label to use to refer to any given picture). The next trial was initiated 5000msec after the onset of the participant's response. A set of practice trials was given before the experimental session. In the writing group, the participants were instructed not to change their answer once they had written down a word. Whenever they did not recognize the depicted "object" or did not

find a word for any presented picture, they were asked to mark an "X". In the naming group, the participants had to pronounce the words aloud. Whenever they failed to recognize the depicted "object" or to find an appropriate label, they had to say aloud "stop". The items were presented in a different random order for each participant.

Producing Words from Words Presented Auditorily. The trials had the same structure as previously described except that words were presented auditorily by means of headphones. Depending on the group, the participants were required either to pronounce or to write down each item heard. To prevent participants looking at their hand, which would result in availability of visual guidance and output monitoring being confounded with input modality, fixation of the screen was required. Warm-up trials were given at the beginning of the session.

Producing Words from Words Presented Visually. The trials had again the same structure as previously described, with the exception that words were presented in their visual form in the centre of the screen. Depending on the group, the participants were required either to speak aloud or to write down each given word. Warm-up trials were given at the beginning of the session.

Results

Naming latencies and writing latencies were measured from speech onset and writing onset respectively.

Naming Latencies. Trials on which the participants produced items other than the expected ones, repaired their response, or produced mouth clicks were excluded from the analyses. Overall, 3% of the observations were discarded.

Writing Latencies. The written responses were timed as follows. The participants sat with the stylus hovering above the tablet so that RT was the time to make contact. Observations were discarded from the analyses whenever any of the following conditions held: (1) words were misspelled; (2) a technical problem occurred; (3) an item other than the expected one was produced; (4) the subject merely touched the tablet and then paused; (5) the subject wrote a letter or two and then paused. On the basis of these criteria, 6.3% of the data were excluded.

Medians were computed instead of means because some data would have been excluded and, thus, there would have been few values in some of the cells. The RTs were submitted to two ANOVAs with participants and items as random factors, respectively. The ANOVA performed on participants was a 2 (Output type: Naming vs. Writing) × 3 (Input type: Pictures vs. Indirect [i.e. heard words written and read words spoken] vs. Direct [i.e. read words written down and heard words spoken aloud] × 2 (Number of syllables: One vs. Two syllables) × 3 (Frequency: Low vs. High) design involving independent measures on the factor Output type. In order to generalize the effects upon items, an ANOVA on items was performed with the same factors with Input type and Output type as within-group factors and the remaining factors as between-group factors. In this experiment and in all subsequent experiments, analyses are only reported by participants whenever both sets of analyses were in agreement. When a discrepancy occurred between the two sets of analyses, both analyses are reported. The dependant variable (measured to the nearest millisecond) was the duration between the onset of the presentation of the item and the initialization of the naming/writing response.

The overall results are presented in Table 1. In all the analyses reported in this paper, there was no significant main effect of number of syllables, nor did this factor interact significantly with any other factor.

The main effect of output type was significant (Writing: 1084msec, Naming: 673msec), $F(1,19)$

TABLE 1
Mean Median Latencies (Msec) Relative to Mediation Type (Pictures, Indirect, Direct), Output Type (Naming vs. Writing), Frequency of Items (HF: High-frequency Items vs. LF: Low-frequency Items)

	HF	*LF*
Pictures		
Naming	890	993
Writing	1292	1464
Indirect		
Naming	603	602
Writing	998	1064
Direct		
Naming	496	454
Writing	827	856

= 71.40, $P < .0001$, MSE = 291,487. The main effect of input type was significant (Pictures: 1160msec, Indirect: 817msec, Direct: 658msec), $F(2,38) = 106.45$, $P < .0001$, MSE = 101,527. Planned comparisons revealed that the latency for pictures was significantly longer than the latencies for direct and indirect input conditions, $F(1,19) = 169.46$, $P < .0001$, MSE = .115E+06. Indirect was also significantly different from Direct, $F(1,19) = 23.57$, $P < .0001$, MSE = 87,702. Although the Output type × Input type interaction effect was not significant on participants, $F_1 < 1$, it was marginally significant on items, $F_2(2,64) = 2.57$, $P < .08$, MSE = 14,869.34.

The main effect of frequency was significant (HF: 851msec, LF: 906msec), $F(1,19) = 24.35$, $P < .0009$, MSE = 15,149.4, as was the Frequency × Output type interaction effect, $F(1,19) = 9.69$, $P < .006$, MSE = 15,149.4. This interaction indicated that the frequency effect was greater in the written modality than in the spoken modality. Frequency × Input type interaction was significant, $F(2,38) = 29.08$, $P < .0001$, MSE = 7,832.6. This interaction shows that the frequency effect was greater with pictures (−137msec) than with linguistic input (−13msec). Output type × Input type × Frequency interaction was not significant, $F < 1$. Planned comparisons revealed that the frequency effect was significant in writing with pictures (HF: 1292msec, LF: 1464msec), $F(1,19) = 23.23$, $P < .0001$, MSE = 22,897.3, with indirect (i.e. heard words written down) (HF: 998msec, LF: 1064msec), $F(1,19) = 12.5$, $P < .002$, MSE = 6,301.14, and with direct in the by-participant analysis only (HF: 827msec, LF: 856msec), $F_1(1,19) = 9.66$, $P < .006$, MSE = 1,616.1; $F_2 < 1$. In naming, the frequency effect was significant with pictures in the by-participant analysis (HF: 890msec, LF: 993msec), $F_1(1,19) = 11.21$, $P < .0033$, MSE = 22,897.3, but failed to reach significance in the by-item analysis, $F_2(1,32) = 3.27$, $P < .08$, MSE = 14,021.38. With indirect (i.e. reading aloud words), the frequency effect was not significant, $F < 1$. With direct (i.e. repeating aloud words), the reversed frequency effect was significant in the by-participant analysis (HF: 496msec, LF: 454msec), $F_1(1,19) = 25.66$, $P < .0006$, MSE = 1,616.10, but not in the by-item analysis, $F_2 = 1.08$.

Discussion

The goal of this experiment was to investigate some of the processes involved in the generation of words in writing and in naming from pictures, from words presented auditorily, and from words presented visually.

In the view we took as a starting point, a phoneme-to-grapheme procedure was considered to play a secondary role for the written production of known French words. Following the assumption proposed by Véronis (1988), words presented auditorily are not spelled via a nonlexical route. Evidence for this view comes from the finding of a frequency effect in the writing task with words presented auditorily. This frequency effect cannot be due to the retrieval of acoustico-phonological forms because such a frequency effect was not observed in the naming taks. Nor can it be due to acoustic differences because an ANOVA performed on the acoustic duration of items revealed that only the number of syllables factor was significant, $F(1,32) = 5.37$, $P < .03$, MSE = 11,061.56. As concerns frequency effects in naming and in writing from pictures, they were as expected. The frequency effect with pictures was significant in the writing task on both participants and items but it was only marginally significant on the items in the naming task. This could be due to the fact that some words are more frequent in speech than in writing. However, this latter hypothesis cannot be tested insofar as no French oral frequency counts are available. We interprete the observed frequency effect with pictures as a result of lexical access contingencies. Nevertheless, two alternative accounts of the frequency effects observed in naming and in writing from pictures cannot be ruled out on the basis of our findings. First of all, a conceptual locus of the frequency effect cannot be excluded. Jescheniak and Levelt (1994) ruled out a conceptual account in their study on frequency effects in picture naming. However, such an hypothesis should be tested with the stimuli used in this experiment. This hypothesis was tested in Experiment 2. Second, if a conceptual locus of the frequency effect appears to be ruled out, a postlexical locus of the frequency effect will also have to be taken into account. This latter hypothesis was tested in Experiment 3.

Concerning frequency effects, one finding was surprising: no frequency effect was observed with reading words aloud, although this effect has often been reported in the reading literature (Forster & Chambers, 1973; McRae, Jared, & Seidenberg, 1990; but for contradictory results see Hudson & Bergman, 1985; Richardson, 1976). The interpretation that the frequency effect was not captured because of the frequency con-

trast used in our experiment, was ruled out by the significant frequency effect found in a previous experiment, in which a lexical decision task with the same items was used on 10 adults (HF: 533msec; LF: 555msec), $F(1,9) = 17.16$, $P < .002$, $MSE = 566$. Unfortunately, no satisfying explanation can be given to account for our failure to find a significant frequency effect in the reading task.

The writing latencies were longer than the speaking latencies across all kinds of input (pictures, auditorily presented words, and visually presented words). This finding could be interpreted as favouring a phonological mediation claim of lexical access in writing. However, the latency difference may only be due to specific writing output processes. Experiment 1 data do not allow us to determine which of these two alternative hypotheses is valid. These were tested using a delayed production task in Experiment 3.

The results of Experiment 1 are in line with the assumption that pictures—unlike linguistic input—have no *direct* connections with word representations in the mental lexicon. It is assumed here that to retrieve the appropriate label associated with a picture, speakers and writers cannot bypass the structural and semantic levels, making written or spoken latencies longer with pictures than with words (there is, however, some neuropsychological evidence that semantic level could be bypassed in object naming, Kremin, 1986). However, the interpretation that the observed difference can be ascribed to encoding processes and/or to slower semantic access for pictures than for words cannot be excluded on the basis of our present results. For oral production, Fraisse (1967, 1969) showed that latencies were longer for the naming process, i.e. giving the verbal label of a picture, than for the reading process, i.e. reading aloud the word associated with a picture. Fraisse concluded that the latency difference may be due to the uncertainty of coding in the naming process. These alternative accounts will be considered in Experiment 4. Furthermore, our findings are consistent with the view that when linguistic input can directly activate appropriate lexical representations (relative to the output modality) in the lexicon, the computation is faster than when a transformation must be applied to the input (and indeed, we found that the latencies were shorter with visually presented words written down than with orally presented words written down).

EXPERIMENT 2: IDENTIFICATION TASK

There is evidence in the literature on spoken production for a lexical locus of the frequency effect (see Jescheniak & Levelt, 1994). Neither Huttenlocher and Kubicek (1983) nor Jescheniak and Levelt (1994) found a frequency effect in an object recognition task (see also Bartram, 1976; Wingfield, 1967, 1968; but see Kroll & Potter, 1984). The goal of the following experiment was to determine whether the frequency effects observed in naming and in writing from pictures could be ascribed to identification processes. Such an account implies that objects with high-frequency names might simply be more common objects, which are more frequently encountered and therefore more easily identified. This hypothesis was tested because, even if the results in the literature generally rule out a conceptual locus of the frequency effect in picture naming, they are not numerous and are not completely consistent (for example, Kroll & Potter, 1984). This hypothesis was also tested in Experiment 2 because a frequency effect was found in writing from pictures. To our knowledge, such an effect has never been reported on normals, and thus, we were primarily interested in determining whether the frequency effect observed in writing words from pictures can be ascribed to identification processes. For that reason, the participants in Experiment 1 were used again in Experiment 2. Likewise, it was possible to compare for the same participants frequency effects in naming and in writing, with a task requiring identification processes.

A picture recognition task was used (as in Jescheniak & Levelt, 1994). Participants saw a word immediately followed by a picture. Their task was to decide whether the word denoted the object in the picture and to press a yes or no button accordingly.

Method

Participants

Participants from Experiment 1 were tested 1 week after Experiment 1.

Stimuli

The experimental pictures used in Experiment 1 were used for this experiment. Additional pictures were included for the no responses such that

there was an equal number of yes and no responses. The experimental pictures were always associated with a yes response. Warm-up trials were included.

Procedure

Participants were tested individually in a session lasting about 30 minutes. All visual stimuli were presented centred on the screen. The words were displayed in Palatino 28. Two push buttons were used, one for the yes response and one for the no response. The yes button was always assigned to the participant's preferred hand. The structure of a trial was as follows. Participants first saw a word for 1995msec. After a pause of 1000msec, the target picture was displayed until the response. After a period of 1000msec, the next trial began. No feedback was provided concerning the participant's response. Participants received warm-up trials before the experimental session.

Results and Discussion

Median reaction times were submitted to ANOVAs with both participants and items as random factors. The ANOVA preformed on participants was a 2 (Number of syllables: One vs. Two syllables) × 3 (Frequency: Low vs. High) design involving repeated measures. In order to generalize the effects upon items, an ANOVA on items was performed.

The frequency effect was not significant either in the writing group (HF: 585msec; LF: 598msec), $F < 1$, or in the naming group (HF: 557msec; LF: 547msec), $F < 1$.

The goal of this experiment was to determine whether the frequency effects observed in naming and in writing words from pictures can be ascribed to identification processes. The findings suggest that frequency effects in naming and writing words from pictures are not rooted to the conceptual level. However, the absence of an effect could be due to identity priming. A word may prime the recognition of a picture it denotes. This could have obliterated any frequency effect in the recognition task. If this priming account is correct, a frequency effect should be obtained on the negative trials, that is, when the word does not match the picture name. This hypothesis was tested by analyzing the RTs for the negative trials. Because the items had been drawn from the whole continuum of the frequency distribution rather than its extremes, we correlated RTs with frequency. These analyses revealed that for the writing group, the correlations between median RTs and log frequencies were weak and not reliable, $r = -.13$. For the naming group, the same pattern of results was obtained, $r = -.11$. This result is in line with what Jescheniak and Levelt (1994) found in their object recognition task. Thus, the priming hypothesis was not confirmed by the present analyses. One could still argue that the frequency effect was not captured by our object recognition task because the participants were familiar with the pictures. However, the experiment reported by Jescheniak and Levelt had been run on participants who had not previously named the pictures.

The results provided so far do not rule out the hypothesis that the frequency effects observed in naming and in writing can be, at least partially, ascribed to output processes, i.e. articulatory processes in naming and allographic selection and/or graphic-motor pattern retrieval in writing. This hypothesis was considered in Experiment 3.

EXPERIMENT 3: IMMEDIATE AND DELAYED PRODUCTION TASKS FROM PICTURES

The purpose of this experiment was two-fold. In Experiment 1, a latency difference was observed between naming and writing across the different kinds of input: pictures, words presented auditorily, and words presented visually. Our first goal was to determine whether the writing latencies were longer than the naming latencies due to a systematic mediation by phonology in writing or simply to output processes specific of writing. The second goal was to find out whether the frequency effect observed in writing and naming from pictures can be partially or totally ascribed to output processes.

In Experiment 1, we observed a systematic latency difference between naming and writing. However, the data did not help us to determine why such a difference occurred. To gain further insight into this problem, two different hypotheses were stated. In the first (the one we favoured), the latency difference is assumed to be due solely to the output processes involved in writing. In the second, the latency difference is assumed to be due to the systematic phonological mediation of writing. In other words, to produce the written form of words, phonological information would have to be systematically retrieved.

Concerning the frequency effects in naming and in writing, our hypothesis was that they are attributable to a lexical level (the lexeme level), but the alternative hypothesis that these frequency effects take place after access to the mental lexicon also had to be tested. An articulatory locus for the frequency effect in naming had already been ruled out by Jescheniak and Levelt (1994). Nevertheless, because of the lack of experimental research on lexical access on normals in writing, such an account had to be tested.

Balota and Chumbley (1985) showed that the word frequency effect could partially be attributed to articulatory processes. Such a view implies that articulatory programs for high-frequency words may be compiled and executed faster than those for low-frequency words. The main support for this view comes from the persistence of a frequency effect in a delayed naming task. In delayed naming (or writing for that matter), participants see a word and prepare its pronunciation. After a variable delay, a cue signals them to initiate the vocal response. It is assumed that response preparation will proceed as far as it can. If the cue delay is long enough, the word will have been recognized and the articulatory motor program assembled and stored in a buffer. Upon detection of the cue, the participants retrieve and execute the motor program. Thus, any remaining effect of frequency has to be ascribed to the response execution stage.

In their study on frequency effects in naming, Jescheniak and Levelt (1994) found no frequency effect in a delayed word naming task. However, they did not use a *delayed picture naming task*, considering that there is no principled reason to expect qualitatively different results with picture stimuli. This hypothesis had to be tested with pictures instead of being accepted on a priori grounds. In the experiment reported here we used a delayed picture naming task. For writing, the hypothesis that part of the frequency effect might be ascribed to a postlexical level has never been tested. This hypothesis was tested using a delayed production task.

An experiment was run in which some participants had to name pictures and then write down words from pictures immediately (and vice versa) while others had to do the same but only after a cue rather than immediately, i.e. delayed production. The delayed naming/writing task allowed us to test the above hypotheses. In a delayed naming/writing task, it is assumed that lexical access has taken place and that participants only have to retrieve and execute the motor program.

In line with a mediation account of lexical access in writing, an interaction between production type and output type was predicted. Such an interaction was predicted not to occur with an "output hypothesis" of the latency difference between naming and writing. Relative to the "lexical hypothesis" of the frequency effect, it was predicted that the frequency effect would only be observed in an immediate writing/naming task.

Method

Participants

Twenty native speakers of French recruited at the University of Bourgogne served as participants for course credit. None had participated in any of the previous experiments.

Stimuli

The same pictures were used as in Experiment 1.

Apparatus

The same apparatus was used as in Experiment 1.

Procedure

Participants were randomly assigned either to the delayed production task (10) or to the immediate production task (10), but had to produce in the written modality as well as in the oral modality (the output modality order was counterbalanced across participants). The immediate production task was the same as in Experiment 1 for the picture condition. For the delayed production task, an experimental trial had the following structure. A ready signal was presented for 500msec. Then, the screen was empty for 100msec, after which a picture was displayed. The picture remained on the screen for 1500msec. After a variable delay of 1200, 1400, 1600, or 1800msec, a cue ("????") indicated participants should initiate the word. The cue remained visible until the response was initiated.

Results

Applying the same criteria as used in Experiment 1 on the naming latencies and on the writing latencies of Experiment 3 led us to discard 12% and 10% of the observations, respectively.

Two ANOVAs were conducted on the median latencies. The ANOVA on participants was a 2 (Production type: Immediate vs. Delayed) × 2 (Output type: Writing vs. Naming) × 2 (Position: Naming followed by writing vs. Writing followed by naming) × 2 (Frequency: Low vs. High) × 2 (Number of syllables: monosyllabic words vs. bisyllabic words), with independent measures on the Production type and Position factors. The ANOVA on the items was conducted on the same factors, with Production type, Output type, and Position as within-subject factors.

The overall results are presented in Table 2. The main effect of production type was significant (Immediate: 1120msec, Delayed: 630msec), $F(1,16) = 64.84$, $P < .0005$, $MSE = 295,822$, as was the main effect of output type (Naming: 689msec, Writing: 1060msec), $F(1,16) = 47.29$, $P < .00037$, $MSE = 232,825$. The main effect of position was reliable (Position 1: 967msec, Position 2: 783msec), $F(1,16) = 64.84$, $P < .008$, $MSE = 295,822$. Output type × Production type interaction effect was not significant, $F < 1$. The latency difference between naming and writing was +376msec in the delayed production task and +367msec in the immediate production task. This finding suggests that the latency difference between naming and writing is due to output processes and not to systematic phonological mediation in writing. The latency difference between naming and writing was observed in the immediate production task as well as in the delayed production task for all output positions.

The Production type × Position interaction was significant, $F(1,16) = 5.36$, $P < .034$, $MSE = 295,822.1$. This interaction showed that the locus of the facilitatory effect observed on latencies was not postlexical. Planned comparisons indicated that the latency difference between positions 1 and 2 was significant in the immediate production task, $F(1,16) = 14.21$, $P < .0016$, $MSE = 295,822$, and not significant in the delayed production task, $F < 1$. Although the Production type × Output type × Position interaction effect was not significant on participants, $F_1 < 1$, it was significant on items, $F_2(1,32) = 4.28$, $P < .05$, $MSE = 9,042.16$. Planned comparisons between naming in position 1 and naming in position 2 indicated that the observed facilitatory effect (−287msec) was significant in the immediate production task, $F(1,16) = 23.37$, $P < .0001$, $MSE = 70,400$, but not significant in the delayed production task, $F < 1$. A significant facilitatory effect (−362msec) was observed in the immediate writing task, $F(1,16) = 5.70$, $P < .03$, $MSE = 458,248$, but this effect (−99msec) was not significant in the delayed writing task, $F < 1$. For the immediate production task, planned comparisons revealed that the facilitatory effect was significantly greater in writing than in naming in the by-item analysis, $F_2(1,32) = 15.15$, $P < .0004$, $MSE = 13,168.5$, but not in the by-participant analysis, $F_1 < 1$.

The main effect of frequency was significant (HF: 850msec, LF: 900msec), $F(1,16) = 17.45$, $P < .0007$, $MSE = 11,373.9$.

The Production type × Frequency interaction was significant, $F(1,16) = 22.46$, $P < .0002$, $MSE = 11,373.9$. This interaction shows that the frequency effect is not attributable to postlexical processes. The frequency effect was reliable in the immediate production task, $F(1,16) = 39.75$, $P < .0001$, $MSE = 11,374$, but not in the delayed production task, $F < 1$.

The three-way interaction between production type, output type, and frequency was not significant, $F < 1$. As can be seen from Table 2, the frequency effect was observed on the immediate production task in naming as well as in writing across all levels of the position factor. Planned comparisons revealed that the frequency effect was significant for the immediate production task in naming as well as in writing across the levels of the position factor. Planned comparisons between frequency effects observed for the

TABLE 2
Mean Median Latencies Relative to Production Type (Immediate vs. Delayed), Output Type (Naming vs. Writing), Position (Position 1 vs. Position 2) and Frequency of Items (HF: High-frequency Items vs. LF: Low-frequency Items)

	Naming				*Writing*			
	Position 1		*Position 2*		*Position 1*		*Position 2*	
	HF	*LF*	*HF*	*LF*	*HF*	*LF*	*HF*	*LF*
Immediate production task	1033	1156	757	829	1423	1545	1083	1162
Delayed production task	444	427	451	448	878	856	706	776

immediate production task in position 1 and 2 indicated that this frequency effect was significantly smaller in naming, $F(1,16) = 4.63$, $P < .04$, $MSE = 7{,}020.22$, and in writing, but the decrease was not reliable for this latter comparison, $F < 1$. The Frequency × Position and Frequency × Output interactions were not significant, Fs < 1. The interaction between frequency, position, and output type was not significant, $F < 1$. The Production type × Position × Frequency interaction effect was marginally significant in the by-participant analysis, $F_1(1,16) = 3.45$, $P < .08$, $MSE = 11{,}373.9$, and significant in the by-item analysis, $F_2(1,32) = 4.63$, $P < .03$, $MSE = 18{,}190.16$. For the item means, this interaction showed that the latencies were greater for low-frequency items than for high-frequency items in each condition except delayed production-position 1.

Discussion

Regarding the latency difference between writing and naming, the results firmly confirm the hypothesis that this difference essentially stems from postlexical processes. Although the results cannot precisely determine which writing processing levels are responsible for this difference (allographic selection and/or graphic motor pattern retrieval and/or execution), they clearly suggest that a phonological mediation hypothesis is not viable. According to this hypothesis, written latencies are longer than spoken latencies due to systematic mediation by phonological information. Thus, the written latency difference should have been longer in the immediate production task than in the delayed production task. But no significant interaction was found between output type and production type.

Regarding the frequency effect, our purpose was to establish whether it could be ascribed, at least in part, to output processes both in naming and in writing. None of the frequency effects were reliable in delayed naming or writing, whereas the frequency effects were systematic in immediate production for both writing and naming. Thus, these frequency effects are rooted to a lexical level.

The results showed that the frequency effect was observed in prior naming and in prior writing and in picture naming after same-picture writing and in picture writing after same-picture naming. Thus, producing in one output modality and then in another does not cancel the frequency effect. Moreover, the frequency effect was significantly shorter when pictures were named after their names had been written down than when the same pictures were named without prior writing of their names. The same trend was observed for picture names written after having been named compared to picture names written without a preceding production task, but the decrease in the frequency effect on the latter comparison was not reliable. Analysis of the cumulative frequencies showed that the frequency effect was observed over the entire latencies distribution, both in writing and naming "alone", as well as in naming preceded by writing and in writing preceded by naming. Moreover, these analyses showed that, when naming preceded writing (or vice versa), the latency range relative to frequency was shorter compared to naming and writing alone. These findings are consistent with the view that the frequency effect could partially be attributable to the mapping of the conceptual and verbal representations (Vitkowitch & Humphreys, 1991).

Two questions remain concerning the frequency effects: could frequency effects be related to lexical density? In oral production, Jescheniak and Levelt (1994) demonstrated that the frequency effect observed in picture naming was not related to lexical density. Such effects have been reported in word reading (Andrews, 1989; Grainger, 1990, cited in Segui & Grainger, 1992). Analyses performed on our data showed that the linear correlations between the orthographic neighbourhood density and the written versus oral latencies were weak and non-significant (rs = .01 and .20 in Exp. 1 and in Exp. 3 respectively; rs = .10 [written latencies] and .08 [spoken latencies] in immediate production position 1; rs = .19 [written latencies] and .16 [spoken latencies] in immediate production position 2). This suggests that the properties of a word form's lexical environment cannot account for the frequency effects in either writing or naming from pictures. For oral production, our results are consistent with those obtained by Jescheniak and Levelt (1994), but for written production, they are unique.

EXPERIMENT 4: CATEGORIZATION TASK

In Experiment 1, the results showed that the latencies were longer with pictures than with linguistic input in both output modalities. This result was

interpreted as supporting the hypothesis that in oral production as well as in written production, speakers or writers retrieving a verbal label associated with a picture cannot bypass the structural and semantic levels, whereas linguistic input can benefit from direct access to linguistic representations (Bajo, 1988). However, there are two other, nonexclusive interpretations for this pattern of results.

In the first interpretation, linguistic input is encoded more rapidly than pictorial input. Fraisse (1960, 1969) showed that if naming is longer than reading it is not because of perceptual processes. He interpreted the latency difference between naming and reading as being the result of an association process. This interpretation is not far from our account (based on current views of speech production) that pictures require structural and semantic access whereas lexeme representations can be activated by the visual (or auditory) presentation of the words.

In the second alternative interpretation, the latency hierarchy observed in Experiment 1 may result from the fact that pictures require more time to contact the semantic system than linguistic input. However, the results provided so far in the literature are not compatible with this account. Potter and Faulconer (1975) showed that picture naming was shorter than word naming whereas picture categorizing was shorter than word categorizing (see also Bajo, 1988; Durso & Johnson, 1979; Pellegrino, Rosinski, Chiesi, & Siegel, 1977). The results obtained so far are in line with the idea (Durso & Johnson, 1979, p. 457) that "words have initial access to phonemic information, whereas pictures may have easier access to information about meaning".

To test these hypotheses, a categorization task was used on a new pool of participants. The same items as in Experiment 1 were used in this experiment. Participants were required to categorize items, i.e. pictures, words presented visually, and words presented auditorily, as being either "artificial" or "natural". Because semantic processing is indeed required in this task, we could test whether the input type difference observed in Experiment 1 was due to encoding processes and/or differential access time to the semantic system for pictures and linguistic input, or, as we hypothesized, to the fact that pictures cannot bypass the structural and semantic levels.

Method

Participants

The participants were 12 native speakers of French. All were undergraduates at the University of Bourgogne and had not participated in any of the previous experiments.

Stimuli

The stimuli used in Experiment 1 were used in this experiment. However, to have the same number of artificial and natural objects (e.g. *harp* versus *cow*), 10 new items belonging to the natural category were selected. Likewise, there were 25 objects in each category.

Procedure

The session lasted approximately 1 hour. Participants had to categorize pictures, visually presented words, and auditorily presented words. The tasks were counterbalanced across participants. An experimental trial had the following structure: after a ready signal presented for 500msec (+), the screen remained blank for 1000msec and then an item was displayed (depending on the task, a picture, a word presented visually, or a word presented auditorily). Participants had to respond as quickly as possible, using one of two push buttons to indicate whether the stimulus presented was "natural" or "artificial". Some practice trials were given before the experiment.

Results

To allow for comparisons between the RTs obtained in the categorization task and the writing and naming latencies, the data from Experiment 1 were included in the following analyses. Trials from the categorization task were discarded when a wrong response was provided (8%). To allow for comparisons between the RTs and the latencies, median RTs were computed.

ANOVAs were conducted on the participants and items. The ANOVA performed on participants was a 3 (Type of tasks: Categorization vs. Naming vs. Writing) $\times$ 3 (Input type: Pictures vs. Auditorily presented words vs. Visually presented words) design with independent measures on the Output type factor. The ANOVA on items was performed with the same factors with a repeated measures design.

The main effect of task was significant (Naming: 673msec; Writing: 1084msec; Categorizing: 936msec), $F(2,30) = 36.31$, $P < .001$, $MSE = 38,234.54$, as was the main effect of input type (Pictures: 1092msec; Auditorily presented words: 866msec; Visually presented words: 735msec), $F(2,60) = 30.87$, $P < .0001$, $MSE = 34,351.48$.

The Task × Input type interaction (see Fig. 1) was also significant, $F(4,60) = 10.39$, $P < .0001$, $MSE = 34,351.48$. Planned comparisons revealed that mean picture RT was significantly longer than linguistic input RT in naming, $F(1,30) = 35.80$, $P < .0001$, $MSE = 36,218$, and in writing, $F(1,30) = 32.31$, $P < .0001$, $MSE = 36,218$. In the categorization task the RT difference between pictures and words was not significant, $F < 1$.

Discussion

The goal of this experiment was to determine whether the latency hierarchy for input types observed in naming and in writing in Experiment 1 was indeed due to the fact that speakers and writers cannot bypass the structural and semantic levels, whereas linguistic input can benefit from direct access to lexical representations.

Two nonexclusive accounts were considered. In the first, the hierarchy observed in writing and in naming is thought to be the result of encoding processes: pictures are assumed to require more perceptual processing than linguistic input. In the second, the hierarchy reflects the fact that with pictures, it takes longer to access the semantic system compared to linguistic input. The latter account has not been supported by the evidence accumulated so far in the literature. The results obtained for the categorization task showed that linguistic input was not categorized faster than pictures, whereas in naming and in writing, latencies were faster with linguistic input than with pictures. These findings support the hypothesis that the observed hierarchy is due to the fact that the speaking and the writing of words from pictorial stimuli involves structural and semantic access, whereas linguistic input benefits from prior access to linguistic representations.

GENERAL DISCUSSION

In the Introduction we noted that whereas oral production has been the focus of some recent experimental studies on language production, these studies did not try to address the corresponding questions for written production. In contrast, there appeared to be a substantial amount of work in the area of cognitive neuropsychology

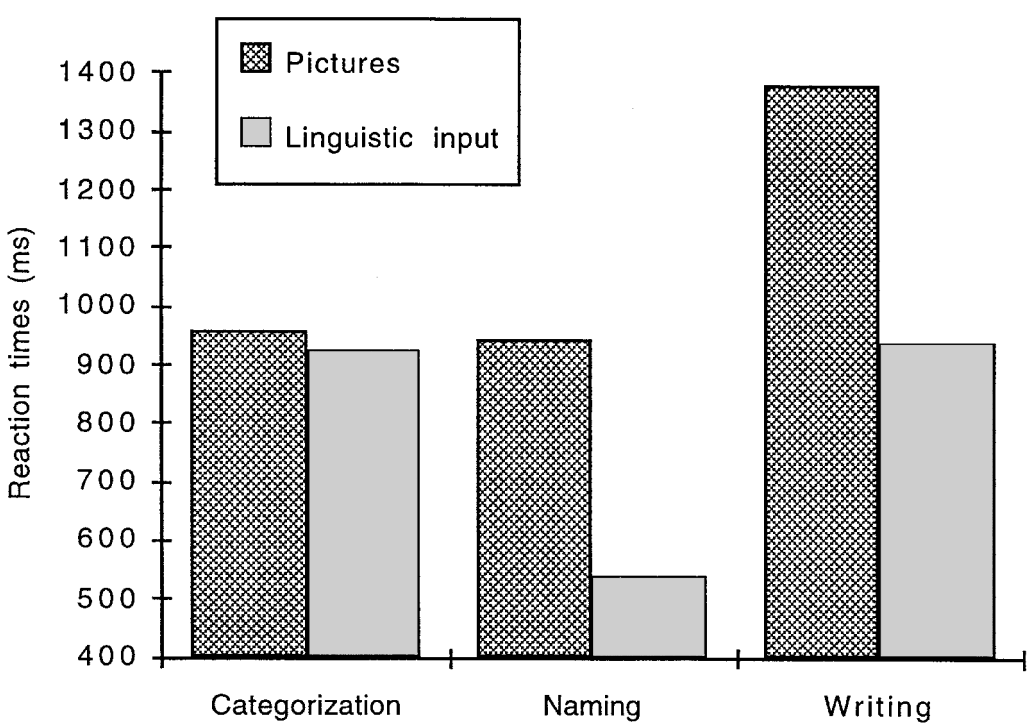

FIG. 1. Mean median reaction times (in msec) relative to Type of Tasks (Categorization vs. Naming vs. Writing) and Input Type (Pictures vs. Linguistic Input)

focusing on written production and its relationship to phonological codes that are activated to guide oral production. We therefore took an experimental approach to compare lexical access in the written and oral production of isolated words. Our main purpose was to gain evidence supporting the view that writing and naming may share some processing components, and that writing may also have some processing components of its own. We ran a series of four experiments on literate adults to investigate both written and oral production.

The main experiment (Experiment 1) was aimed at investigating some of the processes involved in the oral and written generation of words from pictures, or from auditorily and visually presented words. Writing and naming latencies were systematically compared and analyzed. The main findings obtained are discussed next.

Frequency Effects

1. Experiment 1 furnished some interesting findings concerning frequency effects. A frequency effect was observed in writing from words presented auditorily. Our interpretation was that this effect was the result of access to the orthographic lexicon. The alternative interpretation, that it is the result of encoding processes and/or of the retrieval of acoustico-phonological representations, was ruled out by the finding that no frequency effect was observed in naming from the same input. These results are in line with those provided by Véronis (1988). According to this author, a phoneme-to-grapheme mapping for the written production of known French words (from auditory presentation) is not used because such a procedure would lead to one word out of two being misspelled. Moreover, a post-hoc analysis failed to show an effect of spelling irregularity on the written production of auditorily presented words. Spelling irregularity was defined as phoneme-to-grapheme consistency of the consonant-vowel (CV) structure. We observed null correlation between phoneme-to-grapheme consistencies of the CV structure and written latencies, $r = .0008$. This result adds further support to our interpretation that a phoneme-to-grapheme procedure is not involved in the written production of known French words presented auditorily. However, the potential effects of the different kinds of spelling irregularity in the French language on the written production of words require further systematic investigation.

2. The classical frequency effect in reading words aloud was not observed in Experiment 1. The interpretation that the null effect was the result of a failure to get a sufficiently broad frequency contrast was discarded because, as mentioned in the Discussion of Experiment 1, we observed a reliable frequency effect in a lexical decision task performed on the same items.

In Experiments 1 and 3, frequency effects were observed in naming and in writing words from pictures. Experiment 2 showed that these frequency effects could not be ascribed to identification processes. Experiment 3 ruled out a post-lexical locus of these frequency effects. Post-hoc analyses did not show that orthographic context played a role in naming and writing from pictures. One could argue that some of the pictures used in our experiments were not easily identified, because the criterion used was not strong enough (the picture had to be rated as very easily or easily recognized by at least 85% of the participants), and that this could have accentuated the observed frequency effects. Post-hoc analyses performed on the data from Experiment 1 revealed that the correlations between the percentages of participants rating the pictures as very easy or easy to recognize and the picture naming and writing latencies were significant, $r = -.31$, $P < .05$; $r = -.56$, $P < .0001$, respectively. However, the correlation between the frequency and the percentages of participants rating the pictures as very easy or easy to recognize was not significant, $r = .25$. Thus, even if the pictures would ideally have been recognized at first glance by 100% of the participants, difficulty in recognizing some of the pictures cannot account for the observed frequency effects in picture naming and writing.

Latency Difference between Naming and Writing

Experiment 1 showed that written latencies were longer than naming latencies across the different kinds of input (pictures, auditorily presented, or visually presented words). Experiment 3 allowed us to determine that this difference did not have a lexical locus. These findings thus argue against the systematic phonological mediation view of writing. If this latter claim were valid, written latencies would be longer than spoken latencies due to systematic mediation via phonological information, in which case the latency difference

would be greater in an immediate production task than in a delayed production task. The critical interaction between output type and production type was not found. The data provided by these experiments are thus consistent with the view proposed by cognitive neuropsychologists that phonological information is not necessarily needed for the retrieval of orthographic information.

Latency Hierarchy between Linguistic and Pictorial Input

In Experiment 1, the results showed that the latencies for naming and for writing words from pictures were longer than the latencies for naming and for writing words from linguistic input. This difference was interpreted as resulting from the fact that structural and semantic access is necessary with pictures but not with linguistic input. It also shows that linguistic input may involve prior access to lexical representations. Experiment 4, using a categorization task, ruled out two alternative interpretations: (1) that this difference is the result of encoding processes and/or (2) that this difference results from longer access time needed with pictures for accessing the semantic system than with linguistic input.

Overall, our findings converge with the view presented in the Introduction. First, some processing components are shared by lexical access in naming and in writing, and in the light of most current work on oral production, we contend that these processes lie at the structural and semantic levels. However, it is already clear that further research is needed to refine this view. Second, some processes are specific to each output modality. More precisely, we mentioned in the Introduction that a problem concerning lexical access in writing, and subject to much debate, is the role of phonological information. Some cognitive neuropsychological studies have shown that the writing of isolated words is still possible even when the ability to name those same words has been damaged (Lhermitte & Dérouesné, 1974; Rapp & Caramazza, 1994). Thus, producing words in writing may not require the systematic retrieval of all phonological information. We have shown experimentally that the observed latency difference between naming and writing in an immediate production task was of the same size as in a delayed production task. Such a finding is taken as evidence that the written production of isolated words does not require the prior and systematic retrieval of phonological information, because otherwise, the latency difference would have been greater in an immediate production than in delayed production, due to the systematic mediation by phonological information in writing. Our findings argue against a view of the writing process that assumes that written language skills are entirely dependent upon spoken language knowledge and processes. Even if the findings provided by these experiments do not rule out the involvement of phonological information in writing, they nevertheless clearly indicate that phonological information is not a mandatory prerequisite to orthographic information retrieval. The precise role of phonological information in writing is not yet fully understood and thus requires further investigation (see also Bonin, Fayol, & Gombert, 1977).

In conclusion, we hope to have shown that it is possible to investigate the relationships between spoken and written language production in a systematic experimental way, and that this approach is complementary to the clinical approach used by cognitive neuropsychologists.

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APPENDIX

List of experimental items used in Experiments 1 through 4. The approximate English translation is given in brackets.

High-frequency items (one syllable)
tasse (cup), ongle (nail), vache (cow), plume (feather), botte (boot), noeud (knot), tronc (trunc), queue (tail), poing (fist), croix (cross)

Low-frequency items (one syllable)
zèbre (zebra), cible (target), toque (cap), crabe (crab), loupe (lens), hotte (hod), bouée (buoy), gland (acorn), clown (clown), harpe (harp)

High-frequency items (two syllables)
lapin (rabbit), piano (piano), avion (plane), canon (cannon), nuage (cloud), sabot (sabot), wagon (wagon), tapis (carpet), fusil (gun), fumée (smoke)

Low-frequency items (two syllables)
écrou (nut), micro (microphone), évier (sink), patin (skate), stylo (pen), robot (robot), momie (mummy), capot (hood), radis (radish), béret (beret)