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Lexical and Phonological Processing in Visual Word Recognition by Stuttering Children: Evidence from Spanish

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Abstract. A number of studies have pointed out that stuttering-like disfluencies could be the result of failures in central and linguistic processing. The goal of the present paper is to analyze if stuttering implies deficits in the lexical and phonological processing in visual word recognition. This study compares the performance of 28 children with and without stuttering in a standard lexical decision task in a transparent orthography: Spanish. Word frequency and syllable frequency were manipulated in the experimental words. Stutterers were found to be considerably slower (in their correct responses) and produced more errors than the non- stutterers ($\chi(1) = 36.63$, $p < .001$, $\eta^2 = .60$). There was also a facilitation effect of syllable frequency, restricted to low frequency words and only in the stutterers group ($t1(10) = 3.67$, $p < .005$; $t2(36) = 3.10$, $p < .001$). These outcomes appear to suggest that the decoding process of stutterers exhibits a deficit in the interface between the phonological-syllabic level and the word level.

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Although stuttering was previously considered to be a motor deficiency, interruptions to speech fluency might be the result of stuttering rather than the cause (Armson & Kalinowski, 1994). Consistent with this line of reasoning is the observation that the linguistic characteristics of an utterance influences stuttering, which suggests that central processes are playing a role as opposed to purely peripheral processes (e.g., Hernández-Jaramillo & Álvarez, 2009; Watson, Byrd, & Carlo, 2011a).

Studies in Spanish have consistently found that the pattern of stuttering depends on several linguistic variables. The following examples are just a small sample: (1) word class: content words are most prone to stuttering than function words (Au-Yeung, Vallejo-Gómez, & Howell, 2003); (2) utterance length (Watson, Byrd, & Carlo, 2011b); and (3) Phonetic complexity and metrical factors, such as stress (Howell, 2004; Howell & Au-Yeung, 2007). Descriptive studies have also shown an association of phonologic disorders with the amount of disfluencies and stuttering severity (Arndt & Healey, 2001; Yaruss, La Salle, & Conture, 1998).

This research has led to psycholinguistic explanations of stuttering which suggest that stuttering starts during speech planning, before oral production (Anderson & Conture, 2000; Melnick, Conture, & Ohde, 2003). Among these approaches, the Covert Repair Hypothesis proposes that a slow phonological processing system triggers many phonological encoding errors with disfluencies resulting from the covert auto-repair of these errors (Postma & Kolk, 1991; 1993). Thus, children who stutter would have a less-developed or a less-organized phonological system than those with normal fluency (Melnick et al., 2003), stuttering being the result of a problem in the phonologic coding (Byrd, Conture, & Ohde, 2007).

To test whether this disrupted reading was due to problems in phonological coding, several experiments have assessed subjects with and without stuttering in a range of linguistic processing tasks, including, priming techniques (Byrd et al., 2007; Melnick et al., 2003; Pellowski & Conture, 2005), phoneme monitoring (Sasisekaran & De Nil,2006) and pseudo-word repetition tasks (Bakhtiar, Abad Ali, & Sadegh, 2007). In all cases subjects who stutter had slower responses than fluent subjects, even when silently reading words and sentences. These results suggest a relationship between lexical structural segmentation and the ability to fragment word sounds. Thus phonologic encoding appears to be an important component and part of the

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explanation of how stuttering occurs. However, see for example Nippold (2002) for results inconsistent with this point of view, and Brocklehurst and Corley (2011) for a recent review of evidence for and against phonological difficulties in stuttering. Brocklehurst and Corley provide both explicit support for Postma and Kolk's (1993) Covert Repair Hypothesis and evidence inconsistent with the assertion that stuttering depends only on covert repairs of errors coming from phonological encoding.

Thus in summary, there is evidence that stutterers demonstrate a phonological deficit in production while some studies have also shown deficits in general phonological decoding processes during reading. The present research was designed to explore the performance of girls and boys with and without stuttering in a silent reading task, focusing on phonological processing. A lexical decision task (i.e., deciding if the presented stimulus is a word or not) was used in Spanish, a language in which psycholinguistic factors that could be related with stuttering have received relatively little attention. Spanish is an excellent candidate to investigate possible phonological deficits in tasks that do not require articulation (i.e., silent reading) by stutterers for several reasons: (1) Correspondences between graphemes and phonemes are very regular; (2) The syllable boundaries are well defined, and (3) The empirical evidence strongly suggests that, in this language, there is a rapid sublexical computation of phonology from orthography, involving a phonologically defined syllabic representation (Conrad, Grainger, & Jacobs, 2007) as suggested by the syllable frequency effect (SFE).

The SFE has been plentifully studied in Spanish, a shallow language with clear syllable boundaries. The basic finding in lexical decision tasks with adult readers is reaction times (RTs) and error rates are greater for words with high frequent syllables, particularly the first syllable (e.g., Álvarez, Carreiras, & Taft, 2001; Álvarez, Carreiras, & de Vega, 2000; Carreiras, Álvarez, & de Vega, 1993; Domínguez, de Vega, & Cuetos, 1997; Perea & Carreiras, 1998). This is the well-known inhibitory effect of syllable frequency. It has been assumed that the SFE reflects competition among word nodes activated by the syllabic units that share the first syllable. If the first syllable of a word is of high frequency, a greater number of candidates (words starting with that syllable) will be activated, as well as more candidates of higher frequency than the presented word, competing for recognition with the presented word. This co-activation interferes with the recognition of the stimulus word and consequently increases both response time and the probability of an error. The SFE has also been found in other languages such as French (e.g., Conrad et al., 2007) and German (e.g., Conrad & Jacobs, 2004). This research has reached a well-established conclusion: Syllables are important processing units, at least in shallow languages with clear syllable boundaries, being an intermediate level of processing between letters and words. Specifically, the SFE is located at the level of the sublexical input phonology, which is syllabically organized (Ferrand, Seguí, & Grainger, 1996). The main reason for manipulating this factor in the current experiment is that it has been found that the SFE is phonological in origin and is not exclusively orthographic (Álvarez, Carreiras, & Perea, 2004; Conrad et al., 2007, in French).

In contrast to the inhibitory SFE, facilitatory effects of syllable frequency (faster RTs and fewer errors for words with high-frequency syllables) have been found in tasks that do not require lexical access, such as word naming in shallow languages where naming a written word can be performed just by converting graphemes into phonemes (e.g., Carreiras et al., 1993; Carreiras & Perea, 2004, both in Spanish). In the case of speech production literature, this result (initially observed in Dutch) was considered support for the existence of the mental syllabary first proposed by Levelt (e.g., Levelt & Wheeldon, 1994). Likewise, the facilitatory effect has been found in English-speaking adult readers, a language with unclear syllabic boundaries (Macizo & Van Petten, 2007). In addition, and more remarkable for the present study, these facilitatory effects have also been observed in beginning readers, both in Spanish (Jiménez & Hernández-Valle, 2000) and in French (Chétail & Mathey, 2009; Maïonchi-Pino, Magnan, & Écalle, 2010). According to the evidence, the inhibitory pattern occurs only in older children, about eleven or older (Chétail & Mathey, 2009 in French, and Jiménez & Rodrigo, 1994 in Spanish).

Hence, we decided to manipulate two factors: A phonological factor, syllable frequency, and another related to the lexical level of processing: Word frequency. If stuttering is associated only with speech planning processes, then word and syllable frequency factors would not be expected to differentially affect performance of children with or without stuttering in a lexical decision task, as this task does not require articulation. However, we expect the SFE should be reduced in stuttering. This would be an evidence of linguistic (and central) factors, not exclusively related with production, influencing stuttering. Based on previous studies in other languages suggesting deficits in lexical processing and a possible general phonological deficiency in stuttering, and assuming that this deficiency is reflected in silent word reading tasks, we expect that the word frequency effect should be reduced in the stuttering group. More importantly, differences in the SFE between the two groups would be evidence of a phonological-based disability. Taking into account the variability in age of our participants, the inhibitory SFE should appear only in the older non-stutter participants as this effect is associated with a mature and normal interface between syllabic and word levels of processing. A lack of this effect in the whole group of stutterers would be support for the notion of stuttering as a general and central deficit related to lexical and sublexical processing.

Method

Participants

The experimental groups were drawn from 84 girls and boys, for which the experimenters were given access to school reports as well as reports from therapeutic-support staff including speech-language pathologists and occupational therapists. All children with a history of developmental, neurologic, intellectual, emotional or sensory disorders were excluded. The sample was drawn from Capital District public institutions (Bogotá, Colombia).

Two criteria were used to define a child as a stutterer. The first was a measure of speech disfluency based on records of conversational interactions between the children and their mothers. A child was considered a stutterer if he/she exhibited three or more disfluency instances (e.g., repetition of a sound or syllable, word or parts of a word or a sound extension) per 100 syllables in the conversational speech sample. In addition, a boy or girl was considered stutterer if he/she had a total score equal or greater than 11 on the *Stuttering Severity Instrument for Children and Adults* (SSI-3) (Riley, 1994). This score is regarded as medium or moderate severity stuttering and to ensure homogeneity of the experimental group only those children with moderate stuttering severity were included. All the stuttering children were diagnosed with developmental (not acquired) stuttering. Of the 32 youngsters identified with stuttering, 17 were classified as of moderate severity.

The non-stuttering control group was also drawn from the initial pool of 84 children. A child was considered a non-stutterer if he/she exhibited two or less disfluency instances per 100 syllables of the conversational speech and had a total score equal or less than 6 (i.e., equivalent to normal or mild) according to the stuttering diagnosis criteria of SSI-3.

Prior to the experimental phase, participants of both groups were screened with three subtests of the Readers Process Assessment Test PROLEC and PROLEC-SE (Cuetos, Rodríguez, & Ruano, 1996). In the first subtest, *Reading words*, participants read 40 words, 20 high and 20 low frequency words. All words were balanced in length and syllabic structure. The obtained score is derived from the accuracy (error rate), and reading time of the whole list. The more words read correctly and in less time, the better the performance in this task. The second subtest, *Pseudoword reading*, consisted of 40 pseudowords, which were constructed by changing a letter or two on each end of the list of words from the previous task, both lists share similar characteristics, since they have the same length and the same syllable structure. Again the obtained score was based on speed and accuracy of reading. In the final subtest, *Reading comprehension*, participants were asked to read passages and answer comprehension questions. There were no differences between groups in error rates ($p = .403$), or reading times for word reading ($p = .841$) or in errors ($p = .785$) or reading time ($p = .598$) for pseudowords reading. In addition, no differences were observed in the comprehension test ($p = .863$).

Two children with stuttering were excluded from the study because they were markedly below the mean in the word and pseudoword reading sub-tests, which presumably measure lexical processes. In addition, four children were unable to participate in the experiments for personal and family reasons.

Thus, 11 children (6 boys and 5 girls) with developmental stuttering participated in the experiment, with a mean age of 9.6 years. At the time of the experiment all participants of the stuttering group were receiving between 1 and 3 sessions of speech therapy per month (mainly based on breathing and relaxing methods). The 17 non-stutterers (9 boys and 8 girls, selected from the original 84 children) had a mean age of 9.7 years ($t < 1$). The age of both groups ranged from 8 to 13 years. Educational level ranged from the third level of a basic primary education degree to the third level of a basic secondary education degree (scholarship average of 4.18 for the experimental -stuttering- group and 4.09 for the control non-stuttering-group; $t < 1$). Thus, the two groups were matched according to age and educational grade. All of them were monolingual Spanish speakers and with normal or corrected to normal visual skills. Written informed consent was obtained from the parents for all the participants.

Design and materials

An experimental 2x2x2 mixed design was used. The between-participant factor was group (children with or without stuttering), and the within-participants factors were word frequency (high versus low) and first syllable frequency (high versus low).

A total of 157 bisyllabic CV.CV and CV.CVC (consonant-vowel and consonant-vowel-consonant structure, the dot marking the syllable boundary) words were selected from the LEXESP Spanish corpus (Sebastián-Gallés, Martí, Carreiras, & Cuetos, 2000), based on their word frequency and the syllable frequency of the first syllable, taking the most extreme possible values derived by the *BuscaPalabras* application (Davis & Perea, 2005).

Prior to the experiment, the *test* words were piloted on 32 children matched for mean age and education level range with the experimental participants, to ensure that the words were known and in the vocabulary repertoire of children of the same age and school grade. None of these 32 children participated in the experiment proper. Those words with a bellicose or sexual content, and those considered inappropriate for children were excluded thus fulfilling normative regulations of the public Colombian institutions and regulations of ethical committees for research in vulnerable populations. In addition, the inventory of test words was reviewed to ensure that the experimental words had the same meaning and usage in Colombian Spanish, since the LEXESP does not consider such variations. Finally, 88 bisyllabic words were used as stimuli. Mean frequency for high-frequency words was 284.6 per million and for low frequency, 7 per million. Mean frequencies of the first syllable were 4305 for high and 858 for low, respectively. Length, second syllable frequency, neighbor density and frequency and initial phoneme were controlled across conditions ($p > .05$ in all the possible comparisons among conditions).

For the lexical decision task, a total of 88 pseudowords were constructed from the test words through the substitution of the second syllable of the word stimuli (two or three letters were replaced), maintaining the same length and structure of the original words (the stimuli are listed in the Appendix).

Procedure

The experimental task was a standard lexical decision in which participants were presented with a sequence of letters, in the center of a computer screen, and they had to decide if it was a real Spanish word or not, pressing one of two keys. One of them was labeled "SÍ" ("yes" in Spanish) and was colored in green, and the other was labeled "NO" and was in red. Each trial consisted of a blank screen for 500 ms followed by a fixation point ("+") for 500 ms and then the stimulus. Participants were asked to answer as quickly and as accurately as possible. Stimuli were presented randomly in four blocks, with a rest interval of five minutes between each block. Reaction times (RTs) and error rate were recorded by the computer. Prior to the test blocks, a practice session consisting of 5 word and pseudowords pairs was conducted.

Results

RTs for correct responses and error rates were analyzed according to the three factor design previously mentioned: Group (between-participants but within-items: stutterers vs non-stutterers), Word Frequency (WF: high vs low) and First Syllable Frequency (SF: high vs low), the last two being within-participants but between-items factors. For analyses, linear mixed effects models (Baayen, Davidson, & Bates, 2008; Bates, 2005) were used, which simultaneously take participant and item variability into account. These analyses were performed using the R statistics software with the package lme4 (Bates & Maechler, 2009).

Mean RTs and error rate are presented in Table 1. Times shorter than 200 ms and longer than 4000[1], as well as those times 2 standard deviations above or below the mean (for each participant and for each condition), were removed from the RT analyses (4.9% of the data). The 2x2x2 analyses of RTs for correct responses showed that the Group factor was significant, $\chi(1) = 36.63$, $p < .001$, $\eta^2 = .60$, with stutterers (M = 2047 ms, SD = 761 ms) taking longer times than non-stutterers (M = 1209 ms, SD = 576 ms). There was also a significant facilitatory syllable frequency effect, $\chi(1) = 21.82$, $p < .001$, $\eta^2 = .36$, with RTs longer for words with low frequency syllables (M = 1718 ms, SD = 651 ms) than for high frequency syllables (M = 1537 ms, SD = 686 ms). There was no significant word frequency effect (high WF, M = 1606 ms, SD = 669 ms; low WF, M = 1650 ms, SD = 668 ms). Two two-way interactions were significant: the Group x syllable frequency interaction, $\chi(1) = 11.95$, $p < .001$, $\eta^2 = .14$ (the difference between high and low SF was three times greater in stutterers than controls) and syllable frequency x word frequency interaction, $\chi(1) = 4.32$, $p < .05$, $\eta^2 = .11$ (the SF effect was significant only in low frequency words). Perhaps more importantly, the three-way interaction was also significant, $\chi(1) = 4.10$, $p < .05$, $\eta^2 = .05$. The simple effect analyses indicated that the only significant difference was between high and low syllable frequency in low-frequency words for stutterers, $t1(10) = 3.67$, $p < .005$; $t2(36) = 3.10$, $p < .001$, but not for controls.

In the analyses of error rates, three effects yielded significance. The Group main effect, $\chi(1) = 20.70$, $p < .001$, $\eta^2 = .44$, with considerably more errors produced by the stutterers group (M = 22, SD = .4) than by the non-stutterers (M = 6.5, SD = 2.5). There were also significantly, SF, $\chi(1) = 29.37$, $p < .001$, $\eta^2 = .66$, more errors for words with low syllable frequency (M = 21, SD = 4) than high syllable frequency words (M = 7, SD = 2). Only the Group x SF interaction was significant, $\chi(1) = 24.69$, $p < .001$, $\eta^2 = .27$ indicating that the difference between high and low syllable frequency was greater in the stuttering group than in the control group.

[1]This is a standard procedure in visual word recognition experiments, since an interval of 200 ms is too short to reach lexical access. Similarly, times over 4 seconds are too long to be attributed only to the process of visual word recognition, surely being artifacts.

Table 1. *Mean Reaction Times (RT) for correct responses and Percentage of Errors (Err) and Standard Deviations for both measurements (in parentheses), as a Function of Group (Stutterers vs. Non-stutterers), Syllable Frequency (SF): High vs. Low, and Word Frequency (WF): High vs. Low*

	High SF		Low SF	
	High WF	Low WF	High WF	Low WF
Stutterers	RT: 1.943 (771) Err: 12 (.2)	1.884 (741) 12 (.3)	2.089 (780) 32 (.5)	2.273 (752) 33 (.6)
Non-stutterers	RT: 1.167 (601) Err: 2 (.2)	1.157 (632) 3 (.2)	1.227 (525) 13 (.3)	1.285 (548) 8 (.3)

As already noted, the developmental research has consistently shown that the SFE effect is facilitatory in younger normal children and becomes inhibitory when reading ability approaches adulthood. Given the variability in age of our participants, both effects (facilitation in the younger and inhibition in the older children) could be cancelling each other out. Thus, in order to test this last hypothesis, we decided to carry out a post-hoc analysis only with the older participants of both groups over the RT data. Thus, we selected the four oldest participants in both the stuttering and non-stuttering groups (older than eleven). Even with so few participants, the ANOVA indicated a reliable word frequency effect, $F(1, 6) = 6.51$, $p = .043$, and that stutterers had significantly longer RTs than control, $F(1, 6) = 15.52$, $p = .008$. Most importantly however there was also a significant Group x Syllable Frequency interaction, $F(1, 6) = 9.66$, $p = .014$. As expected, the SFE was inhibitory and approaching significance in the non-stutterers: high SF, $M = 1385$ ms $SD = 620$ ms, and low SF, $M = 1301$, $SD = 670$ (Bonferroni test: $p = .11$) whereas it was facilitatory (and significant) in the stutterers: high SF, $M = 1973$ ms $SD = 772$, and low SF, $M = 2179$ ms $SD = 780$ ms, (Bonferroni test: $p = .026$). Due to the small number of participants, the non-parametric Mann-Whitney test was carried out for the main contrasts and the same significant effects were obtained.

Discussion

The purpose of this study was to identify if there was a difference in children's performance with and without stuttering in a lexical decision in Spanish, a task commonly considered an appropriate measure of word processing in reading that involves lexical access but not articulation. We investigated the role of first syllable frequency and word frequency according to the following logic: If stuttering is a deficit produced by factors exclusively related to speech (i.e., oral production processes), no difference in RTs for correct responses or errors between stuttering and non-stuttering children would be expected. This is because the task does not require any kind of verbalization or articulation, and thus a similar pattern of results for both manipulated factors should emerge for both groups. However, as previous studies have shown, stuttering could also be the result of a pre-articulatory central processing deficiency related to the psycholinguistic processing of words, both at a strictly lexical level and/or a sub-lexical level, in this case a phonological syllable level. Thus, some differences between stutterers and non-stutterers should be observed during lexical access, and these differences will differ depending on the manipulated lexical and phonological factors.

The first outstanding result is that the stuttering children were considerably slower in their RTs for correct responses and produced more errors than non-stutterers. This is interesting, since both groups, matched for age and grade, were also matched in the PROLEC Reading Test. However, in the manipulated words and according to the data, both groups do not process the same words with the same speed and accuracy. We suggest that this result, by itself, indicates that there are differences between stutterers and non-stutterers at a central level not strictly related with articulation. Stuttering involves difficulties related to lexical and/or sublexical processing, even when the performance of both groups was equivalent in reading tests. However, there is an important difference between the Reading Test and the lexical decision task, as only the second task requires pressing a key, a manual procedure not required in the Reading Test. Thus, the difference between groups in the lexical decision task might be the result of differences in manual and motor skill rather than a difference in language processing and interpretations of differences between the groups needs to bear this in mind.

Despite this possible limitation, this result is the first of this kind obtained in Spanish, a transparent language with very consistent grapheme-to-phoneme conversion rules and clear syllable boundaries. These characteristics make Spanish an ideal language in which to investigate phonological processing in stuttering and yet it has received virtually no experimental investigations. More importantly, it is consistent with previous findings in other languages in which stutterers have been shown to take longer to read words and sentences than persons without stuttering (Postma, Kolk, & Povel, 1990; Weber-Fox, Spencer, Spruill, & Smith, 2004). For example, in the study by Postma et al. (1990), longer timeframes were found in different kinds of linguistic material production between stutterers and non-stutterers not only in the sub-vocalization and overt articulation conditions, but also in silent reading. The difference between groups in the silent reading and lexical decision performance suggest that subjects with stuttering require more time to process words. Bosshardt and Nandyal (1988) obtained a similar pattern of results when stutterers had to read polysyllabic words, as did Brutten, Bakker, Janssen, and Van der Meulen, (1984) with eye movements during silent reading.

A number of researchers (e.g., Bakhtiar et al., 2007; Byrd et al., 2007) have suggested that subjects who stutter could have problems with lexical segmentation and processing of a word's constituent sounds. To explore this possibility we manipulated the frequency of the first syllable, which has been shown to affect reading times and has a well-established phonological basis (Álvarez et al., 2004; Conrad et al., 2007). The standard phenomenon observed in adults in lexical decision tasks is an inhibitory effect of syllable frequency: Words with high frequent first syllables result in longer RTs and more errors than words with low frequency syllables (e.g., Álvarez et al., 2001; Carreiras et al., 1993). When the lexical decision data from stuttering and non-stuttering children are examined separately, an interesting pattern arises. First, in the non-stuttering group, the SFE did not appear clearly in either the high frequency or in the low frequency words. This result was expected, since the group was heterogeneous in terms of age and grade as the non-stuttering group was matched to the stuttering participants. Thus, the facilitatory effect expected in the younger children and the inhibitory effect (expected in the older ones) might have cancelled each other out. However, there was a facilitatory SFE in the stuttering group only significant for low frequency words. This effect will be discussed below.

The analysis including only the older participants of each group confirmed that the direction of the SFE (i.e., inhibitory or facilitatory) depends on the age and level of the non-stutterers: It is inhibitory for skilled and older readers and facilitatory in the case of beginning readers. As expected, the older non-stutterers showed a tendency (nonsignificant) to an inhibitory effect whereas it was facilitatory in the case of the older stutterers.

Our interpretation of the data from the stuttering group is based on research into the beginning readers and reading disabilities in children. This research has demonstrated that lexical factors such as word frequency result in similar effects in children and adults. Studies of word recognition in children with reading difficulties reveal deficiencies in lexical and sublexical processes. Particularly, they are slower in the lexical access than those who are competent readers (e.g., Colé, Magnan, & Grainger, 1999; Rodrigo & Jiménez, 2000). In addition, many studies have argued for a deficit in phonological processing as an explanation of reading disabilities (e.g., Jiménez & Hernández-Valle, 2000).

We argue that a "soft" (but appealing) parallel can be drawn between the developmental account of the SFE, the stutterers' performance and research into children with reading disabilities. Although, of course, we are not arguing that stutterers are readers with disabilities. At present and given our modest outcomes, it is premature to establish a strong parallel between stuttering, early readers and children with reading disabilities but the similarities between these lines of research and our word recognition findings in stuttering children move us to some conclusions.

As stated earlier, the facilitatory SFE occurs in beginning readers, because reading acquisition can be described "as a progressive and gradual improvement in the connections between phonological and orthographic sublexical units" (Maïonchi-Pino et al., 2010). In addition, the connections between sublexical and word representations are essential to reduce cognitive load and speed-up word recognition. In normally developing readers, greater reading experience strengthens these connections between sublexical and word units at the same time as implicit knowledge about statistical regularities is progressively growing so that reading becomes more and more automatic and faster. Once this knowledge and the connections between sublexical and lexical units become strong enough, the word frequency effect and the inhibitory SFE arise. Similarly, the performance of younger readers resembles to some extent a reading disability. The phonological route and the connections between phonological and word units are either less developed or missing, particularly for infrequent words. The surface similarity between stutterers and younger readers is in that stutterers were also much slower to make lexical decisions and also made more errors than non-stutterers. Using the same logic used to explain reading development and reading problems, this suggests that stuttering is a central linguistic deficit related to the processes of lexical access.

The reliable facilitatory SFE in low frequency words, only found in the stuttering group, indicates that the possible linguistic deficit involved in stuttering is particularly evident with the non-frequent units. Thus, low frequency words appear to be more vulnerable to disfluencies, because the connection between the syllabic and word representations is deficient in the stuttering speaker. This argument is again consistent with previous explanations of development of the SFE during reading acquisition. The result is also consistent with the observation that lower frequency words tend to result in more disfluencies in older children and adults with stuttering (e.g. Anderson, 2007; Hubbard & Prins, 1994).

Finally, the persistence of the facilitatory SFE even in the older stutterers, but not the older non-stutterers, supports the notion that these individuals are relying heavily on a pure and not-too-automated phonological route. More specifically, our findings are consistent with the existence of dysfunctional connections between the phonological (i.e., syllabic) level and the word level of processing. In other words, our results could be reflecting a poorly developed interface between these two levels in decoding processes. Similarly, earlier research has suggested that children who stutter exhibit a less organized phonological system than non-stutterers. For example, Byrd et al. (2007) found that stutterers showed a delay in phonological encoding in comparison with non-stutterers in a picture-naming task using auditory primes. Interestingly, consistency of the present data with this earlier evidence suggests that phonological difficulties in stuttering are not restricted to production (i.e. encoding) but can be also observed in decoding processes. Stuttering-like disfluencies may stem, at least partially, from a more general phonological deficit affecting both input and output processes. Further research comparing both types of processing is needed to determine the validity of this proposal.

This study has been conducted in Spanish, a language with clear syllabic boundaries. Of course, a limitation of the present study is that our results cannot be extrapolated to other languages. In this sense, cross-linguistic comparisons of effects are necessary. Another limitation that must be highlighted is that several criteria were used to select the stutterers in our experiment, including one with English norms. We adopted this procedure because no Spanish standardized methods were available and tehrefore we decided to select only children with moderate, and not mild, severity. Also related with the selection of stutterers, it is worth mentioning that the children who stutter have received between one and three sessions of therapy (breathing and relaxing procedures) at the moment of the experiment. We consider that this training should have no impact on the findings here reported. However, the effects of this relaxation training on the tasks completed in the study are unknown.

In this research, only a single task, lexical decision, was employed. Although it is generally assumed that this task engages those processes necessary for word reading, it would be useful to investigate if the same outcomes appear with other tasks related with reading. Similarly, in this experiment we manipulated syllable frequency only in the word stimuli, since we were mainly interested in the role of phonological processing in "real" reading by stutterers. However, it is also possible to manipulate syllable frequency in nonwords. Such a manipulation would isolate pure phonological/sublexical effects from effects arising from the lexical level.

Finally, we consider that the theoretical implications of our set of results add to the growing body of evidence (e.g., Au-Yeung & Howell, 2002; Au-Yeung, Howell, & Pilgrim, 1998; Perkins, Kent, & Curlee, 1991; Postma & Kolk, 1991) that phonological encoding might be a factor in an overall explanation of stuttering. Where this study extends previous finding is in supporting a more general phonological deficit that includes problems in decoding processes. This is the first study of its kind in Spanish and research already in progress will continue to shed light on the central and general phonological deficits apparent in stuttering.

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Appendix

Stimuli list employed in the experiment

Words

mira
mitad
área
tema
morir
mujer
poca
temor
poco
poder
tener
poner
saber
sala
tipo
salir
salud
señor
seres
serie
sitio
suyo
malo
mamá
toda
todo
matar
mayo
papel
toma
parar
tomar
pared
pasa
pasar
total
paso
pena
pero
peso
sola
solo
sólo
mirón
misil
sumo
tacón
mojar
momia
picar
tejas
polar
poro
tejer
posar
puñal
sabio
tibio
sana
sapo
saque
seda
seña
simio
sucio
mamut
maní
paje
pala
panel
paño
patín
pato
pava
pelar
pera
sobar
socio
soda
sodio
sofá
soñar
sopa
topar
tope
topo
toro
tono

Pseudowords

minel
mimú
tayo
terea
mosa
muca
pomio
tetad
pocio
pojer
tena
poñor
sado
sapar
ticón
samo
saso
sero
secio
serar
siño
suna
mapo
mapo
tola
tofá
mamia
mañal
payo
totar
palar
pada
tored
pama
pape
pamor
tola
pamar
petal
pelud
perie
soto
sora
sipa
mimut
mitio
sulo
taña
mora
mopo
pirir
telo
pores
pola
teder
poque
pulo
saro
tima
sajer
saso
sava
seco
sebio
siber
surón
malar
mada
paná
paner
pañar
padio
palir
pajas
pabio
pebar
peda
sosar
sopel
soner
soro
sosar
socar
sosil
toje
tojar
totín
torar