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Morphological Processing in Reading Disabled and Skilled Spanish Children

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This article presents the results of a lexical decision experiment in which the base frequency (BF) effect is explored in reading disabled children and skilled readers. Three groups of participants were created. The first group was composed of children with reading disorders, the second group of skilled readers matched with the first group for chronological age and the third group of skilled readers matched for vocabulary size. The results of the experiment showed strong effects for Group, BF and also for the Group by BF interaction. Children matched for chronological age with children with reading disorders were significantly faster and more accurate than children of the other groups, who did not show any difference from each other. The effect of BF showed that children responded faster to stimuli composed of frequent bases than to stimuli with less frequent bases. However, the analysis of the interaction between Group and BF showed that only the skilled readers matched to children with reading disorders for chronological age benefited from the BF effect. The results of the experiment are discussed in the framework of theoretical accounts of morphological processing in children as well as considering the role played by the experimental task. Copyright © 2013 John Wiley & Sons, Ltd.

Keywords: base frequency; children; dyslexia; morphological processing; morphology

INTRODUCTION

Most words in any speaker's lexicon are complex, that is, they are composed of at least two morphemes (e.g. Booij, 2002 for Dutch; Rey-Debove, 1984 for French). Correspondingly, the majority of unfamiliar words are also morphologically complex (e.g. Thornton, Iacobini, & Burani, 1997). The ability to construct the meaning of words from their morphemic constituents is therefore important to favour reading comprehension (Ehri, 1998; McBride-Chang, Wagner, Muse, Chow, & Shu, 2005; Ramírez, Chen, Geva, & Kiefer, 2010). This ability is even more important when one frequently has to cope with unfamiliar complex words, as it is the case for children. Children become increasingly aware of morphological relationships between constituents of complex words (e.g. Carlisle, 2000; Carlisle & Stone, 2005; García & González, 2006), and their increase in morphological awareness has a direct impact on their reading comprehension (Kieffer & Lesaux, 2008; Kirby, Deacon, Bowers, Izenberg, Wade-Woolley, & Parrila, 2012).

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Although there is broad consensus for the important role of morphological processing, there are different accounts nonetheless that explain the nature of this process in children. One such account is offered by authors such as Carlisle (2000) or Seymour (1997), who maintain that the ability to process complex words into morphemes is acquired and develops gradually. According to these authors, morphological skills begin to develop with formal reading instruction and are fully acquired only at an advanced stage of learning to read. Children with formal instruction and learning capabilities would be able to successfully parse and analyse words into their constituent morphemes while beginning readers would not. Therefore, this theoretical account predicts that only more experienced children should show differences in processing simple versus complex words because of their ability to parse and process morphemes.

This developmental account of morphological processing is supported by some empirical evidence. Bertram, Laine and Virkkala (2000a) carried out an experiment in which 3rd and 6th grade children performed a definition task. Stimuli were complex words combining high-frequency and low-frequency stems and suffixes, with simple words used as controls. The results for the youngest children showed that complex words with high-frequency morphemes were more adequately defined than complex words with less frequent morphemes and simple words. However, there were no significant differences between simple and complex words made up of infrequent morphemes. The results for the oldest children also revealed a pattern showing better definitions for the complex words composed of high-frequency stems and suffixes than for the other stimuli but, in addition, they also showed that complex words comprised of infrequent stems and suffixes were better defined than simple words. Bertram *et al*. (2000a) concluded that older children are more effective at morphological processing than younger children, and for this reason, differences between simple and complex words composed of infrequent constituents only appeared among the oldest children.

In Spanish, an effect of the frequency of constituent morphemes on children's ability to comprehend new words has been demonstrated by Lázaro (2012b). In a pseudoword definition task, 7 to 9-year-old children with and without reading difficulties were able to benefit from the frequency of the stem of the base word, defining better the meaning of the pseudowords that were made up of more frequent word stems. These results indicated that children even in the first years of learning to read and also those with lesser reading abilities may be able to process relevant information in morphemes.

However, more frequent content morphemes, and especially stems, usually belong to the core vocabulary of a language. Thus, it might be argued that more frequent morphemes are recognized more easily by children, not only because they are more frequent, but also because they are more basic semantically. Accordingly, the use of the definition task, in which semantic processing is crucial, might allow younger and less skilled readers to match the performance of older, more skilled children. In addition, the definition task might be comparatively easier for less skilled children because it is not usually performed under time limitations. Davies, Cuetos and Glez-Seijas (2007) and Zoccolotti, De Luca, Judica and Burani (2006) both reported that for transparent orthographies such as Spanish and Italian, reading disabled children could improve their reading performance and even performed as well as their peers, when they were given enough time to complete the task.

If recognition of morphemic units by less skilled children requires both a sufficiently long period for processing the orthographic stimulus (Davies *et al*., 2007; Zoccolotti *et al*., 2006) and relies primarily on the meaning of morphemes (Beyersmann, Castles, & Coltheart, 2012), then morphological effects might be less likely to occur when children with reading difficulties are exposed to other tasks. One example is on-line lexical decision tasks, in which rapid orthographic processing is crucial to access the lexicon, and in which semantic processing is not involved to the same extent as in the word definition task (see, e.g. Balota & Chumbley, 1984; Plaut, 1997).

In the present study, we investigated morphological processing in children using lexical decision, performed under time constraints. In making lexical decisions, children with reading difficulties and younger readers are not expected to benefit from the presence of constituent morphemes to the same extent as skilled readers because this task requires participants to quickly access a lexical representation for a letter string.

EXPERIMENT

We conducted a lexical decision experiment in which we manipulated the base frequency (BF) of the word, to gain further insight into morphological processing in children with reading disorders and skilled readers. BF is defined as the frequency of the target word's stem, including all inflected and derived words that share that stem. For example, according to the database of Alameda and Cuetos (1995), the Spanish word *jardinero* (gardener) has a surface frequency of seven, but a BF of 93. The latter is the frequency of its stem *jarďín* (garden) in all the words that include it. A facilitatory BF effect on word recognition has been observed in several studies of adult readers in Dutch, Italian, English and Spanish (e.g. Bertram, Schreuder, & Baayen, 2000b; Burani & Caramazza, 1987; Ford, Davis, & Marslen-Wilson, 2010; Lázaro, 2012a). These studies have shown that complex words with high-base frequencies elicit faster responses than words with low-base frequencies in lexical decision tasks. These results suggest that adult readers rely on morphological processing during recognition of complex words. However, it may also be predicted that children who have not yet acquired good decoding abilities, such as children with reading difficulties or children in the first years of reading instruction, may not benefit from the presence of morphemes in a word to the same extent as skilled readers.

METHOD

A 3 (Group: children with reading disorders, skilled readers matched for chronological age and skilled readers matched for vocabulary level) $\times$ 2 (BF: high and low BF) mixed factors factorial design was used. Reading group was the between subjects factor and BF the repeated measure.

PARTICIPANTS

Sixty children from three different public schools completed the lexical decision task, 20 in each of the three experimental groups. The schools were located in a middle class neighbourhood of Talavera de la Reina, a city with an average socioeconomic level for Spain. All children and parents were native Spanish speakers. The age difference between the children with reading disorders and the age-matched skilled readers was not significant ($t(19) = 2.06$, $p > 0.07$), but the age difference between the youngest children and the reading disabled group was different statistically ($t(19) = -14.8$, $p < 0.01$). Between the oldest and the youngest skilled readers, there were also statistically significant difference in age ($t(19) = -10.06$, $p < 0.01$). See Table 1.

Children with reading difficulties were selected from the population of children attending the Speech and Language Therapy service of schools. All were diagnosed as 'reading disabled' with no suggestions of other language or speech disorders. To further assess the children's reading difficulties, all children also completed the PROLEC-R test (Cuetos, Rodríguez, Ruano, & Arribas, 2007). This test is validated for Spanish children aged between 6 and 12 years and consists of nine different subtests: letter identification, same–different word, reading words aloud, reading nonwords aloud, grammatical structures, punctuation marks, simple sentence comprehension, text comprehension and oral comprehension. The performance on each exam is evaluated as being normal, slightly below normal or far below normal compared with a normative sample of children of the same age. The children selected for the present study did not attain a 'normal' score on any measure, although 'oral comprehension' was not considered a critical measure for inclusion.

The children in the group of skilled readers were selected randomly from four different classrooms, excluding children that had previously received any treatment for speech or language disorders. Teachers confirmed that none of these children had demonstrated any issues concerning poor language, hearing, speech or motor skills.

It is widely acknowledged that differences in children's vocabulary sizes predict their attainment on particular reading tasks (e.g. Lee, 2011; Stanovich, 1986; Verhoeven & van Leeuwe, 2008). As in Ouellette and Beers's (2010) study, all our children completed the Peabody Picture Vocabulary Test (Spanish version by Lunn, Dunn, & Arribas, 2011) to establish their receptive vocabulary size. As expected, skilled readers matched for chronological age had significantly larger vocabulary scores than the reading disabled group ($t(19) = 6.1$, $p < 0.01$). The youngest group's scores were similar to those of the reading disabled children on the Peabody Picture Vocabulary Test ($t(19) = -0.6$, $p > 0.5$), but they were lower than those of the older skilled readers ($t(19) = 6.8$, $p < 0.01$). See Table 1.

Table 1. Mean age and scores on Peabody test of participants (standard deviations in brackets)

Group	Chronological age in months	Peabody's raw scores
Reading disabled children	98.5 (9.3)	112.4 (29.2)
Skilled children matched on vocabulary size	85.0 (4.0)	116.9 (26.3)
Skilled children matched on chronological age	94.1 (4.6)	138.1 (13.2)

STIMULI

A set of 40 suffixed derived words was selected, 20 with a high BF and 20 with a low BF. The controlled variables were word surface frequency, suffix productivity (considered as the number of different complex words in which the suffix occurs), orthographic neighbourhood density (N hereafter), letter length of words and suffixes and morphological family size (see Table 2). Between groups *t*-tests showed no significant differences between the high BF and the low BF experimental sets in the values of the matching variables, except in the case of N ($t(19) = 3.64$, $p < 0.01$) and suffix productivity ($t(19) = 2.87$, $p < 0.01$), which had higher values in the set of words with high BF. Considering that a higher N may facilitate recognition of low-frequency words (see, e.g. Andrews, 1997) and a higher suffix productivity may facilitate the emergence of the BF effect (Ford *et al*., 2010), the possible contribution to the results of the differences in these values – both in favour of words with a high BF – will be considered in the results section later in the text. Because there is no single database in Spanish that provides counts for all the variables we considered, we used three different resources. All word and stem frequencies were taken from Martínez and García's (2004) child frequency count, whereas the other variables were taken from Alameda and Cuetos (1995) database. The inverse dictionary of Bosque and Pérez (1987) in which words are listed from the ending letter was employed to count suffix productivity. The 40 nonwords were created by changing one or two letters in the stems of the real complex words; suffixes were therefore not modified.

PROCEDURE

Participants were instructed to judge as quickly as possible whether the presented letter strings were real words or not, while avoiding errors. Participants sat at a distance approximately 50 cm from a laptop screen in a quiet room. A fixation point was presented on a screen for 1 s, followed by the presentation of a word or nonword target for 3 s or until the participant responded. After a response or time out, a blank screen was displayed for 500 ms. The order of presentation of the stimuli was fully randomized.

Prior to the experiment, five trials were presented in this same manner. None of the five stimuli presented in this training session were used in the subsequent experiment.

Table 2. Descriptive statistics of the experimental items (standard deviations in brackets)

	BF	SF	N	LL	Stem FS	Suffix productivity
Low BF	42	6.7	1	8.1	7.2	990
	(30)	(7.3)	(.8)	(.9)	(1.8)	(988)
High BF	243	9.5	1.6	7.8	7	1515
	(209)	(11)	(1.4)	(1.3)	(1.8)	(984)

Note: frequency per 1.200.000 words. BF, base frequency; SF, word surface frequency; N, neighbourhood density; LL, letter length; FS, family size.

RESULTS

Response times associated with incorrect responses were not considered in the analyses. Given the high standard deviations, there were no scores faster or slower than 2.5 standard deviations from the mean. However, responses faster than 300 ms (less than 1% of the data) were excluded from the analyses.

Response times were log-transformed to correct for proportional group differences in overall response times and rescaled to a common metric that allows for more reliable identification of group differences (Baayen, Feldman, & Schreuder, 2006).

Mean latencies and error rates are reported in Table 3. The RT results showed a strong effect of Group in both the analyses by participants ($F1(2,57) = 14.07$, $MSe = 0.01$, $p < 0.001$) and by items ($F2(1,38) = 15.88$, $MSe = 0.001$, $p < 0.001$). The results also showed a strong BF effect ($F1(2,57) = 27.98$, $MSe = 0.01$, $p < 0.01$; $F2(1,38) = 9.24$, $MSe = 0.003$, $p < 0.005$). The interaction between these variables was significant in the analysis by participants ($F1(2,57) = 6.44$, $MSe = 0.007$, p 0.05) and marginally significant by items ($F2(1,38) = 3.88$, $MSe = 0.005$, $p = 0.056$). The interaction is shown in Figure 1. A planned comparison, carried out on participant mean scores, showed that the BF effect was significant in the case of the oldest skilled readers ($p < 0.001$), close to significant in younger children ($p = 0.07$), but not significant in children with reading difficulties ($p = 0.1$).

Analysis of error rates showed a Group effect in the analysis by participants ($F1(2,57) = 7.95$, $MSe = 7.86$, $p < 0.05$) but not in the analyses by items

Table 3. Mean response latencies (in millisecond) and mean error rates (out of total stimuli) per experimental condition (standard deviations in brackets).

Group	BF	Response latencies	Errors
Reading disabled children	High BF	1983 (311)	4.3 (2.9)
	Low BF	2068 (298)	5.3 (2.2)
Skilled children matched	High BF	1897 (350)	4.0 (2.4)
on vocabulary size	Low BF	1974 (324)	5.2 (3.4)
Skilled children matched	High BF	1459 (249)	2.8 (1.7)
on chronological age	Low BF	1670 (236)	2.5 (1.6)

BF, base frequency

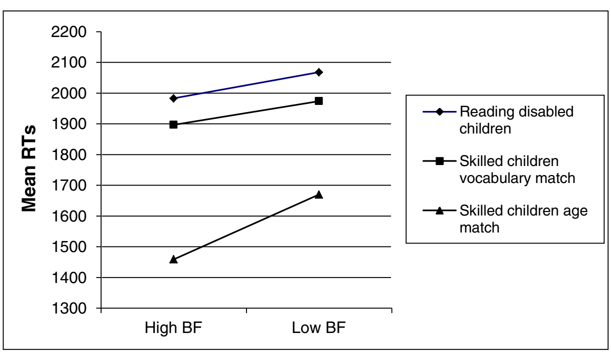

Figure 1. Group by base frequency (HF = high frequency; LF = low frequency) interaction on response latencies (millisecond).

($F2(1,38) = 2.45$, $MSe = 3.7$, $p < 2$). The BF effect failed to reach significance in either the analyses by participants ($F1(2,57) = 3.34$, $MSe = 3.41$, $p = 0.07$) or by items ($F2(1,38) = 3.34$, $MSe = 29.5$, $p = 0.075$). The interaction between these variables was not significant ($F_s < 1$).

To assess the potential mediating role of N and suffix productivity on the significant difference between high BF and low BF stimuli (see description of Stimuli and Table 1), we performed an analysis of covariance on mean RTs of items with N and suffix productivity as covariates. The results showed effects for Group, BF and a Group $\times$ BF interaction that were similar to those obtained with the previous ANOVAs. The effects of N and suffix productivity were far from significant (both $F_s < 1$). Therefore, the analysis of covariance confirmed that differences in N and suffix productivity between conditions did not have a significant impact on the reported results.

DISCUSSION

The results of the lexical decision experiment showed significant effects for Group, with BF effects limited to decision latencies. The effect of Group indicates that older skilled readers were faster and more accurate than both younger skilled readers and children with reading disabilities.

The BF effect on RTs suggests that children were sensitive to the morphological manipulation. However, the significant interaction between Group and BF showed that only the older skilled readers, matched to children with reading difficulties on chronological age, were sensitive to the BF effect. This result indicates that only children with faster processing abilities and a large enough vocabulary may benefit from the frequency of the base, suggesting that morphological processing becomes particularly relevant as children and their vocabularies grow.

In contrast to the results from the present study, no significant interaction between reading ability and BF was found by Lázaro (2012b) in a pseudoword definitions task, with Spanish children of the same age as the ones participating in the present study. The difference in the results of these studies might be due to the different tasks employed. The definition task adopted by Lázaro (2012b) is performed without a time limit and relies mainly on semantic processing. It is therefore suitable for use with readers with dyslexia, who can benefit from additional time to access the orthographic forms corresponding to morphemes, and process their meanings and the meaning of the resulting combination. In comparison, lexical decision is very demanding for reading disabled children. It is typically performed under time pressure, which imposes heavy constraints on the disabled readers who have a limited capacity for building the correct word form to access the lexicon. This makes the discrimination process particularly difficult, especially in cases where nonwords are particularly word-like[1] (Balota & Chumbley, 1984; Plaut, 1997). Under such time constraints, reading disabled children may not be able to fully parse a morphologically complex word into morphemes, even when the stem has a high frequency of occurrence. In contrast, skilled readers are more efficient at the morphological segmentation stage of processing, which for some authors is mandatory when making a lexical decision on low-frequency morphologically complex words (e.g. Duñabeitia, Perea, & Carreiras, 2008; Meunier & Longtin, 2007; Schreuder, Burani, & Baayen, 2003). Skilled readers can thus benefit from the BF effect more than children with reading disabilities in a lexical decision task.

Overall, our data fit well with the view that morphological processing becomes more efficient as children and their vocabularies grow. However, the present results do not necessarily contradict the idea that morphological processing is a process that younger and reading disabled children may employ to compensate for their reading difficulties when performing a different task such as reading aloud (see e.g. Burani, Marcolini, De Luca, & Zoccolotti, 2008; Elbro & Arnbak, 1996; Marcolini, Traficante, Zoccolotti, & Burani, 2011). For example, Marcolini *et al.* (2011) reported data to support this compensatory strategy view in a study with Italian children carried out with three groups of participants (reading disabled children, young skilled readers and adults). The results from a reading aloud paradigm showed that children with a reading disorder always named complex words faster than simple words, irrespective of the word's surface frequency. In contrast, skilled readers showed shorter naming latencies for complex words than for simple words, but only when they had a low frequency, whereas naming latencies for simple and complex words did not differ when words had a high surface frequency. In adults, no differences were found between simple and complex words under any word frequency condition. From these results, Marcolini *et al.* (2011) concluded that in languages with a transparent orthography such as Italian and Spanish, children with reading disorders may compensate for their difficulties in reading the word as a whole form by relying on morphemes. Morphemes provide shorter reading units for readers with a limited capacity of orthographic processing. Morpheme-based reading aloud would thus be an efficient strategy and less prominent in adults and skilled child readers because skilled readers would rely more on whole word reading (Burani *et al.*, 2008).

Similar to lexical decision tasks, reading aloud is usually performed within strict time limitations. Why should then morphological processing be present and beneficial to less skilled readers in reading aloud, but not in lexical decision tasks? To address this question, the different requirements of the two tasks – reading aloud and lexical decision – should be considered. In the reading aloud task, naming times are registered at the onset of pronunciation and measure the time taken by the reader to initiate pronunciation. When long stimuli are presented to be read aloud, the child with a reading disability may benefit from the morphological composition of the stimulus, by starting pronunciation on the basis of the initial lexical unit (the stem morpheme) only, without necessarily processing the entire stimulus (Traficante, Marcolini, Luci, Zoccolotti, & Burani, 2011). Thus, children with reading difficulties may obtain faster naming times for morphologically complex stimuli by relying on the stem morpheme only, relative to stimuli of similar length that have no morphological constituents (Burani *et al.*, 2008; Marcolini *et al.*, 2011). In contrast, when making lexical decisions for morphologically complex stimuli, the reader must process both constituents of the stimulus (the stem and the suffix) to be able to correctly decide on the lexicality of that combination. For reading disabled children, the necessity to process the whole stimulus may thus result in similar difficulties when deciding on long words, irrespective of their morphological constituents.

Additional research is necessary to better understand morphological processing in children. From our point of view, a key issue for further research is the relationship between the experimental task and the results obtained. To test the validity of different accounts, the differences between the experimental tasks investigated in children must be taken into account.

Appendix A

STIMULI OF THE EXPERIMENT:

Low BF	High BF	Pseudowords	Pseudowords
Frutero (fruiterer)	Ayudante (helper)	Dutarero	Canrante
Pescador (fisherman)	Bañista (bather)	Prafera	Calizeta
Moraleja (moral of a fable)	Jardinero (gardener)	Refante	Linviador
Codera (patch)	Pensador (thinker)	Diresdor	Arpitud
Tramposo (cheater)	Obrero (worker)	Todil	Mufical
Inventor (inventor)	Papelera (paper bin)	Anibado	Camejero
Simpleza (simplicity)	Librero (book seller)	Carfero	Amarítica
Olvidadizo (forgetful)	Cocinero (Cook)	Patelera	Pantacal
Cucharada (tablespoon)	Limpiador (cleaner)	Jadaza	Monrañoso
Pegajoso (sticky)	Mentiroso (liar)	Esdribura	Perodazo
Aceitoso (oily)	Telefonista (telephonist)	Gransura	Guanpazo
Temible (fearsome)	Cabezazo (header)	Llumioso	Jufador
Estacazo (stake blow)	Lechoso (milky)	Visidor	Hojecero
Vigilancia (vigilance)	Pobreza (poverty)	Confinenta	Mampilla
Grasiento (greasy)	Peludo (hairy)	Vienzoso	Vencabal
Montaje (assembly)	Golpazo (great blow)	Lumero	Jepatura
Coronilla (nape)	Rojez (redness)	Amilismo	Pasablero
Patinaje (skating)	Flautista (flautist)	Guetilla	Cancefoso
Pelotazo (ball blow)	Orejera (earmuff)	Pabador	Espartera
Carruaje (carriage)	Montañero (mountaineer)	Sabonera	Baidatín

BF, base frequency

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