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The role of derivative suffix productivity in the visual word recognition of complex words

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In this article we present two lexical decision experiments that examine the role of base frequency and of derivative suffix productivity in visual recognition of Spanish words. In the first experiment we find that complex words with productive derivative suffixes result in lower response times than those with unproductive derivative suffixes. There is no significant effect for base frequency, however. In experiment two, the same procedure was undertaken with pseudowords, showing that when they are composed by productive derivative suffixes they take longer to be rejected than when they are composed by unproductive derivative suffixes. Again, the role of base frequency fails to reach significance. These results endorse the view that derivative suffixes have a relevant role in visual recognition of complex words. According to our results, derivative suffixes create the conditions for taking a lexical candidate as a legal lexical entry and therefore they contribute decisively to the lexical decision.

In recent years, morphological processing and its role in lexical recognition have become a major focus of research activity within psycholinguistics, as demonstrated by the large amount of work published on the subject. This processing has been studied in both normally developing children and those presenting some sort of pathology (e.g. Beyersmann, Castles, & Coltheart, 2012; Burani, Bimonte, Barca, & Vicari, 2006; Carlisle, & Katz, 2006; Lázaro, Moraleda & Garayzábal, 2013, Lázaro, Burani & Camacho, 2013; Schiff, Raveh, & Kahta, 2008 Verhoeven & Schreuder, 2012), as well as in adults (e.g. Badecker, &

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Allen, 2002; Deutsch, Frost, Pollatsek, & Rayner, 2000; Domínguez, Alija, Rodríguez-Ferreiro, & Cuetos, 2010; Feldman, 2000; Giraudo & Grainger, 2000; Lehtonen, Cunillera, Rodríguez-Fornells, Hultén, Tuomainen, & Laine, 2007; Marslen-Wilson, Tyler, Waksler, & Older, 1994). The literature also includes studies with and without priming, masked or otherwise. We have access, then, to a myriad of information, although, as Amenta and Crepaldi (2012) note in their recent review of findings, much more information is needed in order not only to make progress in possible fuzzy areas, but also to clarify results that appear to be contradictory.

One result that might seem to contradict our understanding of derivational morphology in adults looked at the role of Base Frequency (henceforth BF) and Affix Productivity (henceforth AP) using an unmasked lexical decision task. The BF is the lemma frequency of a given stem (Baayen, Wurm & Aycock, 2007) –a count based on tokens. Concerning AP, it is clear that some derivative suffixes appear in more words than others. The derivative suffix *–ero* appears in many Spanish words, e.g. *jornalero* (casual labourer), *portero* (goalkeeper), *monedero* (purse), whereas, say, *–azgo* appears in relatively few, e.g. *cacicazgo* (chiefdom), *hartazgo* (surfeit). Here we are referring not to the frequency with which a lemma appears, but rather to the number of words that contain the derivative suffix, regardless of frequency – in other words, a count based on types. Burani, Thornton, Iacobini & Laudanna (1995) call this variable numerosity, and demonstrate a very high positive correlation with calculations based on tokens.

Nevertheless, this is not the only way productivity can be operationalized. Laudanna, Burani and Cermele (1994), for instance, posed that productivity can be computed as the proportion of complex words that present a particular suffix over the total words that end with the same letter pattern, i.e., for Spanish, the suffix "-eza" is present in simple words as in "cerveza" (beer) or "cabeza" (head) as well as in complex words as in "extrañeza" (strangeness) and "rareza" (rarity). The simple words that present this letter ending are called pseudoaffixed. Laudanna et al., (1994) obtained relevant results in an experimental series in which they computed the proportion between real affixed words and pseudoaffixed words. Although this strategy might be interesting in general, it goes beyond our scope in this contribution given that appropriate empirical materials for such computations are lacking. Accordingly, we operationalize productivity as type frequency. We will come back on this issue in the discussion.

The role of BF and AP has been studied in different languages using different methodologies. The research of Baayen et al. (2007) in English, of

Burani and Thornton (2003) in Italian, and of Lázaro (2012) in Spanish is particularly relevant to our present purposes. It is rather clear that cross-linguistic comparisons are relevant since differences across languages might contribute to account for some of the empirical findings. Although in some cases different theoretical frameworks might result more suitable for some languages than for others (Smolka, Preller & Eulitz 2014), the benefit of comparing results across different languages can primarily come from the analysis of somewhat different methodologies.

In Burani and Thornton's (2003) research, three unprimed lexical decision experiments were carried out. In the first experiment, they combined real derivative suffixes with inexistent stems, thus creating pseudowords. The suffixes were categorized into three groups: highly productive, regularly productive and highly unproductive. They were then compared with pseudowords that contain no existing morphological elements. The results show that response latencies were only significantly longer for pseudowords with highly productive suffixes, when compared to pseudowords containing no valid morphemes, thus showing a significant AP effect. In the third experiment, focused on words, base frequency and affix productivity (with two levels each –high and low) were manipulated altogether. They noted that the variable BF played a key role, since words with frequent stems elicited significantly faster responses than those with infrequent stems. Nonetheless, in this experiment no significant results were obtained for the variable AP –words evoked response latencies independently of the productivity of their suffixes. From the results of this experiment, the authors drew the logical conclusion that BF plays a fundamental role in the visual recognition of complex words, not so AP, thus defending the notion that words with common lexemes share representations in the lexicon (Ford, Davis and Marslen-Wilson, 2010).

In Spanish, Lázaro (2012) conducted a study similar to Burani and Thornton's (2003) third experiment, obtaining a different pattern of results. Lázaro (2012) observed a significant facilitative effect for AP, but no main effect for the variable BF – the BF effect was only significant when words had high AP.

Lastly, Baayen et al. (2007) carried out two experiments. In the first experiment they obtained an AP effect, whilst the BF effect was not significant. However, in contrast to Lázaro (2012), the interaction between the two variables was not significant. In their second experiment both variables presented significant main effects. The difference between both experiments lays in the stimuli presented: in the first only low frequency stimuli were used, while, in the second, stimuli of all frequencies were used.

These results imply that the BF effect depends on the linguistic context (see also Andrews, 1986) –in particular it depends on the frequency not only of the stimuli under study, but also on the frequency of those presented as fillers, which therefore contribute to generate the context. Because all the studies of Burani and Thornton (2003), Lázaro (2012) and Baayen et al.'s first experiment (2007) were carried out with low frequency words, the observed differences cannot be attributed to the frequency of the stimuli. Necessarily, other methodological differences should be related to the findings observed. In fact, these methodological differences might have biased the results in different ways. Whereas Burani and Thornton (2003) controlled their stimuli for familiarity, neither Lázaro (2012) nor Baayen et al. (2007) did so. Taking together the results of the Burani and Thornton's (2003) second and third experiments, it can be shown that stimulus familiarity seems to play an important role. In fact, they observed that when this variable is controlled -in the third experiment-, the BF effect persists while the AP effect –which was significant in the second experiment disappears; stimulus familiarity was not controlled in the other experiments. Burani and Thornton (2003) and Baayen et al., (2007) introduce low frequency filler items that reflect the regularity of Italian and English vocabulary –both complex words (stem and derivative morpheme) and simple words (stems). In sharp contrast, Lázaro (2012) does not introduce fillers that reflect the same properties of the Spanish vocabulary; Lázaro chose, instead, pseudowords in the lexical decision task. This methodological difference may have had serious consequences, because the context created by the Lázaro's (2012) test might have facilitated the development of some reader strategies. This sounds unlikely when the words are different each other.

In order to better understand these discrepancies and shed light on the different role of stems and derivative suffixes in lexical recognition of complex words, two new experiments were conducted in Spanish. In the first experiment, both variables AP and BF were manipulated by using words; the main effects of these variables and its interaction were examined. In the second experiment, in order to explore these effects in depth, the same manipulation was carried out by using pseudowords. Our expectation was that the results should be consistent with those of the first experiment.

EXPERIMENT 1

The exam of BF and AP is intended in this first experiment. A 2 (BF: High vs. Low) × 2 (AP: High vs. Low) factorial design is used.

METHOD

Participants. Twenty-nine right-handed native Spanish readers (25 women, 4 men of age 21 years in average) completed the experiment on a voluntary basis. All students were Speech and Language Therapy students. They received course credits for their participation. All students had normal or corrected-to-normal vision.

Stimuli. A total of 80 low frequency words were selected, 20 words per experimental group. There were 20 high BF and high AP words, 20 high BF and low AP words, 20 low BF and high AP words and 20 low BF and low AP words. Additionally 80 simple words were included as filler items, each consisting of a single lexeme. For the lexical decision task another set of 160 pseudowords were created. Half of them had no derivative suffix while the other half did. These stimuli were obtained using real words, changing one or two letters to convert them into pseudowords (see Appendix 1).

The experimental variables –shown in Table 1– are word frequency (frequency per million 0.1-13.5), neighborhood density (0-5), family size (FS; 5-10), number of letters (5-11), suffix letter length (see Kuperman, Bertram, & Baayen, 2010; 2-4), familiarity (3.5-6.6) and frequency of the initial bigram. The calculations were performed using data from the *ESPAL database* (Duchon, Perea, Sebastián-Gallés, Martí & Carreiras, in press). To calculate affix productivity (AP), we used the reverse dictionary (Bosque and Pérez, 1987) which lists Spanish words in alphabetical order starting from the last letter and ending with the first.

Procedure. A lexical decision task was programmed by using the software E-prime (Schneider, Eschman & Zuccolotto, 2012). Participants were instructed to judge as quickly as possible whether the letter strings were existing words or not, reducing errors at minimum. Participants were placed about 70 centimeters from the laptop screen in a quiet room. As Ford et al., (2010) did in their experiments, the experiment sequence proceeded this way: the screen showed a fixation point "+" for 250 ms. to claim attention on the point where the stimulus was to appear. After this signal the target was presented for 500 ms. or until participants responded, moment in which the letter pattern disappeared and a blank screen was shown for 1 second; responses were collected at that very moment. The order of presentation was randomized across stimuli. Prior to the experiment, ten trials were presented in the same manner. None of the five stimuli presented in this training session were used in the subsequent experiment.

Table 1. Descriptive statistics of experiment 1.

	Freq	BF	AP	Stem Length	FS	N	Suffix Length	Bigram Freq.	Famil.
High BF-High AP	2.2	133	1795	7.9	7.4	1.9	3,25	11771	5.1
	(3)	(103)	(872)	(1)	(2)	(1)	(.55)	(14205)	(1)
High BF-Low AP	3.01	128	173	7.7	7.7	1.3	3.15	11772	4.9
	(4)	(89)	(83)	(1)	(1)	(1)	(.36)	(9427)	(1)
Low BF-High AP	2.1	15	1850	7.7	7	1.2	3	11403	5.5
	(2)	(9)	(774)	(1)	(1)	(1)	(.32)	(11551)	(.9)
Low BF-Low AP	2.8	13	186	7.5	7.4	1.5	3,4	10581	5.1
	(3)	(9)	(106)	(1)	(1)	(1)	(.5)	(16131)	(1)

Means and standard deviations (in parentheses).

RESULTS

Response times associated with incorrect responses, response times more than two and a half standard deviations above the mean for the condition, and responses faster than 300 milliseconds were not included in the statistical analyses. The elimination of these latencies accounted for 3.6% of the total data set included in the analyses.

The results can be viewed in table 2. The results involving words show a close-to-significant effect for BF in the analysis by participants ($F1(1,28)= 3.01$, $MSe=32500$, $p=.09$) but a non significant effect in the analyses by items ($F2(1,79)= 1.79$, $MSe=16976$, $p>.1$). The difference between words regarding BF is not significant (578 vs. 588 ms.). However, a significant AP main effect emerges both in the analyses by participants and by items ($F1(1,28)= 24.67$, $MSe=53280$, $p<.01$), ($F2(1,79)=21.01$, $MSe=180479$, $p<.01$), respectively. Complex words with productive suffixes were responded faster than complex words with unproductive affixes (563 vs. 603 ms. respectively). The interaction between the two variables did not reach significance (F2 < 1), (F2 < 1).

The analysis conducted on error rates shows a significant BF effect (F1(1,28)= 7.1,MSe=1.38, p<.05), as well as an AP effect (F1(1,28)=22.82, MSe=4.04, p<.01) in the analysis by participants. However, in the analysis by items only the effect of AP reaches significance (F2(1,79)=1, MSe=4, p>.05) and (F2(1,79)=3.7, MSe=.81, p=.05). Words with high frequent suffixes were better classified than words with infrequent suffixes. The interaction between these variables did not reach significance (F1 < 1).

Table 2. Results from experiment 1.

	RT	% ER
High BF-High AP	557	1.3
	(78)	(1.2)
High BF-Low AP	598	3.3
	(105)	(2.5)
Low BF-High AP	569	2.1
	(99)	(1.9)
Low BF- Low AP	608	3.8
	(106)	(2.5)

RT –averaged response latencies, % ER –averaged error scores. Standard deviation in parentheses.

With regards to pseudowords, the t tests performed by items and participants show that complex stimuli required more time to be rejected than simple pseudowords (t(28)= -2,89, p<.01); (t(79)=-101, p<.01). They also produced more errors than simple words (t(28)= -3,11, p<.01); (t(79)=100, p<.01).

DISCUSSION

In the first experiment, the results obtained clearly show a relevant role for derivative suffixes in the recognition of complex words. Our findings are totally coherent with those of Baayen et al. (2007), who showed no significant effect for base frequency, as opposed to a significant effect for affix productivity. Our results opposed those obtained by Burani and Thornton (2003), who observed a significant BF effect but not a significant AP effect. Moreover, our results do not show the significant interaction between the two variables found by Bertram et al. (2000a), Ford et al. (2010) and Lázaro (2012).

To explain our results we can reasonably use Baayen et al.'s (2007) arguments. These authors argue that stems show weaker (or even null) effects compared to derivative suffixes because they offer little information in the probabilistic decision of the word identity in complex words. Highly productive derivative suffixes actually create the conditions for judging a letter string as a word, even in cases in which its combination with a letter string does not constitute a legal word. Therefore, derivative suffixes play a major role in judging lexicality.

Morphological processing assumes that the stem activates candidates that are compatible with it; in other words, it activates the morphological family of the stem itself. The number of morphological family members is called Family Size (FS), defined as the number of words that share a given stem. This variable has been studied repeatedly in different languages (e.g. Bertram, Schreuder & Baayen, 2000b; Dijkstra, Moscoso del Prado Martín, Schulpen, Schreuder & Baayen, 2005; Moscoso del Prado Martín, Deutsch, Frost, Schreuder, De Jong & Baayen, 2005; de Jong, Nivja, Schreuder & Baayen, 2000; Lázaro & Sainz, 2012; Schreuder & Baayen, 1997) and its facilitative effect has been demonstrated.

Nonetheless, once the morphological family becomes active, the most frequent or most productive candidates facilitate lexical access inducing more rapid responses. The stronger the activation, i.e. the bigger the family, the greater the facilitation. In our experiment the stem of complex words activate morphological candidates associated to them and, as a consequence, generate faster responses. Notwithstanding, since the same number of candidates exist for each item in this experiment (see table 1), the facilitatory effect should be neutralized, and this is what actually happened. Though, in the context of our experiment the same number of candidates become active, their relative frequency might have an impact on response latencies. It sounds reasonable to expect that the most frequent candidates should be responded faster than less frequent candidates. In this experiment surface frequency was controlled, as well. Therefore the surface frequency should not have any relevant role. The only variable linked to stems that remains, for which an impact on the results might be expected, is the general activation level represented by the frequency of the morphological family. However this study reveals that the level of activation level of morphological families by itself does not play a substantial role.

Under this interpretation of the data, the mutual relationship between stem and both FS and BF becomes evident – in fact, Burani and Thornton (1997) have shown the high positive correlation between the two variables. This view confers greater importance to the FS effect, an effect supported by numerous studies showing its significance. Nonetheless, the stem triggers not only the activation of candidates, but also the actual level of activation of the stem with which suffixes are to be concatenated –the BF effect. This factor, the level of stem activation, is what seems not to play a fundamental role in our experiment, although, as Baayen et al. (2007) explicitly point out, with robust experimental designs, this variable can have a significant effect (as they found to be the case in other tasks, such as naming). This is due, in fact, to the facilitation offered by a highly activated stem when a suffix comes to be concatenated, i.e. higher BF stems activate lexical candidates more easily, and therefore faster.

For our first experiment, we might assume, in accordance with Baayen´s et al.'s proposal, that with more participants and items (more statistical power), the BF effect should have emerged. The close-to-significant effect of BF in the analysis of latencies and errors by participants partially support this view. It is important to realize that, yet in Lázaro's (2012) experiment, the effect of BF was reported as not significant, since it did not reach significance in the analysis by items, but only in the analysis by participants. The current results are closed to what then it was observed. Altogether the results are consistent with the claim we pose. A more powerful design should be implemented to capture significant differences in this respect. There is, however, a relevant difference between Lázaro's (2012) results and ours: the lack of a significant interaction between BF and AP. As we have seen, the literature shows results consistent with this interaction when it emerges and when it does not. The different results in Spanish might be a result of the control of familiarity (Burani & Thornton 2003), the use of fillers and higher frequency items -that affects the lexical context (Baayen et al., 2007)–, and the affix length –not reported in their experiment. All these differences strongly suggest the interest of conducting more research in Spanish to systematically relate the results obtained with the methodological manipulations performed in previous studies.

The rationale for conducting a new experiment is to examine whether the use of pseudowords instead of words would produce results coherent with the results obtained in the previous experiment. If we use pseudowords composed of real stems and derivative suffixes whose concatenation does not result in words, e.g. "*futbolura*" (footballness), then, the joint activation of morphological families of stems and of derivative suffixes should become decisive in determining letter-string lexicality. Thus, when stems are read we might assume that only those derivative suffixes which generate real words should be activated, not those that cannot be lexically concatenated with those stems. Therefore, the final decision is only performed when all possible derivative suffixes are discarded or inhibited.

By using pseudowords, we can expect that productive suffixes will show an inhibitory effect because of their strong activation level. This activation would be consistent with the "word" status and therefore this response has to be inhibited in the task. This inhibition would be more costly in the case of high productive suffixes than in the case of low productive suffixes because the more powerful activation of the former. Our prediction is then that pseudowords made up of productive suffixes will produce slower responses than pseudowords made up of low productive suffixes.

EXPERIMENT 2

In this second experiment, the effects of BF and AP are explored in pseudowords. As in the previous experiment, a 2 (FB: High vs. Low) × 2 (AP: High vs. Low) factorial design is used.

METHOD

Participants. Seventeen right-handed native Spanish readers (15 women and 2 men of average age 21.9 years) served on a voluntary basis. All of them were Speech and Language Therapy students. They received course credits for their participation. All students had normal or corrected-to-normal vision.

Stimuli. In order to form complex pseudowords, real stems and derivative suffixes were chosen and concatenated together such that no real words resulted from its concatenation. In this way, a total of 80 pseudowords were created, 20 per experimental group: 20 high BF and high AP pseudowords, 20 high BF and low AP pseudowords, 20 low BF and high AP pseudowords and 20 low BF and low AP pseudowords. Another 80 pseudowords were also prepared, each made up of a single real lexeme with one letter changed. For the lexical decision task, another 160 stimuli were created, in this case words - half of them complex and the other half simple (see Appendix II).

The controlled variables (shown in Table 3) were neighborhood density (0-5), number of letters (6-11), family size of stems (5-12), suffix letter length (2-5) and frequency of the initial bigram.

Table 3. Descriptive statistics of experiment 2.

	BF	AP	Pseudoword Length	N	Suffix Length	Bigram Freq.
High BF-High AP	135	1572	8.1	.9	3.2	11771
	(103)	(797)	(1)	(1)	(.7)	(14205)
High BF-Low AP	128	215	8.1	.6	3.4	11772
	(89)	(98)	(1)	(1)	(.7)	(9427)
Low BF-High AP	13	1560	8.3	.6	3.3	11403
	(9)	(832)	(1)	(1)	(.6)	(11551)
Low BF-Low AP	13	231	7.7	.4	3.5	10581
	(9)	(94)	(1)	(1)	(.7)	(16131)

Means and standard deviations (in parentheses).

Procedure. The same procedure as in the first experiment was performed.

RESULTS

Response times associated with incorrect responses, response times more than two and a half standard deviations above the mean for the condition and responses faster than 300 milliseconds were not included in the statistical analyses. The elimination of latencies affected 16.1% of the total data set included in the analyses, but no participant or item was specifically removed. The high error rate can be accounted for by two different reasons. First, error rates are computed for pseudowords instead of for words. Error rates for pseudowords tend to be higher than error rates for words. Second, these pseudowords are composed of real stems and derivative suffixes generating an activation consistent with "word status". This kind of pseudowords are more difficult to reject than pseudowords without morphological structure (Caramazza, Laudanna & Romani, 1988).

The results show a non-significant effect for BF ($F1 > 1$ and $F2 > 1$). However, a significant AP effect emerges both in the analysis by participants and in the analysis by items (F1(1,16)= 9.03, MSe=1883.1, p<.05), (F2(1,79)= 8.82, MSe=2083.1, p<.05). Complex pseudowords with productive suffixes were rejected more slowly than complex pseudowords with unproductive affixes (696 vs. 663 ms. respectively; 608 for simple pseudowords). (See table 4). The interaction between the two variables did not reach significance (F1 <1 and F2 <1).

With regards to the analysis of error rates, the results show a lack of significance for the BF effect (F1<1 and F2 <1). However, the results show a significant effect of AP in the analysis by participants (F1(1,16)=7.33, MSe=3.55, p<.05), but it fails to reach significance in the analysis by items (F2(1,79)=1.65, MSe=1.8, p>2). Pseudowords with productive suffixes showed more errors than pseudowords with unproductive suffixes. The interaction between these variables did not reach significance (F1(1,16)=1.03, MSe=3.4, p> .3) (F2<1).

Table 4. Results from experiment 2.

	RT	% ER
High BF-High AP	697	17
	(85)	(3.7)
High BF-Low AP	667	15
	(92)	(4.1)
Low BF-High AP	694	17
	(83)	(4.1)
Low BF- Low AP	659	16
	(102)	(3.2)

RT –averaged response latencies, % ER –averaged error scores. Standard deviation (in parentheses).

Regarding words, the t tests performed by participants and items show no difference between complex and simple stimuli neither on latencies (t(16)= -.7, p<.5); (t(79)=.1, p>.05) nor on error rates (t(16)= -1,2, p<.3).

DISCUSSION

The results of this experiment show a significant AP effect whilst showing a lack of significance for both the BF effect and the interaction between these two variables. These results offer new evidence concerning the role played by derivative suffixes in the visual recognition of complex words in Spanish.

Bearing in mind that the pseudowords were constructed using existing stems, we might suggest that the pseudoword stems had activated their morphological candidates, just as they would have done if they had formed part of real words. In this context, the morphological candidates should be pre-activated when suffix processing takes place. By definition, the suffixes of the presented pseudowords would not be among those activated, since they do not generate valid lexical entries when they become concatenated with the stem. Therefore, the AP effect may be due to the late stage described earlier. Once a stem has been processed, and some derivative suffixes have been preactivated or deactivated, the reader computes the likelihood of such stimulus to determine whether it is a real word or not. This process is even more difficult in cases where the derivative suffix is highly productive. The results suggest that highly productive suffixes lead to high activation, resulting in a tendency for readers to consider its presence as a cue of lexicality. Therefore, although items become activated strongly and easily, the result is inhibition since the readers have to press the pseudoword button instead of the word button. Activation of low productive derivative suffixes is also congruent with "word" status because they are existing suffixes and therefore they contribute to increase latencies on complex pseudowords as compared to simple pseudowords. This time, however, inhibition is less costly –lower activation provides the reader an indication of lexicality lesser than a more productive suffix. Thus, once existing derivative suffixes have provided a cue of lexicality, readers must inhibit the response "word" when it arises. The higher the affix productivity is, the greater the costs of inhibition are. Consistent with these results are the ones by Caramazza, Laudanna and Romani (1988) and Burani and Thornton (2003), who showed that pseudowords containing real morphemes took longer to be rejected than pseudowords that contained no morphemes (see Duñabeitia, Perea and Carreiras, 2008, for similar results in Spanish).

GENERAL DISCUSSION

The results presented in this paper show a relevant role for derivative suffixes in visual lexical recognition of complex words in Spanish. Although the methodology used is similar to that of Burani and Thornton (1997) and Lázaro (2012) (an unmasked lexical decision task), our data are not identical to theirs. Burani and Thornton observed a different effect for derivative suffixes and stems, but, in contrast to our findings, they figured out a significant effect for BF but not for AP. Our results show an AP effect in both experiments; this effect was previously observed by authors such as Bertram et al. (2000a), Ford et al. (2010) and Lázaro (2012), although these authors obtain a significant interaction between BF and AP, an effect that does not reach significance in our experiments. Our data do fully coincide with those of Baayen et al. (2007), which in some ways underline current difficulties in this complex field, where the researcher is faced with data that sometimes produce inconsistencies. The data available support Simona and Crepaldi's (2012) statement that we have strong evidence in favor of the role played by morphological analysis, although it remains to be seen whether we will be able to construct a processing model to the underlying processes and integrate all the evidence.

The results obtained seem of show that the stems are involved in activating candidates; these candidates accelerate recognition. If we assume two fixations for seven- or eight-letter complex words (e.g. Hyönä and Pollatsek, 1998; Baayen et al., 2007) like those in our experiment, then we are confronted with a reading process that does not end with reading the stem, but must continue with the next segment fixated upon. It is in this context that the system awaits processing of the final element –the affix– in order to take a lexical decision. The stem, then, can activate candidates to a greater or lesser extent depending on its family size, but the lexical decision is to be deferred until the derivative suffix is processed, determining the lexicality of the letter-string.

At this point we should distinguish between the variables FS and BF in terms of their impact in our results. In our experiments, the former was controlled while the latter was manipulated. Thus, with the presentation of stems, approximately the same number of candidates was activated in each case; the only variable was the activation of the stem itself (BF effect). In the Burani and Thornton's (1997) paper, the positive correlation between these two variables is made explicit (see also Carlisle & Katz, 2006). These variables account for that frequent stems tend to have larger families than less frequent stems. In their experiment words with high base frequency have more family members than words with low base frequency. In our view, this means that the BF effect might be confounded with the FS effect in their results, even though they have been shown to be independent (Ford et al., 2010). This cannot occur in our study since the variable FS was kept constant throughout the corpus.

The BF effect, then, does not consist of activating a given number of candidates (FS variable), but rather the activation of the stems with which suffixes should later be concatenated. This stem frequency effect seems less powerful than the word frequency effect (Baayen et al., 2007; Ford et al., 2010; Plag & Baayen, 2009) but its significant value cannot be discounted if the design features sufficient strength (Baayen et al., 2007). In our first experiment, the design cannot be considered extraordinarily powerful with 29 participants and 20 items per experimental condition, and hence the BF effect does not reach significance, although signs of significance are present in the analyses by participants of latencies and errors, showing partial evidence for the facilitative effect attributed to stem activation level.

Concerning the AP effect, it seems to have proved significant in several studies, with the exception of that of Burani and Thornton (1987). The lack of significance for the variable FS in their study may have more to do with the stimuli chosen than with the methodology.

One additional important remark to discuss is the way the variables BF and AP have been computed. In the case of AP, we count the number of words sharing a derivative suffix (which is identical to the count of FS for stems), but we count the BF as the frequency of the lemma. Therefore, we are comparing results based on tokens and type counts. This has to do with the general lack of databases and resources in Spanish to better control psycholinguistic variables. It is hard to imagine summing one by one the frequencies of more than 2500 words that contain the derivative suffix –ero. This manipulation has probably been decisive in the results obtained, even more if we consider that, as a consequence, the range and differences between high and low values for AP and BF were very large (1850 vs. 173 vs. 133 vs. 13 respectively, see Table 1). The fact that Burani et al. (1995) demonstrated the expected significant positive correlation between frequency and productivity does not imply that counting of stems and derivative suffixes as tokens or types respectively does not play a relevant role. Given the fact that differences between low and high BF values were much lower than differences between low and high AP, it is understandable that the statistical results for BF were weaker and that very powerful designs have to be performed to obtain significance. We adhere to Lázaro (2012) claiming for new software and tools for Spanish psycholinguistic research. It is clear that broader investigation is needed in the field of morphological processing, both with and without priming and in different languages, as there is currently a clear disparity between findings that confounds the understanding of the processes under examination.

RESUMEN

El papel de la productividad de los sufijos derivativos en el reconocimiento visual de palabras complejas. En este artículo presentamos dos experimentos de decisión léxica que examinan el rol de las variables de frecuencia de base y de la productividad de los sufijos derivativos en el reconocimiento visual de las palabras. En el primer experimento encontramos que las palabras complejas con sufijos derivativos productivos tardan menos tiempo en ser respondidas que aquellas otras con sufijos derivativos improductivos. Se observa también la falta de significación para la frecuencia de base. En el experimento dos se lleva a cabo la misma metodología pero con pseudopalabras, mostrando que cuando éstas están compuestas por sufijos derivativos productivos tardan más tiempo en ser rechazadas que cuando están compuestas por sufijos derivativos improductivos. De nuevo la variable de frecuencia de base no alcanza valor significativo. Estos resultados respaldan la visión de que los sufijos derivativos tienen un rol relevante en el reconocimiento visual de las palabras complejas. De acuerdo a nuestros resultados, los sufijos derivativos crean las condiciones para tomar un candidato como una entrada léxica legal y por lo tanto contribuyen decisivamente a la decisión léxica. Estos resultados se interpretan finalmente a la luz de estudios previos centrados en las mismas variables.

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APPENDIX 1. STIMULI FOR EXPERIMENT 1

Complex Words				Simple Words			
Low BF-High AP	**Low BF-Low AP**	**High BF-High AP**	**High BF-Low AP**	**Simple Words**			
Frutero	Mordisco	Cristalero	Arboleda	Alcázar	Brújula	Dialecto	Heraldo
Pescador	Temible	Ayudante	Extrañeza	Abdomen	Quicio	Dinamita	Higiene
Duradero	Limítrofe	Bañista	Ventanuco	Acacia	Cactus	Diploma	Iguana
Habitable	Laxitud	Jardinero	Palaciego	Alambre	Caimán	Disfraz	Incienso
Codera	Fijeza	Pensador	Pobreza	Albañil	Merluza	Pupitre	Laberinto
Aceitoso	Drogata	Obrador	Veraniego	Alergia	Capricho	Eclipse	Langosta
Mantecoso	Vagancia	Cabezada	Pasaje	Alfalfa	Caspa	Embrión	Lombriz
Ligadura	Plomizo	Papelera	Corredizo	Amazona	Cheque	Epidemia	Júbilo
Tintero	Fianza	Librero	Andanza	Antojo	Caricia	Epíteto	Mandíbula
Puñal	Vigilancia	Cocinero	Peludo	Antorcha	Caucho	Escrúpulo	Náusea
Caldero	Grasiento	Limpiador	Alteza	Anécdota	Escayola	Esgrima	Obeso
Quesero	Montaje	Mentiroso	Perruno	Asterisco	Chato	Esguince	Palenque
Tramposo	Llaneza	Colorista	Pedriza	Avispa	Chorro	Estupor	Pizarra
Inventor	Labranza	Telefonista	Bajeza	Bacteria	Cicatriz	Euforia	Prodigio
Ruinoso	Barcaza	Boquilla	Golpazo	Percance	Cisterna	Fragua	Revólver
Orejera	Morisco	Letrista	Moraleja	Batuta	Coliseo	Fulgor	Tertulia
Montañero	Patinaje	Lechoso	Simpleza	Bigote	Manicomio	Estiércol	Toalla
Armonioso	Picuda	Ojoso	Carnaza	Biopsia	Corbata	Gaviota	Trópico
Cucharada	Pelotazo	Coronilla	Patriota	Acequia	Fósforo	Guadaña	Presagio
Pegajoso	Carruaje	Floral	Olvidadizo	Algarabía	Insomnio	Hamaca	Vampiro

Complex Pseudowords				Simple pseudowords			
Dutarero	Viasura	Redadeza	Terudo	Dudarema	Tersuder	Tiaser	Ojemedaro
Draguera	Rebardición	Calizeta	confinete	Drajesi	Mazetaso	Errebardio	Ifoinenta
Redadío	Fordadero	Viomileza	Linviadiego	Resadol	Tiviad	Foldalea	Liomilisol
Gemedal	Faludoso	Pequebeza	Arpitud	Diresyo	Arituso	Ralluos	Gequebed
Toldal	Cadendador	Tenclanza	Musediego	Todirer	Mutedies	Tadendas	Lenclan
Anibación	Pendator	Contariuco	Camezajo	Anibasina	Tamejer	Lendatose	Bontariose
Arnero	Tiandero	Mifagranza	Amaranza	Alnetose	Mamarítice	Piandeso	Cifagrer
Sotretero	Combufable	Guanpazo	Pandayazo	Soresta	Taldaya	Rombufilo	Ruanpaca
Jadacero	Banferilla	Orpenanza	Monrañaje	Jadasra	Moraños	Tanderil	Serpenan
Esdribura	Mosista	Tedolista	Perodazo	Edricuca	Ceroces	Nosisres	Redolise
Gransada	Frezador	Catalledíza	Guidasiaje	Griser	Juidadi	Crezaded	Calalledí
Llumioso	Jufador	Amilismo	Alnavenaje	Lunios	Rufadeos	Palnavena	Mamilisme
Visidor	Candante	Pardilario	Hojecez	Vitiroris	Lojeces	Acandanse	Opardilari
Aifoso	Parbidista	Accipentajo	Naltilliego	Aidorel	Tatillase	Barbidiso	Cacilen
Vienzoso	Ambucancia	Sondogez	Vencabal	Vinzose	Nencadasa	Lambuance	Rondoge
Lumero	Perzonajal	Tramagadez	Jepateja	Lujeder	Guepatur	Porzonaji	Tramala
Hatrador	Oldemador	Piayista	Pasableja	Hadrapora	Tasablesa	Poldemado	Liayiste
Guetada	Mafetal	Prasdifazo	Cancefeta	Jopilar	Tancefos	Emafetí	Brasdifila
Pabador	Calesdera	Camudez	Espartez	Dafados	Desparter	Edaleded	Tamudosi
Consador	Hosdipalura	Chifriota	Amioleta	Siboner	Elensuar	Itrasmorna	Baidatio

APPENDIX 2. STIMULI FOR EXPERIMENT 2

Complex Pseudowords				**Simple pseudowords**			
Low BF- High AP	**Low BF- Low AP**	**High BF- High AP**	**High BF- Low AP**	**Simple Words**	Teruder	Viaser	Gemeda
Pescadoso	Temereza	Ayudero	Extrañiego	Draguesi	Calizetaso	Rebardio	Confinenta
Flautador	Limitud	Bañadal	Ventanaza	Redadol	Linviad	Fordaleca	Viomilistol
Habitoso	Laxanza	Jardinal	Palazote	Diresda	Arpituso	Falude	Pequebed
Codista	Fijazo	Pensadista	Pobriego	Todiler	Musedies	Cadembas	Tenclan
Aceitista	Drogancia	Obradero	Veranuda	Anibacina	Camejer	Pendatose	Contariose
Mantecal	Vaguizo	Cabecista	Pasancia	Arnerose	Amaretice	Tiandevo	Mifagrer
Ligadista	Plomanza	Pepeloso	Corredeza	Sotreta	Pandaya	Combufilo	Guanpaca
Tintadero	Fiadaje	Librista	Andanaje	Pusdasa	Monraños	Banferile	Orpenana
Puñador	Vigilaje	Cocinador	Peleza	Esdribuca	Perodace	Mosires	Tedolise
Caldable	Grasancia	Limpioso	Altancia	Granser	Guidadi	Frezaded	Catalledíz
Quesura	Montanza	Mentirista	Perriza	Llumios	Jufados	Alnavena	Amilisme
Trampada	Llanazo	Colorero	Pedranza	Visidoris	Hojeces	Candanse	Pardilari
Inventoso	Labradizo	Telefonal	Bajadaje	Cafosel	Matillase	Parbidiso	Accipentaz
Ruinista	Barcuda	Boquista	Golpaje	Vienzos	Vencabasa	Ambucace	Sondoge
Orejista	Mordaje	Letrura	Moralaza	Pemereti	Vepature	Perzonajida	Tramagad
Montañada	Patinanza	Lechura	Simplaje	Hatradoraz	Pasablesa	Trodemane	Piayiste
Armoniero	Picaje	Ojerista	Carnariego	Guetil	Cancefos	Mafetí	Prasdifica
Cucharoso	Pelotanza	Coronero	Patriadizo	Pabados	Esparter	Caled	Camudosi
Pegajante	Carrodaje	Florador	Olvidadota	Siboner	Lensuar	Trasmorna	Baidatio

Complex Words				**Simple Words**			
ampliación	fundador	Apelativo	entonación	Alcázar	Brújula	Dialecto	Heraldo
asociación	guerrero	Apretón	escasez	Abdomen	Quicio	Dinamita	Higiene
capacidad	habilidad	Arenal	escuadrón	Abismo	Cactus	Diploma	Agencia
editorial	mecanismo	armadura	firmeza	Alambre	Caimán	Disfraz	Incienso
festival	nobleza	aspereza	fragancia	Albañil	Merluza	Fiebre	Laberinto
identidad	organismo	añadidura	gratitud	Alcalde	Basílica	Eclipse	Bahía
jugador	prosperidad	cigarrillo	honradez	Alfalfa	Capucha	Embrión	Lombriz
resistencia	reinado	clientela	indicador	Amazona	Péndulo	Epidemia	Lámpara
afirmación	riqueza	colaborador	legalidad	Antojo	Caricia	Epíteto	Mandíbula
asesinato	separación	colocación	llanura	Antorcha	Recinto	Escrúpulo	Náusea
ciudadano	señorita	comerciante	maquinaria	Anécdota	Escayola	Legión	Horror
combinación	utilidad	complicidad	matanza	Asamblea	Chacal	Esguince	Palenque
corredor	vivienda	conducción	narrador	Avispa	Chorro	Estupor	Pizarra
creador	absolución	creyente	nitidez	Laguna	Cicatriz	Hembra	Prodigio
defensor	acelerador	crudeza	pasajero	Percance	Cisterna	Fragua	Revólver
deportivo	aclaración	curvatura	pesimismo	Batuta	Coliseo	Fulgor	Tertulia
dictadura	aficionado	decorado	poniente	Bigote	Manicomio	Mariposa	Toalla
embajador	agilidad	delicadeza	prisionero	Biopsia	Corbata	Gaviota	Trópico
fabricación	alumbrado	dentadura	pureza	Acequia	Marqués	Guadaña	Presagio
fortaleza	amplitud	desnudez	registrador	Avestruz	Insomnio	Hamaca	Huracán

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