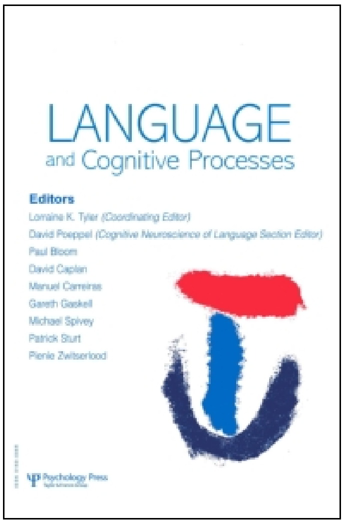


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# On the role of consonants and vowels in visual-word processing: Evidence with a letter search paradigm

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# On the role of consonants and vowels in visual-word processing: Evidence with a letter search paradigm

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Prior research has shown that the search function in the visual letter search task may reflect the regularities of the orthographic structure of a given script. In the present experiment, we examined whether the search function of letter detection was sensitive to consonant-vowel status of a pre-cued letter. Participants had to detect the presence/absence of a previously cued letter target (either vowel or consonant) at the initial, central or final position in a five-letter Spanish word or pseudoword. Results showed a significant effect of consonant-vowel status on letter search function which paralleled the orthographic constraints of Spanish. When searching for a consonant, participants showed faster identification of the initial position compared to the central and last positions. The opposite pattern was found for vowels. This result suggests a differential contribution of consonants and vowels to the identification of the orthographic structure of words, in terms of their relative position in Spanish words.

***Keywords:*** Letter position/identity; Visual-word recognition; Vowels/consonants.

A wealth of research in alphabetic languages across different paradigms has revealed that the identification of a printed word is mediated by the consonant-vowel status of its component letters (see Berent & Perfetti,

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1995; Caramazza & Miceli, 1990; Carreiras, Duñabeitia, & Molinaro, 2009; Carreiras & Price, 2008; Lee, Rayner, & Pollatsek, 2002; New, Araújo, & Nazzi, 2008; Perea & Lupker, 2004, for evidence across a wide range of tasks and procedures). Furthermore, a word's orthographic structure seems to play a role in visual-word recognition. For instance, Berent, Bouissa, and Tuller (2001) found that a word's phonological assembly was facilitated when prime and target shared the same CV orthographic structure, compared with a condition in which they did not share it. This finding suggests that the visual word recognition system is sensitive to the skeletal CV structure of words (see Berent & Marom, 2005, for further evidence). If this is so, the processing of consonants and vowels may be mediated by the structure of orthographic representations. At present, however, most computational models of visual-word recognition – for the sake of parsimony – do not assume any processing differences between consonants and vowels (e.g., multiple read-out model, Grainger & Jacobs, 1996; dual-route cascaded model, Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001; SERIOL model, Whitney, 2001; overlap model, Gómez, Ratcliff, & Perea, 2008; SOLAR model, Davis, 1999; open-bigram model, Grainger & van Heuven, 2003; but see Plaut, McClelland, Seidenberg, & Patterson, 1996).



To obtain further converging evidence of the role of consonants and vowels in letter/word identification, we examined the time needed to recognize consonants and vowels in different letter locations of words/pseudowords using a visual letter search paradigm in a transparent orthography (Spanish). In a visual letter search task (see Green, Hammond, & Supramamian, 1983; Green, Liow, Tng, & Zielinski, 1996; Green & Meara, 1987; Ktori & Pitchford, 2008; Pitchford, Ledgeway, & Masterson, 2008, 2009; Ziegler & Jacobs, 1995), participants have to identify whether or not a previously cued letter is embedded within a random letter string (e.g., 'does the letter 'A' appear in the sequence RBFAD?'). This task allows the position in which the target appears in the test string to be manipulated. The response time to detect a target stimulus appearing in each of the positions of the test string can be determined, and the observed search function is thought to reflect the processes used by participants when carrying out the task. In the present experiments, participants had to detect the presence/absence of a previously cued letter target at the initial, central, or final position in a five-letter Spanish word or pseudoword. (Because of the restrictions when creating the word stimuli, we manipulated three letter positions rather than the five letter positions.) Two sets of items were created to this purpose. In one set, items had a CVCVC structure (e.g., the word JOVEN or the pseudoword TAPEL), and in the other one items had a VCVCV structure (e.g., the word ERIZO or the pseudoword ALIDE).

It is important to note that previous findings with the letter search task are consistent with the results obtained using other laboratory word recognition tasks. For example, in a letter search task, Hammond and

Green (1982) observed that external letters where processed faster than internal letters (see Forster, 1976; Humphreys, Evett, & Quinlan, 1990; Peressotti & Grainger, 1995, for evidence with other paradigms). More important, the letter search task provides key information about low-level processes that underpin the recognition of a certain orthographic structure. For instance, the search function obtained with the letter search task seems to reflect the directional scanning process required for reading: Prior evidence suggests that there is a relation between the search function and the orthographic properties of a given language. For example, using the letter search task with random letter strings, Green et al. (1983) found that the letter search function obtained in alphabetic orthographies was M shaped, whereas the one obtained for logographic strings was U shaped. They concluded that the search function reflects procedures adapted to the demands of the orthographic script (see Green & Meara, 1987; Ktori & Pitchford, 2008; Ziegler & Jacobs, 1995). More recently, Pitchford et al. (2008) observed that the visual word recognition system was sensitive to statistical learning; more specifically, the search function in English was – to some extent – dependent on letter frequency. One caveat of previous letter-search studies though, is that they used unpronounceable random strings of letters. Thus, one might argue that the underlying processes in those circumstances may not reflect the early processes during normal reading. For that reason, we believe that it is necessary to examine whether the search function varies with pronounceable orthographic structures – with word and pseudoword stimuli. Therefore, we examined not only whether the consonant-vowel status of letters plays a role in detecting a specific letter, but also whether the letter search function is mediated by lexical status.

Given that the letter search task appears to be sensitive to orthographic regularities in a given language, it is critical to consider the way in which consonant-vowel orthographic structures are formed (i.e., how frequent consonants and vowels are in each letter position). We computed the percentage of cases in which consonants and vowels appear in each letter position from a total of 7,639 non-inflected nouns, adjectives, and infinitive verbs of five letters in the Spanish database (Davis & Perea, 2005). As can be seen in Figure 1, consonants are particularly frequent in the initial position – CV is the most frequent (initial) syllable in Spanish (Harris, 1991), whereas the proportion of vowels (relative to consonants) is higher than that of consonants at the end of the word – note that the final vowel in Spanish provides gender information. If participants are sensitive to the regularities of the consonant-vowel proportions in Spanish, detection times for consonants should show a positive slope (i.e., faster response times for the more frequent, initial letter than for the less frequent, final letter), whereas detection times for vowels should show a negative slope (faster response times for the more frequent, final letter than for the less frequent, initial letter).

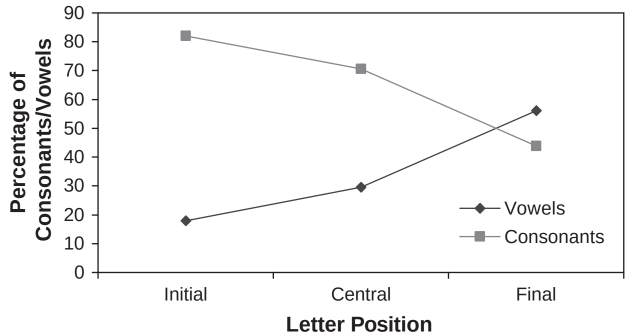


**Figure 1.** Percentage of cases in which consonants and vowels appear in each position in five-letter Spanish words.



In sum, the main goal of the present experiment is to examine whether the letter detection time depends mostly on consonant-vowel regularities (i.e., if the pattern of letter detection times mimics the regularities of the Spanish orthography). This finding would suggest that orthographic constraints – in particular, in terms of an abstract CV structure – influence lexical access. Furthermore, we examined whether the letter search pattern is modulated by the lexical status of the target stimulus – bear in mind that prior research focused on random letter strings.

# METHOD

## Participants

Twenty-two students from the Universitat de València ($M = 19$ years, $SD = 0.8$) received course credit for participating in the experiment. All of them either had normal or corrected-to-normal vision and were native speakers of Spanish. Their level of English was intermediate. None of the participants reported any reading/speech problems.

## Materials

For the word trials, we selected 360 three-syllable Spanish words of five letters from the Spanish database (Davis & Perea, 2005). In all cases the letter strings were composed of five nonrepeated letters.[1] The trials were divided

[1] In the cases in which there was no word with the required word and syllable frequency that had either a vowel or a consonant in the needed position, we selected a word with another structure – this occurred in less than 2% of the stimuli. The same criterion was applied when there was a repeated letter across the word, as in the word *lobos* (this occurred in less than 1% of the stimuli).

into two sets. The first set consisted of 180 words with a VCVCV structure for the vowel search task. Ninety of these words comprised a previously cued vowel (A, E, I, O, or U). The relative frequency of these letters of the target word at either the initial, central, or final position is .122, .103, .086, .093, and .042 respectively, in the Spanish database (Davis & Perea, 2005). In the remaining 90 words the previously cued vowel was absent – the frequency with which each vowel appeared as a cue was equated across the experimental trials in which the target was either present – across positions – or absent. The second set consisted of 180 words with a CVCVC structure for the consonant search task. Ninety of these words comprised a previously cued consonant (D, R, L, N, or S). The relative frequency of these letters of the target word at either the initial, central, or final position is .057, .061, .083, 094, and .085, respectively, in the Spanish database (Davis & Perea, 2005). (The selection of these five consonants was constrained by the fact that they can appear in *all* the manipulated positions forming Spanish words.) In the remaining 90 words, the cued consonant was absent – again, the frequency with which each consonant appeared as a cue was equated across the experimental trials in which the target was either present – at each position – or absent. All the vowel and consonant targets appeared an equal number of times at the initial, central, and final positions (6 words $\times$ 3 positions = 30 times per position). The trials were randomised for presentation, in order to avoid any potential strategy effects derived from blocking sets. Written word frequency was controlled (mean word frequency: 1.1 per million for the vowel set and 1.8 for the consonant set, $t(179) = 1.6$, $p > .09$) in all positions of the two groups. All the stimuli selected for the experiment – and their corresponding word-frequency index per million words – are included in the Appendix. For the purposes of testing lexical effects, two sets of 180 pseudoword targets of five letters were created – these sets were paired in all factors and conditions with the target words. We created 180 VCVCV pseudowords (i.e., the 'A' initial positive detection word <u>ALIÑO</u>, was paired with an 'A' initial positive detection pseudoword <u>ATONE</u>; whereas the 'A' negative detection word <u>OPUSE</u>, was paired with an 'A' negative detection pseudoword <u>IGENO</u>) and 180 CVCVC pseudowords (i.e., the 'D' initial positive detection word <u>DOLER</u>, was paired with a 'D' initial positive detection pseudoword <u>DETIN</u>; whereas the 'D' negative detection word <u>FAJOS</u>, was paired with a 'D' negative detection pseudoword <u>TEPIN</u>).

## Procedure

Participants were tested individually in a quiet room. The experiment was run using DMDX (Forster & Forster, 2003). The stimuli were presented in Courier New 12 pt. Reaction times were measured from target onset until the participant's response. The procedure essentially mimicked that in the letter search experiment of Ktori and Pitchford (2008): On each trial, a fixation cross (+) was presented in the centre of the screen for a duration of 2000 ms, followed by a lowercase letter cue which was also presented in the centre of the screen, for a duration of 750 ms. Next, a forward mask consisting of a row of hash marks (######) matched in length with the target, was presented for 500 ms in the centre of the screen. The mask was immediately replaced by an uppercase target item, which remained on the screen until the response. Participants were instructed to press one of two buttons on the keyboard to indicate whether the letter cue was present or absent in the target or not ('m' for yes and 'z' for no). Participants were instructed to make this decision as quickly and as accurately as possible. Each participant received a different order of trials. Each participant received a total of 22 practice trials prior to the experimental trials.



## RESULTS

Incorrect responses and reaction times less than 250 ms or greater than 1500 ms (less than 1%) were excluded from the latency analysis. The mean latencies for correct responses and error rates are presented in Table 1. Participant and item ANOVAs for the 'yes' response latencies and percentages of error on positive trials were conducted based on a 2 (Lexicality: word, pseudoword) $\times$ 2 (Type of letter: vowel, consonant) $\times$ 3 (Position: initial, central, final).[2] All significant effects had $p$ values less than the .05 level.

Neither lexicality nor the interactions between Lexicality with the other factors were significant in the latency data (all $F$s $< 1$). Reaction times for letter identification in words were only 5 ms shorter than reaction times for letter identification in pseudowords (662 vs. 667 ms, respectively). In addition, there were no signs of a main effect of Type of letter: reaction times of vowels and consonants were remarkably similar (626 vs. 617 ms, respectively). More important, there was a significant interaction between Type of letter and Letter position, $F_1(2, 40) = 6.75$; $F_2(2, 336) = 6.98$. This interaction reflected a different pattern of Letter position for consonants and for vowels (i.e., there was a descendent slope for vowel identification and an ascendant slope for consonant identification across position; see Figures 1 and 2). For consonants, there was a significant effect of Position, $F_1(2, 40) = 4.43$, $F_2(2, 162) = 4.17$ –which reflected a *positive* linear trend for

[2] Sixteen items were excluded from the analysis due to a coding mistake in the program script. One of these belonged to the word negative vowel detection group, another one belonged to the nonword negative vowel detection group, twelve belonged to the nonword positive consonant detection group, and the remaining two belonged to the nonword negative consonant detection group. These items have been highlighted in bold in the Appendix.

TABLE 1
Reaction times and percentage errors for positive detections of consonants and vowels across positions

| | *Words* | | *Nonwords* | |
|---|---|---|---|---|
| | *Vowels* | *Consonants* | *Vowels* | *Consonants* |
| Position | | | | |
| Initial | 626 (7.3) | 606 (6.3) | 645 (6.8) | 608 (7.1) |
| Central | 617 (4.4) | 608 (4.4) | 634 (4.6) | 621 (5.4) |
| Final | 614 (2.4) | 636 (6.0) | 619 (2.5) | 624 (7.0) |

the initial, middle, and final letters, 607, 615, and 630 ms, respectively, $F_1(1, 20) = 6.54$. For vowels, the effect of Position approached significance in the analysis by items, $F_1(2, 40) = 2.19$, $p = .13$; $F_2(1, 162) = 2.87$, $p = .06$ – this reflected a *negative* linear trend for the initial, middle, and final letters, 635, 626, and 616 ms, respectively, $F_1(1, 20) = 2.97$, $p < .10$.[3]

The ANOVA on the error data showed a main effect of position, $F_1(2, 40) = 7.44$; $F_2(2, 336) = 12.17$: there was a greater error rate for initial than for final positions (6.8 vs. 4.2%, respectively). More important, there was a significant interaction between Type of letter and Letter position, $F_1(2, 40) = 4.66$; $F_2(2, 336) = 6.22$. Again, this interaction reflected a different error pattern of Letter position for consonants and for vowels: there was a descendent slope for vowel identification and an ascendant slope

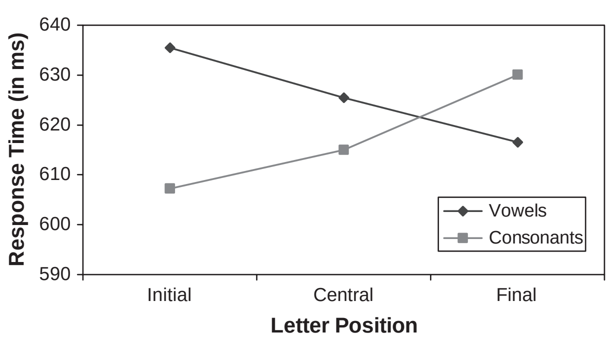


**Figure 2.** Visual search functions for vowel and consonant letter detection reaction times across positions (ms).

[3] At the level of individual letters, we found a descendent slope for vowel identification for four out of the five vowels (A, E, I, U; the letter O failed to show an effect), while we found an ascendant slope for consonant identification for four out of the five consonants (L, N, R, S; the letter D failed to show an effect).

for consonant identification across position. The effect of Position was significant for vowels, $F_1(2, 40) = 12.40$; $F_2(2, 162) = 16.6$, which reflected a *negative* linear trend for the initial, middle and final letters, 7.3, 4.4, and 2.4%, respectively, $F_1(1, 20) = 18.43$, but it was not significant for consonants.

Thus, the interaction between Type of letter and position shows that the identification of vowels and consonants was modulated by their position within the string. It may be interesting to note here that Pitchford et al. (2008) found a marginal effect of letter frequency ($p < .10$, two-tailed) in a letter search task. However, the absence of a main vowel/consonant effect suggests that letter frequency did not play a strong role in the present data: vowels are more frequent than consonants. What we should also note here is that within the vowel group, the response time of highest frequency vowel (*a*) (684 ms) when collapsed across positions did not differ significantly from the response time for the lowest frequency vowel (*u*) (665 ms); $t_1(17) = 1.70$, $p = .10$. Similarly, the response time for the highest frequency consonant (*s*) (643 ms), did not differ significantly from the response time for the lower frequency consonant (*d*) (647 ms), $t_1(17) < 1$. Additional post hoc analyses (using regression coefficients) on the relationship between the reaction times and absolute letter frequency (or relative letter frequency per position) also failed to reveal a significant influence of letter frequency on response times – note however that the present experiment was not specifically designed to test this hypothesis. Thus, the present findings seem to be due to a more abstract CV orthographic skeleton, as proposed by Berent and Marom (2005); Marom & Berent, 2009), rather than by absolute/relative letter frequency.[4]



## DISCUSSION

The main findings from the present experiment can be summarised as follows: (i) the consonant search pattern showed an ascendant slope, whereas the vowel search pattern showed a descendent slope, (ii) the search pattern with vowels and consonants *mimics* the CV orthographic regularities of Spanish, and (iii) the same pattern holds for word and for pseudoword stimuli (i.e., there was no lexicality effect). Thus, the present findings support

[4] In a recent study, Pitchford et al. (2009) reported a post hoc analysis in which skilled readers – but not dyslexics – were 19 ms faster at detecting vowels than consonants collapsed across positions in a letter search task. Additional cross-linguistic research is necessary to examine the apparent discrepancies between consonant/vowel processing in English and Spanish (see Colombo, Zorzi, Cubelli, & Brivio, 2003, for a cross-linguistic comparison between English and Italian – a Romance language).

the relevant role of consonant/vowel status in a task which requires abstract letter information, but not lexical access.

The present data are consistent with prior research using the visual letter search task which examined how the search function varied across different scripts (English vs. Greek; see Ktori & Pitchford, 2008). Here we adopted a different strategy: we employed a single language (Spanish) and were interested in finding out whether the search pattern obtained for consonants and vowels reflected the structural regularities (in terms of CV structure) of the Spanish language. Indeed, the letter search function paralleled the function corresponding to the proportion of consonants/vowels in a given position in the Spanish database (e.g., compare Figures 1 and 2): the search pattern showed faster vowel detection times at the final position (i.e., a grammatically important position for vowels) than at the initial position (i.e., a less important position for a vowel). Likewise, the time needed to detect a consonant at the initial/central position was faster than the time needed to detect it in the final letter position – due to a lower probability to find a consonant than a vowel at this position. That is, letter encoding processes appear to be mediated by the orthographic structure of words in a given language. Note that this consonant/vowel dissociation is consistent with the experiments reported by Berent et al. (2001) on early phonological representations and skeleton structure (consonant/vowel) in the lexicon.

The present findings are also consistent with recent studies that have shown that the visual search task may reflect visual sensitivity to informative contextual information and to statistical regularities of stimuli (see Chun, 2000, for review). According to this view, the visual search pattern may reflect the sensitiveness of the visual word recognition system to the orthographic structures of a certain language, rather than merely a serial or parallel processing. Furthermore, cross-linguistic studies have provided evidence that the variation in the orthographic structure of languages may significantly affect the development of written word recognition skills and reading skills in general (Frith, Wimmer, & Landerln, 1998; Goswami & Ziegler, 2006). Finally, post hoc analyses on the present data failed to obtain any clear signs of an effect of letter frequency on letter search times (cf., Pitchford et al., 2008). (In fairness to Pitchford and colleagues, we should indicate that they used all English letters in their experiment, and thus the range of 'letter frequency' was wider than in the present experiment.) This suggests that letter identification at a low-level processing may be based not only on statistical constraints as a result of orthographic learning but also on a more abstract vowel-consonant categorisation – via a CV skeleton.

One remarkable finding is the absence of a main effect or interaction for word/pseudoword stimuli – note that prior studies used consonant letter strings. Response patterns were similar for word and pseudoword stimuli, presumably because this task, as also occurs with the same/different task (see

Perea & Acha, 2009), taps low-level processes involved in the early stages of word processing. In this case, the presence of an effect of CV orthographic structure suggests that the effect of linguistic knowledge on reading for skilled readers is automatic (see Marom & Berent, 2009, for a recent review). This explains why we found similar effects for words and pseudowords. As Marom and Berent (2009) indicated, 'readers compute the skeleton using a productive process that assembles skeletal frames from print'.

What are the implications of the present findings for the models of visual word recognition? As indicated in the Introduction, the contribution of consonant-vowel information seems to differ in the process of lexical access (see Carreiras, Gillon-Dowens, Vergara, & Perea, 2009, for ERP evidence). Furthermore, consonants are statistically more informative than vowels (e.g., Keidel, Kluender, Jenison, & Seidenberg, 2007). Most current models of visual-word recognition do not account for the consonant-vowel dissociation, and as such they run into difficulties trying to accommodate a number of findings in the literature on word recognition – including the present data. Furthermore, most of these accounts are static and they do not provide a feedforward mechanism that could reproduce top-down processes as a result of learning by experience, unlike connectionist models (see Plaut et al., 1996, for a model using letter position coding based on articulation components: onset, vowel, and coda). At some processing level, all these models need to be modified to account for the consonant-vowel differences. To date, the use of explicit coding for consonants and vowels has been considered in the models of Berent and Perfetti (1995) and Caramazza and Miceli (1990); however, these (verbal) models have not been implemented yet.

In sum, the present experiment provides empirical evidence for a distinction between consonants and vowels in terms of orthographic regularities in a given language. This pattern is consistent with the view that consonants and vowels are distinct constituents of orthographic structures in a language, and the visual recognition system is sensitive to this distinctiveness. This result is in line with the assumption that readers automatically represent the skeletal CV structure of the visually presented words and pseudowords (Berent & Marom, 2005).

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# APPENDIX

Stimuli in the experiment. The written frequency per million words (B-Pal; Davis & Perea, 2005) is presented in parentheses.

## Words selected for positive detection of vowels

ALIÑO (0.18), ANULÓ (1.25), AYUDO (1.43), ALIJO (1.61), APEGO (3.57), APURO (5.18), ÓPALO (0.18), IZADO (1.07), UFANO (1.43), ÉBANO (1.61), ENANO (4.64), USADO (8.04), OJERA (0.18), OBESA (1.07), ELIJA (1.61), ÉPICA (4.11), OVEJA (6.61), OPERA (8.57), ELUDO (0.18), ERIZO (0.71), ELIJO (1.43), EVOCO (1.43), EVITA (7.86), EDIPO (9.46), IBERO (0.18), OMEGA (0.36), ABETO (1.25), AMENO (1.79), TIESO (5.89), ÓPERA (11.07), OPINE (0.18), ANOTE (0.71), APOYE (1.61), ADUCE (1.79), ÁPICE (5.36), ASUME (9.82), ILOTA (0.18), IGLÚS (0.36), ILUSA (0.71), ILUSO (0.89), IMPAR (1.79), ILESO (1.96), EDITO (0.18), ANIDE (0.18), OXIDA (0.54), ÁRIDO (1.61), ÁTICO (1.79), EXIJA (1.96), YANKI (0.18), BAMBI (0.36), PUNKI (0.89), DERBI (1.43), CAPRI (1.79), ZOMBI (3.39), OKUPA (0.18), OJIVA (0.71), ORUGA (1.61), ORUJO (1.79), OYERA (3.75), OLIVA (4.82), ÉPOCA (106.96), APOYÉ (0.71), ASOMÉ (1.07), AZOTE (2.86), ADOBE (3.75), ACOGE (5.18), APELO (0.18), ACUSO (0.71), AVINO (1.07), ÁRIDO (1.61), ÉTICO (10.18), ACERO (5.54), UBICÓ (0.18), UNIRÁ (0.54), UBICA (1.07), URANO (1.43), URDÍA (0.89), UNIÓN (29.46), ACUNO (0.18), EDUCO (0.18), ABUSÓ (0.54), ANULE (1.07), ASUMO (1.43), VIUDO (5), SENSU (0.36), MAHOU (0.36), SALOU (0.36), STATU (0.36), PALAU (1.07), TRIBU (12.68)

## Words selected for negative detection of vowels

OPUSE (0.18), ORINÉ (0.36), EVITO (0.71), OCUPE (3.93), UNIDO (21.96), EXIGE (33.21), OSITO (0.54), EJIDO (0.54), OMITE (0.89), ÓBICE (1.25), ERIGE (1.25), EVITÓ (2.32), ELUDÍ (0.18), OXIDE (0.18), EXIJO (0.71), OMISO (1.96), **OSADO** (3.21), ÉXITO (103.04), UBICÓ (0.18), ACUSO (0.71), ACUDO (1.43), ANIMO (3.57), ASILO (9.11), ABUSO (12.32), OVULA (0.18), ASIDO (0.89), OÍDAS (1.07), AGITÓ (4.29), AYUDÓ (11.25), AVISO (18.57), AÑICO (0.18), AÑITO (0.54), AGITO (0.89), AYUNO (2.32), ODIAR (4.64), AGUDO (12.14), ADORE (0.18), APOYÉ (0.71), PEAJE (1.07), ALEGÓ (1.43), OCASO (5.18), OREJA (21.96), ALOJE (0.18), ASEOS (0.36), EDUCA (0.54), AÑEJO (0.89), BEATO (1.07), AYUDE (6.96), ACUÑO (0.1), OJEAN (0.36), ENOJA

(0.54), CUAJO (0.54), ANEXO (0.89), EVOCA (4.11), EMULA (0.18), ILUSA (0.71), ARIES (0.89), EDITA (1.79), ABEJA (3.57), UNIDA (12.14), APILÉ (0.18), EMITA (0.36), AYUDÉ (0.71), URGÍA (1.07), ABUSA (1.79), ACUDÍ (2.14), ANUDE (0.18), RUECA (0.54), ETNIA (0.89), ACUSE (1.61), ALUDE (4.11), IGUAL (104.46), ATIZO (0.1), AFILÓ (0.36), OJIVA (0.71), ATAÑE (4.29), OASIS (6.61), OPINA (12.68), AGITÉ (0.36), ALISO (0.36), FIADO (0.54), ESTÍO (1.07), ALERO (4.82), ORINA (10.18), EMITO (0.18), AHÍTO (0.36), ATINO (0.36), ILEAL (0.36), EDITÓ (1.07), ORGÍA (6.61)

## Words selected for positive detection of consonants

DÁTIL (0.18), DOLER (1.07), DECÍS (1.25), DONAR (1.79), DEBUT (2.86), DIVÁN (6.96), SEDAL (0.36), PEDOS (0.89), RUDOS (1.96), MUDAR (2.14), HEDOR (4.82), RODAR (7.32), VELAD (0.18), TALUD (0.89), VENID (1.07), MIRAD (1.96), TIRAD (0.1), PARED (66.61), LOBAS (0.18), LEÑOS (0.71), LEGOS (1.07), LODOS (1.61), LUCIR (5.54), LOBOS (8.57), BULAS (0.36), MOLER (0.71), RELAX (1.25), POLAR (1.96), BOLAS (5.54), GALÁN (7.86), PERAL (0.18), ZAGAL (0.89), PAÑAL (1.07), SENIL (1.96), NAVAL (4.46), HÁBIL (8.75), NÓBEL (0.18), NEVAR (0.89), NULOS (1.25), NOGAL (1.61), NIDOS (4.82), NUDOS (5.54), MINAR (0.36), RENAL (0.89), MONAS (1.25), PANEL (1.96), PANES (2.86), TENOR (5.36), JOVEN (0.18), BIDÓN (0.89), BESAN (1.25), VISÓN (1.96), COJÍN (3.04), VAGÓN (5.36), REZAD (0.18), RULOS (0.89), REMOS (1.79), ROSAL (2.32), RETOS (3.57), ROTAS (5.89), PURÉS (0.18), HURÓN (0.71), CURAN (1.25), PARÓN (2.32), VERAZ (3.39), TÓRAX (5.89), MUTAR (0.18), FÉMUR (0.89), COLAR (1.25), POSAR (2.32), SECAR (3.21), BESAR (6.07), SÍLEX (2.14), SOBAR (0.71), SIFÓN (1.43), SENIL (1.96), SECAR (3.21), SUMAR (6.43), BISEL (0.36), MISAL (0.89), POSAN (1.43), FÓSIL (1.96), TESÓN (3.39), COSER (5.71), BICIS (0.18), RULOS (0.89), RIMAS (1.25), FETOS (1.96), LUJOS (3.39), MULAS (5.89)

## Words selected for negative detection of consonants

FAXES (0.18), FAJOS (0.71), CAREY (1.25), COMAS (2.14), BECAS (3.04), FAROL (5.18), JETAS (0.18), BATEN (0.71), ZARES (0.71), CAPOS (2.5), BUZÓN (3.39), PACES (1.25), BEMOL (0.18), BÓXER (0.1), ZUMOS (0.89), CIMAS (2.86), TALÓN (3.75), BATIR (6.43), TUFOS (0.36), FUMAS (0.71), BÚHOS (1.61), FOCAS (2.14), CAÑAS (3.21), VINOS (7.68), FADOS (0.36), BOTAR (0.71), GEMAS (1.43),

FOGÓN (2.14), CABOS (4.29), FINOS (9.29), RABOS (0.36), CIÑEN (0.71), MOTÍN (1.43), VIÑAS (2.32), TEJAS (3.57), FIJAR (12.68), PIVAS (0.18), FORAL (1.07), CAÑOS (1.79), FETAL (2.5), CEPAS (3.04), FUSIL (5.18), JUGAD (0.18), CEPOS (0.89), GOCES (1.61), HITOS (2.68), CUBOS (4.11), FUGAZ (11.25), DOPAR (0.18), MUDEZ (0.71), TAJOS (1.43), JUGOS (2.14), TACOS (4.64), MORAS (6.43), CANES (0.18), BATÍN (0.89), BAJÓN (1.79), FILÓN (2.68), TAXIS (4.64), VALEN (9.29), LACÓN (0.18), CUPOS (0.89), COLES (1.61), GOMAS (2.86), VANOS (3.57), TELÓN (7.5), ZOCOS (0.18), GALÉS (0.71), TIFUS (1.43), MENÚS (2.14), VIGAS (4.29), GOZAN (4.64), GALÓN (0.18), GOCEN (0.1), FÚTIL (1.43), CITAN (2.32), CORAL (3.21), VELOZ (6.96), ROJEZ (0.18), TOPAR (0.89), GEMIR (1.43), MOTEL (2.14), TACÓN (4.64), VIGOR (7.86), FAGOT (0.18), HACED (0.89), TONEL (1.43), CÁLIZ (2.86), HARÉN (3.57), TIRÓN (7.68)



## Nonwords selected for positive detection of vowels

ATONE, ADUFO, AJETI, AFOPE, AGUPO, AJONE, ÉJATE, USAFE, ELAMI, ÍTARE, UCASI, ERAFO, UPINA, ITOMA, IFUPA, ÍJUCA, UMIGA, EJOMA, ETILA, ENOMA, ETIPA, ECUNA, ENALI, ETOGA, ALENI, UREPO, IFELA, UNECA, FAECA, UJECO, UGARE, IRALE, UGOPE, OFINE, IPONE, URIME, IFOLE, IPRÉN, IFANO, ILEVA, IRGES, IFONE, ALIDE, EVIMA, URIFO, ÉMIBA, ÓDIRE, ONIPA, PENFI, LERTI, JOSDI, DONTI, MUGLI, CARFI, OTIJE, OPUME, OCAPI, OSIPA, OJEMA, OTUCA, ÁJOME, IGOPÚ, UROVA, EMOFA, ELOTA, INOPU, EGAFO, INERO, USIMO, ÉMAFO, ÉLANO, ISURO, UTINÉ, USEMÓ, UTARE, UNIVA, USLÍO, UCEOS, OSUMA, ATUVI, ILUMÉ, OSUTA, ECURA, MEUFO, MARMU, SITAU, ROLAU, STIBU, JETEU, BLOTU

## Nonwords selected for negative detection of vowels

IGENO, UMICÓ, OCULE, EMIGO, ISOTE, OCIPU, UCEFO, EPOLU, ISEFO, ÓTISU, EVIPO, OFILÉ, UBOTÉ, IUO, IMOPU, OSINU, ONUFI, ÚCILO, AFICÓ, OMAVI, USIBA, ICOSU, OMIFU, ADOVI, ACUFO, OMUTA, AÍLUS, OPILÚ, IJATU, ICOMU, OSIVU, AMIDU, OPAFI, UJOSA, OTAIS, OPITU, ETONA, AJOPÉ, GOEYA, ETAJÓ, URAVE, UNOGA, EFUPO, ORUEN, ULANO, OSUGA, LEUFO, UGOLE, ENUSO, UPAOS, ESAPO, NOUGA, UCONA, ENOSU, AÑETI, EFICA, INEAR, ABIFE, ITEGA, EMAFI, EGUTÁ, UCALE, IPELÚ, USPEI, ITENA, URATÍ, AMIFU, NIASU, ULSIA, ESIRA,

UBILA, UPAIT, OLARE, ATEFÓ, EPOMA, IDOSA, EORIN, OGEMA, EYOLÁ, OTISE, DEILO, **ANFÚE**, ITAMO, OSICA, ERILA, ODÍFE, ADIMO, EBOAT, ALIFÉ, AMPÍE

## Nonwords selected for positive detection of consonants

DÍFAT, DETIN, DIVAR, DACOS, DOFIL, DUCÍS, CODET, **JALOR, NALIR, CUTIR,** TODIN, **NITUR**, COTED, FOTID, **SONEL**, LIMOD, VAROD, **JOMIL**, LITEN, LOMAN, LUPIS, LIBEN, LONES, LAFEN, TILEN, RALUS, NOLIR, GALUS, TILON, JOLÉS, YOMEL, **NEJUT**, JEVOL, ROMAL, VUREL, TEDOL, NÁTID, NIVUS, NETIR, NEJUT, NOLER, NOBAR, CUNIS, MONIT, SINER, JONAT, GUNOR, LANIS, GICON, **TELÍS**, TANUR, RUCÁN, ZIPÚN, COPÉN, RUMAT, RETON, RUCIN, RIVAD, ROFAS, RUFEN, JONER, BIRÉS, **MUSIN**, GORÍS, NARES, LÚRIN, **NOBES**, LÍNER, VITER, GENIR, RUVER, TAMIR, SÓTEN, SELIR, SADÚR, SACOT, SORIN, SIVUN, **TERIL**, **RONOT**, GUSER, DÓSET, FASÚR, MISON, TENOS, COTIS, NACOS, LITES, FOPAS, MIDOS

## Nonwords selected for negative detection of consonants

TONIR, TEPIN, NOSUP, NIVER, LOSUR, BUNIT, GILON, TEFUS, MIVOR, SIJON, FEMOS, GANUR, FASIT, LOMIN, VANER, SURON, FITOS, TAFUN, FIDEN, TINER, DEBIN, BUMAN, SORAN, COVIS, TUFER, DOFES, PERAN, TIJOS, VUFAN, TAREN, SIFUR, VUNOS, ROFES, CUMEN, FOPEN, TUGOS, JOMER, LASIT, MUSER, DOBAF, RIGOS, DMT, GOPAL, VUJAR, PISUR, DOFAR, SATOR, LOYAS, FOJIS, CILOS, FOPIR, POYER, LUMAR, CAVOR, SOMEN, TEFOM, DUGOS, FODIS, LUCON, CETOS, DOMUS, VICEN, CATON, **PUREN**, SOMIN, BEDIS, MIXON, PETOZ, LUDAN, VOCEZ, MIJON, **PERUZ**, PETIR, JOMIN, DABOT, MUDER, VOMET, METON, VACUR, FIJOZ, PERIN, CUDEL, LAMIR, CEPUN, TAPEL, BEMIL, FIROT, MOFER, BUCAZ, LUVER