The locus of the orthographic consistency effect in speech recognition: a cross-linguistic study

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1. Introduction

During the last 20 years, the influence of orthographic knowledge on speech processing has been demonstrated in several studies using different experimental paradigms. However, the main question concerning the locus or loci of orthographic effects in the speech processing route remains unanswered.

To address this issue, orthographic effects must be considered as a function of the processing mechanisms tapped by the tasks. In auditory tasks involving metaphonological components, the influence of orthographic knowledge has been consistently observed when the relation between the phonological and the orthographic representations of the stimuli was manipulated. For example, judging that two words rime is faster for orthographically similar pairs like "turn-burn" than with orthographically dissimilar pairs like "turn-learn" [1]. However, evidence is less clear as regards the impact of orthographic knowledge on speech recognition processes. At this stage, we proposed to make a distinction between the prelexical and lexical levels of processing [2, 3, 4]. In our view, the prelexical level is strictly perceptual, involving modular operations that are influenced only by early linguistic experience. Perceptual segmentation of the acoustic representation would be carried out at this level. On the contrary, the lexical or post-perceptual level would involve attentional processes and other sources of knowledge that re-elaborate the output of the first level before it reaches conscious recognition. Orthographic effects in spoken word recognition may arise at either the lexical or the prelexical processing level. Here, we provide information that may allow us to decide between these two interpretations.

The distinction between prelexical and lexical processing levels should be dissociated from the one between sublexical and lexical processing. While *prelexical* refers to all the *processes* that intervene between the perception of the acoustic signal and the contact with the lexical representations, hence, to a stage-of-processing concept, *sublexical* refers to the grain size of speech *units*, namely to those units that are smaller than the word (e.g, phonemes, onset and rime). Hence, prelexical processing necessarily takes place before lexical access, while sublexical representations may be activated before or after lexical activation. Many studies have demonstrated that the processing of sublexical units may be influenced by lexical context, for example in phoneme monitoring [5, 6], phonetic categorization [7], or phoneme restoration [8, 9]. In line with this reasoning, an orthographic influence at the sublexical level of structure does not imply that the effect takes place prior to lexical access. In the same way, the absence of orthographic effect at the prelexical processing stage does not imply that the effect is restricted to whole-word units, either.

In an attempt to identify the locus or loci of orthographic effects in the speech processing system, we discuss in the next sections how the findings from different studies could contribute to clarify this issue. To this aim, we focus on one specific orthographic effect that has been reported in word recognition, namely the *orthographic consistency effect*. First, we examine the conditions for the effect to emerge, focusing on its dependency on and modulation by lexical factors (section 2.1) and then further discuss the graded or all-or-none nature of the effect (section 2.2).

2. Literature review

2.1 The lexical nature of the orthographic consistency effect

In 1998, Ziegler and Ferrand [10] have convincingly demonstrated the occurrence of an orthographic consistency effect on spoken word recognition. By manipulating the orthographic (in)consistency of words and pseudowords presented in lexical decision, the authors found that French words with rimes that can be spelled in several ways (i.e., inconsistent words) produced longer reaction times and more errors than did words with rimes that can be spelled only one way (i.e., consistent words). However, their results did not allow us to identify the processing level at which this effect took place, since lexical decision requires not only prelexical but also lexical and post-lexical processes [11, 12, 13].

One way to specify the origin(s) of the orthographic consistency effect consists in studying its occurrence in several tasks tapping different speech processing levels. In our recent work [4, 14], we manipulated the orthographic consistency of words

and pseudowords presented in both lexical decision and shadowing. In contrast to lexical decision, the shadowing response requires only a precise analysis of the phonetic properties of the stimulus in order to build an articulatory plan, and does not rely on any binary choice decision. As such, shadowing is considered as biasing participants towards the prelexical level and/or as being exempted of decisional processes [15, 12, 16, 17]. The same experimental design was applied to both Portuguese [4] and French [14] materials. The comparison of these two languages is of interest since they differ in their degree of orthographic (in)consistency, French orthography being much more inconsistent than Portuguese orthography.

In both languages, while inconsistent words produced longer auditory lexical decision latencies than consistent words, no word consistency effect was found in shadowing. Further experiments conducted in Portuguese also demonstrated that the consistency effect observed in lexical decision was due to the lexical rather than to the decisional component of the task. Indeed, the comparison of two situations in which the shadowing response was made contingent upon either a lexical or a phonemic criterion showed a significant effect of orthographic consistency only in lexically-contingent shadowing. Concerning pseudowords, an unreliable consistency effect was found with the French material in both lexical decision and shadowing, but only for the slowest respondents, i.e., participants presenting the longer average response latencies. For the faster respondents, further analyses performed on the French lexical decision data showed a stronger consistency effect for low- than for high-frequency words.

Under a stage-of-processing view, the fact that with words the orthographic consistency effect occurred only in tasks requiring lexical processing (i.e., lexical decision and lexically-contingent shadowing) demonstrates the critical role of this factor in the emergence of the effect. This finding, combined with the absence of a word consistency effect in standard and phonemically-contingent shadowing, suggests that the impact of orthographic knowledge on spoken word recognition is restricted to lexical processing and does not pervade the prelexical stage. Another argument in favor of the lexical origin of the orthographic effect is the finding that the size of the consistency effect varied according to word frequency: if the influence of orthographic knowledge were taking place at the prelexical processing stage, the orthographic inconsistency effect would not have been influenced by such a lexical variable.

This lexical interpretation may seem to be contradicted by the occurrence of the pseudoword consistency effect we found in our French lexical decision and shadowing studies. Nevertheless, we doubt that this finding reflects a genuine orthographic prelexical effect. Indeed, in addition to be unreliable, this effect was limited to the slowest respondents. The reason why only the slowest respondents did display an orthographic effect on the pseudowords may be related to their using of a putative *post-identification verification strategy*. The pseudowords were created by derivation from real words so that they also activated word candidates to some extent. The fastest respondents have in all likelihood reacted immediately upon identification, whereas the slowest respondents might have first checked whether the presented item was actually a pseudoword instead of some relatively similar word. Allowing a confrontation with concurrent lexical representations could pave the way for an orthographic influence on pseudoword decisions or repetitions. No such confrontation was in principle required in the case of shadowing responses on words and, coherently, no orthographic consistency effect has been observed for these stimuli.

As already commented on, the impact of orthographic knowledge on prelexical processing must be dissociated from its impact on sublexical units. While there is no reliable evidence for a prelexical orthographic effect, several arguments support the view that the orthographic inconsistency effect arises at the level of sublexical representations. First, the orthographic (in)consistency manipulation in both Zeigler and Ferrand's study [10] as well as in our own study involved only the rime unit, not the whole word. Second, the influence of orthographic knowledge at the level of sublexical representations was also documented by Ziegler, Muneaux and Grainger [18]. Using both lexical decision and shadowing, these authors demonstrated the influence of both phonological and orthographic neighborhood, but in an opposite direction. In both tasks, phonological neighborhood induced an inhibition effect while orthographic neighborhood induced a facilitation effect. The authors interpreted the phonological neighborhood effect in terms of lexical competition between similar sounding words, and the orthographic neighborhood effect as reflecting the consistency of sublexical mapping between phonology and orthography, since this effect was facilitatory and disappeared when phonology-orthography consistency was factored out from the analyses. Given that one ought to distinguish between the qualifier "lexical" as referring to either a unit or a representational level, it is not paradoxical to say that orthographic neighborhood effects reflect the intervention of sub-word units in the course of activation of word representations. Third, the orthographic inconsistencies at the subword level may account for the modulation of the word consistency effect we observed in French-speaking fast respondents, with a stronger consistency effect for low- than for high-frequency words. The same result pattern was previously observed in the study of Seidenberg, Waters, Bernes, and Tanenhaus [19], who examined the consistency effect in the visual modality. According to these authors, this pattern may be accounted for by the fact that high- and low-frequency

words differ by the amount of learning or the degree of familiarity. Being overlearned and more familiar, high-frequency words would be rapidly processed at a more global level (possibly at the word level) compared to low-frequency words for which more time and more analytic evaluation is needed before a "word" decision can be made. Since, in general, inconsistency at the word level is smaller than inconsistency at the subword level, it is thus possible that, being processed at the word level, inconsistent high-frequency words would overcome competition at the subword level more efficiently than inconsistent low-frequency words do.

2.2 The graded nature of the orthographic consistency effect

As discussed in the former section, when an orthographic consistency effect is observed, its size varies as a function of word frequency, probably because high-frequency words are processed at a coarser grain-size than low-frequency words, and hence overcome orthographic inconsistencies at the subword level more efficiently. Other studies have shown that the size of the orthographic consistency effect also varies as a function of the degree of orthographic inconsistency of the words. Using the same experimental paradigm as Ziegler and Ferrand [10], Ziegler, Ferrand and Montant [20] reported that lexical decision performance on inconsistent words sharing the same phonological rime (e.g., "pain" and "faim") differed according to the probability with which its phonology mapped into spelling: words with dominant spelling ("pain") yielded better performance than words with subdominant spelling ("faim"), and consistent words elicited still better. This finding suggests that the size of the consistency effect increases with the degree of word inconsistency. According to the authors, this assumption seems plausible if one accepts the idea that, during words recognition, there are interactions between different kinds of representations. Thus, the greater the inconsistencies between different representations, the longer it takes for the system to reach the stable state. This led Ziegler et al. [20] to conclude that the consistency effect had a graded nature.

In the same line of reasoning, one would expect the consistency effect to vary between languages, for example between French and Portuguese. More specifically, since French is a language in which orthographic inconsistencies are much stronger than in Portuguese, one would expect the consistency effect to be larger in French. The results from our cross-linguistic analysis showed that even though there was a tendency for a stronger consistency effect in French, the difference between these two languages was not significant, despite their huge difference in degree of orthographic (in)consistency.

To understand the discrepancy between the graded consistency effect observed by Ziegler et al. [20] in their within-language comparison and our between-language results, one ought taking into account the characteristics of each language as well as their consequences on the speakers' cognitive system. Growing in a linguistic environment that has a high degree of consistency between phonology and orthography like Portuguese probably turns natives accustomed to the fact that the same sound is represented by the same spelling, and vice-versa. As a result, native speakers of such languages may become much more sensitive even to small inconsistencies between phonology and orthography (which are considered as exceptions in their language), compared to speakers of a language having a high degree of inconsistency. Thus, it was not surprising to find that Portuguese speakers faced with inconsistent words that had a lower degree of inconsistency compared to French words showed as strong a consistency effect as French speakers.

Thus, even though our cross-linguistic results do not illustrate the graded nature of the consistency effect proposed by Ziegler et al. [20] they do not disagree with that assumption, either. Although the orthographic effect may be graded in nature within a specific language (we have not examined this issue), this notion cannot be directly generalized to the comparison between different languages without taking into account their distinctive characteristics. In other words, taking together the results from both within- and between-language comparisons, one may say that it is not only the degree of inconsistency of the stimuli per se that determines the magnitude of the consistency effect, but also the degree of inconsistency of the stimuli relative to the overall (in)consistency between the phonological and the orthographic representations in a given language.

3. Conclusion

Nowadays, it is widely accepted that orthographic knowledge has an influence on several speech processing situations. The main aim of the present study was to specify the locus or loci where orthographic effects take place in the processing route leading to spoken word recognition. More precisely, we examined the conditions of occurrence of the orthographic consistency effect unveiled by Ziegler and Ferrand [10] in order to specify whether this effect occurs at the prelexical or the lexical processing stage. Taken together, our findings [4, 14] as well as those reported in other relevant studies [10, 18, 20] clearly point to the importance of the involvement of lexical representations. First, there is no convincing evidence for the orthographic consistency effect in speech processing tasks to occur at the prelexical level. Second, lexical variables like word frequency modulate the size of the effect. This does not preclude, however, orthographic knowledge to affect the processing of sublexical units, a finding that supports the view that the prelexical vs. lexical and sublexical vs. lexical distinctions must be dissociated. Lexical

representations may be structured as compounds of sublexical units, and orthographic influences may arise at the level of these sub-word units in the course of activation of word representations. Finally, we discussed some apparently contradictory results about the graded nature of the orthographic consistency effect. These may be reconciled by assuming that, in addition to the degree of inconsistency of the stimuli per se, what matters for performance to be affected by orthography is the degree of inconsistency of the stimuli relative to the overall (in)consistency between the phonological and the orthographic representations in a given language. Under such a view, even small inconsistencies may lead to orthographic effects in natives of very regular written systems.

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