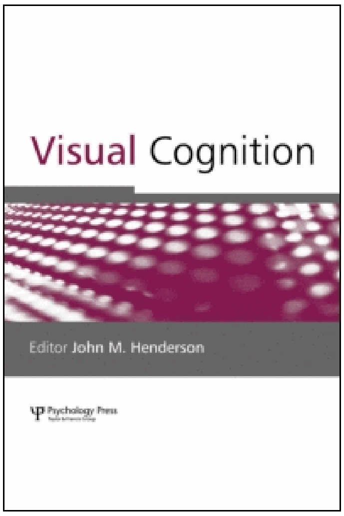

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Eye movements when reading words with $YMOL$ and NUM83R5: There is a cost

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Eye movements when reading words with $YMβOL$ and NUM83R5: There is a cost

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Recent evidence from masked priming experiments has revealed that readers regularize letter-like symbols and letter-like numbers into their corresponding base letters with minimal processing cost. However, one open question is whether the same pattern occurs when these items are presented during normal silent reading. In the present study, we respond to this question in an eye-movement experiment that included sentences with words that had symbols and numbers as letters, as in "YESTERDAY I SAW THE SECRE74RY WORKING VERY HARD". Results revealed that there is a greater reading cost associated with letter-by-number replacements than with letter-by-symbol replacements, especially when the replaced letters occur at the beginning of the word. We examine the implications of these findings for models of visual word recognition and reading.

Keywords: Visual word recognition; Number processing; Letter processing; Letter-like characters

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To recognize a printed word, readers have to process correctly the identity and position of its letters in order to distinguish between perceptually similar words (e.g., *casual* and *causal*; see Grainger, 2008; Rayner, White, Johnson, & Liversedge, 2006). Although recently proposed input coding schemes successfully capture the empirical evidence of letter position encoding (Gomez, Ratcliff, & Perea, 2008; Grainger, Granier, Farioli, van Assche, & van Heuven, 2006), how letter identity assignment is achieved is still a matter of debate.

Readers effectively extract the meaning of a word regardless of features such as case, size, or font (see McCandliss, Cohen, & Dehaene, 2003; Rayner & Pollatsek, 1989). Here we focus on whether letter-like characters can activate the appropriate letter representations during online sentence reading. A recent study by Perea, Duñabeitia, and Carreiras (2008; see also Carreiras, Duñabeitia, & Perea, 2007) examined whether briefly presented words spelled with letter-like symbols or numbers could effectively activate a target word. Participants in this study had to decide if a given target word was a real word or not (lexical decision task). Target words were briefly preceded by a 50 ms prime that included letter-like numbers and symbols. Primes, which were strings containing at least 50% of letter-like numbers or symbols (e.g., M4T3R14L and MΔT€R!ΔL), facilitated the recognition of the target words (e.g., MATERIAL) nearly as much as an identity priming condition (i.e., MATERIAL), and produced response times substantially faster than the control conditions (e.g., MOTURUOL, M6T2R76L, MΔT€R!ΔL). These results were interpreted in terms of symbol-to-letter and number-to-letter regularization processes (i.e., 4, 3, and 1 in M4T3R14L were processed as A, E, and I) which occur with masked, briefly presented stimuli. As stated by Carreiras et al. (2007), these results pose some problems for a domain-specificity view of cortical detectors (Dehaene, Cohen, Sigman, & Vinckier, 2005; Reinke, Fernandes, Schwindt, O'Craven, & Grady, 2008), since Perea et al. (2008) showed that number and symbol identities activated to a large degree letter identity representations. Nonetheless, it could be argued that the specific information of digits and symbols embedded in briefly presented, masked stimuli was not accessed in the first place. The question under scrutiny in the present study is whether, under conscious processing, the reading of letter-like characters will be equally effortless. In other words, this study is aimed at exploring whether NUM83R5 and $YMβ0L$ can be used as letters in a sentence, and if the resulting sentence can be perfectly understood. To that end, we conducted an online reading experiment that explored whether there is a reading cost associated with replacing letters with symbols or numbers that have form resemblance. In addition, we also examined whether initial letters have a special status in visual word recognition, by including letter-like character manipulations at the beginning of a critical word (e.g., $€NTENCE, 53NTENCE) or in internal positions (e.g., SEN†€NCE, SEN73NCE).

In a recent eye-movement study in normal silent reading, Rayner et al. (2006; see also White, Johnson, Liversedge, & Rayner, 2008) explored the presence of nonwords created by letter transpositions (e.g., *jugde*; see Perea & Lupker, 2003). Even though readers can easily read sentences in which there are transposed-letter nonwords, Rayner et al. highlighted a reading cost associated with words with transposed letters inserted in sentences, relative to correctly spelled words. This cost was particularly large when letters were transposed at the beginning of a word, consistent with evidence of a privileged role of the initial letter position (see Whitney, 2001, among others). Participants made more and longer fixations and regressions on "The boy oculd not oslve the rpoblem so he saked for help" than in the correctly written version of the same sentence "The boy could not solve the problem so he asked for help".

The present experiment follows a similar reasoning to the Rayner et al. (2006) study, except that we examined how letter identity (instead of letter position) is attained. We presented participants with sentences in which the letters of a target word were replaced by letters or by symbols, in initial or middle positions, while maintaining the rest of the sentence correctly written (e.g., YESTERDAY I SAW THE SECRE†ΔRY WORKING VERY HARD). In light of recent evidence regarding letter, number and symbol processing, several predictions could be made. First, recent neuroimaging studies suggest that letters, symbols, and, in particular, numbers seem to invoke different cortical areas (Polk et al., 2002; Reinke, Fernandes, Schwindt, O'Craven, & Grady, 2008). For instance, Reinke et al. (2008; see also Baker et al., 2007) found that the left fusiform gyrus is more responsive to words and letter strings than numbers. If this is the case, a gradation in the reading cost associated with letter-like characters should emerge, where digits elicit greater disruption than symbols and correct letters. Second, behavioural evidence from different paradigms shows that the encoding of numbers and symbols differs in a substantial way, thus suggesting that the overlapping receptive fields for number and symbol detectors are different in terms of size and shape (see Tydgat & Grainger, 2009, for a review). If this is the case, the firing of number and symbol detectors—in particular under conscious perception—may lead to different processing costs associated to letter-like symbols and digits. Furthermore, in light of recent evidence regarding the importance of the external characters of a string, some other predictions could also be made. Rayner et al. (2006; see also White et al., 2008) explored letter transpositions in a paradigm parallel to the one in this study, and included position manipulations. In line with previous evidence (e.g., Rayner & Kaiser, 1975), Rayner and colleagues showed that external beginning transpositions (e.g., *rpoblem*, instead of *problem*) led to considerable disruption—as shown by the reading cost associated with this condition. Accordingly, we expected to find a greater reading cost associated with letter-like character replacements at word-beginning locations than at internal positions.

METHOD

Participants

Twenty undergraduate students from the Universidad de La Laguna took part in this experiment. They received €5 for their collaboration.

Materials

A set of 75 sentences was created. The letters of a single target word were replaced by letter-like numbers or by letter-like symbols, in initial or middle positions (see Appendix). Hence, the critical word in each sentence started either with two letter-like symbols (beginning symbols, BS) or two numbers (beginning numbers, BN), or alternatively contained two letter-like symbols or numbers in internal positions (internal symbols and internal numbers, IS and IN). A baseline condition was also included, in which the critical word in each sentence was correctly written (normally written, N). The sentences were presented in Spanish; the English examples 1a–1e (see Table 1) reflect the different manipulations.[1] The 75 critical words had a mean frequency of 28.94 (range: 0.71–743.93), a mean length of 7.4 letters (range: 6–9), and a mean of 0.85 orthographic neighbours (range: 0–6) in the Spanish database (Davis & Perea, 2005). The 75 sentences were all eight words long, and the target word was always the fifth one. All the sentences fitted in a single screen line.

Apparatus

Eye movements were recorded with an EyeLink II eyetracker manufactured by SR Research Ltd. (Canada). The sampling rate for the pupil size and location was 500 Hz. Registration was binocular, although only data from the right eye were analysed. The position of the participant with respect to the screen was controlled by a head-tracking camera that served to compensate possible head motion.

[1] All the sentences were presented in uppercase, because letter-like symbols and numbers are more physically similar to the corresponding base uppercase letters (M4T3R14L-MΔT€R!ΔL-MATERIAL vs. m4t3r14l-mΔt€r!Δl-material; see Perea et al., 2008).

TABLE 1
Eye movement measures for sentences in the five conditions and English examples of the materials

	Condition				
	Normal sentence	*BS (beginning symbol)*	*IS (internal symbol)*	*BN (beginning number)*	*IN (internal number)*
First fixation duration	249 (33)	258 (24)	261 (36)	295 (42)	273 (45)
Gaze duration	369 (134)	506 (146)	470 (104)	680 (230)	635 (197)
Total time	448 (161)	613 (218)	600 (151)	902 (313)	810 (295)
Mean number of fixations	2.0 (0.7)	2.5 (0.7)	2.5 (0.5)	3.4 (1.0)	3.1 (1.0)

Examples of sentences:
1a (N) YESTERDAY I SAW THE SECRETARY WORKING VERY HARD.
1b (BS) YESTERDAY I SAW THE $€CRETARY WORKING VERY HARD.
1c (IS) YESTERDAY I SAW THE SECRE†ΔRY WORKING VERY HARD.
1d (BN) YESTERDAY I SAW THE 53CRETARY WORKING VERY HARD.
1e (IN) YESTERDAY I SAW THE SECRE74RY WORKING VERY HARD.

Procedure

Participants completed this experiment in a well-lit soundproofed room. The experimenter controlled the eyetracker from outside. Participants were seated in a fixed chair that ensured a distance of 75 cm from the centre of the screen. After the calibration and validation process, participants read four practice sentences for comprehension. Each trial started with the presentation of a fixation point that was aligned to the left (coinciding with the location of the first letter of each sentence). Participants had to gaze at that point, and the system automatically corrected calibration drifts. When the fixation point disappeared, the target sentence was displayed. Participants were instructed to read for comprehension and to press one button on a gamepad as soon as they finished reading the sentence. After 25% of the sentences, comprehension questions were displayed, and participants had to press one of two buttons on the gamepad to respond. The next trial started with the presentation of the fixation point. The whole session lasted about 20 min.

RESULTS

Participants responded correctly to 94% of the comprehension questions, revealing that they understood the meaning of the sentences despite the manipulations on a critical word. Fixations shorter than 80 ms or longer than 800 ms were not included. We examined the following measures: First fixation duration (the mean duration in milliseconds of the first fixations on the critical word), gaze duration (the sum of the durations of the fixations made on the target word before the eyes left that word), total time (the sum of the durations of all the fixations on the target word, including fixations from regressions), and number of fixations (the total number of fixations on the target word). ANOVAs were conducted based on a 2 (letter-like character: Symbol, number) $\times$ 2 (position of the insertion: Beginning, internal) $\times$ 5 (list: 1, 2, 3, 4, 5) design. In addition, we conducted *t*-tests for all the conditions relative to the baseline (see Table 2).

First fixation duration

First fixation durations on words including letter-like numbers were longer than those on words with letter-like symbols, $F1(1, 15) = 17.72$, $MSE = 687$, $p < .01$; $F2(1, 70) = 17.34$, $MSE = 2684$, $p < .001$. The main effect of position was not significant (all $ps > .14$). The interaction between the two factors approached significance in the analysis by participants and was significant in the analysis by items, $F1(1, 15) = 3.16$, $MSE = 1057$, $p = .10$; $F2(1, 74) = 3.91$, $MSE = 3066$, $p = .05$: This interaction reflected that letter-by-number replacements in word-initial positions produced longer fixations than letter-by-number replacements in internal positions, $F1(1, 15) = 5.19$, $MSE = 954$, $p < .05$; $F2(1, 70) = 4.81$, $MSE = 3790$, $p < .05$, whereas the parallel difference did not occur for letter-by-symbol replacements (all $ps > .66$). Finally, *t*-tests showed that normally written sentences involved shorter first fixation durations on the target words than sentences that involved letter-by-number replacements, whereas first fixation durations on the critical words did not differ between the normally written sentences and the sentences with letter-by-symbol replacements.

Gaze duration

Gaze durations were longer for words containing numbers than for words containing symbols, $F1(1, 15) = 47.71$, $MSE = 11994$, $p < .001$; $F2(1, 70) = 30.78$, $MSE = 70019$, $p < .001$. Furthermore, words with manipulations in initial positions produced longer gaze durations than words with manipulations in internal locations, $F(1, 15) = 4.66$, $MSE = 7016$, $p < .05$; $F2(1, 70) = 3.47$, $MSE = 34708$, $p = .07$. The interaction between these two factors did not approach significance (all $ps > .70$). Results of *t*-test comparisons of the normally written condition with all the other conditions showed that sentences that were written normally involved shorter gaze durations than sentences in the other conditions.

TABLE 2
Statistical comparisons between each manipulation condition and the baseline condition (normally written, N)

	Condition			
	BS (beginning symbol)	*IS (internal symbol)*	*BN (beginning number)*	*IN (internal number)*
First fixation duration	$t1(19) = 1.02$, $p > .31$	$t1(19) = 1.62$, $p > .12$	$t1(19) = 4.70$, $p < .001$	$t1(19) = 3.03$, $p < .01$
	$t2(74) = 1.40$, $p > .17$	$t2(74) = 1.62$, $p > .11$	$t2(74) = 6.51$, $p < .001$	$t2(74) = 2.74$, $p < .01$
Gaze duration	$t1(19) = 8.11$, $p < .001$	$t1(19) = 4.82$, $p < .001$	$t1(19) = 6.53$, $p < .001$	$t1(19) = 8.52$, $p < .001$
	$t2(74) = 5.60$, $p < .001$	$t2(74) = 5.30$, $p < .001$	$t2(74) = 5.60$, $p < .001$	$t2(74) = 8.19$, $p < .001$
Total time	$t1(19) = 5.47$, $p < .001$	$t1(19) = 6.24$, $p < .001$	$t1(19) = 7.72$, $p < .001$	$t1(19) = 8.66$, $p < .001$
	$t2(74) = 5.30$, $p < .001$	$t2(74) = 5.06$, $p < .001$	$t2(74) = 9.72$, $p < .001$	$t2(74) = 9.40$, $p < .001$
Mean number of fixations	$t1(19) = 5.04$, $p < .001$	$t1(19) = 5.03$, $p < .001$	$t1(19) = 7.85$, $p < .001$	$t1(19) = 8.67$, $p < .001$
	$t2(74) = 4.83$, $p < .001$	$t2(74) = 4.10$, $p < .001$	$t2(74) = 9.26$, $p < .001$	$t2(74) = 8.19$, $p < .001$

Total time

Words with numbers embedded took longer to read than words with symbols embedded, $F1(1, 15) = 75.35$, $MSE = 16566$, $p < .001$; $F2(1, 70) = 45.87$, $MSE = 102039$, $p < .001$. In addition, the manipulation at the beginning of words produced longer reading times than the manipulation in internal positions, even though the effect was not significant in the item analysis, $F1(1, 15) = 10.53$, $MSE = 5119$, $p < .01$; $F2(1, 70) = 2.49$, $MSE = 77911$, $p = .11$. The interaction between the two factors was not significant ($p > .11$). All the experimental conditions revealed significant differences with respect to the control condition (normally written condition).

Number of fixations

Participants made more fixations on words containing numbers than on words containing symbols, $F1(1, 15) = 51.82$, $MSE = 0.21$, $p < .001$; $F2(1, 70) = 39.61$, $MSE = 1.04$, $p < .001$. Words with initial manipulations produced more fixations than words with internal manipulations, $F1(1, 15) = 8.17$, $MSE = 0.09$, $p < .02$; $F2(1, 70) = 3.23$, $MSE = 0.82$, $p = .08$. The interaction was not significant (both $ps > .14$). Finally, normally written sentences received fewer fixations than sentences in the other conditions.

DISCUSSION

The present experiment examined how letter identity is attained in normal silent reading. Specifically, we explored whether there is a reading cost associated with the replacement of letters with symbols or numbers which have form resemblance, and whether this cost varies when these replacements occur at the beginning versus in the middle of a word. The results were clearcut: (1) When reading for comprehension, words with embedded letter-like symbols and digits yielded a reading cost; (2) letter-by-number replacements were consistently more disruptive than letter-by-symbol substitutions; (3) manipulations of the initial letter of a word produced a greater reading cost than manipulations of internal letters; and (4) word-initial letter-by-number replacements produced a greater reading cost than word-internal replacements (as shown by the first fixation durations).

As we indicated in the Introduction, Perea et al. (2008; see also Carreiras et al., 2007) suggested that letter detectors can be activated by letter-like numbers and symbols, despite the fact that these units have their own abstract meaning. That is, when the task does not involve conscious processing, and when attention is not directed to detecting each individual letter, numbers and symbols that resemble letters are processed as the correct alphabetic characters. The present experiment extends and limits the scope of these masked priming experiments. Readers can successfully perceive letter-like words (SECRE†ΔRY/SECRE74RY) in a sentence—as deduced from the comprehension data. However, this process involves a reading cost.[2] This divergence between masked versus visible presentation of an item is consistent with prior evidence showing that masked associative priming effects occur even when the masked prime is not a word (e.g., *julge* facilitates the processing *COURT*, via *judge*), whereas when the prime is visible (e.g., at a 250 ms SOA), only the appropriate base word produces an associative priming effect (Bourassa & Besner, 1998; Duñabeitia, Carreiras, & Perea, 2008).

What do these results tell us about letter detectors? Carreiras et al. (2007) interpreted the results of Perea et al. (2008) as evidence of a top-down regularization mechanism in letter identity assignment (i.e., at the earliest stages of letter/word encoding, the activation of M4T3R14L, MΔT€R!ΔL, and MATERIAL would be, to some degree, similar). Carreiras et al. indicated that these results posed some problems for the Local Combination Detectors (LCD) model (Dehaene et al., 2005), since this model assumes the existence of specific letter detectors. Dehaene and Cohen (2007) responded to this argument indicating that the LCD model includes letter detector neurons that "rest on a robust pyramid of lower-level feature detectors with increasingly larger receptive fields and with a considerable redundancy" (p. 456). They argued that a letter like A receives converging input from horizontal and diagonal bars, with some degree of tolerance in placement and orientation. Thus, the letter A can be activated at the early stages of word processing with the presentation of A, and 4, and Δ. Although this explanation may account for the results reported by Perea et al., the present reading experiment has shown that letter-like symbols and numbers disrupt the process of normal reading—with the later being more disruptive than the former. According to Dehaene and Cohen's model, however, the two conditions (symbols and numbers) should produce a similar reading cost.

[2] It should be mentioned that we conducted a parallel study in which participants were presented with sentences that were constructed with at least 50% of the words (see Rayner et al., 2006), which had embedded either words with two letter-like symbols or words with letter-like numbers in beginning or internal letter positions, as in the sentences THE †!NIEST $€CRETARY WAS $€NSIBLE AND Δ†TENTIVE and THE TINI35T SECRE74RY WAS SENS18LE AND ATTEN71VE. Results were parallel to those obtained in the present experiment, showing a greater reading cost associated with sentences with letters substituted by numbers as compared to symbols. There was also a greater reading cost when the letter substitutions were at the beginning of words relative to the letter substitutions in internal positions. However, due to the characteristics of the materials, only global measures (e.g., mean fixation duration, total sentence reading time, mean number of fixations) could be analysed—thereby, we believe that the present study represents a stronger and more powerful test.

Nonetheless, in terms of the Dehaene and Cohen (2007) proposal, it might be argued that the observed differences across symbols and digits could have been due to visual similarity (i.e., the featural overlap between characters) rather than condition type (symbols vs. numbers). To explore the potential impact of visual similarity in the present experiment, an additional sample of 28 participants completed a questionnaire in which they rated the visual similarity between each of the critical symbols/digits and their corresponding letters.[3] The similarity values for each item in each experimental condition with respect to the base word are presented in the Appendix. Post hoc correlation analyses were conducted on an item-by-item basis between: (1) The difference for each of the three reading duration measures (first fixation, gaze duration, and total time) between the symbol-by-letter string and the number-by-letter string in initial and internal positions, and (2) the difference in rated visual similarity between the symbol-by-letter string and the number-by-letter string. Results showed that visual similarity played a role in the difference between number-to-letter and symbol-to-letter regularization processes in *internal* positions in total time (and, to some extent, in gaze duration), thus providing some support for Dehaene and Cohen's proposal in late stages of word processing, but not in the case of *initial* letters (see Table 3). This finding is consistent with the view that beginning letters are critical for word recognition, whereas the processing of internal letters may be more shallow and influenced by regularization (e.g., see Jordan, Thomas, & Scott-Brown, 1999, for an illusory letter phenomenon with "missing" internal letters; see also Rayner et al., 2006).

One alternative explanation for the gradation of the reading cost is that the receptive fields for numbers and symbols are different in terms of shape and size (Tydgat & Grainger, 2009). Specifically, Tydgat and Grainger proposed that because of the constant exposure of a reader to numeric and alphabetic strings—and to optimize identification of alphanumeric stimuli—the receptive fields of letter and number detectors are highly similar. Considering that a reader seldom encounters symbol strings, the receptive fields of symbol detectors would be different. When reading letter-like numbers and symbols, the corresponding number detectors are fired faster than the symbol detectors—on the basis of differences in the receptive fields for both types of characters. That is, when A is substituted by 4 in a

[3] This questionnaire included the critical letters and their associated letter-like symbols (e.g., S-$) or digits (e.g., S-5), together with a set of filler letters, numbers, and symbols. Participants rated the visual similarity between the two characters of each pair on a 1–7 Likert scale. What should be noted here is that an estimated visual similarity rating task may overplay the similarity-driven processes that take place during silent reading when the same characters are presented in a word context.

TABLE 3
Results of the correlation analysis between the difference in visual similarity scores for symbols and digits and the difference in first fixation duration, gaze duration, and total reading time for the word-beginning and word-internal manipulations for letter-like symbols and digits

	Conditions	
	Word-beginning manipulations	*Word-internal manipulations*
First fixation duration	$r = -.01$	$r = -.06$
	$p > .92$	$p > .60$
Gaze duration	$r = .13$	$r = .20$
	$p > .25$	$p = .08$
Total time	$r = .15$	$r = .30$
	$p > .18$	$p < .01$

consciously perceived letter string (e.g., as in M4T3R14L), the numerical value of 4 might be activated, and the cognitive system then has to suppress that information since it mismatches the global input (a letter string, not a number string). In the case of symbols, the properties of Δ might not be activated as fast, and the information suppression would occur to a lesser degree.

To summarize, readers can successfully perceive letter-like words (SECRE†ΔRY or SECRE74RY) in a sentence, but this normalization process involves some cost, as revealed by the eye-movement data during reading. This cost is particularly important when the nonletter occurs at the beginning of the word—consistent with a special role of initial letter position in visual-word recognition. Furthermore, the reading cost is greater when the nonletter is a number than when it is a symbol, which is consistent with the idea of different cortical mechanisms involved in each process and with the idea of different receptive fields of number and symbol detectors.

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APPENDIX

Visual similarity values for each item with respect to the base word

Base word	*Beginning symbol*	*Internal symbol*	*Beginning number*	*Internal number*
ESENCIA	€$ENCIA (5.615)	E$€NCIA (5.615)	35ENCIA (5.04)	E53NCIA (5.04)
SALITRE	$ΔLITRE (5.75)	SAL!†RE (5.635)	54LITRE (5.115)	SAL17RE (4.865)
TENISTA	†€NISTA (5.575)	TEN!$TA (5.675)	73NISTA (4.08)	TEN15TA (5.825)
TARJETA	†ΔRJETA (5.71)	TARJ€†A (5.575)	74RJETA (4.155)	TARJ37A (4.08)
ESPOSAS	€$POSAS (5.615)	ESPO$ΔS (5.75)	35POSAS (5.04)	ESPO54S (5.115)
TATUAJES	†ΔTUAJES (5.71)	TΔ†UAJES (5.71)	74TUAJES (4.155)	T47UAJES (4.155)
SECRETOS	$€CRETOS (5.615)	SECR€†OS (5.575)	53CRETOS (5.04)	SECR37OS (4.08)
SILBATO	$!LBATO (5.675)	SILβΔTO (5.73)	51LBATO (5.825)	SIL84TO (5.135)
BATALLAS	βΔTALLAS (5.73)	BA†ΔLLAS (5.69)	84TALLAS (5.135)	BA74LLAS (4.46)
TABERNA	†ΔBERNA (5.71)	TAβ€RNA (5.595)	74BERNA (4.155)	TA83RNA (5.06)
TABLERO	†ΔBLERO (5.71)	TΔβLERO (5.73)	74BLERO (4.155)	T48LERO (5.135)
ESTROFA	€$TROFA (5.615)	E$†ROFA (5.77)	35TROFA (5.04)	E57ROFA (4.81)
TIROTEO	†!ROTEO (5.635)	TIRO†€O (5.575)	71ROTEO (4.865)	TIRO73O (4.08)
TESTIGO	†€STIGO (5.575)	TES†!GO (5.635)	73STIGO (4.08)	TES71GO (4.865)
TINTERO	†!NTERO (5.635)	TIN†€RO (5.575)	71NTERO (4.865)	TIN73RO (4.08)
AEROBIC	Δ€ROBIC (5.555)	AEROβ!C (5.655)	43ROBIC (4.385)	AERO81C (5.845)
ASTILLA	Δ$TILLA (5.75)	AS†!LLA (5.635)	45TILLA (5.115)	AS71LLA (4.865)
ESTUCHE	€$TUCHE (5.615)	E$†UCHE (5.77)	35TUCHE (5.04)	E57UCHE (4.81)
SISTEMA	$!STEMA (5.675)	SI$†EMA (5.77)	51STEMA (5.825)	SI57EMA (4.81)
ESCRITO	€$CRITO (5.615)	ESCR!†O (5.635)	35CRITO (5.04)	ESCR17O (4.865)
BILLETE	β!LLETE (5.655)	BILL€†E (5.575)	81LLETE (5.845)	BILL37E (4.08)
ESTABLO	€$TABLO (5.615)	ES†ΔBLO (5.71)	35TABLO (5.04)	ES74BLO (4.155)
ESTATUA	€$TATUA (5.615)	ESTΔ†UA (5.71)	35TATUA (5.04)	EST47UA (4.155)
TITANIO	†!TANIO (5.635)	TI†ΔNIO (5.71)	71TANIO (4.865)	TI74NIO (4.155)
BIBERÓN	β!BERÓN (5.655)	BIβ€RÓN (5.595)	81BERÓN (5.845)	BI83RÓN (5.06)
ASIENTO	Δ$IENTO (5.75)	AS!€NTO (5.48)	45IENTO (5.115)	AS13NTO (5.095)
TABIQUE	†ΔBIQUE (5.71)	TAβ!QUE (5.655)	74BIQUE (4.155)	TA81QUE (5.845)

APPENDIX (*Continued*)

Base word	*Beginning symbol*	*Internal symbol*	*Beginning number*	*Internal number*
BAUTIZO	βΔUTIZO (5.73)	BAU†!ZO (5.635)	84UTIZO (5.135)	BAU71ZO (4.865)
SILUETA	$!LUETA (5.675)	SILU€†A (5.575)	51LUETA (5.825)	SILU37A (4.08)
ESTANCO	€$TANCO (5.615)	ES†ΔNCO (5.71)	35TANCO (5.04)	ES74NCO (4.155)
TIBURÓN	†!BURÓN (5.635)	T!βURÓN (5.655)	71BURÓN (4.865)	T18URÓN (5.845)
ASESORA	Δ$ESORA (5.75)	AS€$ORA (5.615)	45ESORA (5.115)	AS35ORA (5.04)
BISONTE	β!SONTE (5.655)	B!$ONTE (5.675)	81SONTE (5.845)	B15ONTE (5.825)
ABANICO	ΔβANICO (5.73)	AβΔNICO (5.73)	48ANICO (5.135)	A84NICO (5.135)
ESTUDIO	€$TUDIO (5.615)	E$†UDIO (5.77)	35TUDIO (5.04)	E57UDIO (4.81)
BARBERO	βΔRBERO (5.73)	BARβ€RO (5.595)	84RBERO (5.135)	BAR83RO (5.06)
BISTURÍ	β!STURÍ (5.655)	BI$†URÍ (5.77)	81STURÍ (5.845)	BI57URÍ (4.81)
ESPASMO	€$PASMO (5.615)	ESPΔ$MO (5.75)	35PASMO (5.04)	ESP45MO (5.115)
BISAGRA	β!SAGRA (5.655)	BI$ΔGRA (5.75)	81SAGRA (5.845)	BI54GRA (5.115)
ABADESA	ΔβADESA (5.73)	ABAD€$A (5.615)	48ADESA (5.135)	ABAD35A (5.04)
ASTUCIA	Δ$TUCIA (5.75)	A$†UCIA (5.77)	45TUCIA (5.115)	A57UCIA (4.81)
ESTANQUE	€$TANQUE (5.615)	ES†ANQUE (5.77)	35TANQUE (5.04)	ES7ANQUE (4.81)
ESTACIÓN	€$TACIÓN (5.615)	ES†ΔCIÓN (5.71)	35TACIÓN (5.04)	ES74CIÓN (4.155)
BALDOSAS	βΔLDOSAS (5.73)	BALDO$ΔS (5.75)	84LDOSAS (5.135)	BALDO54S (5.115)
ESTANCIA	€$TANCIA (5.615)	ES†ΔNCIA (5.71)	35TANCIA (5.04)	ES74NCIA (4.155)
ABANDONO	ΔβANDONO (5.73)	AβΔNDONO (5.73)	48ANDONO (5.135)	A84NDONO (5.135)
BANQUETE	βΔNQUETE (5.73)	BANQU€†E (5.575)	84NQUETE (5.135)	BANQU37E (4.08)
ABERTURA	ΔβERTURA (5.73)	Aβ€RTURA (5.595)	48ERTURA (5.135)	A83RTURA (5.06)
BARROTES	βΔRROTES (5.73)	BARRO†€S (5.575)	84RROTES (5.135)	BARRO73S (4.08)
SINTAXIS	$!NTAXIS (5.675)	SIN†ΔXIS (5.71)	51NTAXIS (5.825)	SIN74XIS (4.155)
ESTRELLA	€$TRELLA (5.615)	E$†RELLA (5.77)	35TRELLA (5.04)	E57RELLA (4.81)
AISLANTE	Δ!SLANTE (5.615)	A!$LANTE (5.675)	41SLANTE (5.17)	A15LANTE (5.825)
BANQUETA	βΔNQUETA (5.73)	BANQU€†A (5.575)	84NQUETA (5.135)	BANQU37A (4.08)
ABUELITA	ΔβUELITA (5.73)	ABUEL!†A (5.635)	48UELITA (5.135)	ABUEL17A (4.865)
ATENCIÓN	Δ†ENCIÓN (5.71)	A†€NCIÓN (5.575)	47ENCIÓN (4.155)	A73NCIÓN (4.08)
ESCRITOR	€$CRITOR (5.615)	ESCR!†OR (5.635)	35CRITOR (5.04)	ESCR17OR (4.865)

APPENDIX (*Continued*)

Base word	*Beginning symbol*	*Internal symbol*	*Beginning number*	*Internal number*
SIMPATÍA	$!MPATÍA (5.675)	SIMPΔ†ÍA (5.71)	51MPATÍA (5.825)	SIMP47ÍA (4.155)
BARRIADA	βΔRRIADA (5.73)	BARR!ΔDA (5.615)	84RRIADA (5.135)	BARR14DA (5.17)
BASUREROS	βΔSUREROS (5.73)	BΔ$UREROS (5.75)	84SUREROS (5.135)	B45UREROS (5.115)
SEÑORITA	$€ÑORITA (5.615)	SEÑOR!†A (5.635)	53ÑORITA (5.04)	SEÑOR17A (4.865)
TIRANTES	†!RANTES (5.635)	TIRAN†€S (5.575)	71RANTES (4.865)	TIRAN73S (4.08)
ASAMBLEA	Δ$AMBLEA (5.75)	A$ΔMBLEA (5.75)	45AMBLEA (5.115)	A54MBLEA (5.115)
SERIEDAD	$€RIEDAD (5.615)	SER!€DAD (5.48)	53RIEDAD (5.04)	SER13DAD (5.095)
SALTADOR	$ΔLTADOR (5.75)	SAL†ΔDOR (5.71)	54LTADOR (5.115)	SAL74DOR (4.155)
TABURETES	†ΔBURETES (5.71)	TABUR€†ES (5.575)	74BURETES (4.155)	TABUR37ES (4.08)
BAILARÍN	βΔILARÍN (5.73)	BΔ!LARÍN (5.615)	84ILARÍN (5.135)	B41LARÍN (5.17)
ESPÍRITU	€$PÍRITU (5.615)	ESPÍR!†U (5.635)	35PÍRITU (5.04)	ESPÍR17U (4.865)
BARONESA	βΔRONESA (5.73)	BARON€$A (5.615)	84RONESA (5.135)	BARON35A (5.04)
TESORERO	†€SORERO (5.575)	T€$ORERO (5.615)	73SORERO (4.08)	T35ORERO (5.04)
BARBACOA	βΔRBACOA (5.73)	BARβΔCOA (5.73)	84RBACOA (5.135)	BAR84COA (5.135)
BISTEC	β!STEC (5.655)	BIS†€C (5.575)	81STEC (5.845)	BIS73C (4.08)
TIEMPO	†!EMPO (5.635)	T!€MPO (5.48)	71EMPO (4.865)	T13MPO (5.095)
ESTRÉS	€$TRÉS (5.615)	E$†RÉS (5.77)	35TRÉS (5.04)	E57RÉS (4.81)
TEATRO	†€ATRO (5.575)	TEΔ†RO (5.71)	73ATRO (4.08)	TE47RO (4.155)
BASTÓN	βΔSTÓN (5.73)	BA$†ÓN (5.77)	84STÓN (5.135)	BA57ÓN (4.81)