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Reading aloud pseudohomophones in Italian: Always an advantage

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Abstract In the present article, the lexical contribution to nonword reading was evaluated using Italian pseudohomophones that contained atypical letters or letter sequences. Pseudohomophones were read faster than orthographically matched nonwords in both mixed (Experiment 1) and pure (Experiment 2) lists; in addition, a base-word frequency effect was obtained in both conditions. The same pseudohomophone advantage was observed when nonwords without atypical letter sequences were mixed in the experimental list (Experiment 3), and it disappeared only in lexical decision, in which pseudohomophones were rejected as quickly as control nonwords. The pattern of results was explained by assuming that, due to their orthographic properties, the Italian pseudohomophones did not benefit from an orthographic lexical contribution and were mainly processed through the interaction system between the sublexical mechanisms and the phonological output lexicon.

Keywords Reading · Word recognition · Pseudohomophones · Phonology · Orthography

A central issue that has been examined with novice, disabled, and skilled readers is how lexical and sublexical knowledge is exploited during reading of words that have never been seen before. Most research that has addressed this issue has focused on the relative contributions of orthographic and phonological knowledge used by expert readers to quickly translate a novel visually presented letter string into its phonological/phonetic correspondence (e.g., nonwords such as BLARK). One approach used to examine the lexical contribution to reading aloud is to examine performance for pseudohomophones (PSHs; e.g., BRANE), a special class of nonwords whose pronunciations, but not their spellings, are identical to those of real words (e.g., McCann & Besner, 1987). Recent research has suggested that the time taken to read PSHs aloud is strongly influenced by both orthographic and phonological lexical representations. The goal of the present study was to investigate these issues further by exploiting the alphabetic characteristics of Italian to create PSHs that should minimally activate orthographic lexical representations.

The most widely accepted models of visual word recognition and reading aloud postulate that skilled readers have two procedures available for translating print into phonology: a lexical route and a nonlexical route (see Fig. 1). There are currently two computational instantiations of this class of models for English: Coltheart and colleagues' dual-route cascaded model (DRC; Coltheart, Rastle, Perry, Langdon, & Zeigler, 2001) and Zorzi and colleagues' connectionist dual-process model (CDP: Zorzi, Houghton, & Butterworth, 1998; CDP+: Perry, Ziegler, & Zorzi, 2007). These two models are very similar, using a "nested" approach to computational modeling in which subsequent models build upon the success of previous ones. Consequently, both models have had tremendous success in simulating a wide range of empirical findings in the literature.

In the DRC and CDP + models, the lexical route consists of an orthographic lexicon, which contains our memories for word spellings, and a phonological lexicon, which contains our memories for word pronunciations. In contrast,

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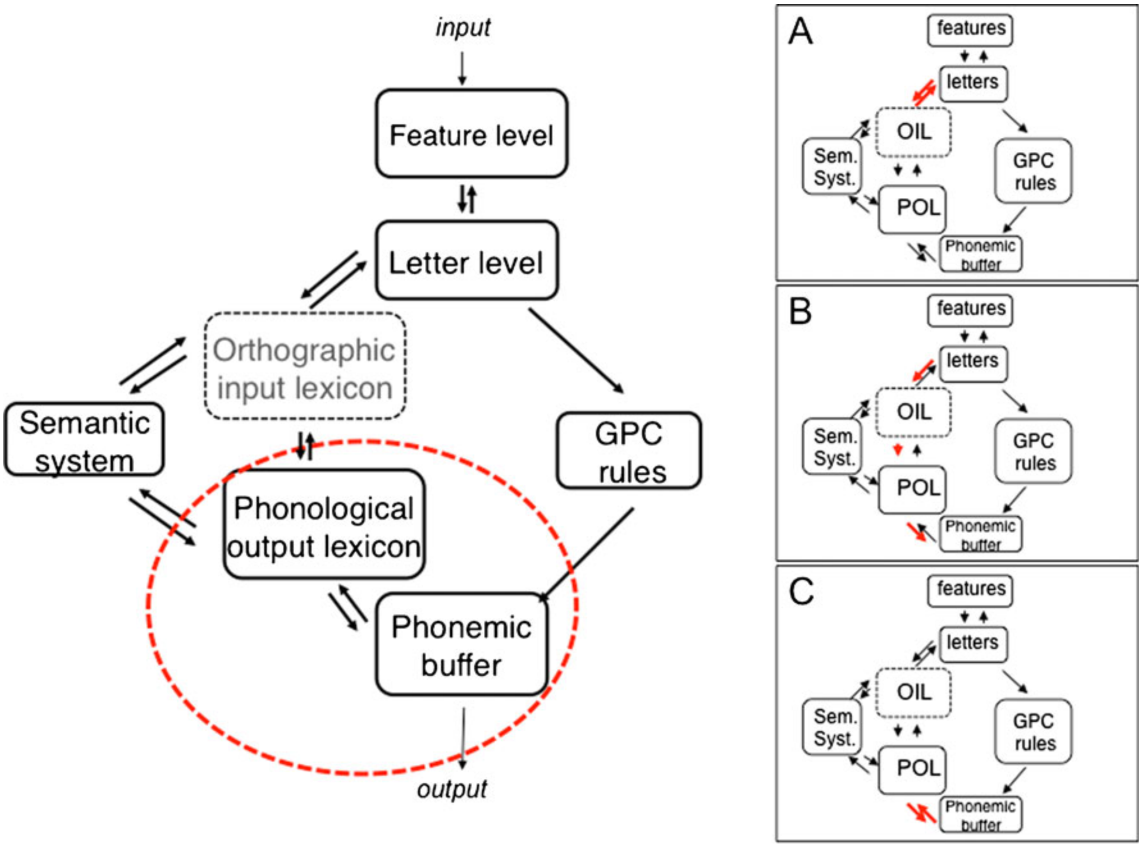

Fig. 1 Architecture of the DRC model. In the main figure, the right side represents the nonlexical route of grapheme-to-phoneme correspondence rules, terminating in the phonemic buffer. On the left are represented the three possible pathways through which lexical knowledge can affect the sublexical computation of phonology: (**a**) Orthographic lexical knowledge can affect the letter level through reciprocal connections. (**b**) Orthographic lexical knowledge can affect the phoneme level through feedforward connections to the phonological lexicon, and then to the phoneme system. (**c**) Phonological lexical knowledge can affect the phoneme level through reciprocal connections. Italian pseudohomophones, as well as control matching nonwords, do not activate the orthographic input lexicon (dotted grey rectangle); the pseudohomophones' advantage originates within the interactive activation system between the phonological output lexicon and the phonemic buffer (dotted circle)

the nonlexical route consists of knowledge about sublexical spelling-to-sound correspondences. In DRC, sublexical knowledge is represented as grapheme-to-phoneme correspondence rules, whereas in CDP + sublexical knowledge is represented as position-specific statistical mappings between onset, vowel, and coda units. Irrespective of the type of nonlexical route used in these models, the lexical route can generate correct pronunciations for regular words (e.g., HINT) and exception words (e.g., PINT), but not for nonwords (e.g., ZINT), and the nonlexical route can generate correct pronunciations for regular (consistent) words and nonwords, but not for exception (inconsistent) words.

Critically, although these models postulate that nonwords require the nonlexical route in order to be read aloud correctly, the sublexical generation of a phonological code can be influenced by lexical information through reciprocal connections between the letter level and the orthographic lexicon, on one hand, and the phoneme level and the phonological lexicon, on the other. As can be seen in Fig. 1, there are three ways that lexical knowledge affects the sublexical computation of phonology. First, orthographic lexical knowledge can affect the letter level through reciprocal connections (A: Besner, Reynolds, & O'Malley, 2009). Second, orthographic lexical knowledge can affect the phoneme level through feedforward connections to the phonological lexicon and then to the phoneme system (B: Reynolds & Besner, 2004). Finally, phonological lexical knowledge can affect the phoneme level through reciprocal connections (C: McCann & Besner, 1987). Consequently, understanding how lexical information and sublexical knowledge are combined is critical to refining models of reading and reading impairment.

Given the evolutionary and developmental priority of oral language as compared to visual language, understanding how representations in the phonological lexicon are recruited when reading new words has been an important goal of reading research (Andrews & Scarratt, 1998; Van

Orden, 1987). However, isolating the contributions of the phonological lexicon–phoneme system interconnections from the feedforward orthographic lexical contribution is particularly difficult. The aim of the present study is to exploit the characteristics of a language in which orthography-to-phonology and phonology-to-orthography inconsistencies are extremely rare in order to isolate the effects of the phonological component from those deriving from the orthographic component.

Extent of lexical involvement in pseudohomophones

One widely used approach for isolating the phonological lexical contribution to sublexically computed phonology is to compare performance for nonwords that sound like real words (i.e., PSHs such as BRANE) with nonwords that do not sound like real words (i.e., nonword controls such as FRANE). For instance, McCann and Besner (1987) reported that when PSHs and nonword controls were randomly intermixed, the PSHs were read aloud faster than the nonword controls (a PSH advantage), but were not affected by how frequently their base word was encountered in print (absence of a base-word frequency effect). McCann and Besner accounted for the PSH advantage and the absence of a base-word frequency effect by means of interactive activation between the phoneme system and the phonological lexicon. According to this account, the PSH advantage arises because the PSHs activate a matching entry in the phonological lexicon. The null base-word frequency effect arises because lexical entries are not sensitive to how frequently the lexical entry is encountered. Instead, word frequency affects the connections between the orthographic lexicon and the phonological lexicon. Consistent with this interpretation, the time to read aloud the PSHs was not affected by how visually similar they were to known words.

Subsequent research from Reynolds and Besner (2005)—in particular, simulations based on a version of the DRC model—has provided evidence that the time to read aloud a PSH is heavily influenced by the extent of activation of the entries in the orthographic lexicon. In particular, as described below, they interpreted the effects of the context in which PSHs were presented (i.e., with or without inclusion of control nonwords) as evidence of greater or lesser involvement of the orthographic lexicon. When PSHs and nonword controls are read aloud in the same list context (i.e., they are randomly intermixed), a PSH advantage is observed (McCann & Besner, 1987; Grainger, Spinelli, & Ferrand, 2000; Herdman, LeFevre, & Greenham, 1996; Marmurek & Kwantes, 1996; Reynolds, Besner, & Coltheart, 2011). In contrast, when PSHs are read aloud before nonword controls and in a pure list (i.e., consisting only of PSHs), the PSHs take longer to read aloud than the nonword controls (Borowsky, Owen, & Masson, 2002; Reynolds & Besner, 2005). In addition, a base-word frequency effect is observed when PSHs are presented in a pure list (Borowsky et al., 2002; Marmurek & Kwantes, 1996; Reynolds & Besner, 2005) or mixed with exception words (Reynolds et al., 2011).

In order to explain this complex pattern of results, Reynolds and Besner (2005) proposed that skilled readers may strategically vary the impact of the lexical contribution when reading aloud. According to this account, the scope of the lexical contribution can be narrow, so that only a few lexical entries are activated by a stimulus (a specific activation strategy, SAS), or broad, so that many lexical entries are activated by a stimulus (a general activation strategy, GAS). When the scope is narrow, it takes longer to read aloud a PSH, because it receives little support from neighbors, but the base word affects performance. When the scope is broad, and more neighbors thus contribute to the general activation, PSHs are read aloud more quickly and the time to read aloud a PSH is not affected by its base word's frequency.

To demonstrate that changes in the extent of orthographic lexical activation could produce the complex pattern of results observed in PSH naming, Reynolds and Besner (2005) implemented the model in Coltheart and colleagues' (2001) DRC account. Critically, they successfully simulated the complex pattern of results by either increasing or decreasing the values of the inhibitory connections *from* the letter units *to* the orthographic lexicon. As a result, there was either a decrease or an increase (respectively) in the number of lexical entries activated in the orthographic lexicon and, through feedforward connections along the lexical route, in the phonological lexicon (see Fig. 1). This strongly suggests that feedforward activation *from* the orthographic lexicon along the lexical route plays an important role in PSH naming.

Further support for the idea that the orthographic lexicon plays a crucial role in the pattern of PSH effects comes from evidence that PSHs show a neighborhood (N) size effect (Grainger et al., 2000). Neighborhood size is a measure of the number of orthographic neighbors of a specific word (Coltheart, Davelaar, Jonasson, & Besner, 1977) and correlates negatively with the latency in naming low-frequency words. The effect has been interpreted as a marker of the number of orthographic entries activated by a specific word. Thus, a significant neighborhood size effect for PSHs implies that presentation of these nonwords activates the base word's orthographic neighbors.

According to Reynolds and Besner's (2005) account, when PSHs are read with a narrow lexical scope (i.e., in pure lists), fewer lexical entries should be activated than when PSHs are read aloud with a broad lexical scope. Thus, expectations from this account would be that the N size effect should be larger in mixed than in pure-list contexts. The data from Grainger et al. (2000) might be consistent with this account. They reported N size effects in mixed lists for PSHs derived from both high- and low-frequency words. This result can be considered a marker of wide involvement of the orthographic lexicon in this condition. On the contrary, in pure lists the N size effect interacted with the frequency of the base words, being present only when PSHs derived from low-frequency base words were named—that is, with slow responses. Interestingly, in a recent work, Reynolds and Besner (in press) showed that when PSHs were mixed with nonwords, in the absence of a base-word frequency effect, N size effects were larger than in the pure lists of PSHs, in which a significantly smaller N size effect was associated to a significant base-word frequency effect.

In conclusion, Reynolds and Besner's (2005) proposal assumes that PSH reading performance depends on the extent to which the orthographic lexicon is involved. If the PSH can be read with the contribution of (many) orthographic lexical entries, as happens in mixed lists, reading times would be fast; instead, when only one or few orthographic entries are activated, as happens in pure lists, reading times would be slow. Crucially, according to this proposal, in mixed lists not only PSHs, but also the control nonwords, are affected by the activation of orthographic neighbors in the lexicon. However, in pure lists, control nonwords cannot receive support from single units, since they do not activate a single unit more strongly than others; therefore, even in pure lists, the lexical contribution for these stimuli, if present, can only be "broad"—that is, based on the activation of many orthographic entries—leading to relatively fast latencies as compared to PSHs (i.e., PSH disadvantage)

The present study

One important implication of these findings is that PSHs do not provide a pure estimate of the phonological lexical contribution to performance. Indeed, it seems that in English, the orthographic lexicon has a pervasive impact on the time to read aloud a PSH. In order to isolate the respective contributions of the different mechanisms, we exploited the regularity of the Italian language. Unlike English, Italian has very regular spelling-to-sound correspondences. Thus, to construct PSHs, we used letters that are not part of the Italian alphabet (k, j, or y) or a silent letter (h). The result was a letter sequence that was pronounceable but had an atypical spelling (e.g., *prestho* is pronounced like *presto* (soon): /presto/). Although these items contained unusual letters or letter sequences, and were therefore orthographically atypical, it was quite easy to derive a pronunciation. This claim is supported by pretests carried out on children at the end of the first grade, showing that these items were easily pronounced.

Using orthographically atypical PSHs and control nonwords with the same orthographic features has a number of straightforward implications in the context of dual-route models such as Coltheart et al.'s (2001) DRC model and Zorzi et al.'s CDP (Zorzi et al., 1998) and CDP + (Perry et al., 2007) models (see Fig. 1). First, orthographically atypical PSHs and the corresponding nonwords should activate very few, if any, representations in the orthographic lexicon (pathway A in Fig. 1), as shown by the fact that they have very few orthographic neighbors. Consequently, activation of representations in the phonological lexicon via feedforward connections from the orthographic lexicon should be only minimal (pathway B in Fig. 1). In contrast, activation along the nonlexical route should be less disrupted by strange characters, because even though the stimuli contain non-Italian letters, the spelling-to-sound correspondences are well known because they are taught in school and have become familiar in loan words. Finally, sublexically computed phonology should activate representations in the phonological lexicon via the phoneme buffer's reciprocal connections (pathway C in Fig. 1). Importantly, this is true for PSHs (C in Fig. 1), which necessarily activate a specific lexical entry. Control nonwords are orthographically matched to PSHs, and therefore do not receive indirect activation from orthographic entries (via pathways A and B). Thus, they do not even benefit from the activation of single phonological units in the phonological output lexicon and should always be named slower than PSHs. In sum, the PSH stimuli used in the present study should show an advantage with respect to control nonwords independent of the context, and this advantage should arise mainly from the contribution of phonological lexical activation. This prediction is in line with Reynolds and Besner's (2005) proposal. In their model, the modulation of PSH reading times according to the context is implemented by varying the amount of the orthographic lexical contribution. Assuming that the present PSHs do not activate (or minimally activate) the orthographic lexicon, and that their orthography is processed via the only available procedure (i.e., sublexically), they should not be sensitive to the context manipulation.

Furthermore, if, as proposed by Reynolds and Besner (2005; see also Reynolds et al., 2011), constraining activation in the orthographic lexicon (i.e., reading with a narrow scope) increases the base-word frequency effect, a further related prediction could be made, that the PSHs we used, which were read with very limited contribution from the orthographic lexicon, should show a base-word frequency effect.

The present article aimed at testing these predictions. In Experiment 1, we used control nonwords matched for orthographic complexity (hereafter called *matched nonwords*, MNW), which thus contained the same "strange" spellings as the PSHs, in mixed lists to test for the PSH effect. In Experiment 2, the same stimuli were included in pure lists of PSHs and nonwords. In Experiment 3, PSHs and MNWs were used in combination with another type of control nonword that did not contain unusual spellings, and thus was phonologically, but not orthographically, matched to the PSHs. Finally, to further explore our hypothesis about the relative contribution of orthography to the PSH effect, in Experiment 4 we performed a lexical decision task with the same stimuli.

Experiment 1

The purpose of Experiment 1 was to investigate the PSH effect using PSHs and nonword controls in a mixed-list context. If the orthographically atypical PSHs and nonword controls yielded only minimal activation of the orthographic lexicon, then, following the logic of Reynolds and Besner's (2005) study and consistent with their account of the PSH effect, this should yield a PSH advantage and the presence of a base-word frequency effect.

Method

Participants A group of 32 students (19 female, 13 male) at the University of Padova took part in the experiment. All participants were native Italian speakers with normal or corrected-to-normal vision.

Materials A total of 60 high-frequency words (mean frequency = 2,297 per million) and 60 low-frequency words (mean frequency = 39.3 per million) were selected from the corpus of the Istituto di Linguistica Computazionale di Pisa (1988). From each base word, a PSH was derived in the following way: The grapheme "c" (/k/) was replaced either by "ch" (8 cases) or by "k" (18 cases); the graphemes "ch" (/k/) and "cc" and "cch" (both /kk/) were replaced by "k," "kk," and "kk" (6, 2, and 2 cases, respectively); the grapheme "i" (/I/) was replaced either by "y" (28 cases) or by "j" (20 cases); the grapheme "qu" (/ku/) was replaced by "cu" (12 cases), and the grapheme "cu" (/ku/) was replaced by "qu" (4 cases); finally, in 20 cases, the letter"h," which in Italian is silent, was inserted after a consonant. From each PSH, a pronounceable control nonword was derived by changing one letter. In this way, the PSHs and nonwords (MNWs) were matched for orthographic complexity. All stimuli were disyllabic and ranged from four to seven letters in length. The PSHs, nonwords, and base words are listed in the Appendix.

PSHs derived from high-frequency base words were matched with the MNWs for phonologic neighborhood size (mean phonological N = 5.25 for both stimulus types) and for orthographic neighborhood size (mean orthographic N = 1.61 and 1.36, respectively). PSHs derived from low-frequency base words were matched with the MNWs for phonological neighborhood size (mean phonological N = 4.65 and 4.71, respectively); however, these PSHs and MNWs differed slightly in terms of orthographic neighborhood size (mean orthographic N = 1.41 and 0.88, respectively) [$t(118) = 2.12$, $p = .036$]. Note that in all reported statistics relative to orthographic neighborhood size, the base word corresponding to the highest-frequency neighbor of a target nonword was included in the N count. PSHs derived from high- and low-frequency base words were matched for orthographic N (1.61 and 1.41, respectively), for phonological N (5.25 and 4.65, respectively), and for length (5.26 and 5.43 letters, respectively).

Procedure The experiment took place in a dimly lit sound-attenuated room equipped with a microphone connected to a PC. Stimulus presentation and response time (RT) recording were accomplished with E-Prime software. The participant sat in front of a monitor at a viewing distance of 40 cm and was asked to read each stimulus aloud as fast as possible, avoiding errors. Each trial consisted of a fixation point that remained on the screen for 350 ms and was followed after 50 ms by the stimulus, written in black letters on a white background. The stimulus appeared in the center of the computer monitor and remained visible until the participant started the vocal response. The experimenter scored each trial as correct or incorrect. A trial was classified as incorrect if a participant mispronounced the stimulus. When participants pronounced the nonword correctly but a valid latency measure was not available because of a voice-key error, such trials were not included in the RT analyses, but only in the accuracy data. The intertrial interval was 800 ms.

Two lists of 60 PSHs and 60 MNWs were constructed so that if a given PSH (e.g., *storya*, /storIa/) was included in a list, the corresponding control nonword (e.g., *stofya*, /stofIa/) was included in the other list. The two lists were matched for base-word frequency, orthographic N, phonological N, and length. Half of the PSHs and MNWs in each list were derived from high-frequency base words, and half from low-frequency base words. Each participant was randomly assigned to one of the lists. The experiment started with a practice session of 12 PSHs and 12 MNWs not included in the experimental list. In order to facilitate error scoring, four pseudorandom orders of stimulus presentation were generated from each list. Each participant was randomly assigned to one of the orders.

Results and discussion

Voice-key failures (2.3%) were excluded from further analyses. Correct RTs were submitted to the Van Selst and Jolicœur (1994) trimming procedure, which excluded 2.6% of the data. Mean naming latencies for each condition are reported in Table 1. ANOVAs by participants (F_1) and items (F_2) were performed with Stimulus Type (PSH vs. MNW) as a main factor. A significant advantage for PSHs over MNWs emerged in both analyses [$F_1(1, 31) = 32.29$, $MSE = 609.44$, $p < .001$, $\eta^2 = .51$; $F_2(1, 238) = 17.72$, $MSE = 5{,}288.6$, $p = .001$, $\eta^2 = .07$].

A separate ANOVA was conducted on the PSHs to test for the effect of base-word frequency. This effect was significant in the analysis by participants [$F_1(1, 31) = 7.5$, $MSE = 1{,}016.99$, $p = .01$, $\eta^2 = .19$] and in the analysis by items [$F_2(1, 118) = 4.08$, $MSE = 4{,}317.76$, $p = .046$, $\eta^2 = .03$].

Overall percentages of errors were quite low (6.5%). The pattern of errors reflected the RT distribution. Accuracy was higher for PSHs than for MNWs [$F_1(1, 32) = 38.67$, $MSE = .001$, $p < .001$, $\eta^2 = .55$; $F_2(1, 238) = 4.89$, $MSE = .015$, $p = .028$, $\eta^2 = .02$]. No significant effect of base-word frequency was observed on errors (3.7% and 4.6% errors for the high- and low-base-word-frequency PSHs, respectively, $F = 1.3$).

Table 1 Mean response times (RTs, in milliseconds) and error percentages (in parentheses) in Experiments 1, 2, and 3, with pseudohomophone (PSH) effects on the left and base-word frequency (BWF) effects on the right

	Pseudohomophone Effect		Base-Word Frequency Effect	
Experiment 1	PSH	588 (4.1)	High BWF	577 (3.7)
	MNW	623 (10.5)	Low BWF	599 (4.6)
		−35		−22
Experiment 2				
PSH first block	PSH	591 (4.1)	High BWF	576 (4.2)
	MNW	633 (11.1)	Low BWF	606 (4.0)
		−42		−30
MNW first block	PSH	623 (4.9)	High BWF	618 (5.8)
	MNW	668 (8.5)	Low BWF	629 (4.0)
		−45		−11
Experiment 3	PSH	586 (3.6)	High BWF	580 (3.5)
	MNW	623 (10.5)	Low BWF	594 (3.7)
	UNW	574		
		−35		−14

MNW, matched nonword; UNW, unmatched nonword

The results of Experiment 1 showed a robust PSH advantage, consistent with data in other languages. In line with our predictions, but in contrast with the English data, a base-word frequency effect was also observed. This pattern can be explained by assuming that the PSHs and MNWs of the present study were both orthographically processed mainly via the sublexical pathway and activated the phonological lexicon via the interactive activation system with the phonemic buffer. The phonology of PSHs, computed sublexically, corresponded to a specific unit (the base word) in the lexicon that becomes active and contributes to the final response as a function of the speed of activation within the unit—that is, of the base-word frequency. The difference between the present results and those of the English studies, in which a base-word frequency effect was not found in the mixed-list condition, can be accounted for by assuming that English PSHs, which do have many neighbors, broadly activate the orthographic lexicon, and thus the role of specific activation of the base-word unit (which is modulated by frequency) is quite limited.

Experiment 2

The purpose of Experiment 2 was to provide additional evidence that our orthographically atypical PSHs yielded minimal activation of the orthographic lexicon. To do this, we examined the PSHs in a pure-list context. Previous research has consistently demonstrated longer RTs for English PSHs presented in a pure-list context. This PSH disadvantage is also accompanied by a significant base-word frequency effect (Borowsky et al., 2002; Reynolds & Besner, 2005).

This pattern of change according to reading context has been explained in Reynolds and Besner's (2005) account by assuming that activation produced by letter strings in the orthographic lexicon varies according to the context: More precisely, the reading system strategically settles into a narrow-reading procedure, mainly activating the base-word units in the orthographic lexicon, when faced with a list that contains only PSHs, whereas it uses a broader activation strategy when a list also contains control nonwords. Obviously this change in strategy is possible in English, given that English PSHs as well as control nonwords have many neighbors and, consequently, can be processed in the mixed-list context using a "broad" activation strategy.

Italian PSHs, due to their orthographic characteristics, minimally activate units in the orthographic lexicon, and therefore the time required to read them should not change according to the reading context. Nonetheless, they should be read faster than MNWs, since, unlike the MNW stimuli, the corresponding base-word units in the phonological lexicon are strongly activated (via the interactive connections between the phonemic buffer and the phonological lexicon, pathway C in

Fig. 1). Therefore, we predicted that, unlike with English PSHs, an advantage for Italian PSHs was to be expected, and would be associated with a base-word frequency effect when PSHs and MNWs were read in separate lists.

Method

Participants A group of 32 students (22 female, 10 male) took part in the experiment. All participants were native Italian speakers with normal or corrected-to-normal vision.

Procedure This was the same as in Experiment 1, except that the PSHs and MNWs were separated into two lists of 60 PSHs and two lists of 60 MNWs. Each participant was presented with a list of PSHs and a list of MNWs. The order of presentation was counterbalanced between participants. In order to facilitate error detection, four pseudo-random orders of each list were generated, and participants were randomly assigned to one of the orders. In the practice session, 10 PSHs and 10 MNWs not included in the experimental material were presented in two separate blocks following the same order as in the experimental session.

Results

Voice-key failures were excluded from further analyses (1%). Correct RTs were then submitted to the Van Selst and Jolicœur (1994) trimming procedure, which excluded 2.04% of the data. Mean naming latencies for each condition are reported in Table 1. ANOVAs were performed with Order of List Presentation (PSHs first vs. MNWs first) and Stimulus Type (PSH vs. MNW) as the main factors. Significant effects of stimulus type were obtained [$F_1(1, 30) = 12.94$, $MSE =$ 2,286.02, $p = .001$, $\eta^2 = .30$; $F_2(1, 238) = 38.2$, $MSE =$ 93.05, $\eta^2 = .14$, $p < .001$; all other Fs < 1]. Again, PSHs were read faster than MNWs, and the advantage was the same for the two orders of presentation.

In the analyses of latencies, performed with Base-Word Frequency as a within-participants factor and Order of List Presentation as a between-participants factor, only the effect of base-word frequency was significant [$F_1(1, 30) = 10$, $MSE = 700.38$, $p = .004$, $\eta^2 = .25$]. The frequency effect was 20 ms larger when PSHs were presented first than when MNWs were presented first, but the interaction did not reach significance [$F_1(1, 30) = 1.98$; $F_2(1, 118) = 1.17$]. A separate by-items analysis showed a significant effect of frequency when PSHs were presented in the first block [$F_2(1, 118) =$ 10, $MSE =$ 4,017.54, $p = .019$, $\eta^2 = .05$], but no effect when they were presented after MNWs ($F < 1$).

The overall percentage of errors was 7.16%. ANOVAs on the error data including Stimulus Type and Order of List Presentation as the main factors showed a significant effect of stimulus type [$F_1(1, 30) = 10.39$, $MSE = .003$, $p = .003$, $\eta^2 = .26$; $F_2(1, 238) = 10.47$, $MSE = .25$, $p = .001$, $\eta^2 = .042$] and no effect of order [$F_1 < 1$; $F_2(1, 238) = 2.2$, $p = .13$]. The interaction between order of presentation and type of stimulus was significant only in the by-items analysis [$F_1(1, 30) = 1.46$, $p = .24$; $F_2(1, 238) = 5.26$, $MSE = .008$, $p = .023$, $\eta^2 =$ .022]. Participants were more accurate in naming PSHs than MNWs. Also, more errors were made in response to MNWs when PSHs were presented first than when they were presented second. The ANOVAs on error rates with Base-Word Frequency and Order of List Presentation as the main factors showed no significant main effects or interactions (all Fs < 1). In only a few cases did errors result in lexicalizations, and this happened more often in response to the MNWs (9 cases) than to the PSHs (5 cases, in which a real word different from the base word was pronounced).

Discussion

The results of Experiments 1 and 2 showed that the PSH advantage was fairly independent of list composition: PSHs were read faster than MNWs in both mixed and pure lists. Since both PSHs and MNWs included unfamiliar letters or letter sequences, and thus, presumably, only minimally activated the orthographic input lexicon, we suggested that this advantage would emerge at the phonological level, within the interactive activation system between phonemic buffer and phonological system.

This pattern is consistent with the idea that the modulation of the PSH advantage with list composition for English PSHs is mainly due to the different extent of orthographic lexical activation induced by stimulus presentation, as suggested by Reynolds and Besner (2005). The difference between the pattern reported by Reynolds and Besner (2005 ; i.e., PSH disadvantage and base-word frequency effect) and the present data, (i.e., PSH advantage and base-word frequency effect, independently of list composition) is due to the fact that the English PSH reading strategy can be modulated by the context, implying either a narrow or a broad contribution of feedforward activation from the orthographic to the phonological lexicon. Instead, Italian PSHs are constrained by the properties of their orthographic format, and the only lexical contribution comes from the interactive activation system between the phonemic buffer and the phonological output lexicon. As is shown by the results of the present experiment, this contribution cannot be modulated by the context but is greater for PSHs than for MNWs, and therefore an advantage is always observed.

Kwantes and Marmurek (2007) elaborated further on Reynolds and Besner's (2005) proposal by suggesting that the shift from general to specific lexical activation in the DRC model can also be indirectly simulated by manipulating the reading-aloud criterion in that model, a mechanism controlling the level of activation that has to be reached in each slot of the phonemic buffer before its output can be delivered to the articulatory system. When this parameter is set high, the criterion is reached later, and therefore naming latencies are slowed down. This change, however, not only determines the beginning of reading times but also affects the way in which lexical activation contributes to the process of phonological assembly. In the model, when a lexical unit receives activation, it inhibits all other units within the lexicon. On successive processing cycles, through this mechanism of lateral inhibition, the system gradually converges on a single unit that corresponds to the target stimulus. Therefore, when the response criterion is set low and naming latencies are short, several lexical units (i.e., all units that share some letters and phonemes with the target) are activated, even if not very strongly, and they all contribute to the assembly of target phonology; in this way, the general activation strategy was simulated by Kwantes and Marmurek. In contrast, when the response criterion is set high, activation becomes less diffuse and the contribution of single lexical units increases, as well as the probability of observing frequency effects, thereby simulating the specific activation strategy.

In our study, reading times were rather slow, as compared with other studies in which disyllabic nonwords have been used (e.g., Mulatti, Peressotti, & Job, 2007), indicating that participants presumably used a high reading-aloud criterion. In pure lists of PSHs, the criterion should be set high, as participants would always expect a match with a lexical entry, but in pure lists of nonwords and in mixed lists, the criterion should be lowered. Thus, the problem with Kwantes and Marmurek's (2007) account is that, in its current form, it cannot account for the present study's experimental conditions (Borowsky et al., 2002; Reynolds & Besner, 2005).

Our interpretation is that, while the reading criterion might indeed be strategically changed according to list context, a different involvement of the orthographic lexicon may not exclusively depend on a change in the reading-aloud criterion. Furthermore, the nature of our PSHs (and related controls) did not allow for a strategic change in the reading-aloud criterion: Participants could not be faster, because they used the only available procedure to assemble phonology—that is, the sublexical procedure. Maintaining a reduced lexical activation constant, the pattern of effects also remained constant, with a PSH advantage and a base-word frequency effect jointly present. This interpretation was verified in Experiment 3, where conditions were set in which participants might strategically alter their processing mechanisms or, in agreement with Kwantes and Marmurek's (2007) proposal, their response criterion.

Experiment 3

The results of Experiments 1 and 2 were consistent with the idea that the orthographically atypical PSHs and nonword controls activated few, if any, representations in the orthographic lexicon, and that activation in the phonological lexicon was almost exclusively a result of the sublexical recoding mechanism. The aim of Experiment 3 was to verify whether this might be altered by including "typical" nonwords that could activate the orthographic lexicon to a great extent, due to their larger neighborhood size. As a result, the pattern of PSH effects might change, as well. That is, if the orthographic lexicon's involvement could be strategically broadened, mixing "regular" nonwords with the stimuli used in Experiments 1 and 2 might reduce the impact of specific lexical activation for PSHs, consequently reducing or even canceling the base-word frequency effect.

In Experiment 3, we replicated Experiment 1, but included nonwords that had many orthographic neighbors but were phonologically identical to the orthographically atypical nonword controls. As an example, from the MNW *chaufa* (/kaufa/) the new nonword *caufa* (/kaufa/) was derived, which did not include the atypical letter sequence "cha." The two letter strings *chaufa* and *caufa* are pronounced the same way (/kaufa/), but they are written differently, the latter being more similar to a typical Italian word than is the former. Consequently, these nonwords (unmatched nonwords, UNWs) had the same phonological neighbors as the MNWs but had a larger orthographic neighborhood size. Any difference between the MNWs and UNWs must therefore be due to feedforward activation from the orthographic lexicon for unmatched nonwords, resulting in faster overall latencies.

Method

Participants A group of 27 students (20 female, 7 male) took part in this experiment. All were native Italian speakers with normal or corrected-to-normal vision who had not participated in the previous experiments.

Materials and procedure From each of the 120 MNWs used in Experiments 1 and 2, a new nonword was derived with the same phonological form but a different orthography. In this way, for each PSH we had two control nonwords, one that was matched for orthographic complexity with the PSH (MNW) and one with the same phonological form as the MNW but with a simpler orthographic form (UNW). The UNWs were matched to the MNWs for letter length and phonological neighborhood size. Clearly, each UNW had more orthographic neighbors than its MNW, since the phonological and orthographic neighborhood sizes were almost equivalent for the former stimulus type, as is the case for the large part of Italian words.

Three experimental lists of 40 PSHs, 40 MNWs, and 40 UNWs were constructed so that if a given PSH (e.g., *storya*, /storIa/) was included in a list, the corresponding MNW (e.g., *stofya*, /stofIa/) was included in the second list, and the corresponding UNW (e.g., *stofia* /stofia/ was included in the third list. The three lists were matched for base-word frequency, orthographic N, phonological N, and length. Half of the PSHs and the nonwords in each list were derived from a high-frequency base word, and half from a low-frequency base word. Each participant was randomly assigned to one list. In order to facilitate error detection, three pseudorandom orders of each list were generated, and participants were randomly assigned to one of the orders. In the practice session, 10 PSHs and 10 nonwords not included in the experimental materials were presented in a mixed block. All other details of the procedure were the same as in Experiment 2.

Results

Voice-key failures were excluded from further analyses (0.6%). Correct RTs were then submitted to the Van Selst and Jolicœur (1994) trimming procedure, which excluded 2.06% of the data. Mean naming latencies are reported in Table 1. The ANOVAs by participants and items showed a main effect of stimulus type [$F_1(2, 52) = 15.39$, $MSE = 1{,}154.21$, $p < .001$, $\eta^2 = .37$; $F_2(2, 357) = 16.89$, $MSE = 7{,}159.05$, $p = .001$, $\eta^2 = .086$]. MNWs were named aloud more slowly than both UNWs [$F(1, 26) = 32.05$, $MSE = 814.32$, $p < .001$, $\eta^2 = .55$] and PSHs [$F(1, 26) = 10.25$, $MSE = 3{,}531.1$, $p = .004$, $\eta^2 = .28$], whereas no difference was observed between the latter types of stimuli (Fs > 1). No base-word frequency effect was found on PSH reading times in either the ANOVA by participants [$F_1(1, 26) = 1.6$, $p = .21$] or the ANOVA by items ($F_2 < 1$).

The overall percentage of errors was 7%. More errors were made in response to MNWs (10.5%) than to UNWs (4.3%) or PSHs (3.6%). This effect was statistically significant, $F_1(2, 52) = 27.15$, $MSE = .001$, $p < .001$, $\eta^2 = .51$; $F_2(2, 357) = 15.17$, $MSE = .011$, $p < .001$, $\eta^2 = .078$. The ANOVA performed on error rates to PSHs, with Base-Word Frequency as the main factor, showed no significant effect ($F < 1$).

Discussion

PSHs were again named faster than MNWs, but not faster than UNWs. PSHs, as well as MNWs, do not activate the orthographic lexicon, so that lexical activation for these stimuli is mainly driven by the sublexical processes that activate lexical units through the connections between the phonemic buffer and the phonological lexicon (pathway C in Fig. 1). Due to the perfect overlap with a phonological unit in the lexicon, PSHs were responded to faster, because they benefited from lexical activation. On the other hand, UNWs gained from an additional source of lexical activation, since they broadly activated the orthographic lexicon, and this activation spread to the phonological output lexicon (pathways A and B in Fig. 1), thus speeding them up. For this reason, no advantage of PSHs was observed with respect to UNWs. A similar result was found by Goswami, Ziegler, Dalton, and Schneider (2001), who compared performance on PSH reading of German- and English-speaking children. Since English PSHs were orthographically similar to real words, while German PSHs contained somewhat unusual spellings, two types of control nonwords were used. One type of nonwords was orthographically legal and similar to real words (similar to our UNWs), and the other type of nonwords contained unusual spellings and was less plausible at both the phonological and orthographic levels (our MNWs). The results showed that German children read PSHs more accurately than unusual nonwords but showed no PSH advantage relative to legal nonwords, whereas English children were more accurate in reading PSHs as compared to both types of nonwords.

Experiment 3 was carried out to investigate the idea that the inclusion of UNWs (nonwords with many orthographic neighbors) might have induced participants to use a reading strategy with a broader scope, and/or to alter their response criterion: When several lexical units are active, the contribution of specific lexical information would be reduced, and therefore the base-word frequency effect would disappear. However, a null base-word frequency effect in Experiment 3 might reflect the weak power of the experiment, not the effect of a change in strategy. If the different patterns of base-word frequency effects reflected the effects of different processes going on in Experiments 1–2 and 3, an interaction would be expected. We carried out further analyses, combining the data of the three experiments and including Base-Word Frequency and Experiment as main factors. A significant PSH advantage [$F_1(1, 88) = 43.59$, $MSE = 1{,}516$, $p < .001$, $\eta^2 = .33$; $F_2(1, 238) = 31.41$, $MSE = 12{,}172.5$, $p < .001$, $\eta^2 = .12$] and a significant base-word frequency effect were found [$F_1(1, 88) = 15.09$, $MSE = 1{,}069.38$, $p < .001$, $\eta^2 = .15$; $F_2(1, 118) = 31.41$, $MSE = 8{,}238.4$, $p = .031$, $\eta^2 = .04$], but no main effect of experiment and no interaction (Fs < 1). The absence of interactions supports the hypothesis that PSH reading could not be modulated by the context. The base-word frequency effect was small-sized in some conditions and slightly larger in others, but the difference was not significant. Also, even in the conditions in which it was larger (and significant), it accounted for a very small amount of variance (around 2%–3% in Exps. 1 and 2 with PSHs first). Moreover, the size of the PSH advantage was nearly the same in all experimental conditions.

Unlike what had been observed in previous studies, PSH reading was not subject to strategic control, because of the intrinsic nature of our stimuli, as was suggested in the discussion of Kwantes and Marmurek's (2007) proposal. We propose that this was due to the fact that the lexical contribution was limited to phonological activation driven by sublexical procedures, and the significant base-word frequency effect suggests that activity in phonological units was sensitive to word frequency. Also, and more critically, it suggests that in our reading conditions, the lexical contribution to the assembly of phonology in PSHs, though sublexically driven, was mainly supported by the activation of single units (i.e., the base words).

Experiment 4

It is commonly held that lexical decision can be carried out on the basis only of orthographic representations under some conditions. For example, several studies have shown that lexical decisions can be carried out without lexical consultation when nonwords formed by random letter strings are included in the stimuli (e.g., James, 1975; Peressotti, Cubelli, & Job, 2003). Thus, we might predict that when presenting the stimuli of Experiment 3 mixed with real words in a lexical decision task, participants might easily discriminate PSHs and MNWs from real words, responding solely on the basis of the unusual orthographic form, and giving a relatively fast "no" decision. In contrast, discrimination of UNWs from real words should mainly be based on lexical consultation. Accordingly, no PSH advantage should be found in lexical decision, while UNWs should receive slower responses than both PSHs and MNWs.

Method

Participants A group of 24 students at the University of Padova (20 female, 4 male) took part in the experiment. All participants were native Italian speakers with normal or corrected-to-normal vision.

Materials and procedure A total of 60 high-frequency and 60 low-frequency words matched to the base word for letter length were selected. These were added to the three experimental lists of Experiment 3. Within each list, items were presented in a new random order to each participant. Participants were randomly assigned to one of the experimental lists. The stimuli were presented one at time on the screen with the same presentation conditions as in the previous experiments. Participants were asked to indicate whether the stimulus on the screen was a word or a nonword by pressing a keyboard key. Half of the participants were asked to press the "m" key if the stimulus was a word and the "z" key if the stimulus was a nonword. For the other half, this pairing was reversed. Immediately after the response, feedback showing the RT (in milliseconds) appeared at the center of the screen for 700 ms. If the response was incorrect, the RT was reported in red numbers; otherwise, the numbers were green. The intertrial interval was 800 ms.

Results

Correct RTs to the "nonword" response were submitted to the Van Selst and Jolicœur (1994) trimming procedure, which excluded 2.5% of the data. The mean RTs and accuracy in each condition are reported in Table 2. ANOVAs by participants and items were performed with Stimulus Type (PSH, MNW, and UNW) as the main factor. This effect was significant [$F_1(2, 46) = 96.29$, $MSE = 2{,}786.46$, $p < .001$, $\eta^2 = .81$; $F_2(2, 357) = 241.35$,

Table 2 Mean response times (RTs, in milliseconds) and error percentages (in parentheses) in Experiment 4

	Base-Word Frequency			Frequency Effect
	High	Low	Mean	
PSHs	597 (3.7)	590 (3.3)	594 (3.5)	+7
MNWs			583 (1.8)	
UNWs			771 (18.3)	
Words			605 (4.9)	

PSH, pseudohomophone; MNW, matched nonword; UNW, unmatched nonword.

MSE = 6,257.79, $p < .001$, $\eta^2 = .58$]. Within-participants contrasts showed that UNWs were responded to more slowly than both PSHs and MNWs [$F_1(1, 23) = 105.22$ and 100.7, respectively, *p*s < .001, which did not differ from each other]. Both the by-participants ANOVA conducted on the PSH naming times, to test for the effect of base-word frequency, and the regression analysis on the $\log_{10}$ of the base-word frequency showed no significant effect.

The overall percentage of errors on the nonword stimuli was 7.88%. Consistently with the RT data, the analyses conducted on error rates showed that more errors were made in response to the UNWs than to the other nonword types [$F_1(2, 46) = 96.29$, $MSE = .005$, $p < .001$, $\eta^2 = .61$; $F_2(2, 357) = 63.19$, $MSE = .015$, $p < .001$, $\eta^2 = .26$].

Discussion

In the literature, the PSH effect in lexical decision is reflected in slower responding to PSHs than to nonwords that do not sound like words. Usually, this effect is considered a marker of automatic phonological activation in visual word recognition (Jacobs & Grainger, 1994). The standard explanation is that a PSH contacts the corresponding phonological unit in the lexicon. Lexical activation spreads from the phonological to the orthographic lexicon, which is assumed to be the level monitored in (orthographic) lexical decision. A high level of activation within the lexicon would bias the "word" response, and this would delay the "nonword" response required for PSHs.

The results of the present experiment showed that Italian PSHs did not generate such a conflict. These stimuli, as well as MNWs, are so "unfamiliar" at the orthographic level that activity in the orthographic lexicon is kept to a minimum. The low activation level in the orthographic lexicon would allow for a very rapid rejection, and the negative response could be delivered before any further activation, mediated by the phonological lexicon, could reach the orthographic level. When nonwords were more consistent with familiar patterns of Italian (UNWs), a subtler discrimination between nonwords and real words had to be made, and the decision was slowed down. The familiarity of "legal" nonwords as compared to both PSHs and MNWs also led to an increase in the probability of errors, suggesting that participants did indeed mainly rely on orthographic, rather than on phonological, characteristics of the stimuli in lexical decision. In contrast, this was not possible in naming aloud, where the task itself forced them to derive a phonological representation of the stimulus.

General discussion

In the present study, Italian participants constantly showed an advantage in naming aloud PSHs constructed in such a way as to mainly activate sublexical phonology, with little orthographic activation, because of unfamiliar letters or letter sequences. Such an advantage co-occurred with a base-word frequency effect that became reliable when Experiments 1, 2 and 3 were pooled together. The advantage resisted the mixed- (Experiment 1) versus pure- (Experiment 2) list manipulation, and only disappeared when participants were required to base their response on orthographic representations, neglecting phonology, which they did in lexical decision (Experiment 4). However, PSHs yielded higher performance only as compared to orthographically matched nonwords, not to nonwords without atypical spellings (Experiment 3).

This pattern is consistent with the proposal put forward by Reynolds and Besner (2005), according to which nonword reading performance is determined by the breadth of lexical activation within the orthographic input lexicon. When a large number of units are active, their activation is fed forward along the lexical route to the phonological output lexicon, and the lexical contribution to phonology assembly is massive. The final response is quickly computed in the phonemic buffer, and the contribution of single units is somehow lost. On the other hand, when few units are active (or the level of their activation is low), the lexical contribution is narrow, RTs are slower, and the contribution of single units becomes more critical. Due to their orthographic nature, PSHs and MNWs were processed with a narrow lexical contribution, in both pure- and mixed-list contexts; with respect to the control MNWs, however, PSH processing was supported by base-word activation, and this produced an advantage.

According to the literature, if activation is narrow, a base-word frequency effect should also be observed. In the present study, the effect was robust and significant only in some conditions, or when the data of Experiments 1, 2, and 3 were pooled together, thereby increasing statistical power. Our hypothesis is that the small size of the effect we observed was due to the base-word frequency effect being exclusively based on the differential activation rates of high- and low-frequency units in the phonological output lexicon. We assumed that in the reading conditions of our study, phonological units in the lexicon received activation via the grapheme-to-phoneme conversion pathway: The size of this activation was necessarily not modulated by frequency. A frequency effect was nevertheless predicted and observed, but the effect was not as strong as in normal reading conditions, where phonological units are also activated via the feedforward connections from the orthographic lexicon. In the latter case, the frequency effect originating within the phonological lexicon is boosted by the frequency effect originating within the orthographic lexicon. In summary, we propose that the base-word frequency effect we observed was indeed present, but not always significantly detected, because it was generated *only within the reciprocal connections between the phonological lexicon and the phonemic buffer*.

Another interesting result worth considering is the difference in latencies observed between MNWs and UNWs. While PSHs and MNWs were matched at the orthographic level and differed as far as phonology was concerned, the relationship between MNWs and UNWs was reversed: They were pronounced in the same way, but they were orthographically different. MNWs included atypical letters and letter sequences and had very few neighbors, UNWs looked like real words and had many neighbors. Indeed, performance for the UNWs was very fast in the naming experiment and very slow in lexical decision, which suggests that they were processed differently—that is, with different contributions of orthographic and phonological information. UNWs gained from the contribution of many orthographic units (broad activation), and RTs were significantly speeded up. Consistent with our data, Grainger et al. (2000) found that the base-word frequency effect was only present in pure lists of PSHs and was twice as large when the PSHs had one neighbor than when they had several neighbors, consistent with the idea of narrow activation producing a base-word frequency effect. Also, the effect of neighborhood size in their study was apparent for both PSHs and control nonwords when PSHs were mixed with nonwords, consistent with the idea that in mixed lists the lexical contribution is broad.

In conclusion, the way in which orthographic and phonological representations interact with each other in the computation of phonology might be responsible for the complex pattern of results obtained for PSH reading in deep orthographies. The present study was an attempt to somehow separate these joint effects by isolating the contributions of the phonological and orthographic components in PSH reading. The results clearly indicated the necessity of testing the reading models proposed in the literature with empirical contributions that are not limited to, or based only on, the English language.

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Appendix

Table 3 List of PSHs, MNWs and UNWs used in the experiments

BASE WORDS	Base-Word Frequency	PSEUDO-HOMO-PHONES	Letter Length	Orthographic N size*	Phonologic N size	MATCHED NONWORDS	Letter Length	Orthographic N size	Phonologic N size	UNMATCHED NONWORDS	Letter Length	Orth=Phon N Size
ANSIA	495	ansja	5	0	1	antja	5	0	1	antia	5	1
ARCO	618	arko	4	2	5	alko	4	4	8	alco	4	8
BORDO	646	bordho	6	0	5	birdho	6	0	2	birdo	5	2
BOSCO	508	bosko	5	0	5	bisko	5	1	8	bisco	5	8
CACCIA	869	kaccia	6	2	7	koccia	6	3	10	coccia	6	10
CALCIO	847	chalcio	7	0	3	cholcio	7	0	3	colcio	6	3
CARNE	1,044	charne	6	0	9	charde	6	0	12	carde	5	12
CARRO	245	karro	5	2	9	kurro	5	1	5	curro	5	5
CASA	8,684	chasa	5	0	11	chapa	5	0	11	capa	4	11
CAUSA	1,988	chausa	6	1	6	chaufa	6	0	2	caufa	5	2
CENTRO	3,666	centhro	7	0	5	cesthro	7	0	3	cestro	6	3
CHIARO	1,278	kiaro	5	0	5	kiano	5	3	4	kiano	5	4

Table 3 (continued)

BASE WORDS	Base-Word Frequency	PSEUDO-HOMO-PHONES	Letter Length	Orthographic N size*	Phonologic N size	MATCHED NONWORDS	Letter Length	Orthographic N size	Phonologic N size	UNMATCHED NONWORDS	Letter Length	Orth=Phon N Size
CHIAVE	936	kiave	5	0	2	kiane	5	3	2	chiane	6	2
CIFRA	550	cjfra	5	0	1	cjpra	5	2	3	cipra	5	3
CIMA	359	cjma	4	1	7	cjda	4	3	8	cida	4	8
CODA	420	koda	4	5	13	kida	4	3	2	kida	4	2
COLPA	799	kolpa	5	1	11	kolva	5	0	7	colva	5	7
COLPO	1,379	kolpo	5	1	10	kolso	5	2	10	colso	5	10
COSA	8,730	kosa	4	5	15	koga	4	4	10	coga	4	10
CULTO	305	qulto	5	0	3	qusto	5	3	3	qusto	5	3
CUOIO	219	quoio	5	1	3	quaio	5	1	1	quaio	5	1
CUORE	2,052	quore	5	4	5	quone	5	2	2	quone	5	2
CURA	1,703	qura	4	6	13	qusa	4	2	9	cusa	4	9
DIETRO	2,721	diethro	7	0	0	diathro	7	0	1	diatro	6	1
FACCIA	1,656	faccya	6	0	6	ficcya	6	0	5	ficcia	6	5
FILO	781	fjlo	4	0	10	fjro	4	2	11	firo	4	11
FIUME	1,258	fyume	5	0	3	fyure	5	0	4	fiure	5	4
FRONTE	3,884	fronthe	7	0	5	frosthe	7	0	4	froste	6	4
GARA	391	ghara	5	1	13	ghava	5	1	9	gava	4	9
GIORNO	6,334	gyorno	6	0	1	gyorzo	6	0	1	giorzo	6	1
GIUGNO	1,346	gyugno	6	1	1	gyagno	6	0	1	giagno	6	1
LIBRO	3,128	lybro	5	0	4	lyvro	5	0	2	livro	5	2
LINGUA	1,335	lyngua	6	0	1	myngua	6	0	1	mingua	6	1
MEDIA	1,732	medya	5	0	5	melya	5	1	3	melia	5	3
MILLE	1,194	mylle	5	0	4	mylte	5	2	6	milte	5	6
MITO	942	mjto	4	2	11	mjgo	4	2	7	migo	4	7
MONDO	8,894	mondho	6	0	8	mindho	6	0	3	mindo	5	3
MOSCA	774	moska	5	1	8	miska	5	1	4	misca	5	4
MURO	634	murho	5	0	14	luhro	5	1	8	luro	4	8
NERO	1,462	nerho	5	2	9	norho	5	0	14	noro	4	14
NIENTE	3,328	nyente	6	0	0	nyante	6	0	2	niante	6	2
OCA	443	oka	3	3	3	oko	3	3	6	oco	3	6
OCCHIO	1,181	okkio	5	0	0	okkia	5	0	1	occhia	6	1
PAIO	944	pajo	4	3	8	pojo	4	4	6	poio	4	6
PIAZZA	1,528	pyazza	6	0	4	pyezza	6	0	1	piezza	6	1
PIETRA	626	pjetra	6	0	1	pjedra	6	0	1	piedra	6	1
PRESTO	1,820	prestho	7	0	4	pristho	7	0	2	pristo	6	2

Table 3 (continued)

BASE WORDS	Base-Word Frequency	PSEUDO-HOMO-PHONES	Letter Length	Orthographic N size*	Phonologic N size	MATCHED NONWORDS	Letter Length	Orthographic N size	Phonologic N size	UNMATCHED NONWORDS	Letter Length	Orth=Phon N Size
QUALE	8,817	cuale	5	1	1	cuole	5	6	6	cuole	5	6
QUANTO	9,817	cuanto	6	1	8	cuonto	6	0	0	cuonto	6	0
QUATTRO	3,971	cuattro	7	0	0	cuottro	7	0	0	cuottro	7	0
QUOTA	1,062	cuota	5	5	4	cuola	5	4	4	cuola	5	4
RADIO	957	radyo	5	0	4	ramyo	5	0	3	ramio	5	3
RICCO	711	rikko	5	0	5	rukko	5	0	4	rucco	5	4
STORIA	7,914	storya	6	1	3	stofya	6	1	2	stofia	6	2
STUDIO	9,346	studyo	6	0	3	stupyo	6	1	2	stupio	6	2
TIPO	5,893	typo	4	1	8	tybo	4	1	7	tibo	4	7
TRISTE	361	trjste	6	0	1	trytte	6	1	4	tritte	6	4
VINO	907	vjno	4	1	12	vjgo	4	1	7	vigo	4	7
VISO	1,008	vjso	4	1	7	vjpo	4	0	4	vipo	4	4
ANCA	46	anka	4	2	5	aska	4	2	7	asca	4	7
ARCA	77	arka	4	5	12	irka	4	1	4	irca	4	4
BLANDO	18	blandho	7	0	4	blardho	7	0	1	blardo	6	1
BRUTO	36	brutho	6	1	4	bratho	6	0	12	brato	5	12
CALCE	80	chalce	6	0	11	cholce	6	0	8	colce	5	8
CALDO	10	chaldo	6	0	11	chalfo	6	0	5	calfo	5	5
CALLO	22	kallo	5	4	15	killo	5	1	0	chillo	6	0
CALVO	25	chalvo	6	0	8	chalpo	6	0	7	calpo	5	7
CAPPIO	26	kappio	6	0	0	koppio	6	1	5	coppio	6	5
CAUTO	85	chauto	6	0	6	chouto	6	0	8	couto	5	8
CHICCO	31	kicco	5	1	2	kacco	5	3	11	cacco	5	11
CHIOSCO	8	kiosco	6	0	0	kiesco	6	1	2	chiesco	7	2
CIGNO	50	cjgno	5	0	2	cjgna	5	1	6	cigna	5	6
CIUFFO	55	cjuffo	6	0	1	cjaffo	6	0	1	ciaffo	6	1
CONCA	57	konca	5	1	8	kunca	5	0	2	cunca	5	2
CORNO	88	korno	5	3	11	kerno	5	2	0	cherno	6	0
COSMO	47	kosmo	5	0	4	kospo	5	1	6	cospo	5	6
CUBO	53	qubo	4	2	8	quto	4	2	9	cuto	4	9
CUFFIA	47	quffia	6	0	1	quffio	6	0	0	quffio	6	0
CUOCO	92	quoco	5	1	6	quolo	5	2	6	cuolo	5	6
CURVO	31	qurvo	5	0	6	qurno	5	1	1	qurno	5	1
DARDO	4	dardho	6	0	9	dordho	6	0	7	dordo	5	7
DOTE	87	dothe	5	2	10	duthe	5	0	9	dute	4	9

Table 3 (continued)

BASE WORDS	Base-Word Frequency	PSEUDO-HOMO-PHONES	Letter Length	Orthographic N size*	Phonologic N size	MATCHED NONWORDS	Letter Length	Orthographic N size	Phonologic N size	UNMATCHED NONWORDS	Letter Length	Orth=Phon N Size
FICO	60	fyco	4	0	7	fybo	4	0	5	fibo	4	5
FIOCCO	43	fyocco	6	0	3	fyucco	6	0	2	fiucco	6	2
FRODE	34	frodhe	6	0	5	fradhe	6	0	6	frade	5	6
FRONDA	13	frondha	7	0	3	frindha	7	0	1	frinda	6	1
GARZA	23	gharza	6	0	5	gharfa	6	0	3	garfa	5	3
GAZZA	17	ghazza	6	1	7	ghuzza	6	0	2	guzza	5	2
KUTE	81	kute	4	2	3	kate	4	7	14	cate	4	14
LIMBO	37	lymbo	5	2	3	lympo	5	1	2	limpo	5	2
LINFA	38	lynfa	5	0	4	rynfa	5	1	4	rinfa	5	4
MICCIA	30	miccya	6	0	2	moccya	6	0	7	moccia	6	7
MUCCA	49	mukka	5	0	2	makka	5	0	11	macca	5	11
MUFFA	22	muffha	6	0	4	maffha	6	0	2	maffa	5	2
MULO	42	mulho	5	0	12	malho	5	2	11	malo	4	11
MUMMIA	15	mummya	6	0	1	mimmya	6	0	1	mimmia	6	1
NENIA	4	nenya	5	0	3	nemya	5	0	1	nemia	5	1
NINFA	14	nynfa	5	0	3	nynza	5	0	4	ninza	5	4
PACCHIA	6	pakkia	6	0	2	vakkia	6	0	3	vacchia	7	3
PIAGA	63	pjaga	5	0	3	pjuga	5	0	3	piuga	5	3
PIGNA	8	pjgna	5	0	9	pjgno	5	2	8	pigno	5	8
PIOPPO	15	pjoppo	6	0	1	pjuppo	6	0	1	piuppo	6	1
PIUMA	20	pjuma	5	0	1	tjuma	5	0	1	tiuma	5	1
QUARZO	49	cuarzo	6	0	2	cuarlo	6	1	1	cuarlo	6	1
QUATTO	6	cuatto	6	1	4	cuitto	6	1	1	cuitto	6	1
QUERCIA	72	cuercia	7	1	1	cuerpia	7	0	0	cuerpia	7	0
QUINTE	94	cuinte	6	0	5	cuonte	6	0	0	cuonte	6	0
RIMA	48	ryma	4	1	12	ryba	4	2	7	riba	4	7
RISSA	71	ryssa	5	3	6	myssa	5	3	7	missa	5	7
SCHIAVO	50	skiavo	6	0	3	skiato	6	3	1	schiato	7	1
SCHIUMA	62	skiuma	6	0	3	skiupa	6	1	2	schiupa	7	2
STOPPIA	1	stoppya	7	0	4	stuppya	7	0	1	stuppia	7	1
STUOIA	13	stuoya	6	0	2	stuaya	6	0	2	stuaia	6	2
TIBIA	6	tybia	5	0	2	tynia	5	1	4	tinia	5	4
TIMO	45	tymo	4	2	9	tyco	4	1	10	tico	4	10
TRIO	42	trjo	4	0	3	prjo	4	0	3	prio	4	3
TRIPLO	53	trjplo	6	0	4	trjppo	6	1	4	trippo	6	4

Table 3 (continued)

BASE WORDS	Base-Word Frequency	PSEUDO-HOMO-PHONES	Letter Length	Orthographic N size*	Phonologic N size	MATCHED NONWORDS	Letter Length	Orthographic N size	Phonologic N size	UNMATCHED NONWORDS	Letter Length	Orth=Phon N Size
VISPO	13	vjspo	5	0	3	vjrpo	5	0	1	virpo	5	1
VITTO	44	vjtto	5	0	8	pjtto	5	3	7	pitto	5	7

*The base word is not included in this count

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