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Health and Disability

Semantic interference on a phonological task in illiterate subjects

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Previous research suggests that learning an alphabetic written language influences aspects of the auditory-verbal language system. In this study, we examined whether literacy influences the notion of words as phonological units independent of lexical semantics in literate and illiterate subjects. Subjects had to decide which item in a word- or pseudoword pair was phonologically longest. By manipulating the relationship between referent size and phonological length in three word conditions (congruent, neutral, and incongruent) we could examine to what extent subjects focused on form rather than meaning of the stimulus material. Moreover, the pseudoword condition allowed us to examine global phonological awareness independent of lexical semantics. The results showed that literate performed significantly better than illiterate subjects in the neutral and incongruent word conditions as well as in the pseudoword condition. The illiterate group performed least well in the incongruent condition and significantly better in the pseudoword condition compared to the neutral and incongruent word conditions and suggest that performance on phonological word length comparisons is dependent on literacy. In addition, the results show that the illiterate participants are able to perceive and process phonological length, albeit less well than the literate subjects, when no semantic interference is present. In conclusion, the present results confirm and extend the finding that illiterate subjects are biased towards semantic-conceptual-pragmatic types of cognitive processing.

Key words: Literacy, phonological word awareness, semantic interference, language.

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INTRODUCTION

Education plays an essential role in contemporary society and is an integral part of modern culture. Mandatory formal education can be viewed as an institutionalized cultural process and is an important source for structured cultural transmission (Petersson & Reis, 2006). Studying adult illiterate subjects who were not provided the opportunity to go to school has been a useful approach in attempting to understand the influence of cultural factors on the brain as well as the outcome of cognitive development (Coppens, Parente & Lecours, 1998; Petersson & Reis, 2006; Petersson, Reis & Ingvar, 2001; Reis, Guerreiro & Petersson, 2003). Extensive research shows that acquiring alphabetic reading and writing skills influences the auditory-verbal language system and lends support to the suggestion that the functional architecture of the brain is modulated by literacy (Petersson, Reis, Askelof, Castro-Caldas & Ingvar, 2000; Reis & Castro-Caldas, 1997). Experimental evidence also shows that formal education influences cognition more broadly (Coppens *et al*., 1998; Petersson & Reis, 2006; Petersson *et al*., 2001).

In contrast to natural language acquisition, which is a human universal and largely a spontaneous, non-supervised, and self-organized acquisition process, learning to read and write is typically achieved by teaching and requires great effort as well as extensive focused practice on the part of the individual. During the acquisition of reading and writing skills, the child creates the ability to represent aspects of the phonological component of language by acquiring an orthographic representation and to relate this to a visuo-graphic input-output code. Experimental evidence suggests that the acquisition of these abilities creates an interactive relation between orthographic and phonological representations (Petersson *et al*., 2001). In addition, several experiments with literate adult listeners provide strong evidence that orthographic knowledge influences spoken word recognition (Hallé, Chéreau & Segui, 2000; Jakimik, Cole & Rudnicky, 1985; Slowiaczek, Soltano, Wieting & Bishop, 2003; Taft & Hambly, 1985). Although spelling information is not necessary for spoken word recognition, spelling influences lexical decision times which are thought to reflect the word recognition processes (Jakimik *et al*., 1985). Altogether, these results support the idea that the orthographic word-form is automatically activated during spoken-word processing. Thus the experimental evidence indicates that the acquisition of orthographic knowledge provides an additional

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representation for language processing and lends support for interactive models of word recognition (Patterson & Lambon-Ralph, 1999; Stone, Vanhoy & Van Orden, 1997; Ziegler & Ferrand, 1998).

The main objective of the present study was to investigate if reading and writing skills have an influence on the notion of words as phonological forms independent of lexical semantics. Previous research suggests that illiterate subjects have a tendency to orient towards semantic-pragmatic aspects of a given environmental context (for a review see Coppens *et al*., 1998). Recent results also suggest that illiterate subjects are particularly sensitive to lexical frequency (Serniclaes, Ventura, Morais & Kolinsky, 2005). The semantic effect has been observed in several experimental settings (Reis & Castro-Caldas, 1997; Silva, Petersson, Faísca, Ingvar & Reis, 2004). For example, Reis and Castro-Caldas (1997) showed that illiterate individuals exhibit greater difficulty on tasks that focus on formal rather than substantive aspects of the stimulus material (e.g., phonological vs. semantic aspects of words). Similar results have been obtained in a Greek population (Kosmidis, Tsapkini, Folia, Vlahou & Kiosseoglou, 2004) and Kolinsky and colleagues (Kolinsky, Cary & Morais, 1987) suggested that learning to read, though not strictly necessary, plays an important role in the development of the ability to focus on the phonological form of words.

In an early study by Kolinsky and colleagues (1987) the notion of word length was investigated in illiterate adults. In one of the experiments, the participants were presented with pairs of drawings and had to decide which drawing corresponded to the longest noun. The relation between the sizes of the depicted object pair and their word lengths was manipulated in three conditions: congruent, neutral, and incongruent. The results suggested that about half of the illiterate participants found it difficult to choose the phonologically longer noun in the incongruent condition. In addition, some illiterate subjects responded with whole phrases as examples of long words in a production task. Thus, the semantic system seemed to be the major attractor for lexical processing in illiterate adults.

In order to investigate if reading and writing skills have an influence on the notion of words as phonological units independent of lexical semantics we manipulated the relation between the phonological length and the size of the object denoted in three word pair conditions corresponding to three different levels of semantic conflict: congruent, neutral, and incongruent word pairs. This procedure allowed us to assess whether and to what extent illiterate subjects can process a phonological form of words independent from their meaning. In contrast to Kolinsky and collaborators (1987), who used graphic or written representations, we presented the stimulus material in an auditory paradigm. If it is the case that lexical semantics interferes with the phonological length decision task selectively for the illiterate group, we predicted lower performance in the illiterate group on the non-congruent word condition. On the other hand, in the absence of lexical semantics, it is an open question whether illiterate subjects would succeed in comparing the phonological length of pseudowords without the support of orthographic representations. This issue was addressed in a pseudoword phonological length decision task.

MATERIAL AND METHODS

Participants

Forty-four healthy female volunteers of similar social-cultural background were included in the study (for a detailed description of the general study population see Reis *et al*., 2003). All participants were screened with two semi-structured interviews as well as a short neuropsychological test battery (for details see Reis *et al*., 2003). The socio-cultural interview assesses socio-cultural background variables including occupation, literacy level of the parents, literacy level, or, in the illiterate cases, the reasons for illiteracy. The medical-health interview assesses medical variables and health history in order to rule out any present or history of neurological, psychiatric, or other disease potentially involving the brain. A simple neuropsychological test battery for mental state assessment was used to exclude significant cognitive dysfunction (for further details of the screening procedures see Reis *et al*., 2003). In our illiteracy studies, including this one, subjects were excluded from further investigations based on the following criteria: (1) Significant histories of neurological, psychiatric or other disease affecting the brain; (2) Functional employment or daily life problems; (3) Literate subjects with problems acquiring reading and writing skills; (4) Results two standard divisions below normative values on the following tests: verbal fluency, verbal memory with interference and orientation (Garcia, 1984; Garcia & Guerreiro, 1983); (5) Illiterate subjects were excluded if they succeeded on a letters/words identification task; literate subjects were excluded if they were unable to read a newspaper text fluently, answer six simple comprehension questions correctly, or made spelling errors on a simple dictation task; (6) Subjects who had started school or an educational program but not finished, or subjects who had or were presently engaged in literacy training for adults. All participants were active and fully functional in their everyday life. The major difference between the two literacy groups relates to the knowledge of reading and writing as well as other skills acquired during the first 4 years of schooling. Altogether 22 illiterate (mean age 68.6 ± 4.1 years) and 22 literate subjects (66.2 ± 7.0; mean education 4.1 ± 0.7 years) participated. There were no significant age differences between groups ($p \geq 0.2$).

Experimental stimuli

Two sets of 15 word pairs (W) each and two sets of 15 pseudoword pairs (PW) were prepared (see Appendix I). The pseudoword pairs were constructed from the word pairs by changing the consonants and maintaining the vowels as well as the length (e.g., *borboleta/pato* – corpomera/dapo). Each word and pseudoword was characterized in terms of number of syllables, number of phonemes (phonological length) and stimulus duration (acoustic length). Each word and pseudoword pair contained a long item (8–10 letters; mean number of syllables 4 ± 0.6; mean acoustic length 1082 ± 121 ms; mean phonological length 8.3 ± 0.9) and a short item (3–5 letters; mean number of syllables 2 ± 0.3; mean acoustic length 739 ± 121 ms; mean phonological length 4.3 ± 0.6). Each subject was presented with a list composed of one W-set (e.g., set 1 W) and one PW-set (e.g., set 2 PW) randomized across subjects with respect to sets and order. This prevents subjects from processing pseudowords derived

from already presented words as well as the reverse. The word-pair condition was divided into three sub-conditions in which the relationship between the words' phonological length and the size of the denoted object was manipulated; (1) Congruent (5 pairs): the longer word denoted the larger object (e.g., *carruagem – bola*/carriage – ball); (2) Incongruent (5 pairs): the longer word denoted the smaller object (e.g., *borboleta – pato*/butterfly – duck); (3) Neutral (5 pairs): only the phonological length varied while denoting objects of similar size (e.g., *prego – parafuso*/nail – screw). Word frequencies were controlled for each list and there was no significant difference between lists (Mann-Whitney *U* Test, $p = 0.53$). We also controlled the word frequencies within each word condition in order to keep the same level of familiarity among the different conditions (Kruskal-Wallis test, set 1: $p = 0.15$; set 2: $p = 0.11$). To guarantee that any observed effect would not be due to uncontrolled frequency differences between long and short words, the frequency ratio between short and long words for each pair was calculated. The frequency ratio was similar across conditions for both lists (Kruskal-Wallis test, set 1: $p = 0.33$; set 2: $p = 0.53$). We also calculated if there was any interaction between stimulus condition (pseudoword, word congruent, incongruent and neutral) and stimulus length (short vs. long) both for acoustic and phonological length. The results showed that there were no significant interactions between stimulus length and conditions for acoustic as well as phonological length ($F(3, 56) = 2.1$, $p = 0.11$; $F(3, 56) < 1$, $p = 0.59$). This ensures that the length difference between short and long items of each pair is statistically equivalent for all conditions.

Experimental procedures

All stimuli were recorded with a female voice on a CD for auditory presentation in a paced paradigm. Each pair was preceded by a get-ready signal (a short beep). The time between the offset of the first item and the onset of the second item in each pair was 600 ms. Total time between the offset of a given pair and the onset of the following pair was 4700 ms. The testing occurred in a quiet environment in which the participant and the tester were sitting at a table. The participants were instructed to decide which item in a pair was the phonologically longer. The subjects were informed that some words would sound longer than others independent of the referent's typical physical size. The task was explained to the subjects by providing several examples of long and short items for the different conditions. Each subject practiced the task in two short instruction sessions. During the first instruction session, the experimental examiner presented the items orally, while in the second, the CD player was used to present the items. This was sufficient to ensure full comprehension of the task in all subjects. Subsequently the experimental tasks were administered during which no feedback was provided. For each condition, the total score (i.e., the sum of correct choices) was submitted for statistical analyses. In addition, at the end of the experimental session, participants were debriefed and asked to explain the grounds on which decisions were made for one correct and one incorrect answer in each condition.

RESULTS

First, we analyzed whether there was any list effect. We performed an ANOVA considering group (illiterates vs. literates) and list (list 1 vs. list 2) as between factors and condition (congruent, incongruent, neutral and pseudowords) as a within factor; the mean accuracy level was considered the dependent variable. The results showed clear condition effects, independent of any list effect for both literacy groups (no significant three-way interaction: $F(3, 120) = 1.08$, MSE = 0.5, $p = 0.36$). We therefore pooled the results over lists in the group comparisons.

As Table 1 shows, large effect sizes (Cohen's $d \geq 0.8$) were observed in all conditions in the group comparisons (Mann-Whitney test) except for the congruent word condition. The literate subjects performed significantly better compared to the illiterate group in the word ($p < 0.001$) and pseudoword condition ($p = 0.001$). The comparisons between the different word conditions demonstrate that illiterates performed least well than literates in the incongruent condition ($p < 0.001$), the condition that entails the greatest semantic interference, as well as in the neutral condition ($p < 0.001$). In contrast, they performed similarly to the literate group in the congruent condition ($p = 0.2$).

The within group comparisons (Wilcoxon matched-pairs test) showed no significant difference between the word and pseudoword condition in the literate group ($d = -0.22$, $p = 0.3$), while the illiterate subjects performed significantly better on pseudowords compared to words ($d = 0.85$, $p < 0.01$). The literate participants performed close to maximum score in each word conditions, raising a potential ceiling effect problem. Nonetheless, significant differences between word conditions were found for the literate group (Friedman test, $\chi^2 = 10.0$, df = 2, $p < 0.01$). These differences are explained by a decrease of the literate performance in the incongruent word condition. In addition, a minority of literate subjects made incorrect responses in the incongruent word condition but spontaneously corrected their answers at the end of the task. This result suggests that although they immediately became aware of their mistake, semantics appears to interfere with their performance. On the other hand, a clear word conditions effect was observed for the illiterate participants (Friedman test, $\chi^2 = 29.2$, df = 2, $p < 0.001$), which was also confirmed by significant differences between the three word conditions (Wilcoxon matched-pairs test, $p < 0.01$).

In addition, we tested whether the illiterate group performed better on pseudowords compared to the performance on words (Wilcoxon matched-pairs test). Specifically, the illiterate group performed better ($p = 0.03$) in the congruent word condition (94%) compared to pseudoword condition (86%). In contrast, they performed significantly

Table 1. *Means, standard deviations, effect sizes (Cohen's* d*) and between group comparisons (Mann-Whitney* U *test)*

	Illiterates	Literates	*d*	*P*
Total of pseudowords	12.8 ± 2.2	14.4 ± 1.1	0.92	0.001
Total of words	10.9 ± 2.4	14.6 ± 1.0	2.16	<0.001
Congruent words	4.7 ± 0.6	5.0 ± 0.0	0.70	0.2
Neutral words	3.6 ± 1.0	5.0 ± 0.0	1.98	<0.001
Incongruent words	2.6 ± 1.5	4.6 ± 1.0	1.56	<0.001

Maximum score = 30 (15 words: 5 incongruent, 5 congruent and 5 neutral; 15 pseudowords).

better in the pseudoword condition compared to both the incongruent (52%) and neutral (72%) word condition ($p < 0.001$ and $p = 0.02$, respectively). An item analysis confirmed the previously observed word condition effects (Friedman test, illiterate group: $\chi^2 = 14.8$, df = 2, $p < 0.001$; literate group: $\chi^2 = 8.7$, df = 2, $p < 0.02$).

Finally, some suggestive observations were made based on the post-experimental explanations provided by the illiterate participants. For example, the interference of lexical semantics is readily apparent in the following typical examples when illiterate subjects were asked to explain their decisions: (1) Incongruent pairs: *cão – lombriga* ("dog – round-worm") "the dog is big, the round-worm is a small animal"; *comprimido – navio* ("tablet – ship") "the tablet is to swallow, the ship is something big"; (2) Neutral pairs: *mosquito – melga* ("mosquito – gnat") "it is the same thing"; *prego – parafuso* ("nail – screw") "the screw is bigger, one can tighten it on the wall". Concerning the correct responses, the illiterate subjects managed in a few cases to estimate the number of syllables in a word, but in most cases the participants did not provide any further explanation or elaboration for their decision: (1) Congruent pair: *aspirador – copo* ("vacuum cleaner – glass") "vacuum cleaner has more sounds than glass"; (2) Neutral pair: *rosa – malmequer* ("rose – daisy") "the rose is smaller than the daisy"; (3) Incongruent pair: *boné – pulseira* – ("cap – bracelet") "bracelet has more words". Along with the results reported above, these qualitative observations suggest that performance is influenced by literacy acquisition and formal education. Thus the absence of an orthographic representation, and consequently a less developed phonological awareness, together with a reliance on the lexical semantic content suggest a difference in word concept as a phonological entity in illiterate compared to literate subjects, and this affects the performance on the phonological length decision task for words.

DISCUSSION

In the present study, we investigated the effects of literacy on the processing of auditorily presented information when semantic and phonological characteristics of the items were manipulated. The results show that performance on the phonological length decision task for words is dependent on literacy. More specifically, the performance of the illiterate group decreased in a dose-response manner with increasing semantic interference in the word conditions.

Our previous investigations of this population have indicated that the acquisition of reading and writing skills influences aspects of the auditory-verbal language system; specifically, aspects of sub-lexical phonological processing (Petersson *et al.,* 2000). This is most prominently expressed in terms of phonological awareness, the most well-accepted difference between schooled and unschooled individuals that does not depend on educational level as such (Coppens *et al*., 1998). In addition, previous results have indicated that there are differences in phonological loop interactions between literate and illiterate subjects (Petersson *et al*., 2000) and it has recently suggested that the phonological loop serves as a language learning device with an integral role in the systems for spoken and written language acquisition (Baddeley, Gathercole & Pagagno, 1998). Now, if it is hypothesized that the relevant cognitive processing for solving the phonological length decision task is channeled through three interactive processing pathways (i.e., the orthographic, phonological and semantic) in literate subjects (Patterson & Lambon-Ralph, 1999; Stone *et al*., 1997; Ziegler & Ferrand, 1998), it is clear that the illiterate subjects can only rely on phonological and semantic processing without the parallel support of orthographic processing. This, in combination with a less developed capacity for sub-lexical phonological processing and phonological awareness, provides an explanation for the greater vulnerability to lexical semantic interference. This is consistent with the finding that the illiterate group performed significantly less well on average in the incongruent and neutral word conditions compared to the pseudoword condition. Moreover, the qualitative observations made in the post-experiment interview suggested that both correct and incorrect decisions often were based on the lexical meaning, and in some cases, on a vague concept about the formal characteristics of the stimulus items. Overall, these results indicate that non-schooled subjects are biased towards meaning, or, in other words, more inclined to consider semantic-pragmatic aspects of a given situation when they attempt to solve a given task, including tasks in which they are instructed to focus on formal criteria, consistent with previous research (cf., Introduction). Thus, in the present case, it appears that when the outcome of semantic processing is in conflict with the outcome of phonological processing, the former tends to determine the response more often in illiterate compared to literate subjects. The present experimental design does not entirely rule out the possibility that the subjects base their decisions on the outcome of purely acoustic processing, but it is likely that phonological representations play a role, since we have no reason to expect any differences in acoustic processing between literate and illiterate subjects. In any case, the outcome of semantic processing seems to be an important determinant of the illiterate response tendencies. An interesting result of the present study is that the awareness of words as independent phonological units is not entirely determined by the acquisition of an orthographic representation, since the illiterate group performed better on pseudowords compared to the average performance on words. More specifically, the illiterate group performed significantly better on pseudoword pairs compared to incongruent and neutral word pairs. This suggests that the illiterate participants were able to perceive and process phonological length, a global aspect of phonological word-form, when no semantic interference was present. However, the literate group performed significantly better compared to the

illiterate in the pseudoword condition, consistent with previous findings (e.g., Reis & Castro-Caldas 1997; Petersson *et al*., 2000; for a review see Coppens *et al*., 1998). These results provide additional support for the suggestion that learning to read plays an important role in the development of the ability to focus on the phonological form of words (Kolinsky *et al*., 1987), but in the present study by using auditory in contrast to visual stimulus material and by including a pseudoword condition.

The relation between metalinguistic awareness and literacy is well documented both in children (Bradley & Bryant, 1991; Brady, Shankweiler & Mann, 1983; Karmiloff-Smith, Grant, Sims, Jones & Cuckle, 1996) as well as in adults that had never acquired an orthographic knowledge (see for example Adrian, 1993; Morais, 1993). Acquiring reading and writing skills gradually promotes the child to create explicit representations and acquire processing mechanisms that allow the child to reflect and analyze different aspects of language function and language use (for a recent review see Ziegler & Goswami, 2005). Meta-cognitive and meta-linguistic awareness develops progressively over the early years of life (Karmiloff-Smith, 1992). When children subsequently learn to read and write, this appears to have repercussions on the phonological representations of spoken language (Petersson *et al*., 2000). Rather than a simple one-way influence, there seems to be a complex interplay between meta-linguistic awareness and reading skills. The influence of orthography on language processing has not only been demonstrated with children and illiterate adults but also in literate children and adults. Literate adults, while performing lexical decisions on spoken words, have been shown to be influenced by the spelling of an immediately preceding item (Jakimik *et al*., 1985) and they find it more difficult to judge whether two words rhyme when their rhymes are differently spelled (Seidenberg & Tanenhaus, 1979). Moreover, in an experiment with fourth-grade students, Ehri and Wilce (1981) provided a direct demonstration that knowing the written form of words influences segmentation. The authors compared the ability of children to segment words with similar pronunciations but with different spellings and found that it was difficult to count the same number of phonemes in for example "rich" and "pitch". This experiment provides strong evidence that readers' conception of segmental structure of words is shaped by knowledge of spelling (Ehri & Wilce, 1981). Thus, the acquisition of reading and writing skills promotes awareness of important aspects of the form of language and language becomes an object for cognition independent of speech and communication.

In conclusion, the present study provides another demonstration of the fact that literacy influences the way we perceive spoken language and extends the finding that illiterate subjects are biased towards semantic-conceptual-pragmatic types of cognitive processing and behavioral strategies. Moreover, the present results support previous work that has suggested that acquisition of alphabetic knowledge influences aspects of the auditory-verbal language system.

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REFERENCES

Adrian, J. A. (1993). Habilidad metafonologica en sujetos analfabetos y malos lectores. *Boletin de Psicologia*, *39*, 7–19.

Baddeley, A. D., Gathercole, S. E. & Pagagno, C. (1998). The phonological loop as a language learning device. *Psychological Review*, *105*(1), 158–173.

Bradley, L. & Bryant, P. (1991). Phonological skills before and after learning to read. In S. A. Brady & D. P. Shankweiler (Eds.), *Phonological Processes in Literacy*. (pp. 37–45). Hillsdale, NJ: Lawrence Erlbaum Associates.

Brady, S., Shankweiler, D. & Mann, V. (1983). Speech perception and memory coding in relation to reading ability. *Journal of Experimental Child Psychology*, *35*, 345–367.

Coppens, P., Parente, M. A. M. P. & Lecours, A. R. (1998). Aphasia in illiterate individuals. In P. Coppens, Y. Lebrun & A. Basso (Eds.), *Aphasia in Atypical Populations* (pp. 175–202). London: Lawrence Erlbaum.

Ehri, L. C. & Wilce, L. S. (1981). The influence of orthography on readers' conceptualization of the phonemic structure of words. *Apllied Psycholinguistics*, *2*, 371–385.

Garcia, C. (1984). *A Doença de Alzheimer. Problemas de diagnóstico clínico*. University of Lisbon, Lisbon.

Garcia, C. & Guerreiro, M. (1983). Pseudo-Dementia in illiterates. Paper presented at the meeting of the International Neuropsychological Society. Lisbon.

Hallé, P. A., Chéreau, C. & Segui, J. (2000). Where is the /b/ in "absurde" [apsyrd]? It is in French listeners' minds. *Journal of Memory and Language*, *43*, 618–639.

Jakimik, J., Cole, R. A. & Rudnicky, A. I. (1985). Sound and spelling in spoken word recognition. *Journal of Memory and Language*, *24*, 165–178.

Karmiloff-Smith, A. (1992). *Beyond modularity: A developmental perspective on cognitive science*. Cambridge, MA: MIT Press.

Karmiloff-Smith, A., Grant, J., Sims, K., Jones, M. C. & Cuckle, P. (1996). Rethinking metalinguistic awareness: Representing and accessing knowledge about what counts as a word. *Cognition*, *58*, 197–219.

Kolinsky, R., Cary, L. & Morais, J. (1987). Awareness of words as phonological entities: The role of literacy. *Applied Psycholinguistics*, *8*, 223–232.

Kosmidis, M. K., Tsapkini, K., Folia, V., Vlahou, C. & Kiosseoglou, G. (2004). Semantic and phonological processing in illiteracy. *Journal of the International Neuropsychological Society*, *10*(6), 818–827.

Morais, J. (1993). Phonemic awareness, language and literacy. In R.M. Joshi & C.K. Leong (Eds.), *Reading disabilities: Diagnosis and component processes* (pp. 175–184). Dordrecht: Kluwer Academic Publishers.

Patterson, K. & Lambon-Ralph, M. A. (1999). Selective disorders of reading? *Current Opinion in Neurobiology*, *9*, 235–239.

Petersson, K. M. & Reis, A. (2006). Characteristics of illiterate and literate cognitive processing: Implications of brain-behavior co-constructivism. In P. B. Baltes, P. Reuter-Lorenz & F. Rösler (Eds.), *Lifespan development and the brain: The perspective of*

biocultural co-constructivism (pp. 279–305). Cambridge, UK: Cambridge University Press.

Petersson, K. M., Reis, A., Askelof, S., Castro-Caldas, A. & Ingvar, M. (2000). Language processing modulated by literacy: A network analysis of verbal repetition in literate and illiterate subjects. *Journal of Cognitive Neuroscience*, *12*(3), 364–382.

Petersson, K. M., Reis, A. & Ingvar, M. (2001). Cognitive processing in literate and illiterate subjects: A review of some recent behavioral and functional neuroimaging data. *Scandinavian Journal of Psychology*, *42*, 251–267.

Reis, A. & Castro-Caldas, A. (1997). Illiteracy: A bias for cognitive development. *Journal of the International Neuropsychological Society*, *3*, 444–450.

Reis, A., Guerreiro, M. & Petersson, K. M. (2003). A sociodemographic and neuropsychological characterization of an illiterate population. *Applied Neuropsychology*, *10*(4), 191–204.

Seidenberg, M. S. & Tanenhaus, M. K. (1979). Orthographic effects in rhyme monitoring. *Journal of Experiemental Psychology: Human Learning and Memory*, *5*, 546–554.

Serniclaes, W., Ventura, P., Morais, J. & Kolinsky, R. (2005). Categorial perception of speech sounds in illiterate adults. *Cognition*, *98*, 835–844.

Silva, C. G., Petersson, K. M., Faísca, L., Ingvar, M. & Reis, A. (2004). The effects of literacy and education on the quantitative and qualitative aspects of semantic verbal fluency. *Journal of Clinical and Experimental Neuropsychology*, *26*(2), 266–277.

Slowiaczek, L. M., Soltano, E. G., Wieting, S. J. & Bishop, K. L. (2003). An investigation of phonology and orthography in spoken-word recognition. *The Quarterly Journal of Experimental Psychology*, *56A*(2), 233–262.

Stone, G. O., Vanhoy, M. & Van Orden, G. C. (1997). Perception is a two-way street: Feedforward and feedback phonology in visual word recognition. *Journal of Memory and Language*, *36*, 337–359.

Taft, M. & Hambly, G. (1985). The influence of orthography on phonological representations in the lexicon. *Journal of Memory and Language*, *24*, 320–335.

Ziegler, J. C. & Ferrand, L. (1998). Orthography shapes the perception of speech: The consistency effect in auditory word recognition. *Psychonomic Bulletin and Review*, *5*, 683–689.

Ziegler, J. C. & Goswami, U. (2005). Reading acquisition, developmental dyslexia, and skilled reading across languages: A psycholinguistic grain size theory. *Psychological Bulletin*, *131*(1), 3–29.

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APPENDIX I

Word and pseudoword pairs (lists 1 and 2)

	List 1	List 2
I W	cão – lombriga (“*dog – round-worm*”)	fogão – alfinete (“*stove – clothpin*”)
PW	colé – futreica	apião – ragalhôpo
N W	sabonete – pêra (“*soap – pear*”)	mosquito – melga (“*mosquito – gnat*”)
PW	têgo – ledupágo	trébo – zapagufo
PW	lorpuilo – zérpa	jadopêge – têga
N W	malmequer – rosa (“*marigold – rose*”)	lula – sardinha (“*squid – sardine*”)
C W	carro – autocarro (“*car – bus*”)	elefante – dedal (“*elephant – thimble*”)
I W	borboleta – pato (“*butterfly – duck*”)	capacete – bote (“*helmet – skiff*”)
PW	plávo – deredipão	góto – asmipadôr
PW	puda – caspilha	carnepuér – tója
PW	torpuinha – pitro	gáza – depegone
N W	prego – parafuso (“*nail – screw*”)	selo – rebuçado (“*stamp – candy*”)
C W	dente – bicicleta (“*tooth – bicycle*”)	banheira – chave (“*bathtub – key*”)
I W	comprimido – navio (“*tablet – ship*”)	guardanapo – barco (“*napkin – boat*”)
PW	nógoa – vopolipaga	dicóropado – táfa
N W	pente – lapiseira (“*comb – pen*”)	frigideira – disco (“*frying pan – disk*”)
PW	triplangé – ônho	tassuáden – lóba
C W	hipopótamo – faca (“*hippopotamus – knife*”)	mola – motorizada (“*peg – motorbicycle*”)
PW	zópe – pâlmeido	marrafólpe – cóga
PW	tuarpalágo – sármo	bontrisigo – câpio
C W	carruagem – bola (“*carriage coach – ball*”)	chimpanzé – olho (“*chimpanzee – eye*”)
PW	paganede – tóbe	corpomera – dápo
I W	casa – telefone (“*house – telephone*”)	conquilha – livro (“*clam – book*”)
PW	janheida – trábe	pêlre – tifitrépa
N W	passaporte – nota (“*passport – banknote*”)	bode – carneiro (“*he-goat – lamb*”)
PW	edêmalpe – bébar	bámo – aulopárro
C W	copo – aspirador (“*glass – vacuum-cleaner*”)	prato – televisão (“*plate – television*”)
PW	trifigeipa – pirgo	cêrfe – talipeica
I W	avião – gafanhoto (“*airplane – grasshopper*”)	boné – pulseira (“*cap – bracelet*”)
PW	zopão – áspirêde	lão – tonclipa

PW: Pseudowords; I W: Incongruent words; C W: Congruent words; N W: Neutral words.