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Phonetic complexity and stuttering in Spanish

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Abstract

The current study investigated whether phonetic complexity affected stuttering rate for Spanish speakers. The speakers were assigned to three age groups (6-11, 12-17 and 18 years plus) that were similar to those used in an earlier study on English. The analysis was performed using Jakielski's (1998) Index of Phonetic Complexity (IPC) scheme in which each word is given an IPC score based on the number of complex attributes it includes for each of eight factors. Stuttering on function words for Spanish did not correlate with IPC score for any age group. This mirrors the finding for English that stuttering on these words is not affected by phonetic complexity. The IPC scores of content words correlated positively with stuttering rate for 6-11 year old and adult speakers. Comparison was made between the languages to establish whether or not experience with the factors determines the problem they pose for speakers (revealed by differences in stuttering rate). Evidence was obtained that four factors found to be important determinants of stuttering on content words in English for speakers aged 12 and above, also affected Spanish speakers. This occurred despite large differences in frequency of usage of these factors. It is concluded that phonetic factors affect stuttering rate irrespective of a speaker's experience with that factor.

Several linguistic factors have been found to increase the likelihood of a word being stuttered. The first investigation into this issue was conducted by Brown (1945) who worked on English-speaking adults who stutter. He found that words early in a sentence, words that started with consonantal sounds, long words and certain grammatical types of word were all more likely to be stuttered than other words. The words which had highest chance of being stuttered by adults were subsequently noted to come from the content word class, which includes nouns, main verbs, adverbs, and adjectives (Hartmann & Stork, 1972; Quirk, Greenbaum, Leech & Svartvik, 1985). The content word class is distinguished from the function word class, which consists of pronouns, articles, prepositions, conjunctions and auxiliary verbs (Hartmann & Stork, 1972; Quirk et al., 1985). Subsequent work has shown that long utterances (Logan, 2001) and phrases (Yaruss, 1999), low frequency words (Hubbard & Prins, 1994) and words that carry lexical stress (Wingate, 2002) also increase the chance of stuttering.

In contrast to what happens with adults, it has been well documented that stuttering in children occurs predominantly on function words (Bloodstein & Gantwerk, 1967; Bloodstein & Grossman, 1981; Howell, Au-Yeung & Sackin, 1999). An account of why different word classes are stuttered at different stages of development has been offered (Howell, 2002; Howell, 2004; Howell & Au-Yeung, 2002). According to this account, the underlying source of all stuttering is a complex nucleus in an utterance which takes a long time to plan relative to simpler surrounding material. If the nucleus is a content word,

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planning time for this word is limited when the words that precede it are executed rapidly (Howell, Au-Yeung & Pilgrim, 1999). This situation results in the plan of the word not being ready when it needs to be executed, so either the speaker has to delay speech output or start a word based on a part-plan. These two alternatives lead to different types of stuttering: One type involves pausing or repeating the simple words (usually function words) that were planned before the complex word (usually content word). This type predominates in childhood. The other type arises because the output of the complex word is commenced with its part plan. This results in stuttering that affects the first part of the complex (usually content) word such as prolongation, part-word repetition and word break. This type predominates from about teenage on. The implication of this account for the current work is that it emphasizes the need to assess how linguistic factors affect stuttering separately on function and content word classes.

Phonetic influences on stuttering in Spanish are examined in this report to see if they provide a measure of complexity within and between the function and content word classes. Two hypotheses are possible concerning what impact phonetic factors would have across languages. First, the effect of phonetic factors might vary across languages due to the amount of experience a speaker has with a particular factor (experiential hypothesis). This would predict that the factors that are complex in one language would be different from those that are complex in a second and that the order of complexity of the phonetic factors would depend on their frequency of usage across the languages. Second, phonetic factors might be inherently complex irrespective of variations in frequency of usage across languages (MacNeilage & Davis, 1990). This would predict that the factors that are complex in one language would be similar to those that are complex in a second and that the order with which phonetic factors affect stuttering would not be determined by differences in frequency of usage across the languages.

Two procedures have been used to examine phonetic influences on stuttering. The first was developed by Throneburg, Yairi and Paden (1994) to provide an indication of word complexity. They assessed words according to whether they contained developmentally late emerging consonants, LEC (derived from a list originating in the work of Sander, 1972), whether the word contained consonant strings, CS, and whether there was just one, or more than one, syllable in the word, MS. MS is a measure of word length rather than phonetic properties of words. Throneburg et al. (1994) found that these factors had no effect on stuttering in pre-school children. Howell, Au-Yeung and Sackin (2000) replicated this result with young children in an analysis in which function and content words were analyzed separately. However, older speakers (teenagers and adults) were affected by phonetic complexity, and the effects occurred specifically on the content words. These results are consistent with the view that younger speakers who stutter avoid stuttering on content words by repeating function words, whereas older speakers attempt the complex content words that are incompletely planned (Howell, 2002; Howell, 2004; Howell & Au-Yeung, 2002).

The phonetic factors CS and LEC vary in frequency of usage across Spanish and English. For Spanish speakers between 6 and 68 years of age, 10% of content words start with CS (4% fewer than in English) whereas 2% of function words do (1% more than in English). Nineteen percent of consonants at pre-initial vowel position in content words emerge late in linguistic development, using Sander's (1972) LEC list (15% fewer than in English) whereas this applies to 16% of function words (4% fewer than in English). CS and LEC show that there is less of a difference in frequency of usage of these factors between function and content words for Spanish than English. In contrast, the difference in frequency of usage of these factors between function and content words across age groups remains roughly constant within each language (both for normally fluent speakers and people who stutter).

This suggests that comparison across languages is an effective way of obtaining speech where the speakers have had different experience with phonetic factors.

Though CS and LEC differ in frequency of usage, a more comprehensive measure of phonetic complexity would be preferred to test the experiential/inherent complexity hypotheses more extensively. One such measure is Jakielski's (1998) “Index of Phonetic Complexity” (IPC). This was derived from MacNeilage and Davis's (1990) theory that babbling behavior has an influence on early phonetic development. Jakielski used observations about babbled speech to derive a set of eight factors where each factor was marked as easy or complex for a young child to produce, based on whether it had an attribute that occurred in babbling or not. The eight factors are summarized in Table 1. Words received a score of one each time the complex attribute occurred, otherwise no score was given for that factor. For the “consonant by place” factor, for example, labials, coronals and glottals are common in babbling and are thus regarded as easy. When consonants with these places occur, they receive an attribute score of zero. Dorsals are rare in babbled speech, thus are marked complex and get an attribute score of one point whenever they occur in a word. The IPC composite score is calculated by summing the scores on the eight separate factors.

Weiss and Jakielski (2001) examined whether the IPC score of words that were stuttered by young speakers (aged 6-11) was higher than that of words they spoke fluently. No effect was found. The earlier observations made by Howell, Au-Yeung and Sackin (2000) with respect to Throneburg et al.'s (1994) study suggest that the analysis ought to be done on older speakers and performed separately on function and content words. Howell, Au-Yeung, Yaruss and Eldridge (in press) analyzed the Howell Au-Yeung and Sackin (2000) data set and found that, for English, that there was a relationship between IPC score and stuttering rate for content words for teenage and adult speakers who stutter, but not for young speakers. Howell et al. (in press) also established which of the factors were important in the relationship between stuttering rate and phonetic complexity for English (the method used is described fully in the results section). They found the order of importance to be consonant by manner (most important), consonant by place, word length and contiguous consonants. Howell et al. (in press) also reported how frequently the IPC factors were used across age groups separately for function and content words.

The present study reports a similar analysis to that described above on English, for Spanish speakers who stutter. The influence of the eight IPC factors across age groups and word classes was determined, as in the study on English (Howell et al., in press). Frequency of occurrence of the eight factors for age group and word class is also reported. In the discussion, the results for Spanish are compared with those for English. The experiential hypothesis would be supported if complexity across languages (indicated by stuttering rate) relates to differences in frequency of usage of the IPC factors across languages. The inherent complexity hypothesis would be supported if stuttering rate across languages was similar irrespective of differences in frequency of usage of IPC factors.

Method

Participants

Thirty-five monolingual Spanish speakers participated in the study. They were all native speakers of Peninsular Spanish and were diagnosed by their speech pathologist as people who stutter. All stuttering was developmental. The participants did not report any other medical problems. Consent to participate was given by each speaker and, in the case of children, was also obtained from their parents. The speakers were recruited from speech clinics from various parts of Spain: Almeria, Cordoba, Granada, Madrid, Mallorca and

Santiago. The sources were private, school-based and university-based clinics. The age of the subjects ranged from 6 to 68 years; there were 6 females and 29 males. All speech samples were over 100 words and have over 3% stuttering rate. They were divided into three age groups roughly equivalent to those in Howell et al. (in press). The division at age eleven divides children who stutter predominantly on function words from those who shift to content words (Howell, Au-Yeung & Sackin, 1999). There were nineteen children in Group 1 (Gl) aged between 6 and 11 (mean age 8.5 years, SD of 2.0), seven teenagers aged between 11 and 17 (Group 2, G2, mean age 13.9 years, SD of 2.0) and nine adults aged 18 to 68 (Group 3, G3, mean age 39.3 years, SD of 15.4).

The recordings were usually conducted in a clinic although, for six participants, the recording had to be made in the speaker's home (indicated in Table 2). Age, gender, group assignment, stuttering rate, location in Spain, setting of recording (clinic or at home) and number of words in the sample are indicated for each individual participant in Table 2. One way ANOVA showed that there were no significant differences in stuttering rate between the three age groups ($F(2,32) = 1.03$, $p = .368$) (a Kruskal-Wallis test also showed no significant differences in stuttering rate, chi square(2) = 2.348, $p = .309$). The mean stuttering rate for Gl is 11.45% (SD 7.06), for G2 is 8.26% (SD 3.81%), and for G3 is 12.29% (SD 3.95%). The ratio of the percentage of function words stuttered to the percentage of content words stuttered is also given in Table 2. A ratio of more than one indicates a preponderance of stuttering on function words and a ratio of less than one a preponderance of stuttering on content words. The ratio was above one for all three groups, indicating that the speakers stuttered most frequently on function words at all ages. There was, however, a decrease in the relative usage of function word to content words stuttering (mean ratio of function words stuttered to content word stuttered dropped from 2.34 for Gl, to 1.61 for G2 to 1.52 for G3).

Recording and Transcription

Spontaneous conversational speech samples between the participant and his/her pathologist were obtained. The speech is characterized as “casual” in terms of Labov's (1978) stylistic continuum. The recordings lasted between two and 20 minutes depending on how long the participant talked on a given subject: The speech was transcribed by a native Spanish speaker who is a trained phonologist with nine years' experience in transcription. The material was transcribed using a broad phonetic transcription in fluent regions and a narrow system in the stuttered regions. Single word answers such as “yes” or “no” in response to occasional prompting questions were excluded from analysis. All remaining words were classified as function or content. All stutterings were marked which included segment, part-word, word and phrase repetitions, segmental and sound prolongations, extraneous sequences (mostly glottalic sounds involving stricture in the glottis), excessive aspiration and pauses longer than 100 ms. A second trained transcriber re-transcribed eight of the Spanish recordings selected at random to obtain inter-judge reliability measures. Agreement on word type was 95% (Cohen's Kappa = .90). Agreement on fluency was 97% (Cohen's Kappa = .93). These scores represent excellent levels of agreement. A check was also made by the two transcribers with respect to accuracy of transcription of each of the IPC factors. The IPC agreement levels are, for seven of the eight individual factors, 92.54%, 84.11%, 94.23%, (no agreement for factor 4), 84.21%, 93.92%, 85.06% and 90.26% respectively. IPC scores. Agreement for factor 4 was not computed as the first transcriber did not mark any rhotic vowels for any speaker. Fluent Spanish does not have rhotic vowels and this factors was dropped from subsequent analysis.

The eight IPC factors are given in Table 1. For factor 1, “consonant by place class”, every dorsal consonant in a word is given one point whilst no points are given for other consonants. For factor 2, “consonant by manner class”, every fricative, affricate and liquid

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consonant in a word is given one point, whereas no points are given to other consonants. Factor 3, "singleton consonants by place", takes into account inter-syllabic relationships. For words with "…VC-CV…" structure (where C stands for a consonant and V for a vowel) at syllable boundary position (singleton consonant on the coda followed by a single consonant onset) if the two consonants have different place classification, a point is given to that consonant pair. For factor 5, "word shape", each word that ends with a consonant is given one point. Under factor 6, "word length in syllables", a word with three or more syllables is given one point and words with one or two syllables are given no points. For factor 7, "contiguous consonants", each consonant string (cluster) is given one point irrespective of the syllable or word position the string occupies. For factor 8, "cluster by place", if the consonants from a cluster have different places of articulation, one additional point is given. Examples of function and content words with different numbers of IPC factors are given in Table 3.

Results

Comparison of the composite IPC scores for function and content words

Related t-tests on individual age groups showed that the IPC scores of content words were significantly higher than those of function words for all age groups (Gl, $\underline{n} = 19$, $\underline{t} = 18.87$, $\underline{p} < .001$; G2, $\underline{n} = 7$, $\underline{t} = 13.29$, $\underline{p} < .001$; G3, $\underline{n} = 9$, $\underline{t} = 9.94$, p > < .001). This is the same pattern as found in English except that more groups differed in Spanish (only the equivalents of G2 and G3 showed a difference in English).

For the content words, the difference between the IPC scores of stuttered and non-stuttered words was significant for G3 ($\underline{n} = 9$, $\underline{t} = 2.43$, $\underline{p} = .041$). Stuttered words had higher IPC scores than fluent words for G3. Howell et al. (in press) reported similar results for G2 as well as G3 English speakers.

The differences between IPC scores of stuttered and non-stuttered words were not significant for the function words in any age group. The same analysis on English by Howell et al. (in press) also showed no significant differences for any age group. IPC scores of individual subjects for stuttered and fluent words are given in Table 4.

What IPC factors affect stuttering in Spanish?

The next intention is to establish what factors operate in Spanish. The general procedure to establish what IPC factors operate and their order of importance was the same as that used by Howell et al. (in press). This involved analyzing the data as indicated in the following three steps:

- **a.** The words were sorted into different categories using their IPC score;
- **b.** Stuttering rate was calculated by obtaining number of stuttered words in each IPC score-category and dividing by the total number of words in the same category;
- **c.** Difference in stuttering rate over IPC scores was determined by analysis of covariance (ANCOVA). The ANCOVAs used stuttering rate for each category as the dependent variable, the IPC-score category as the independent variable and the stuttering rate for individual speakers as the covariate (to take out differences between participants in stuttering rate). The analysis was intended to establish where stuttering rate differed between IPC-score categories. Pearson product moment correlations of stuttering rate over IPC-score categories were also obtained. Each analysis was done separately on content and function words and for each age group.

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In the first analysis, all IPC factors were included to obtain the IPC-score category in order to establish a baseline against which analysis of selected factors could be compared. For the function words, there were not enough words for analysis of words with numerically high IPC scores after steps a) and b). Three categories (IPC score 0, 1 and 1+) were used for Gl and G2 and four IPC categories for G3 (IPC scores 0, 1, 2 and 2+). Stuttering rate did not differ significantly over IPC categories for any of the three age groups in the ANCOVA. No significant Pearson product moment correlation was obtained for any age group. The mean adjusted stuttering rates of function words for individual age groups are plotted, along with the content words in Figure 1. As there appears to be little relation for any age group between stuttering rate and IPC score for function words, analyses are not reported for these words.

In the analysis of the content words, Gl, G2 and G3 had sufficient data for IPC scores 0 to 4 and 4+. Though the ANCOVA showed no significant differences between IPC-score categories, the correlations between stuttering rate and IPC-scores (shown for all three groups in Figure 1) were significant for Gl ($r^2 = .73$, $p = .029$) and G3 ($r^2 = .86$, $p = .008$). The 95% confidence intervals at each IPC value of the content words are plotted in Figure 1 along with the results for the function words. The stuttering rates of function words are above those of the content words with corresponding IPC values for all points for Gl and G2 and for three of the four points in G3. From this it appears that high rates of function word repetition occur across a wider age range in Spanish than in English (in English, higher function word rates were only observed for Gl).

The next analysis examined whether selected factors improve the relationship between IPC score and stuttering rate. Steps a)-c) were conducted for the content words only, with one factor in the IPC dropped from the analysis in turn. The ANCOVA was inspected to see how significance between pairs with different IPC values was affected when each factor, in turn, was removed from calculation of the IPC-score. The logic behind the procedure is that if an IPC factor is important within the IPC scheme, the removal of it will affect the number of pairs that are significant. On the other hand, if a factor is redundant, the removal of it will not affect the predictive power of the scheme and, if it works against the IPC-stuttering rate relation, may even improve the number of significant differences between IPC pairs. The fitting procedure is iterative and the statistical parameter is used as an index of fit, not as repeats of a statistical test (Howell & Dworzynski, 2005).

For Gl, none of the analyses changed the results of the ANCOVA, so this age group was dropped from further analysis. For the other two age groups, the factors that hindered the predictive ability of IPC score on stuttering rates were removed from each age group.

The analysis indicated that factors 1, 2, 3, 5, 6, 8 (place, manner, singleton consonants by place, word shape, word length and cluster by place) should be retained for G2. The ANCOVA using IPC scores based on these factors alone showed a significant difference over IPC scores, $F(5,33) = 2.56$, $p = .046$. Post-hoc Tukey (alpha = .05) showed that the category 4+ is significantly higher than category 0 ($T = 3.3246$, $p = .0243$). The correlation between the mean adjusted stuttering rate and IPC score was improved, but did not quite achieve significance, $r^2 = .613$, $p = .066$. The relationship between stuttering rate and IPC score is shown in Figure 2.

For G3, the iterative analysis indicated that IPC factors 2, 3, 5, 6, 7 (manner, singleton consonant by place, word shape, word length and cluster by place) ought to be retained. The ANCOVA using these factors alone to compute IPC scores led to a significant difference over IPC scores, $F(5,45) = 3.60$, $p = .008$. Post-hoc Tukey (alpha = .05) showed that the category 4+ is significantly higher than category 0 ($T = 3.7242$, $p = .0068$); the category 4+

is significantly higher than category 1 ($T = 3.0910$, $p = .0376$) and the category 4+ is significantly higher than category 2 ($T = 2.9782$, $p = .0497$). The correlation between the mean adjusted stuttering rate and IPC score was significant, $r^2 = .829$, $p = .012$. The relationships between IPC score (using the selected factors) and stuttering rate for the three age groups are shown in Figure 2.

Rank order of the IPC factors

Steps a)-c) were conducted again using factors 1, 2, 3, 5, 6 and 8 for G2 and factors 2, 3, 5, 6 and 7 for G3, with one of these factors dropped in turn. The results were examined in the same manner as above to see how the fit was affected. In this instance, the procedure was conducted for rank ordering of the factors, not to determine whether to include the factor. Factors were put in order of importance based on how much they changed significance (the factor that led to the biggest reduction in significance was most important and so on). The order of importance of the IPC factors for G2 is: 1, 2, 5, 8, 6, 3 (place, manner, word shape, cluster by place, word length and singleton consonant by place), and for G3, 2, 3, 7, 5, 6 (manner, singleton consonant by place, contiguous consonants, word shape and word length).

Phonetic complexity of Spanish compared with English

The English material used for comparison with the Spanish material was collected in a similar manner to the Spanish (the English material was also used in Howell et al., in press which contains a full description). Next comparisons were made between the phonetic properties of Spanish and English using the IPC scores.

Four comparisons were made across languages using material selected to be equivalent from each language and each of the analyses was made across age groups. Thus, in each analysis the data were analyzed by a two-way ANOVA with factors language (English versus Spanish) and age group (Gl, G2 and G3).

The first analysis compared composite IPC scores between stuttered content words in Spanish and stuttered content words in English. The two-way ANOVA showed a significant difference only for age group, $F(2,71) = 3.94$, $p = .024$. Post-hoc Tukey test (alpha = .05) showed a near significant difference ($T = 2.366$, $p = .0534$) between Gl and G3 with G3 higher than Gl. This suggests that the oldest speakers stuttered on phonetically more complex content words than the youngest speakers, and this did not depend on the speaker's language. If the transition to the adult pattern of stuttering had been complete by teenage, G2 should have differed with respect to the children as well. The fact that it did not, suggests that the transition to stuttering on content words is complete at an older age in Spanish speakers who stutter. Alternatively, the difference may be more difficult to detect statistically in Spanish as the transition is gradual (in both languages) and the Spanish speakers have higher rates of function word stuttering at all age groups (Figure 1) than the English speakers.

The second analysis compared composite IPC scores of non-stuttered content words between Spanish and English using an ANOVA with age group and language as factors. No effects were significant.

The third analysis compared composite IPC scores between stuttered function words in Spanish and similar material in English. A two-way ANOVA with factors age and language group (as previously) showed a significant effect for languages, $F(l,71) = 31.81$, $p < .001$. A post-hoc Tukey test (alpha = .05) showed that English stuttered function words have higher IPC scores than their Spanish counterparts ($T = 5.640$, $p < .001$) suggesting that Spanish function words are simpler than English function words (which may explain the high frequency of usage of function word stutterings in all age groups). The Throneburg et al. (1994) analysis on CS and LEC factors suggested that Spanish function words would be more complex than English function words. English function words appear, then, to be more complex with respect to the more extensive set of IPC factors even though they are not for CS and LEC.

The fourth analysis compared the IPC scores of non-stuttered function words in Spanish with those in English, again using a two-way ANOVA with age and language group as factors. The effect of languages was significant, $F(1,71) = 47.45$, $p < .001$. A post-hoc Tukey test (alpha = .05) showed that English non-stuttered function words have a higher IPC score than their Spanish counterparts ($T = 6.888$, $p < .001$). Once again English function words appear more complex with respect to the extra IPC factors over and above Throneburg et al.'s (1994) CS and LEC factors.

From these analyses, one difference that emerges is that function words in English have higher IPC scores than those in Spanish and this applies when only stuttered or only non-stuttered function words are considered. The second difference occurred between age groups on the IPC score of content words. This selection of words had higher IPC scores in the adult age group (G3) which, taken in conjunction with the results from English, suggests that the adults who spoke either language experienced particular difficulty with phonetically complex content words.

As outlined in the introduction, it was intended to examine the relationship between the factors that affect stuttering rate in the different languages and their frequencies of occurrence across the languages. IPC factors affect stuttering rate on content words for G2 and G3 in English and for G3 in Spanish. The analyses reported here are comparisons between languages for frequency of occurrence of each individual IPC factor for G2 and G3. Furthermore, the analyses reported are for occurrence of the factor in all words (not either content or function words). Analysis was done for G2 and G3 (but not G1) as only these age groups are affected by phonetic complexity in at least one of the languages. Occurrence in all words revealed a better relationship with factors affecting stuttering than content words alone. Frequency of occurrence (percentage of words having that factor for words in the selected group) was calculated for content words, function words and all words for each subject. The mean and standard deviation over subjects in each age group (including Gl) and for all speakers irrespective of age are given for each factor and for content, function and all words in Table 5.

Inspection of the table suggests that factors occur at roughly constant rates across age groups for each language, that some factors are rare in both languages (factors 3 and 4, in particular) and that there are marked differences between languages in factor occurrence (this is most marked for factor 5).

Two-way ANOVAs were conducted for each IPC factor (excluding the rhotic vowel factor which, as noted earlier, was absent in Spanish) in which the two factors were age group (two levels, G2 and G3) and language (Spanish versus English). The main effect of language was significant for factors 1, consonant by place ($F(1,38) = 19.22$, $p < .001$), 5, word shape ($F(1, 38) = 314.03$, p <001), 6, word length ($F(1,38) = 223.73$, $p > .001$), 7, contiguous consonants ($F(1,38) = 8.68$, $p = .005$) and 8, cluster by place ($F(1,38) = 4.25$, $p = .046$). Age was not significant as a main effect for any age group. Language interacted with age for factors 1, place ($F(1,38) = 4.79$, $p = .035$) and 6, word length ($F(1,38) = 12.14$, $p < .001$). These interactions are not discussed further as the absence of an age main effect makes their interpretation problematic.

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Discussion

Generally speaking, composite IPC scores using all factors for the Spanish data show similar results to English (Howell et al., in press). The points of similarity (and minor differences) are as follows. First, overall IPC scores of content words were higher than those of function words for all age groups, as had been found in English by Howell et al. (in press). Thus in both languages content words (overall) are more complex than function words. Second, the IPC scores of stuttered words were significantly higher than the non-stuttered words for G3 in Spanish. For English it was found that the difference for teenage speakers (G2) as well as G3 was also significant. For the groups where the difference was significant, stuttered words were more complex (higher IPC scores) than non-stuttered words. Third, the IPC scores of stuttered and non-stuttered function words did not differ for any age group in Spanish (as was also found in English). Thus, stuttering on function words does not appear to be triggered by phonetic complexity.

A set of four analyses was conducted, using composite IPC scores, to compare the phonetic properties of Spanish and English over age groups. First, stuttered content words did not have different IPC scores between Spanish and English though there was a difference over age groups. Post hoc tests showed stuttered IPC scores were higher for speakers in the G3 age group. Second, non-stuttered content words showed no significant differences between Spanish and English. Third, the IPC scores of stuttered function words differed across languages, being higher in English than in Spanish. Fourth, this same result was found for non-stuttered function words.

No relationship between IPC score and stuttering rate occurred for function words in any age group or for content words in G1. These findings are consistent with the view, outlined in the introduction, that stuttering on function words is a stalling type of behavior and, as such, not determined by phonetic complexity (Howell, 2002; Howell, 2004; Howell & Au-Yeung, 2002). The results also support the view that young speakers adopt this strategy to avoid problems on content words.

The order of importance of individual IPC factors was then established for content words for G2 and G3 for Spanish. The factors in order of importance were 1, 2, 5, 8, 6, 3 (place, manner, word shape, cluster by place, word length and singleton consonant by place) for G2 and, 2, 3, 7, 5, 6 for G3 (manner, singleton consonant by place, contiguous consonants, word shape and word length). Similar analyses in English led to an ordering of 2, 1, 6 and 7 (manner, consonant by place, word length and contiguous consonants) over both age groups.

Frequency of occurrence of each of the IPC factors in all words was next compared across Spanish and English for G2 and G3. Only the main effects between the languages for certain of the factors were significant. IPC factors 1 (consonant place) and 6 (word length) occurred significantly more frequently in Spanish than English, while IPC factors 5 (word shape), 7 (contiguous consonants) and 8 (cluster by place) occurred significantly less frequently in Spanish than English. The frequency imbalance between languages was in the same direction for the content words alone, except for factor 1 (consonant place). It occurred slightly, but not significantly, more often in English (for G2, 27.47% in Spanish and 31.3% in English and for G3, 25.22% Spanish and 27.14% English).

The information about which individual IPC factors were important and their corresponding frequency of occurrence are integrated in Table 6. Together, these provide a basis on which to see whether the experiential, or the inherent difficulty, hypothesis is supported. The seven IPC factors that are used in English and Spanish are listed in the top line of the upper section and the rows give the language-by-age group (e.g. Spanish G2). The IPC factor number is entered in a cell when it improved prediction, otherwise the cell is left empty. Only factors

1, 2, 6 and 7 (consonant by place, manner, word length and contiguous consonants) appear for at least three of the four language-by-age groups. Frequency of occurrence for all seven factors (numbered along the top) are given in the bottom part with results for G2 then G3. For each age group, frequency of occurrence for Spanish and English are given in rows one and two and the signed difference in row three. Factors 1, 2, 6 and 7 differ widely in usage. This ranges from factor 7 (contiguous consonants) which is used 9.47% less in Spanish than English for G2, to factor 6 (word length) which is used 13.97% more in Spanish than in English. Despite these big differences in frequency of usage, the four principal factors appear to operate consistently across language and age groups. Experience does not seem to affect whether these factors appear or not and the inherent difficulty explanation appears to be favored for these factors. It is also of note that the two factors from the principal four that showed the biggest differences in frequency of usage, are similar to Throneburg et al.'s (1994) CS and MS.

Factors 3 and 5 (consonant by place, word shape) were never significant in English, but were significant for both age groups in Spanish. Factor 3 occurred infrequently in both languages and in both age groups (around 2% of words were marked for this factor). Thus frequency of occurrence per se does not account for why this factor specifically affects Spanish. Factor 5 may require further refinement before firm conclusions can be drawn: First, Spanish has a larger number of final open syllables than English, and a more restricted set of possible word final consonants. Thus, its use in capturing details of Spanish (before or after refinement) would be restricted. Second, the IPC scheme defines this factor as ending in a consonant (difficult) versus a vowel (easy). For English, this can be a feature of word ending (as in the examples “go”/”goat”) or word-level inflectional morphology (as in “bee”/ ‘bees”). Further refinement of schemes that distinguish word final characteristics is needed. Further work is also required in which word retrieval time is dissociated from word final phonological factors and the impact of each on stuttering rate. Additional work is needed to improve the metrics such as that for contiguous consonants (factor 7).

From a clinical point of view, the results highlight the need to be aware of factors that specifically affect Spanish or English when dealing with a client. At the same time more work is needed to establish the impact of a second language (in particular where frequency of usage influences cross between languages). Also, examination of other languages is recommended, in particular those that have different frequency of usage of IPC factors to those in English and Spanish. With the growing evidence of effects of phonetic factors in adulthood (Howell et al., 2000; Howell et al., in press), metrics appropriate to adult forms of language outside the restricted babbling set is also advisable. Finally, these analyses have been conducted on spontaneous speech samples and, although this allows naturalistic data appropriate to language level to be obtained, it does not allow control of all aspects of the material (use of particular words where word frequency and other factors are controlled). Future work will need to examine the role of factors such as word frequency in spontaneous utterances.

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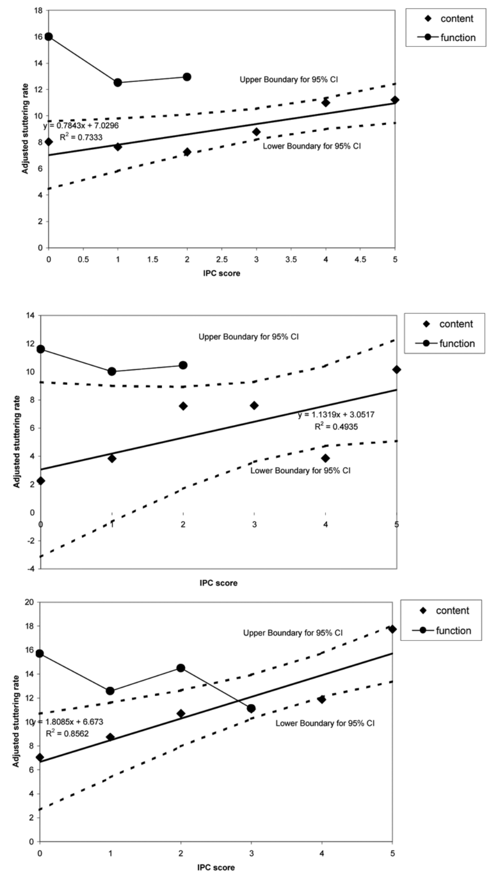

Figure 1.
Adjusted stuttering rate (ordinate) versus IPC score (abscissa) for the eight-factor IPC analysis for each separate age group (G1, top, G2, middle, G3 bottom). Content (diamonds) and function (circle) words are indicated separately. The straight line is fitted to the content words and the upper and lower bounds around this line are indicated by the dashed line. The function word points are connected by a solid line.

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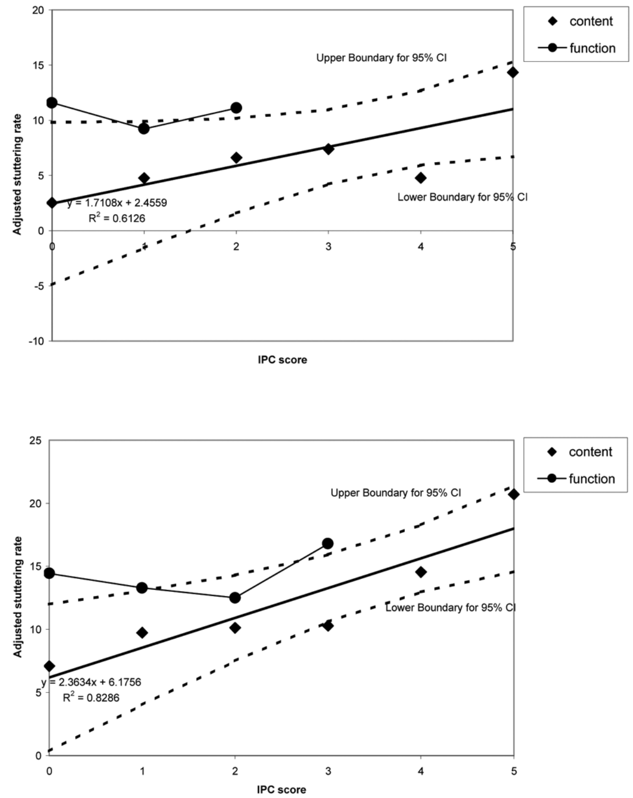

Figure 2.
Adjusted stuttering rate (ordinate) versus IPC score (abscissa) for the four-factor IPC analysis for each separate age group (G1, top, G2, middle, G3 bottom). Content (diamonds) and function (circle) words are indicated separately. The straight line is fitted to the content words and the upper and lower bounds around this line are indicated by the dashed line. The function word points are connected by a solid line.

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Table 1

IPC scoring scheme.

Factor	No Score	One point each
1. Consonant by Place	Labials, coronals, glottals	Dorsals
2. Consonant by Manner	Stops, nasals, glides	Fricatives, affricates, liquids
3. Singleton Consonants by Place	Reduplicated	Variegated
4. Vowel by Class	Monophthongs, diphthongs	Rhotics
5. Word shape	Ends with a vowel	Ends with a consonant
6. Word Length (Syllables)	Monosyllables, disyllables	>=3 syllables
7. Contiguous Consonants	No Clusters	Consonant Clusters
8. Cluster by Place	Homorganic	Heterorganic

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Table 2

Details of speakers (numbered in column 1, Y1 stands for the youngest speaker in G1, T1 for the youngest speaker in G2 and A1 for the youngest adult in G3 etc.) age (given in column 2 in years), Gender (Gen, column 3), Stuttering rate in the sample (SRate, column 4), recording setting (column 5), number of words in the speech sample (column 6) and the ratio of percentage of function words that are stuttered to the ratio of content words that are stuttered (Ratio, column 7).

Speaker	Age	Gen	SRate	Setting	Number of words	Ratio
Y1	6	F	4.78	Clinic	209	2.98
Y2	6	M	21.09	Clinic	294	0.40
Y3	6	M	4.74	Clinic	232	2.00
Y4	6	M	16.51	Clinic	642	1.65
Y5	6	M	13.38	Clinic	553	2.61
Y6	7	M	5.97	Clinic	486	1.91
Y7	7	M	19.60	Clinic	250	5.65
Y8	7	F	8.61	Clinic	697	4.14
Y9	9	M	3.95	Clinic	1012	1.54
Y10	9	M	28.02	Clinic	257	2.86
Y11	9	F	11.06	Clinic	479	2.12
Y12	10	M	5.24	Clinic	649	2.56
Y13	10	M	18.28	Clinic	241	2.80
Y14	10	M	15.28	Clinic	373	1.04
Y15	10	M	12.00	Clinic	500	3.06
Y16	10	F	14.66	Home	614	2.00
Y17	11	M	3.71	Clinic	917	2.71
Y18	11	M	6.96	Clinic	992	0.94
Y19	11	M	3.78	Clinic	821	1.45
					Mean 11.45%	2.34
					SD 7.06%	
T1	12	M	9.82	Clinic	397	1.56
T2	12	M	5.67	Clinic	759	3.26
T3	13	M	4.79	Clinic	355	1.09

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Speaker	Age	Gen	SRate	Setting	Number of words	Ratio
T4	13	M	8.75	Clinic	560	1.26
T5	14	M	13.87	Clinic	476	0.89
T6	16	M	3.40	Clinic	1175	1.79
T7	17	M	11.50	Clinic	200	1.39
					Mean 8.26%	1.61
					SD 3.81%	
A1	20	M	14.16	Clinic	339	1.67
A2	25	M	14.15	Clinic	509	2.32
A3	25	M	8.68	Clinic	288	1.65
A4	36	M	19.57	Home	787	0.39
A5	38	M	13.59	Home	2039	1.10
A6	40	M	13.48	Home	1506	2.00
A7	50	M	12.07	Clinic	1409	0.35
A8	52	F	8.51	Home	1940	2.27
A9	68	F	6.42	Home	2866	2.01
					Mean 12.29%	1.52
					SD 3.95%	

Table 3

Examples of content (top section) and function (bottom section) words that vary in number of IPC factors [number of IPC factors given in parentheses].

π◆ φεσϕ νˈ Θλ	[9]
π◆ε⊗ˈ ΥντΘσ	[8]
π◆ΙνΤˈ Ιπϕ	[7]
τ◆ΘΒˈ Θξ	[6]
Θ β λ Θ ζ	[5]
κ ω ε σ τ Θ	[4]
εσˈ Θμεν	[3]
νΥμεx◆	[2]
μΥτΣ	[1]
μ Ιˈ τ Θ	[0]
κ ω Θ ν Δ	[4]
λ Θ ζ	[3]
ε λ	[2]
ε ◆ Θ	[1]
μ ε	[1]

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Table 4

IPC score for all words.

Age	Fluent	Stuttered	Age	Fluent	Stuttered	Age	Fluent	Stuttered
S1	1.97	1.50	S20	1.47	0.84	S27	2.02	1.69
S2	1.41	1.36	S21	1.50	1.02	S28	2.26	1.59
S3	1.67	1.46	S22	1.85	2.20*	S29	1.14	1.52*
S4	1.84	1.33	S23	1.62	1.88*	S30	1.78	2.71*
S5	1.94	1.35	S24	1.83	2.52*	S31	1.45	1.63*
S6	1.80	1.71	S25	1.27	1.30*	S32	1.28	0.97
S7	1.59	1.00	S26	1.20	1.30*	S33	1.92	3.20*
S8	1.55	1.14				S34	1.39	1.07
S9	1.23	1.22				S35	1.06	1.21*
S10	1.71	1.41						
S11	1.29	1.05						
S12	1.49	1.10						
S13	1.53	1.03						
S14	1.59	2.18*						
S15	1.54	0.90						
S16	1.48	1.52*						
S17	1.46	0.84						
S18	1.58	2.30*						
S19	1.72	1.68						

* (denotes higher IPC score for stuttered than fluent words)

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Table 5

Mean percentage of word (over subjects) and standard deviation of each of the eight IPC factors occurred in all words of the indicated word class (content, function or all words). The data are shown separately for each age group (indicated in the left-hand column) and the results for Spanish are given in the top section and English (from Howell et al., in press) in the bottom section.

Spanish									
Age	**Word**	**Factor1**	**Factor2**	**Factor3**	**Factor4**	**Factor5**	**Factor6**	**Factor7**	**Factor8**
G1	Content	27.88% (4.62%)	74.18% (8.47%)	3.22% (2.14%)	0.00% (0.00%)	19.15% (12.56%)	29.38% (4.74%)	25.37% (9.00%)	12.26% (4.29%)
	Function	15.30% (5.76%)	38.15% (6.61%)	1.33% (1.30%)	0.00% (0.00%)	19.97% (5.74%)	2.16% (2.73%)	3.36% (2.65%)	0.94% (1.10%)
	All words	21.38% (4.03%)	55.16% (5.96%)	2.18% (1.06%)	0.00% (0.00%)	19.50% (8.36%)	14.93% (2.99%)	13.62% (4.73%)	6.18% (2.05%)
G2	Content	27.47% (10.97%)	78.12% (6.97%)	2.67% (1.48%)	0.00% (0.00%)	9.90% (7.17%)	33.16% (5.74%)	25.09% (8.50%)	12.81% (4.61%)
	Function	10.27% (3.32%)	36.83% (10.56%)	1.34% (0.93%)	0.00% (0.00%)	21.21% (9.98%)	2.98% (3.70%)	2.65% (2.82%)	0.48% (0.62%)
	All words	18.73% (5.13%)	57.08% (7.28%)	1.99% (0.85%)	0.00% (0.00%)	15.61% (7.87%)	17.80% (2.82%)	13.60% (5.56%)	6.54% (2.61%)
G3	Content	25.22% (6.90%)	73.09% (8.86%)	3.54% (2.79%)	0.00% (0.00%)	22.95% (16.36%)	30.08% (6.84%)	26.85% (9.66%)	14.43% (5.15%)
	Function	17.99% (2.02%)	42.44% (8.52%)	2.32% (1.49%)	0.00% (0.00%)	22.76% (11.03%)	2.12% (1.26%)	6.53% (7.20%)	1.12% (1.02%)
	All words	21.15% (3.06%)	56.37% (6.90%)	2.82% (1.29%)	0.00% (0.00%)	22.73% (13.29%)	14.72% (3.20%)	15.72% (7.49%)	7.15% (2.88%)
All	Content	27.11% (6.71%)	74.69% (8.27%)	3.19% (2.18%)	0.00% (0.00%)	18.28% (13.27%)	30.32% (5.56%)	25.69% (8.84%)	12.93% (4.54%)
	Function	14.99% (5.24%)	38.99% (8.03%)	1.59% (1.33%)	0.00% (0.00%)	20.94% (8.07%)	2.31% (2.62%)	4.03% (4.43%)	0.89% (1.00%)
	All words	20.79% (4.07%)	55.85% (6.32%)	2.31% (1.10%)	0.00% (0.00%)	19.55% (9.76%)	15.45% (3.16%)	14.16% (5.60%)	6.50% (2.36%)

English									
Age	**Word**	**Factor1**	**Factor2**	**Factor3**	**Factor4**	**Factor5**	**Factor6**	**Factor7**	**Factor8**
G1	Content	25.50% (5.50%)	65.09% (6.61%)	3.04% (1.62%)	0.46% (0.78%)	68.45% (8.30%)	4.92% (1.50%)	30.48% (6.37%)	16.40% (4.30%)
	Function	4.89% (4.07%)	40.74% (10.32%)	0.72% (0.86%)	0.56% (0.74%)	56.07% (4.70%)	0.71% (0.90%)	14.41% (5.85%)	1.37% (1.18%)

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English									
Age	**Word**	**Factor1**	**Factor2**	**Factor3**	**Factor4**	**Factor5**	**Factor6**	**Factor7**	**Factor8**
	All words	15.04% (3.03%)	52.60% (5.55%)	1.88% (1.09%)	0.51% (0.49%)	62.07% (4.55%)	2.78% (0.84%)	22.01% (4.29%)	8.59% (1.95%)
G2	Content	31.30% (5.42%)	66.59% (7.78%)	4.74% (2.27%)	0.25% (0.64%)	72.44% (8.69%)	7.76% (3.12%)	31.74% (7.45%)	17.00% (4.72%)
	Function	2.98% (2.11%)	40.95% (8.15%)	0.46% (0.63%)	0.52% (1.17%)	56.91% (6.74%)	0.50% (0.99%)	15.53% (4.54%)	0.99% (0.84%)
	All words	16.35% (3.52%)	53.20% (5.13%)	2.45% (1.04%)	0.42% (0.76%)	64.22% (5.23%)	3.97% (1.64%)	23.07% (4.62%)	8.54% (2.48%)
G3	Content	27.14% (3.44%)	73.00% (4.97%)	4.48% (1.58%)	1.08% (0.51%)	70.20% (3.48%)	12.62% (4.15%)	34.53% (3.89%)	16.41% (2.81%)
	Function	3.40% (0.84%)	41.90% (3.57%)	0.53% (0.42%)	1.28% (0.71%)	55.86% (3.88%)	0.72% (0.38%)	8.29% (2.64%)	1.90% (1.31%)
	All words	14.01% (1.21%)	55.93% (3.24%)	2.30% (0.68%)	1.20% (0.54%)	62.31% (2.70%)	6.11% (1.98%)	20.06% (2.69%)	8.40% (1.73%)
All	Content	28.10% (5.59%)	67.54% (7.32%)	4.03% (2.01%)	0.53% (0.73%)	70.39% (7.65%)	7.84% (4.13%)	31.92% (6.42%)	16.63% (4.14%)
	Function	3.81% (2.93%)	41.10% (8.14%)	0.58% (0.64%)	0.72% (0.96%)	56.34% (5.31%)	0.63% (0.84%)	13.38% (5.49%)	1.35% (1.13%)
	All words	15.29% (3.01%)	53.62% (5.00%)	2.20% (1.00%)	0.64% (0.68%)	62.94% (4.50%)	4.03% (1.94%)	21.95% (4.18%)	8.52% (2.08%)

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Table 6

The top section indicates which factors improved the stuttering rate-IPC score relationship. All factors that appear in either language or either age group are listed in the top row and age groups in the left column. Cells where the number is included indicate whether the analysis indicates that factor is important for each language and age group. The bottom section indicates the frequency of occurrence of the difficult attribute of each factor as percentage occurrence out of all words for corresponding age groups in Spanish and English and the signed difference (diff.) in frequency of usage.

	1	2	3	5	6	7	8
Factor patterns							
Spanish G2	1	2	3	5	6		8
Spanish G3		2	3	5	6	7	
English G2	1	2			6	7	
English G3	1	2			6	7	

All words								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
G2								
Spanish	18.73	57.08	1.99	0	15.65	17.80	13.60	6.54
English	16.35	53.20	2.45	0.42	64.22	3.97	23.07	8.54
Signed diff.	1.38	3.28	−0.46	−0.42	−48.57	13.97	−9.47	−2.00
G3								
Spanish	21.15	56.37	2.82	0	22.73	14.72	15.72	7.15
English	14.01	55.93	2.30	1.20	62.31	6.11	20.06	8.40
Signed diff.	7.14	0.44	0.52	−1.20	−39.58	8.61	−4.34	−1.25