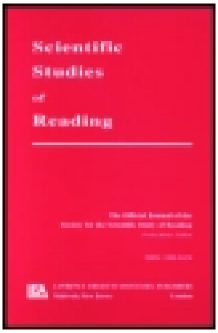

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Individual Differences in Categorical Perception Are Related to Sublexical/Phonological Processing in Reading

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This article examines the relationship between individual differences in speech perception and sublexical/phonological processing in reading. We used an auditory phoneme identification task in which a /ba/-/pa/ syllable continuum measured sensitivity to classify participants into three performance groups: poor, medium, and good categorizers. A lexical decision task manipulated syllable and word frequency. We found that the two tasks were associated. Poor categorizers did not present the typical syllable frequency effect; however, the other groups were sensitive to phonological information to differing degrees and showed the inhibitory syllable frequency effect only for low-frequency words. These results suggest that auditory phoneme identification efficiency may be related to the sublexical processes involved in reading words.

Studies conducted with Spanish, German, and French speakers reveal that phonologically defined syllables affect word recognition during reading. The main piece

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of evidence supporting this claim comes from data that show that words composed of frequent syllables are recognized slower and with more errors than words with less frequent syllables. The number of lexical candidates activated by the first syllable is one explanation of this syllabic frequency effect (SFE): If the syllable is a high-frequency one, then more words should compete for recognition, thereby interfering with the retrieval of the target word, compared to a low-frequency syllable. If, as stated by some authors, the SFE is based on the phonological representations that result from the grapheme–phoneme conversion process, we can infer that such an effect might depend on how well the phonological space is partitioned. A phonemic representational space with clear boundaries between phoneme representations entails a higher degree of specificity in phoneme representations compared to one with ill-defined boundaries. Thus, phoneme representations with a low degree of specificity may obscure the SFE. This claim assumes that such representations are less efficient at activating the syllables thought to mediate the SFE compared to phoneme representations with a high degree of specificity. As a consequence, syllabic frequency manipulation might affect people with clear-cut phonemic representational spaces more than people with ill-defined boundaries between phoneme representations. In the present study, we provide evidence supporting this prediction. Specifically, we assessed whether individual differences in phonemic representational space partitioning modulate the SFE. Observing a modulatory effect would provide converging evidence of the phonological basis of the SFE and would reveal relevant individual differences in lexical access during reading with regard to the role of phonologically defined syllables.

The syllable is a sublexical unit that enables speakers to coarticulate phonemes. A large amount of empirical evidence has accumulated to suggest that polysyllabic words are segmented into their syllabic constituents during silent reading. Recent research has also suggested that the orthographic and phonological properties of language can modulated the role of syllables in reading. The pioneering English-language studies were conducted in the 1970s and 1980s (e.g., Prinzmetal, Treiman, & Rho, 1986; Spoehr & Smith, 1973; Taft & Forster, 1976); however, the deep orthography and ill-defined syllable boundaries of English make it a poor candidate for study. Conversely, a different approach to investigate the role of syllables in visual word recognition began more than a decade ago in Spanish, which has a transparent orthography and clear syllable boundaries. These researchers found what has been called the *positional syllable frequency inhibitory effect*. Words composed of more frequently syllables produce longer reaction times (RTs) and more errors compared to words with less frequent syllables (Carreiras, Álvarez, & de Vega, 1993). This inhibitory effect has been observed primarily for the first syllable of words (Álvarez, de Vega, & Carreiras, 1998; Álvarez, Carreiras, & de Vega, 2000). The first account for this effect was based on the number of lexical candidates activated by the first syllable: If a syllable frequently occurs, then more words compete for recognition. The coactivated words interfere with the recognition of the target word, and accurate lexical access depends on lateral inhibition of these candidates. Subsequent research showed that the number of higher frequency syllabic neighbors (instead of the number of neighbors) accounts for the inhibitory syllabic frequency effect (Álvarez, Carreiras, & Taft, 2001; Perea & Carreiras, 1998). In addition, the effect is larger and easier to find in low-frequency words than in high-frequency words because the frequency of the activated syllabic neighbors that compete for recognition have less influence on high-frequency words than low-frequency words (Álvarez et al., 2000; Álvarez et al., 1998; Carreiras et al., 1993; Perea & Carreiras, 1998). This effect has also been found in French (Conrad, Grainger, & Jacobs, 2007; Mathey & Zagar, 2002) and German (Conrad & Jacobs, 2004). Finally, several studies have ruled out alternative explanations. Specifically, the frequency of letter pairs (Carreiras et al., 1993), morpheme frequency (Álvarez et al., 2001), or orthographic neighborhood variables (Perea & Carreiras, 1998) cannot explain the SFE.

From a theoretical viewpoint, identifying whether orthographically or phonologically defined syllables produces the SFE is important because the role of phonology in reading words is controversial. This question remains difficult to answer in Spanish and German. Spelling and sound are consistent within both languages, with only a few inconsistencies. Álvarez, Carreiras, and Perea (2004) provided evidence that the syllabic effect in Spanish has a phonological origin. In two masked priming experiments with pseudowords as primes (e.g., *birel*), Alvarez et al. (2004) used Spanish inconsistencies (e.g., the graphemes "b" and "v" are phonologically equivalent) to find that primes that shared the first phonological syllable with the targets (but differed in orthography) facilitated target recognition (e.g., *virus*).

In a recent study, Conrad et al. (2007) replicated the SFE in French, which has more inconsistencies between graphemes and phonemes than Spanish. More important, they provided support for the phonological basis of this effect. They conducted six different comparisons in a single lexical decision experiment using a large number of words. They found strong phonological SFEs compared to the orthographic SFE null effects. In addition, the frequency of letter and phoneme clusters did not account for their results. Again, the SFE was stronger when word frequency was reduced, "showing a greater sensitivity to syllabic processing as word frequency diminished" (p. 980).

These results clearly agree with Ferrand, Seguí, and Grainger (1996), who suggested that the SFE is located at the sublexical input phonology level, which is composed of syllables. They postulated that there is a double route to meaning: a direct orthographic route and an indirect phonological route (Ferrand et al., 1996; Grainger & Ferrand, 1996; Jacobs, Rey, Ziegler, & Grainger, 1998). Phonological influences depend on processing speed in the direct route. According to this theoretical framework, when a printed word is presented,

> a sublexical orthographic code generates activation in the appropriate set of phoneme representations that then converge on syllabic representations. These syllable-sized units receive bottom-up input only via phoneme representations and are, therefore, phonologically defined syllables. The syllable representations then control activation at the level of whole-word orthographic and phonological representations. (Conrad et al., 2007, p. 981)

Polysyllabic words that share the first syllable are both activated and point competition begins among the nodes. This fact explains the inhibitory SFE during lexical access. If it is true that syllables receive input only via phoneme representations, then the latter might affect the SFE. The different phonemes share multiple features, and the boundaries among them are arbitrary and unique to each language. For example, the voice contrasts depend on voice onset time (VOT), and the categorical limits of these contrasts change depending on the language. Thus, a clear demarcation of these categorical boundaries should be associated with the use of phonetic representations and (a) a low degree of overlap among receptive fields and (b) a high level of specificity. These representations should be efficient for phoneme identifications and for the correct activation of syllables. Conversely, a diffused definition of categorical boundaries implies the use of representations that overlap the receptive fields. In this case, we would expect fewer correct phoneme identifications (and correct activation of syllables). Thus, if the SFE is based on the activation of phonological-defined syllables, people who have phonetic representations with clear categorical boundaries should show a larger SFE than those with diffuse categorical boundaries.

The phenomenon that discriminating between two sounds in the same category is harder than doing so between different categories (Categorical Perception [CP]) is linked to phoneme representation. This effect occurs even when the acoustic differences between sounds are of the same magnitude (Liberman, Harris, Hoffman, & Griffith, 1957).

Different tasks and measures have been used to investigate CP (see Serniclaes, 2006). Among these tasks, the identification or labeling task is particularly relevant to the present study. This task requires participants to listen to syllables that differ on one feature and to assign them to categories (i.e., phoneme). Of interest, this task seems to share the same representations as reading but in the opposite direction: The visual input (grapheme) activates a category (phoneme), and in turn, the phonemes activate the corresponding syllable. Therefore, the identification task demonstrates a direct relationship between phonemes and syllables.

Some individual differences obtained using the identification task are particularly relevant to our study, especially these results related with the slope parameter. CP in children without learning disabilities is weaker than adults (Hazan & Barrett, 2000; Messaoud-Galusi, 2003) but improves with age (Serniclaes, Van Heghe, Mousty, Carré, & Sprenger-Charolles, 2004). This change is reflected in the slope of the sigmoid function that is commonly used to fit participants' identification responses. Moreover, empirical evidence also has shown differences within adult samples. Serniclaes, Ventura, Morais, and Kolinski (2005) found that, although there were no CP discrepancies between illiterate and literate adult participants, there were significant differences between these groups in the identification task. The slope of the labeling function is a categorical criterion (Simon & Fourcin, 1978): Steeper slopes of literate participants reflect higher precision in the phoneme boundary location.

The slope parameter captures only one part of CP (Serniclaes, 2006). As Sprenger-Charolles, Colé, and Serniclaes (2006) stated, the slope indexes the boundary between categories: the steeper the slope, the higher the precision. Nevertheless, CP can mean either that only the difference between categories can be distinguished or that the within-category variants cannot (Liberman et al., 1957). As some etiological theories of developmental dyslexia have proposed (Serniclaes et al., 2004), within-category measures are related to phoneme representation specificity. The greatest within-category differences are found when participants have more than one boundary. As Serniclaes et al. (2004) stated,

> Understanding written language requires well-defined phonemic representations. A child who perceives allophones instead of phonemes (e.g., /b/, /p/, and /ph/ in a language where only /b/ and /ph/ are phonemic) would have difficulty in attributing the same written symbol (e.g., 'p') to sounds belonging to different categories in his or her oral repertoire (e.g., /p/, /ph/). The mismatch between spoken categories and phonemes might raise important problems for learning to read, even with fairly transparent orthographic systems. (p. 342)

The problem with the slope parameter of the sigmoid function is that it is not sensitive enough to within-category boundaries. Two individuals with the same slope could be taken as having the same CP. However, one of them could still have a within-category boundary, which could reasonably be interpreted as having a poorer CP (Serniclaes, 2006). Thus, a between-category difference measure (the slope) and an additional measure to detect within-category boundaries are needed. In addition, a within-category measure might increase the possibility of finding individual differences in readers without learning disabilities.

The classical free parameters associated with sigmoid fit functions (e.g., intercept, boundary, or slopes) are not sensitive to potential within-category limits. To overcome this limitation, we created an index of the goodness of fit between participants' responses and the sigmoid function. The rationale for this index is that the presence of within-category boundaries causes participant responses to depart from the sigmoid function. As such, we used a fitness error measure. Thus, low error scores would reflect the absence of within-category boundaries, whereas high error scores would reflect the presence of within-category boundaries (i.e., a worse CP).

In sum, our goal is to examine how phoneme representations affect the SFE and to characterize the quality of phoneme representations by using an identification task to consider slope and error scores. In addition, we consider these indexes to be a measure that maximizes the probability of detecting individual differences in a sample of skilled adult readers. We also used a lexical decision task in which word frequency and syllable frequency were manipulated to study the SFE and its possible relationship with word frequency.

METHOD

Participants

This study included 117 undergraduate students from the University of Málaga who received academic credits for their participation. Before the experimental tasks, we required that the students pass a reading efficiency test adapted from Gernsbacher and Varner (1988) to explore any individual differences in reading ability. The task includes two texts, one narrative and one expository, followed by questions to measure comprehension. We submitted reading time measures, success rate to questions, and a composite measure of reading efficiency to analyses of variance (ANOVAs) with group as a between-subjects factor. We did not find significant between-group differences for any measure.

Design and Procedure

Visual stimuli task. We used 120 disyllabic stimuli (60 words and 60 pseudowords between four and six letters long) in a lexical decision task. We selected words from the LEXESP database (Sebastián, Martí, Career, & Cuetos, 2000) using Buscapalabras software (Davis & Perea, 2005). Selections depended on word frequency and the positional syllabic frequency (PSF) of the first syllable. We arranged the words orthogonally using a 2 × 2 design according to word frequency (high vs. low) and the PSF of the first syllable (high vs. low). The range of high-frequency syllables was between 1429.8 and 7122.5 of the logarithm (base 10) of token syllable frequency ($M = 4595.1$, $SD = 1880.2$). This measure corresponds to a logarithmic transformation of the accumulated word frequency of all syllabic neighbors on the corpus. The low-frequency syllables ranged between 115.18 and 718 (*M* = 225.9, *SD* = 197.7). The high-frequency words ranged between 590 and 3,863 (*M* = 1407.7, *SD* = 815.7), and the low-frequency words ranged between 117 and 4 (*M* = 35.1, *SD* = 36.1). The pseudowords were constructed from the same syllables as the 60 words; thus, all stimuli had the same syllable frequency.

We conducted the experiment using a personal computer in a semi-isolated cubicle. E-Prime software version 1.02 presented and recorded all participant responses on the visual task. We randomly presented the 120 stimuli in a standard lexical decision task. Participants attended to the letter strings that appeared on screen and made a lexical decision as quickly and accurately as possible. Before the test phase, participants completed 12 training trials. Each trial began with a fixation point (*****) in the center of the screen for 500 ms. The test item subsequently replaced the fixation point. Participants pressed the “z” key, labeled “si” (i.e., “yes” in Spanish), if the item was a word or the “m” key, labeled “no,” if it was a pseudoword. The item remained on screen until the participant responded or 2,000 ms had elapsed. The next trial began automatically after a 1,000-ms interstimulus interval. Software recorded participant accuracy and RT for each trial.

Auditory stimuli and task. Superlab Pro software presented and recorded the auditory identification task. Participants listened to sounds on headphones to isolate external sounds. We constructed an 11-sound synthetic continuum from the syllable /ba/ to /pa/ by manipulating the VOT (Rosner, López-Bascuas, Garcia-Albea, & Fahey, 2000). VOT is the length of time between the release of an occlusive consonant and vocal cord vibration. Voiced stop consonants (e.g., /b/, /g/, and /d/) have short VOTs, whereas occlusive consonants (e.g., /p/, /k/, and /t/) have longer VOTs. As VOT increases, perceptions of a voiced stop consonant change to an occlusive consonant (and vice versa for decreasing VOTs; F1 cutback; Liberman, Delattre, & Cooper, 1958). The stimuli within each continuum ranged from –60 ms to +60 ms VOT, with 11 sounds separated in steps of 10 or 20 ms (i.e., –60 ms, –40 ms, –30 ms, –20 ms, –10 ms, 0 ms, +10 ms, +20 ms, +30 ms, + 40 ms, and +60 ms).

In the auditory processing test, we presented the stimuli one at a time in an identification task. Before the test phase, we presented 12 training trials. Participants decided whether the stimulus was /ba/ or /pa/ in a forced-choice procedure. We randomly presented each sound on the continuum six times for a total of 66 sounds across the experiment. An identification function was created for each participant by coding the percentage of /pa/ responses as a function of VOT. We used a logistic (or sigmoid) function applied to the 11 points on VOT to predict the frequency of /pa/ responses across the six trials at each VOT. The slope and the boundary parameters were adjusted for each participant according to a minimum squared errors procedure.

We developed a Quality of Categorical Perception (QCP) measure. QCP had two components: the slope and an error measure equal to the sum of squared errors, which can be taken as a measure of the goodness of fit. As said in the introduction, the slope is sensitive to the steepness of between-category boundaries, but it is not a good indicator of the presence of within-category boundaries. The error measure was included because it could be used as a better indicator of the presence of within-category boundaries. QCP is related to both concepts. Thus, an individual is said to have a poor CP either if she or he has a smooth slope, reflecting an ill-defined boundary between categories, or if she or he has a within-category boundary. Because the definition of a poor CP entails the use of an inclusive OR to relate both concepts, the best way to mathematically express QCP is as the sum of the slope and the error measure parameters. Each parameter was independently normalized to *Z* scores. Then, the error measure *Z* score was multiplied by –1. This way, in both cases (the slope and the error measure parameters) a high value would indicate a good QCP, whereas a low value would indicate a poor QCP. Finally, a QCP score was calculated by summing both parameters. Based on this composite measure, we divided the sample into three groups of equal size depending on the quality of their perception (Figure 1). We counterbalanced the presentation order of the lexical decision and auditory tests.

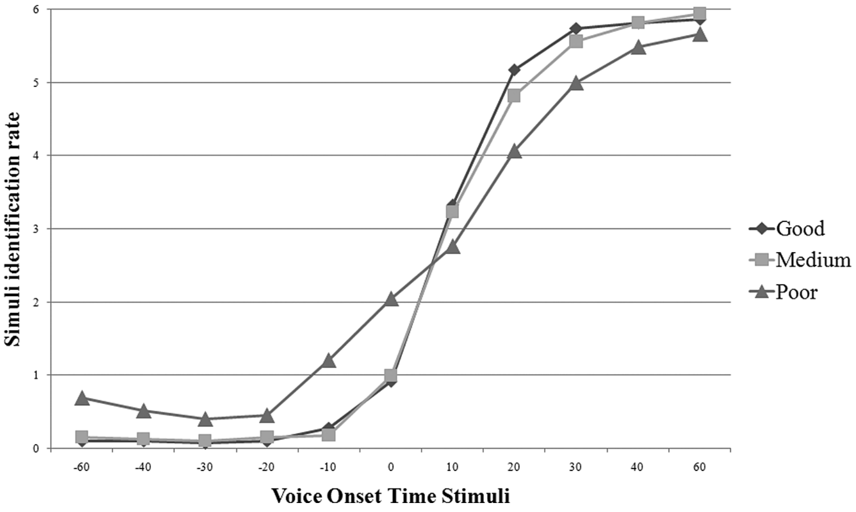

FIGURE 1 Quality of categorical perception groups.

RESULTS

We removed incorrect answers and RTs of less than 300 ms and more than 1,500 ms (4.80% of the data) from the analysis. In addition, we excluded RTs above and below 2.0 standard deviations (2.62% of the data). Because of their high error rates (above 30%), we also excluded 6 participants and nine items from analyses. We submitted mean correct response RTs and error rates (see Table 1) to ANOVAs by participants (F1) and by items (F2) and for words and for pseudowords separately. Words were analyzed including two within-participants factors: word frequency (high vs. and low) and syllable frequency (high vs. and low), and a between-participant factor, QCP (poor, medium, and good categorizer). Similarly, we analyzed pseudowords according to a within-participant factor, syllable frequency, and the between-participant factor QCP.

Although words and pseudowords were analyzed separately, we first examined the lexicality effect by including words and pseudowords in the same analysis. We observed longer RTs for pseudowords, $F1(1, 114) = 389.69$, $p < .001$; $F2(1, 109) = 141.94$, $p < .001$. A separate analysis of RTs for words showed that RTs were longer for low-frequency words, $F1(1, 114) = 262.66$, $p < .001$; $F2(1, 50) = 46.24$, $p < .001$.

We also replicated the inhibitory SFE phenomenon. The interaction of syllable frequency and word frequency was significant, $F1(1, 114) = 46.53$, $p < .001$; $F2(1, 50) = 8.08$, $p = .006$. To study how syllable frequency works in greater detail, we conducted separate the lexical frequency analyses. Post hoc analyses showed that the PSF was significant in low-frequency words and the inhibitory SFE phenomenon was present, $F1(1, 114) = 32.16$, $p < .001$; $F2\ (1, 50) = 4.80$,

TABLE 1
Mean Response Time (in ms), Error Rate in % (in Parentheses), and Standard Deviation as a Function of Word Frequency, Syllable Frequency (SF), and Quality of Categorical Perception (QCP) Group

	Word Frequency											
	High				*Low*				*Pseudowords*			
	High SF		*Low SF*		*High SF*		*Low SF*		*High SF*		*Low SF*	
QCP	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Poor	625 (5.9)	77	628 (4.8)	75	687 (11.8)	85	672 (13.7)	85	758 (8.8)	100	753 (8.6)	97
Medium	614 (3.3)	70	633 (4.4)	66	705 (8.9)	79	658 (13.9)	70	756 (8.3)	93	760 (8.7)	97
Good	609 (4.0)	71	632 (5.5)	70	705 (8.3)	91	679 (13.0)	92	761 (8.7)	101	758 (8.7)	104

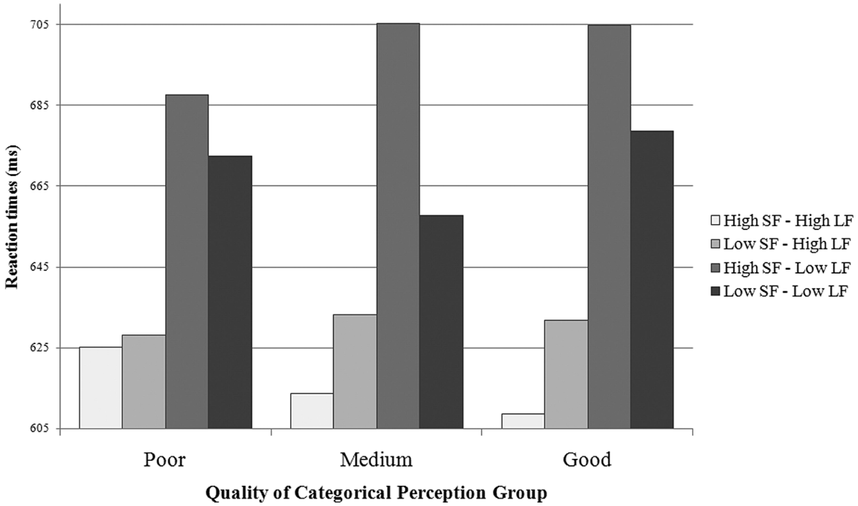

FIGURE 2 Syllable frequency, lexical frequency, and quality of categorical perception group.

$p = .039$, respectively. However, for high-frequency words, the SFE was not significant, although there was a facilitatory tendency, $F1(1, 114) = 13.00$, $p < .001$; $F2(1, 50) = 2.90$, $p = .100$. It is important to note that the three-way interaction among QCP, word frequency, and syllable frequency was also significant, $F1(1, 114) = 4.75$, $p < .010$; $F2(1, 50) = 6.33$, $p < .005$.

To correctly capture the pattern of the data, we studied each group separately (Figure 2). The most striking finding was the lack of the SFE among the poor categorizers. Only word frequency was significant in this group and showed the typical pattern: shorter RTs for high-frequency words, $F1(1, 38) = 68.31$, $p < .001$; $F2(1, 50) = 25.93$, $p < .001$. However, the medium and good categorizers showed a clear SFE. For medium categorizers, both word frequency and the interaction between word frequency and syllable frequency were significant, $F1(1, 38) = 87.79$, $p < .001$, and $F2(1, 50) = 40.16$, $p < .001$; $F1(1, 38) = 24.99$, $p < .001$, and $F2(1, 50) = 16.43$, $p < .001$, respectively. We also found an SFE differential effect: In low-frequency words, the SFE showed an *inhibitory* effect, $F1(1, 38) = 21.54$, $p < .001$; $F2(1, 50) = 11.57$, $p = .002$.

In the good categorizer group, word frequency and the interaction between word frequency and syllable frequency were also significant, $F1(1, 38) = 108.05$, $p < .001$, $F2(1, 50) = 52.08$, $p < .001$; $F1(1, 38) = 24.44$, $p < .001$, $F2(1, 50) = 7.24$, $p < .010$. The SFE was significant for high-frequency words and showed a *facilitatory* effect (i.e., longer RTs for words with low-syllable frequencies), $F1(1, 38) = 11.81$, $p < .001$, $F2(1, 50) = 5.48$, $p = .027$. However, participants, but not items, showed a significant SFE for low-frequency words and an inhibitory effect, $F1(1, 38) = 8.89$, $p = .005$; $F2(1, 50) = 2.88$, $p = .103$.

Finally, more errors were made with low-frequency words compared to high-frequency words, $F1(1, 114) = 148.695$, $p < .001$; $F2(1, 50) = 4.21$, $p = .046$. There were no other significant effects (all *p*s $> .5$).

DISCUSSION

In summary, we observed a lexicality effect in all participants: Words were recognized earlier and with fewer errors than pseudowords. In addition, we obtained the typical word frequency effect: Participants responded to high-frequency words with shorter RTs and fewer errors. We also confirmed the interaction between word frequency and syllable frequency by finding that the inhibitory SFE was restricted to low-frequency words. These data are consistent with Conrad et al. (2007) and others: Lexical inhibition primarily appears with low-frequency words. We assume that competition among word nodes (activated by the first syllable) has less influence over high-frequency words; thus, the inhibitory effect decreases or disappears (Carreiras et al., 1993; Domínguez, de Vega, & Cuetos, 1997). Within high-frequency words, the SFE produces a marginal improvement in reading (a facilitation trend).

Our main objective, however, was to study whether individual differences in the quality of phoneme representations (as measured via an auditory perception task designed to estimate the QCP) modulate the SFE in a lexical decision task. According to this theoretical framework, we expected to find a stronger SFE in people with a good QCP compared with those with a poor QCP. In general, our results are consistent with our prediction because we observed the SFE effect in good and medium perceptual categorizers but not in poor perceptual categorizers.

A closer look at our results reveals how these individual differences are expressed. Poor categorizers were insensitive to the manipulation of syllable frequency in both word frequency conditions. These participants were different from the other two groups and did not show inhibition or facilitation effects. Whereas poor categorizers did not show the typical SFE inhibitory pattern, the other two groups (medium and good categorizers) did show this effect; as expected, it was restricted to low-frequency words. Medium categorizers showed a clear interaction between word frequency and SFE: There was a significant inhibitory SFE in low frequency, but not in high frequency, words. Good categorizers showed similar results to the medium group; however, the inhibitory effect in low-frequency words was only marginally significant.

According to the goals of this study, the results that show a relationship between the quality of phoneme representations and the SFE support the notions of a phonological base for the effect (Álvarez et al., 2004; Conrad et al., 2007) and a direct relationship between the phoneme and syllabic levels (as only suggested but not studied by Grainger & Ferrand, 1996). However, these results do not speak to the concrete way in which phoneme representations of more or less quality affect the syllabic processing of high- or low-frequency syllables. We consider two possible explanations, both of which are compatible with our findings.

Because poor categorizers are thought to have phoneme representations with overlapping receptive fields (or receptive fields that allow for the misperception of different phonemes within the same category region), we might expect that the phoneme representations activated through the grapheme–phoneme conversion process are unspecific. In turn, phoneme representations with a low degree of specificity might activate not only the syllables containing those phonemes but also syllable units that contain similar phonemes. This outcome should undermine the effectiveness of SFE manipulation. Conversely, phoneme representations with a high degree of specificity based on clear categorical limits between their receptive fields should be more effective at activating only the syllables that contain the phoneme that correspond to the presented grapheme. Consequently, people with clear-cut phonemic representational spaces should be more effective at differentiating lexical candidates that share the first syllable compared to those with ill-defined phonemic representations. As a consequence, syllabic frequency manipulation had a more pronounced effect on the former compared to the latter group of participants.

However, these results are also compatible with a theoretical explanation that is not based on lexical access via a phonological route. The low-quality phoneme representations of poor categorizers might enhance the efficiency of the visual route to the detriment of the phonological route in lexical access. The rationale behind this explanation is that poor phonemic representations might be less efficient at the grapheme–phoneme conversion process compared to good phonemic representations. To compensate for this lack of efficacy, poor categorizers might use the visual route to a greater extent compared to good categorizers. This explanation might have obscured the observation of the SFE in poor categorizers if, according to some authors, such an effect requires the more efficient use of the phonological route compared to the visual route.

In sum, we found individual differences affect the SFE in ways not previously shown. Specifically, these differences are related to phoneme representation quality. In fact, both explanations may be correct and compatible; however, this fact does not undermine the relevance of our results. We have shown that adults who are poor categorizers versus those who are skilled categorizers process orthographic and phonological input sources differently, even when their lexical decisions are approximately the same. Furthermore, this result holds when the three groups had the same level of reading efficiency. The present findings are relevant to related research fields. Poor phonological representations may be the basis for developmental dyslexia (for a recent review, see Shaywitz, Morris,

& Shaywitz, 2008). From this perspective, computational simulations have been developed to show how a poor phonological representation might cause severe reading problems (Harm, McCandliss, & Seidenberg, 2003; Harm & Seidenberg, 1999). If the quality of phoneme representations modulates the SFE in normal adult readers (either by the specificity of their representations or by their speed), then this effect may be present in children or adults with dyslexia. Current research in our lab is addressing this possibility.

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