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Comparison of two ways of defining phonological words for assessing stuttering pattern changes with age in Spanish speakers who stutter

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Abstract

Phonological words (PWs) are defined as having a single word that acts as a nucleus and an optional number of function words preceding and following that act as satellites. Content and function words are one way of specifying the nucleus and satellites of PW. PW, defined in this way, have been found useful in the characterization of patterns of disfluency over ages for both English and Spanish speakers who stutter. Since content words carry stress in English, PWs segmented using content words as the nucleus would correspond to a large extent with PWs segmented that use a stressed word as the nucleus. This correlation between word type and stress does not apply to the same extent in Spanish. Samples of Spanish from speakers of different ages were segmented into PWs using a stressed, rather than a content, word as the nucleus and unstressed, rather than function, words as satellites. PWs were partitioned into those that were common to the two segmentation methods (common set) and those that differed (different set). There were two separate segmentations when PWs differed, those appropriate to content word nuclei, and those appropriate to stressed word nuclei. The two types of segmentation on the different set were analyzed separately to see whether one, both or neither method led to similar patterns of disfluency to those reported when content words were used as nuclei in English and Spanish. Generally speaking, the patterns of stuttering in PW found in English applied to all three analyses (common and the two on the different set) in Spanish. Thus, neither segmentation method showed a marked superiority in predicting the patterns of disfluency over age groups for the different set of Spanish data. It is argued that stressed or content word status can lead to a word being a nucleus and that there may be other factors (e.g. speech rate) that underlie stressed words and content words that affect the words around these PW nuclei in a similar way.

Keywords

Development stuttering; Spanish; metrical influences on disfluency; lexical influences on disfluency; EXPLAN theory

Introduction

Function words are pronouns, articles, prepositions, conjunctions and auxiliary verbs and content words are nouns, main verbs, adverbs, and adjectives (Hartmann and Stork, 1972; Quirk, Greenbaum, Leech and Svartvik, 1985). Early observations suggested that young people who stutter are more likely to be disfluent on function than content words

(Bloodstein and Gantwerk, 1967; Bloodstein and Grossman, 1981). Adults who stutter, in contrast, have more problems on content words (Brown, 1945). These different characteristics may signal a change from an early to a persistent form of stuttering. The change to a persistent form of stuttering is also associated with a change from whole- to part-word disfluencies (Conture, 1990).

Howell, Au-Yeung and Sackin (1999) examined spontaneous speech in an attempt to establish the processes behind the age-dependent changes in stuttering on different word types and the forms of disfluency that ensue. The unit they used for analysis was the phonological word (PW) introduced to the study of stuttering by Au-Yeung, Howell and Pilgrim (1998) (see also Hall, 1999 for a general review of work using phonological words or, as they are sometimes called, prosodic words). The original definition used by Au-Yeung et al (based on the work of Selkirk, 1984), maintained a PW consists of a content word with function words acting as prefixes and suffixes. In general, all PW have a nucleus (the content word in the original Au-Yeung et al. (1998) scheme). Non-nuclear words are satellites (function words in the original scheme). The satellites are associated with a particular nucleus by semantic sense unit rules. An example of a PW would be 'I split it' which starts with an initial function word ('I') that acts as a satellite, the content word 'split' that is the nucleus and ends with the function word 'it' which is also a satellite to the function word.

It was assumed in Howell et al.'s (1999) original work on English, that the PWs were useful for two purposes. First, they specify that the nucleus (in their case, the content word) is the source of speech control problems in speakers of all ages. Content words in English are linguistically more complex than function words. Some of the known linguistic characteristics associated with stuttering, that mainly affect difficulty of content words, are the phone a word starts with (Brown, 1945), word length (Brown, 1945), word frequency (Hubbard and Prins, 1994) and lexical stress (Wingate, 1979). The higher linguistic complexity of content words would increase the processing time needed compared to function words. If speech is generated left to right, a speaker would prepare and execute 'I' in a PW like 'I split it' rapidly. Since 'split' is complex, it would take more processing time and this potentially leads to the content word not being ready in time for production. The effects of the linguistic determinants are apparent only in adults who stutter as these are the only speakers who have overt problems with this class of word (Bloodstein and Gantwerk, 1967; Bloodstein and Grossman, 1981).

The second role of PW is that the incidence and type of disfluencies within this unit depend on where a word is positioned relative to the nucleus. Several previous studies have shown stuttering is affected by the context words occur in. Units that have been investigated include utterances, sentences, clauses and phrases (Brown, 1945; Logan, 2001; Silverman and Bernstein Ratner, 1997; Yaruss, 1999). All these segmental units indicate which contexts are difficult but do not give details about which locations in the unit are most prone to disfluency and why there is variation in the type of disfluency in different positions in these units. Specification of the nucleus as the source of the problem for PW-segmentation, allowed two important stuttering patterns to be identified. The first was serial position effects in PW (Au-Yeung et al., 1998). These authors demonstrated that function words (but not content words except in speakers aged 3 – 7) in early positions in PWs had higher percentages of disfluency than those in later positions (percentage function word disfluency is number of these words that are disfluent out of all such words $\times$ 100). They also showed that function words that preceded a content word had higher percentages of disfluency than those that followed the content word. These position effects were explained on the assumption that disfluency on function words that occur in pre-content position in PW serves the role of delaying the time at which the content word is produced (the speaker

produces 'I I I split it' where repetition of 'I' delays the attempt at 'split'). The role of function word repetition could be to obtain more time to get the problematic content word ready for output.

The second stuttering pattern revealed when PW are used is age-dependent. Howell et al. (1999) looked at the relation between disfluency on function words that preceded the content word and disfluency on the content word itself in PW and how this changed over age groups. Disfluency percentages on function words decreased as speakers got older and, correspondingly, content word disfluencies increased (referred to as an 'exchange relation' by Howell et al., 1999). Howell et al. (1999) explained the change over age groups as reflecting different ways of tackling difficulty on content word nuclei. Young people who stutter, repeat or hesitate prior to a content word to complete its preparation as in the 'I I I split it' example (Au-Yeung et al., 1998). Older speakers who stutter attempt content words before they are completely ready, producing utterances such as 'I sssplit it'. Thus, the content word nucleus is the problem at all ages but the way the speakers respond to the underlying problem, changes as they get older. Similar age-dependent changes have been found for Spanish (Au-Yeung, Vallejo Gomez and Howell, 2003) and German (Dworzynski, Howell, Au-Yeung and Rommel, 2004).

All previous studies on exchange relations have used content words to specify the nucleus (Au-Yeung et al., 2003; Dworzynski et al., 2004; Howell et al., 1999). It is not clear whether the exchange of one type of disfluency for another, is due to some inherent property of content words or some property that, though it occurs more often in content words, can be dissociated from this class of words (Brown, 1945; Hubbard and Prins, 1994; Wingate, 1979). For instance, lexical stress is carried on content words in English, so either or both factor/s may operate on the nucleus and lead to it being difficult to produce. Whether content words, stressed words or some other property is the appropriate characterization for the nucleus is examined in this article using Spanish. Stress can be dissociated, to some extent, from lexical word type (function or content) in this language, as function words as well as content words can be stressed. Examples of Spanish function words that can carry primary word stress are *tú* (you) and *qué* (how). The dissociation of lexical word type from stress allows a PW to have a nucleus other than a content word.

The issue whether stuttering patterns occur when stressed words, content words or both are used as nuclei is important for practical and theoretical reasons: Practically, for example, stuttering on content words has been proposed as a diagnostic criterion for stuttering (Conture, 1990). If stress mediates such stuttering, analyses based on content words would be appropriate for English and German but not so readily for a language like Spanish where stress occurs on function words. At a theoretical level, models that emphasise stress rather than content words as the locus of stuttering (e.g. Wingate, 1984) would be supported if stuttering patterns in PW that use non-stressed content words as nuclei were less clear than those that use stressed words (content or function) as nuclei.

The current study employed monolingual Spanish speakers (from various parts of Spain) who stutter. Samples of the speech of these participants were used to see if employing content or stressed words as nuclei of PW leads to serial position effects on satellites (Au-Yeung et al., 1998) and exchange relations over age groups (Howell et al., 1999). The results will indicate what specification of nucleus is appropriate (word class, stress or both) by showing which gives the same pattern of disfluency as reported for English. Similar patterns to those in English when just content words, just stressed words or either are used as nuclei would suggest, respectively, lexical, metrical or some factor common to word class and stress (such as speech rate) governs fluency failure in PW.

Method

Participants

The speech of 46 monolingual native speakers of Peninsular Spanish was used (this is the same material as used in the exchange analysis of Au-Yeung et al., 2003). They were all diagnosed by their speech therapists as people who stutter but did not have any other speech or hearing problem. Consent to participate was given by each participant and, in the case of children, consent was also obtained from their parents. The majority of participants were recruited from speech clinics (the exceptions are indicated below). They lived in Almeria, Cordoba, Granada, Madrid, Mallorca and Santiago. They were aged between 3 and 68 years and there were 10 females and 36 males. The participants were divided into five age groups (G1 – G5) in the following ranges: G1: 3 – 5 years ($n = 7$, three male, four female), G2: 6 – 9 years ($n = 11$, eight male, three female), G3: 10 – 11 years ($n = 10$, nine males, one female who was recorded in her own home), G4: 12 – 16 years ($n = 9$, all nine male) and G5: 20 – 68 years ($n = 9$, three out of seven males and both the females were recorded in their own homes). Mean age and SD, mean disfluency percentage (per cent of words disfluent out of all words) and SD for each age group are given in table 1. Disfluent words included words preceded by filled and unfilled pauses, whole word repetitions, part-word repetition, prolongation, within word breaks and blocks.

The division into age groups is the same as that used in Howell et al. (1999) and there were roughly similar numbers of participants in each age group (seven in G1, 11 in G2, 10 in G3, nine in G4 and nine in G5). Details of individual participants are given in table 2 (age, gender, groups assigned to, disfluency percentage, location in Spain, setting for recording and number of words in their speech sample). Samples were shorter for the youngest participants as is almost unavoidable with speakers of this age. Also, some samples had low overall disfluency percentages. These were retained to avoid biasing the data so that the findings only applied to moderate and severe stuttering.

An analysis of variance on disfluency percentage of individual participants with age group as factor (five levels) showed a significant effect of age group, $F(4,41) = 3.98$, $p < 0.001$. *Post-hoc* Tukey tests ($\alpha = 0.05$) showed participants in G1 had higher disfluency percentages than G3 ($T = 3.329$, $p = 0.0151$) and G4 ($T = 3.588$, $p = 0.0074$). The effect of differences in overall disfluency percentage across age groups was dealt with in the results by including each participant's overall disfluency percentage as the covariate in ANCOVAs. The ANCOVA output adjusted each factor for the effects of the covariate (here the participant's overall disfluency percentage) that effectively removed the influence that factor would otherwise have had on the results.

Speech material

Samples of spontaneous conversational speech between the participant and his or her therapist were obtained. The topics were chosen by participants so little prompting was required by the interviewer (conforming to 'casual' speech in terms of Labov's, 1978, style continuum). The samples were recorded on a Sony DAT recorder using a Sennheiser K6 microphone. The recordings lasted between two and 20 min depending on how long the participant could talk on the subjects suggested.

The recordings were transferred digitally to computer using the Sound Editor program. Once acquired Speech Filing System software was used to select a section of a file for transcription using moveable cursors. The selected extract could be replayed repeatedly until the listener was satisfied with the transcription. Oscillograms and spectrograms were displayed which facilitated assessment of features in the speech such as pause duration and

stress location. The recordings were transcribed by a native Spanish speaker who is a trained phonologist with 9 years experience in transcription.

The transcription scheme used a machine readable (Joint Speech Research Unit) alphabet for phonemes (Kadi-Hanifi and Howell, 1992). This was extended to include phones that do not appear in English but do in Spanish. Symbols for diphthongs which appeared in Spanish but not English were created by combining the monophthongal vowel forms. For example, the diphthong in 'muy' was created by adding 'i' (/i/) to 'oo' (/u/) giving 'mooi' for this example. The extra consonant symbols were 'bh' as in 'haba', 'mg' as in 'confuso', 'gn' as in 'ano', 'ly' as in 'llover', 'xh' as in 'julio', 'jh' as in 'nieto', 'gh' as in 'rogar', 'rx' (trilled /r/) as in 'perro' and rc (tapped or flapped /r/) as in 'pero' (Spanish 'but'). In all the speech (fluent and disfluent), a ':' or '/' preceded each word to indicate whether it was content or function in type (respectively). Syllabification was indicated in multi-syllable words by '-' between the syllables. Syllables which had primary stress were preceded by a double quotation (") mark.

The transcriptions were broad in fluent regions and narrow in the disfluent regions. In the disfluent regions, indications of segment duration, pauses (and their length), unusual prosodies and comments about segments (e.g. creak and aspiration) could be added. Disfluencies included (1) pauses (filled and unfilled), (2) whole word repetitions (1 and 2 occurred on function words on more than 77% of their occurrences for all age groups), (3) part-word repetition, (4) prolongation, (5) within word breaks and (6) blocks (3 – 6 occurred on content words on more than 70% of their occurrences for all age groups)¹.

Single word answers such as 'yes' or 'no' in response to occasional prompting questions by the interviewer were transcribed but not used in the analyses. Agglutinations, where single orthographic words have various inflections, are mainly associated with commands and did not occur in these casual samples.

PW segmentation methods

The data were segmented into PW in two ways. The first segmentation method categorized function words as satellites to content words as nuclei (identical to Au-Yeung et al., 1998 and Howell et al., 1999). A report on the current Spanish data applying this segmentation procedure on the overall data of all speakers has been made by Au-Yeung et al. (2003). The second method is a new scheme in which a word that carries stress is considered as the nucleus of a PW regardless of its function or content word classification. Unstressed words then serve as satellites to the stressed words. A description of the segmentation methods follows with illustrative examples from English (examples from the Spanish data are given later when comparison between the two segmentation methods is described).

Segmentation into phonological words using content words as nuclei (PW1)

To date, Au-Yeung et al. (1998) and Howell et al. (1999) have assumed that function words act as prefixes or suffixes to a neighbouring content word, as do other authors (Levelt, 1989; Selkirk, 1984). Consequently, Au-Yeung et al. (1998) and Howell et al. (1999) defined a PW as including a single obligatory content word (C) plus an arbitrary number of leading and following function words (F). Thus, these PW have the general form $[F_nCF_m]$, where n and m are integers greater than or equal to zero. Au-Yeung et al. (1998) and Howell et al. (1999) developed Selkirk's (1984) semantic sense unit rules to establish which function

¹Although pauses and whole word repetitions occurred most often on function words *for all age groups*, the proportion of disfluencies on function and content words differed across age groups as shown, for instance, in the exchange analysis of the common set (see results).

words are semantically related with each content word in intonational phrases. The direct rules that follow are those Selkirk (1984) proposed.

Direct rules—Two constituents C_i , C_j form a sense unit if (a) or (b) is true of the semantic interpretation of the sentence:

(a) C_i modifies C_j (a nucleus)

Example 1. [I look after] [her cats]

All examples in this paper use square brackets - [] – to enclose each PW. In this example, 'her' is associated with the second PW as it modifies, (and hence is a prefix of), 'cats'.

(b) C_i is an argument of C_j (a nucleus)

Example 2. [He hit me] [in the face]

'He' and 'me' are both arguments to 'hit' and are part of the first PW.

Indirect rules—Selkirk's original two rules do not always segment an utterance into a PW. Au-Yeung et al. (1998) proposed two additional, indirect, rules that deal with cases of PW segmentation that do not conform to rules a and b.

(c) both C_i and C_j modify C_k (a nucleus)

Example 3. [This boy] [seems] [poor to me]

'to me' does not directly modify 'poor' but does 'seems'

(d) both C_i and C_j are arguments of C_k (a nucleus)

Example 4. [He likes] [the jolly] [waiter]

'the' is not directly related to 'jolly' but both are linked to 'waiter'.

Selkirk's (1984) direct rules have precedence over these two indirect rules.

Procedure for PW1 segmentation

1. Identify all content words, each one constitutes the nucleus of a PW1.
2. Apply the above semantic sense unit rules to determine the membership of a function word (satellite) to the nearest preceding or following content word.

Segmentation into phonological words using stressed words as nuclei (PW2)

The stress-based segmentation procedure is based on that used for segmenting PW using function and content words introduced by Au-Yeung et al. (1998). The one difference is that, instead of content words being the nuclei, stressed words are the nuclei and unstressed words are satellites rather than function words. As with function/content word-based PW1, the number of unstressed words before and after the stressed word is optional and can be zero. As only content words are stressed in English, this segmentation procedure is identical to PW1 for this language (examples from Spanish that given different segmentations for PW1 and PW2 are given below).

Procedure for PW2 segmentation

1. Identify all stressed words, each one constitutes the nucleus of a PW2.
2. Apply the above semantic sense unit rules using this nucleus to determine the membership of an unstressed satellite word to the nearest preceding or following stressed word.

Comparison between the two segmentation methods

The content-function (PW1) and stressed-unstressed (PW2) segmentation methods gave rise to 14,816 and 16,885 PWs, respectively, over all age groups. 10,267 of each class were identical both in PW extent and in the word assigned as the nucleus (termed the *common set*). An illustration is given in example 5. The examples here and throughout this section are given (a) according to PW1 segmentation using the transcription scheme detailed above, (b) according to PW2 segmentation again using the transcription scheme detailed above, (c) in Spanish orthographic form, and (d) as a literal English translation. PW1 and PW2 give the same segmentation and extent for the common set (example 5) and the same segmentation extent but a different nucleus in cases like that in example 9.

Example 5a, 5b. [/i : " maa] [: " ko-saa] [/porc-ke : " teng-go]

5c y mas cosa porque tengo

5d and more thing because I have

Four classes were identified when the segmentations differed (*different set*) for the remaining 4,549 content-function (PW1) and 6,618 stressed-unstressed (PW2) PWs. Class 1 was fragmentation of one PW1 into n PW2 (where $n > 1$) and an illustration is given in example 6 (in this example, there is one PW1 and two PW2s):

Example 6a. [/en / " oo-naa :si-tooaa- " thyon]

6b. [/en / " oo-naa] [:si-tooaa- " thyon]

6c. en una situacion

6d. in one situation

Class 2 (example 7) involved fragmentation of one PW2 into n PW1:

Example 7a. [/del :kooaa-rcen-taa] [/i : " sye-te]

7b. [/del :kooaa-rcen-taa /i : " sye-te]

7c. del cuarenta y siete

7d. from forty and seven

Class 3 (example 8) involved recombination of x adjacent PW1 into y adjacent PW2 (where x and y are integers greater than one). Example 8 involves 2 PW1 being recombined into 2 different PW2.

Example 8a. [:aa-lyi] [/e- " too-bhe :ko-2myen-do]

8b. [:aa-lyi /e- " too-bhe] [:ko- " myen-do]"

8c. alli stove comiendo.

8d. there I had been eating.

Class 4 (example 9) represent segmentations that had the same extent over PW1 and PW2 but the position of the nucleus differed:

Example 9a and 9b. [/pooe /e- " taa :mooi]

:mooi is the nucleus for PW1, /e- " taa for PW2

9c. pues esta muy

9d. well it's very.

The numbers for the common and different sets, separately for the above four classes for the different set, are given in table 3 for each age group. Most of the cases where the PW segmentation methods gave a different result. The first three classes all should disrupt context effects when the inappropriate segmentation is used because all involve a PW obtained according to one segmentation method starting and/or finishing at different points relative to the other method. The fourth does not disrupt onset and offset context but, as indicated, affects nucleus location. There were only 249 PW in this category and these were dropped because there were too few for analysis. Insufficient data were available to analyze the three remaining types of different segmentation classes separately except, to some extent, for class 1.

Reliability

Accuracy of transcriptions was established by (a) interjudge comparisons between the Spanish transcriber's English transcriptions (she is a fluent speaker of this language) against the same material transcribed by native English speakers whose reliability was reported in Howell et al. (1999), and (b) intra-judge comparisons of the same Spanish material made on independent occasions. The percentage agreements reported were calculated as number of agreements with regard to the designated property divided by total instances of cases with the designated property and converted to percentages in all the following reports. Her agreement with an English transcriber on randomly-selected samples of the Howell et al. (1999) data was 95.1% on word type (Cohen's Kappa = 0.90), 96.7% on fluency (Kappa = 0.93), 97.10% for PW segmentation extent (i.e. exact agreement as to which satellites were associated with a given content word nucleus) (Kappa = 0.94) and 89.5% on stress (Kappa = 0.79). All represent excellent levels of agreement.

Intra-judge agreement on the Spanish data was comparable for all corresponding comparisons, 96.1% for word type, 97.0% for fluency, 96.9% for PW segmentation extent on content word nuclei and 90.2% for stress. (Cohen's Kappa statistic is not appropriate for intra-judge comparisons). In addition for the Spanish data, when the stressed word was supplied which the transcriber then used as the nucleus, PW segmentations agreed exactly in extent on 97.6% of PW.

General analysis procedure

All the analyses reported used analysis of covariance (ANCOVA) in which mean disfluency percentage of each participant was taken out as covariate to provide a basis for analysis across participants. All the ANCOVAs used disfluency percentage associated with the selected factor as the dependent variable. Disfluency percentages were calculated by dividing the number of disfluent words for the factor (e.g. total number of function words) by the total number of words having that factor (all function words in the sample) and multiplying by 100 to convert to percentages (to give function word disfluency percentage in this case). Each analysis on the data is reported for the class of PW that led to identical segmentations first (common set), and then for PW1 and PW2 on the material for which the segmentations were different.

Results

Disfluency rates on satellites and nuclei

Previous work has shown that speakers change over age from being predominantly disfluent on function words to being predominantly disfluent on content words (Howell et al.'s, 1999 exchange relations). Does this apply when nuclei are defined in other ways? This question was examined by analyzing the common set of data (i.e. the data where PW1 and PW2 segmentations give identical results) and, for the remaining data, separately when PW1 and

PW2 segmentation methods were applied. The question is, which of these sets of data show an exchange relation? If the common set and PW1, but not PW2, show an exchange relation, then PW1 is the appropriate segmentation method. If the common set and PW2, but not PW1, show an exchange relation, then PW2 is the appropriate segmentation method. If the common set, PW1 and PW2 all show an exchange relation, then both segmentation methods apply and, as discussed in the introduction, some common factor like speech rate could apply across the two segmentation methods. Some pre-preparation of the data was required before the analysis was conducted (as indicated in the following section).

Data preparation for the exchange analysis

For the exchange analyses, material was selected that had (a) one or more pre-nuclear satellite/s, as well as (b) its obligatory nucleus according to the segmentation method being applied. This selection was made as both elements (a) and (b) have to be present to assess the chance of disfluency on the elements independently for whatever segmentation method is being applied. This criterion excluded examples like [:looɑ-ghoe] (luego = then) which would be a PW according to the PW1 segmentation method (according to this method, this PW lacks an initial satellite). After this exclusion criterion was applied, at least 47% of the data in the common set were left and 67% at minimum of the disfluencies remained for the different age groups. For the data that resulted in different segmentations when the two methods were applied, the exclusion criterion applied to PW1 segmentations left at least 68% of the data and 83% at minimum of the disfluencies for the different age groups, and the exclusion criterion applied to PW2 segmentations left at least 45% of the data and 59% at minimum of the disfluencies for the different age groups. Table 4 gives the exact proportions of data (column one) and the percentage of disfluencies (column two) that remained for each age group, separately for the common and different sets (both PW1 and PW2 segmentations for the different set).

Disfluencies should only occupy certain positions in PW when the PW-unit has been specified appropriately. Two aspects about the distribution of disfluency in PW are examined in the following. First, if PW segments apply to speech analysis, there should only be disfluency on pre-nuclear (not post nuclear) satellites. Supporting this conclusion, disfluency on post-nucleus satellites was rare, less than 0.2% for the common set, for the different set less than 0.6% when PW1 segmentations were applied and less than 0.4% when PW2 segmentations were applied. A breakdown by age group, data set (common and different) and, for the different set, according to PW1 or PW2 segmentation method is given in column three of table 4. The small proportion of PW that had disfluency on post-nuclear satellites were excluded from further analysis.

Second, according to the work on PW reviewed in the introduction, disfluency on the initial satellite and nucleus should be rare. This is because disfluency on an initial satellite should prevent disfluency on the following nucleus (and, conversely, that if disfluency does not occur on the initial satellite, the chance of disfluency on the following nucleus should increase). Consistent with this prediction, less than 4% of the common set and the different set when the PW1 segmentation method was applied and less than 2% of the different set when the PW2 segmentation method was applied had disfluency on the initial satellite and nucleus. The fact that disfluency occurred exclusively on either the initial satellite or the nucleus when both segmentation methods were applied to the different set suggests that both ways of specifying the nucleus may be appropriate for capturing this aspect about the distribution of disfluencies in PW. A breakdown of occurrences of disfluency on both initial satellite and nucleus in PW by age group, data set (common and different) and, for the different set, according to PW1 or PW2 segmentation method is given in column four of table 4. As there was a small proportion of such instances, they were dropped from further analysis.

The three steps in data preparation led to some variation in how much material in the common and different sets was retained. Nevertheless, the ratio of disfluencies remaining to amount of material retained was roughly constant (1.43, 1.22, 1.31 for common, different set when PW1 and PW2 segmentation procedures were applied, respectively). The selected PW represent about 50% of all PW in the set and contain a high percentage of disfluencies.

Exchange analysis

After these preparation steps, the exchange analysis was conducted on the common and different sets. An exchange occurs when there is a drop off in disfluency rate on initial satellites in PWs over age groups and a corresponding increase in disfluency on nuclei in PWs over age groups. Figure 1 plots disfluency percentages (adjusted using each participant's individual disfluency percentage by ANCOVA) over age groups separately for initial satellites and nuclei for the common set of data. Disfluency on satellite words (in this case unstressed function words) falls off over age groups while that on nuclei (stressed content words here) increases (i.e. an exchange relationship as reported by Howell et al., 1999). A two-way ANCOVA was performed on disfluency percentage with factors word type (two types: pre-nucleus satellites, nucleus) and age group (five groups) to check these impressions. The main effect of word type was significant, $F(1,81) = 73.89, p < 0.001$ (effect size indicated by $\eta^2 = 0.912$, Tabachnick and Fidell, 1996). *Post-hoc* Tukey tests ($\alpha = 0.05$) showed that the disfluency percentage of pre-nucleus satellites was higher than that for the nucleus ($T = 8.596, p < 0.001$). Age group was not significant indicating roughly the same disfluency rate across initial satellites and nuclei when they were combined. The critical statistic for assessing whether an exchange occurred is the interaction of age group by word type that indicates whether or not disfluency on the two word types changed over age groups. This was significant $F(4,81) = 9.16, p < 0.001$ ($\eta^2 = 0.452$). *Post hoc* Tukey tests ($\alpha = 0.05$) showed that for nuclei, the disfluency percentage was significantly lower than that on pre-nucleus satellites for speakers in G1 ($T = 8.3, p < 0.001$) and G2 ($T = 4.727, p < 0.001$). Statistically speaking, disfluency percentages on pre-nucleus satellites was the same as that on nuclei for G3, G4 and G5. Thus, these results suggest a significantly higher incidence of disfluency on initial satellites in the younger age groups (G1 and G2).

Overall, this analysis confirms that an exchange relation occurred between disfluencies on pre-nucleus satellites (declines over age groups) and nucleus words (increases over age groups) for the common set of data. These exchange relations reveal that younger speakers who stutter are more disfluent on the pre-nucleus satellites and that as the percentage of these disfluencies drops off over age groups, percentage of disfluency on the nuclei increases. Such an exchange relation was initially reported by Howell et al. (1999) for English speakers who stutter and has been reported for these Spanish data when all material was analyzed using PW segmented using content and function words (Au-Yeung et al., 2003).

The same basic pattern of results was also obtained when the different set data were analyzed. The first three of the four classes within the different set (table 3) were combined and analyzed according to the content-function definition of PW (PW1) or the stressed-unstressed definition of PW (PW2). The exchange graphs are shown in the same way as with the common set for PW1 in the middle section of figure 1 and for PW2 at the bottom. In both cases there is a decrease in disfluency percentage on pre-nucleus satellites and an increase on the nucleus over age groups. In the corresponding ANCOVA to that performed on the common set, word type was significant for PW1 ($F(1,79) = 46.48, p < 0.001$) ($\eta^2 = 0.588$) and for PW2 ($F(1,79) = 61.21, p < 0.001$) ($\eta^2 = 0.775$). (Slight differences in degrees of freedom across different analyses arise because there are insufficient data points for some subjects in the analyses). *Post hoc* Tukey tests ($\alpha = 0.05$) showed that the

disfluency percentage of pre-nucleus satellites was higher than those for nucleus words for PW1 ($T = 6.818, p < 0.001$) and PW2 ($T = 7.824, p < 0.001$). Age group was not significant but the critical interaction between age group and word type was for PW1, $F(4,79) = 3.52, p = 0.011$ ($\eta^2 = 0.178$) and PW2, $F(4,79) = 8.21, p < 0.001$ ($\eta^2 = 0.416$). *Post hoc* Tukey tests ($\alpha = 0.05$) on PW1 showed that for nuclei, the disfluency percentage was significantly lower than that on pre-nuclear satellites for speakers in G1 ($T = 5.10, p < 0.001$) and G2 ($T = 4.393, p = 0.0014$). *Post hoc* Tukey tests ($\alpha = 0.05$) on PW2 showed that for nuclei, the disfluency percentage was significantly lower than that on pre-nucleus satellites again for speakers in G1 ($T = 7.01, p < 0.001$) and G2 ($T = 4.84, p = 0.0014$). Statistically speaking, for PW1 and PW2 disfluency percentage on pre-nucleus satellites was the same as that on nucleus words for G3, G4 and G5.

There was sufficient data for both segmentation procedures for some participants to perform an exchange analysis on class 1 PWs in which one PW1 (2,316 cases) was fragmented into n PW2 (5,110 cases). The participants who had insufficient data had short samples which became acute (fewer than 25 PWs for this fragmentation class) when the data were partitioned first into the common and different sets and then the class 1 PWs for PW1 and PW2 methods were extracted from the different set. Participants who were dropped for this reason for the PW1 segmentation method were S2 and S7 from G1 and S30 from G4. Participants who were dropped for this reason for the PW2 segmentation method were S2, S3 and S7 for G1, and S10 for G2. The ANCOVA for the sparser PW1 data with age groups (five levels) and word type (nucleus vs. pre-nucleus satellites) showed a significant effect of word type, $F(1,75) = 21.77, p < 0.001$ ($\eta^2 = 0.290$). (Of the remaining terms, only age group by word type remotely approached significance, $F(4,75) = 1.62, p = 0.179$.) The ANCOVA for PW2 had a significant effect of word type ($F(1,73) = 19.72, p < 0.001$) ($\eta^2 = 0.270$) and this interacted with age groups ($F(4,73) = 3.04, p = 0.022$) ($\eta^2 = 0.167$). *Post-hoc* analyses ($\alpha = 0.05$) of the word effect showed pre-nucleus satellites had higher disfluency percentages than nucleus words ($T = 4.441, p < 0.001$) and of the age group by word type interaction showed G1 had a significantly higher disfluency percentage on pre-nucleus satellites than on the nucleus ($T = 3.389, p = 0.0354$). The exchange functions are shown for PW1 and PW2, plotted in the same way as in figure 1 and, although the data are somewhat noisy because of comparatively small amounts of data, both PW1 and PW2 appear to show an exchange relation. Though this is only statistically supported in the case of PW2, bearing in mind the small amount of data for PW1 and the fact that figure 2 appear to show an exchange pattern for this set, there are no strong grounds for preferring PW2 over PW1.

Serial position analyses

If a PW segmentation method is appropriate, disfluency rate should decrease as *satellites* are positioned later in the units (conversely, words in early positions are more likely to be produced disfluently because they are more likely to be used to delay when the nucleus has to be produced). The disfluency percentages were next analyzed over positions in PW separately for pre-stressed satellites and the nucleus. The common and different sets (the latter using PW1 and PW2 segmentation methods) were analyzed by separate ANCOVAs, each with factors age group (five levels) and serial position (positions 1, 2 and 3 for the common and PW2 set and positions 1, 2, 3 and 4 for PW1) for the pre-stressed satellites. Age group was not significant in any of the three analyses. Disfluency percentages differed over position in a PW for all three analyses (common: $F(2,89) = 10.31, p < 0.001$ ($\eta^2 = 0.232$); PW1, $F(3,119) = 17.54, p < 0.001$ ($\eta^2 = 0.442$); PW2: $F(2,79) = 10.94, p < 0.001$) ($\eta^2 = 0.277$). *Post hoc* Tukey tests ($\alpha = 0.05$ throughout) were performed for each of the analyses. For the common set, position 1 was higher than 2 ($T = 4.006, p < 0.001$) and also 3 ($T = 3.265, p < 0.005$). For PW1, position 1 was higher than 2 ($T = 4.900, p < 0.001$),

3 ($T = 5.561, p < 0.001$) and 4 ($T = 6.064, p < 0.001$). For PW2, position 1 was higher than 3 ($T = 4.754, p < 0.001$) and 4 ($T = 3.205, p = 0.009$) and position 2 was higher than 3 ($T = 2.962, p = 0.0196$). The data are shown for each age group in figure 3 separately for the common and PW1 and PW2 analyses (word position on the abscissa, disfluency percentage on the ordinate and age groups can be identified by the points connected together from the caption in the inset). In each case, disfluency percentages on satellites in early positions are higher than rates at later positions. Again there seems to be no strong grounds for concluding that only certain subsets (common) or methods of analysis (PW1 versus PW2) yield clearer results (serial position effects on pre-nucleus satellites here).

Next the equivalent analyses were performed on *nucleus* position for the common and different sets (the latter using PW1 and PW2 segmentation methods). Again each set was analyzed by ANCOVA with factors age group and nucleus position. Neither main effect nor interaction was significant for the common set and PW1 segmentation as found for English (Howell et al., 1999) and the Spanish data overall (Au-Yeung et al., 2003). PW2 gave a significant effect over four nucleus positions ($F(3,102) = 9.17, p < 0.001$ ($\eta^2 = 0.270$)). *Post hoc* Tukey tests ($\alpha = 0.05$) showed position 1 was higher than 3 ($T = 4.754, p < 0.001$) and also 4 ($T = 3.205, p < 0.01$) and that position 2 was higher than 3 ($T = 2.962, p < 0.0196$). The data are shown in figure 4 (plotted in the same way as figure 3) and reveal a clear serial position effect with highest disfluency percentage in early positions in PW. If the view is taken that serial position effects are a desirable pattern, then PW2 would be preferred over PW1 and indicate that position of a stressed word has precedence over position of a content word (Wingate, 1979). However, it is not then clear why stressed content words (the common set) do not show this same pattern of results.

Disfluency percentages on pre- and post-nucleus satellites and the nucleus

Only disfluency on initial satellites in a PW could delay the point in time when the nucleus has to be produced. Thus only when the PW segmentation method is appropriate, should there be a higher rate of disfluencies on pre-nuclear satellites than on post-nuclear satellites. The final analyses examined disfluency percentage over pre-nucleus, nucleus and post-nucleus positions for PW1 and PW2 segmentation methods applied to the different set and for pre-nucleus and nucleus for the common set (there was insufficient data in post-nucleus position for this set, so the prediction about disfluency rate over satellite positions cannot be assessed). The ANCOVAs had factors age groups (five levels) and word position (three levels for PW1 and PW2, pre-nucleus, nucleus, post-nucleus, and just the first two of these for the common set). There were no significant effects of age group of any of the three sets. Word position was significant for all three sets (common: $F(1,81) = 62.02, p < 0.001$ ($\eta^2 = 0.766$); PW1: $F(2,98) = 21.83, p < 0.001$ ($\eta^2 = 0.445$); PW2: $F(2,90) = 16.89, p < 0.001$ ($\eta^2 = 0.375$)). *Post hoc* Tukey tests ($\alpha = 0.05$) showed that disfluency percentage in pre-nucleus position was significantly higher than nucleus position (common: $T = 7.865, p < 0.001$, PW1 $T = 5.171, p < 0.001$; PW2: $T = 4.247, p < 0.001$). Pre-nucleus was significantly higher than post-nucleus position for PW1 ($T = 5.610, p < 0.001$) and PW2 ($T = 5.025, p < 0.001$). Only PW2 showed a significantly higher disfluency percentage between nucleus and post-nucleus ($T = 2.628, p = 0.0270$). For the common and the PW2 sets, there was a significant interaction between age group and word position (common: $F(4,81) = 7.29, p < 0.001$ ($\eta^2 = 0.360$); PW2: $F(8,90) = 2.41, p = 0.021$ ($\eta^2 = 0.214$)). *Post hoc* Tukey tests ($\alpha = 0.05$), showed disfluency percentage in pre-nucleus position was significantly higher than in nucleus position for the common set in G1 ($T = 7.618, p < 0.001$) and G2 ($T = 3.8552, p = 0.0083$) and also for G2 ($T = 3.639, p = 0.0322$) in the PW2 set. Figure 5 shows histograms of disfluency percentages on pre-nucleus and post-nucleus satellites for each segmentation method. The PW1 and PW2 analyses show a clear decrease in use of pre-

nucleus disfluencies with age, a corresponding increase in disfluency rate on the nucleus and lower disfluency percentages for words in post-nucleus position for all age groups.

Discussion

For the common set of words (that both segmentation procedures apply to) the nucleus was a stressed content word and any satellite words either side of the nucleus were unstressed function words. This set should show the same patterns of disfluency in PW as has been reported previously for English (Au-Yeung et al., 1998; Howell et al., 1999) irrespective of whether a stressed word or content word serves as nucleus and unstressed or function words act as satellites. In line with this prediction, the common set showed: (1) An exchange relation (Howell et al., 1999); (2) Serial position functions for unstressed function words with higher disfluency percentage in earlier positions (Au-Yeung et al., 1998); (3) No such serial position effects for stressed content words (Au-Yeung et al., 1998); (4) Higher disfluency percentages for unstressed function words that precede the stressed content word nucleus than on those that follow (Au-Yeung et al., 1998).

The remaining data (the different set) were segmented differently depending on whether a content or stressed word served as the nucleus and allowed the question whether the PW1 or the PW2 segmentation method should be preferred. The three most frequent classes within the different set all shared the property that an inappropriate context results when an inapplicable segmentation method is applied. If only one segmentation method is appropriate, then, only that method should show the disfluency patterns indicated above for the common set. Analyses over the combined data over these three classes using either PW-definition led to the above four characteristic patterns associated with the distribution of disfluencies (with one seeming exception). Putting the possible exception to one side for a moment, the comparable patterns resulting from both segmentation methods suggests that either an unstressed content or stressed function word can serve as the nucleus of a PW or that both are mediated by some common factor.

The potential exception is that disfluency percentage on stressed nuclei showed a serial position effect where no such effect on content word nuclei has been reported in spontaneous English speech except for very young speakers (Au-Yeung et al., 1998, 2003). Thus, no serial position effect would have been expected with spontaneous speech material (also confirmed here for the common set). If this conclusion is correct, then why did the PW2 segmentation method on the nuclei of the different set lead to a serial position effect? The answer is that, in this set, the nuclei are function words and, as such, they show a serial position effect even though they are stressed. This suggests function word status is paramount for obtaining gradients of disfluency over serial positions.

Brown's (1945) account of why words in early positions in sentences showed serial position effects was that they reflect a gradient of meaning (the content words are most meaningful, particularly when they occupy early sentence positions). Contrary to this account, this would suggest a serial position effect for content words should occur, whereas spontaneous material shows one only for function words. Wingate (1979) questioned Brown's explanation and argued that it was the stressed words that caused fluency problems and that serial position effects on disfluency percentage are observed in English because content words are stressed. Hence, a serial position curve for content words is actually a serial position curve for stress position. Though this accounts for serial position effects on stressed words in the different set, it does not explain why there was no serial position effect on stressed words in the common set.

An explanation is needed why stressed function words can sometimes operate as nuclei (giving the exchange pattern occurs for PW2) and sometimes as satellites (giving serial position effects that might reflect an early tendency for repeating these words to offset a problem on a later nucleus). The most frequent category in the different set is category 1. Looking at the frequency of the different segmentations in table 3 over PW1 and PW2, the most frequent category is where one PW1 is split into two PW2. It follows from the definitions of PW1 and PW2 that there is more than one stressed word in these PW when segmented according to PW1 but only one content word. Moreover it is likely that one of the words that is stressed is the content word (even in Spanish, lexical stress often occurs on content words). It is possible that in these circumstances the stressed content word has precedence as the locus of part-word disfluency and that the other stressed word is treated as an ordinary function word (and this leads to a serial position effect). If this category dominates the results as it is most frequent, then overall this would allow stressed function words where there is no stressed content word in its vicinity, all unstressed content words (irrespective of context) to operate as nuclei and give an exchange function but give precedence to a stressed content word when preceded in its near vicinity by a stressed function word.

There were four ways that the two segmentation methods led to different outcomes for the different set. When the different set data were partitioned into these four categories, there were insufficient data to analyze individual categories according to each segmentation method except, to some extent, for category 1. In category 1 a PW segmented according to method PW1 was fragmented into two or more PW when segmented according to method PW2. Predictions can be made about this condition if it is assumed that PW1 is the correct segmentation. Fragmentation of the single PW1 that was started with, into more than one PW2 should interfere with the distribution patterns of disfluencies noted earlier (Au-Yeung et al., 1998; Howell et al., 1999). Contrary to this, the data in figure 2 give the appearance of an exchange pattern when both PW1 and PW2 segmentations are applied to these data. Fragmentation does not appear to destroy the pattern though it should be noted that, statistically, there is only support for an exchange relation for PW2. Even the absence of statistical support for PW1 does not necessarily rule this procedure out as an appropriate basis for predicting disfluency patterns in PW for several reasons: (1) Power is lost because of the smaller n for the PWs in this class within the different set. (2) Figure 2 (top section) gives the appearance of an exchange relation for PW1. (3) The age by word type interaction on PW1 that would support an exchange has a p of 0.179. (4) There is an exchange relation for the PW1 segmentation method when this category is combined with the categories 2 and 3 that are similar to category 1 insofar as they disrupt context. Taking all these observations together, it would be rash to absolutely reject PW1 segmentation showing an exchange relation for this material.

To summarise to this point, stressed words and content words both appear to act as nuclei. An explanation has been offered previously why content words can act as the focus of disfluency and how this leads to the distribution pattern of disfluencies described by Au-Yeung et al. (1998) and Howell et al. (1999). The current data call for an extension of these ideas to allow stressed words (whether or not they are content words) to act as nuclei that trigger disfluency. The explanation offered when content words are considered as the nuclei of disfluency, could be extended directly to include stressed words when they serve as nuclei. In English, content words could still be used to identify the nucleus as these are the words that carry stress, but changing so stressed words can act as nuclei is important for languages such as Spanish.

Extending nuclei to include stressed words that are not content words as well as content words that are not stressed suggests that some other factor may underlie these orthogonal

factors. A possibility for such a common factor is speech rate. Stressed words or content words could conceivably lead to rate changes in the local context they occur in. Evidence has been reported elsewhere that speech rate in the local context preceding a disfluency, is higher than the rate in corresponding fluent stretches (Howell, Au-Yeung and Pilgrim, 1999). Examination whether such fluency-dependent rate changes occur in the local vicinity of stressed function words (PW1) and unstressed content words (PW2) is one way of testing whether rate is a common underlying factor and offer further indication whether the definition of nuclei of PW needs extending to stressed and content words.

The pressing issue for future work is to establish this and other ways of determining whether stressed words and unstressed content words can serve as nuclei rather than content (Au-Yeung et al., 1998; Howell et al., 1999) or stressed (Wingate, 1984) words alone. One way of testing this would be to see whether other factors known to determine whether a word is stuttered or not, show a clearer association with stressed words or content words. One factor that could be examined is an index of phonetic complexity (Jakielski, 1998) that is associated with increases in stuttering rate (Howell, Au-Yeung, Yaruss & Eldridge, submitted). Is the difference between disfluent and fluent words with regards to this complexity index greater when stressed words are considered (suggesting that stress is the appropriate specification of nucleus) or when content words are selected?

The issues of changing or extending the definition of nucleus might also suggest how diagnosis and progress of the disorder could differ between English and Spanish. The more characteristics that are known that distinguish stuttered from fluent speech and the more that is known about how the disorder progresses, the better. Some questions this study raises about these issues are as follows: Do Spanish children at stuttering onset have problems on stressed words, content words or both? Children begin to use content words before function words (Bernstein Ratner, 1997). English children have a period of time during which they may learn to stress the only words they are dealing with (content words) and they never have to learn how to stress function words. Spanish children also have to learn to stress function words when they are acquired. If stress and content words are properties that can jointly lead to stuttering, then it is possible the period during which the disorder is initially established would be more protracted for Spanish than English children. If rate is a common factor that mediates stuttering on content or stressed words, then disfluency is likely to be automatically triggered when a rate change occurs on either type of word. In this situation, a longer period during which the disorder is established for Spanish compared with English would be less likely.

The first main conclusion of this work is that both stressed and content words or some factor common to the two determine whether a word serves as a nucleus of disfluency. The second conclusion is that serial position effects in spontaneous material only occur on function words (whether stressed or not). This supports the different role of disfluency on function as opposed to content words and that speakers either need separate access to this word class or can selectively access this word class by some property of these words that is general to Spanish and English.

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Figure 1.

The mean percentage of disfluent words (adjusted) of pre-nucleus satellites, nucleus, and post-nucleus satellites, for the five age groups. The data for the common set are shown at the top, classes 1, 2 and 3 of the different set segmented according to PW1 are given at the centre and according to PW2 at the bottom

Figure 2.

The mean percentage of disfluent words (adjusted) of pre-nucleus satellites, nucleus, and post-nucleus satellites, for the five age groups for class 1 (1 PW1 leads to n PW2) PWs that led to different segmentations for methods PW 1 (top) and PW 2 (bottom)

Figure 3.

The mean percentage of disfluent words (adjusted) of pre-nucleus words across PW positions for the five age groups. The data for the common set are shown at top, classes 1, 2 and 3 of the different set segmented according to PW1 are given at the centre and according to PW2 at the bottom

Figure 4.

The mean percentage of disfluent words (adjusted) of nucleus words across PW positions for the five age groups. The data for the common set are shown at top, classes 1, 2 and 3 of the different set segmented according to PW1 are given at the centre and according to PW2 at the bottom

Figure 5.

The top section shows disfluency percentage on nucleus and pre-nucleus for each age group for the common set. The disfluency percentage on nucleus, pre-nucleus and post-nucleus for classes 1, 2 and 3 of the different set segmented according to PW1 are given at the centre and according to PW2 at the bottom

Table 1

Mean age and standard deviation (SD) and mean disfluency percentage (Dis%) and SD for each age group

	AGE		Dis%	
	Mean	SD	Mean	SD
G1:	4.429	0.787	16.54	9.00
G2:	7.091	1.300	10.62	5.44
G3:	10.400	0.516	7.23	5.80
G4	13.778	1.856	6.28	4.19
G5:	39.33	15.39	10.92	3.46

Table 2

Individual speaker data (Speaker), age in years (Age), Gender (Gen), Age group (Group), Disfluency percentage in the sample (Dis%), residence location (Location), recording setting (Setting) and number of words in the speech sample (Words)

Speaker	Age	Gen	Group	Dis%	Location	Setting	Words
S1	3	M	G1	22.53	Madrid	Clinic	275
S2	4	F	G1	26.25	Madrid	Clinic	132
S3	4	F	G1	9.35	Madrid	Clinic	159
S4	5	M	G1	11.60	Madrid	Clinic	640
S5	5	M	G1	3.81	Madrid	Clinic	967
S6	5	F	G1	15.00	Granada	Clinic	487
S7	5	F	G1	27.27	Madrid	Clinic	138
S8	6	F	G2	4.91	Granada	Clinic	210
S9	6	M	G2	20.31	Madrid	Clinic	294
S10	6	M	G2	5.15	Cordoba	Clinic	234
S11	6	M	G2	15.73	Madrid	Clinic	650
S12	6	M	G2	11.68	Mallorca	Clinic	554
S13	7	M	G2	5.65	Almeria	Clinic	486
S14	7	M	G2	15.51	Mallorca	Clinic	253
S15	7	F	G2	8.13	Mallorca	Clinic	687
S16	9	M	G2	4.39	Almeria	Clinic	1017
S17	9	M	G2	14.88	Madrid	Clinic	259
S18	9	F	G2	10.45	Almeria	Clinic	480
S19	10	M	G3	1.43	Almeria	Clinic	348
S20	10	M	G3	4.76	Almeria	Clinic	651
S21	10	M	G3	18.38	Madrid	Clinic	241
S22	10	M	G3	12.46	Madrid	Clinic	373
S23	10	M	G3	11.24	Madrid	Clinic	500
S24	10	F	G3	11.52	Cordoba	Home	615
S25	11	M	G3	2.56	Almeria	Clinic	920
S26	11	M	G3	5.81	Almeria	Clinic	991
S27	11	M	G3	2.43	Almeria	Clinic	804
S28	11	M	G3	1.75	Almeria	Clinic	1308

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Speaker	Age	Gen	Group	Dis%	Location	Setting	Words
S29	12	M	G4	8.60	Almeria	Clinic	398
S30	12	M	G4	2.86	Cordoba	Clinic	87
S31	12	M	G4	5.44	Granada	Clinic	761
S32	13	M	G4	4.03	Madrid	Clinic	353
S33	13	M	G4	6.85	Almeria	Clinic	561
S34	14	M	G4	12.74	Almeria	Clinic	476
S35	15	M	G4	1.14	Granada	Clinic	317
S36	17	M	G4	12.27	Madrid	Clinic	198
S37	16	M	G4	2.61	Almeria	Clinic	1165
S38	20	M	G5	11.34	Madrid	Clinic	340
S39	25	M	G5	12.20	Santiago	Clinic	508
S40	25	M	G5	8.56	Madrid	Clinic	286
S41	36	M	G5	16.74	Granada	Home	792
S42	38	M	G5	13.32	Cordoba	Home	2037
S43	40	M	G5	11.26	Cordoba	Home	1489
S44	50	M	G5	12.36	Santiago	Clinic	1406
S45	52	F	G5	7.47	Cordoba	Home	1939
S46	68	F	G5	5.05	Cordoba	Home	2909

Table 3

PW counts for the common set, fragmentation of one PW1 into n PW2, fragmentation of one PW2 into n PW1, recombination of x PW1 into y PW2 and for the same segmentation extent, different nucleus position (each category labelled in column 1). Age group is indicated in column 2. Cells in columns 3 and 4 indicate the total number of PW for the respective set and age group (where appropriate) for each segmentation type (indicated in the labels of columns 3 and 4)

Type	PW1	PW2
<i>Common set</i>		
Total	10,267	10,267
G1	1,023	1,023
G2	1,855	1,855
G3	2,414	2,414
G4	1,502	1,502
G5	3,473	3,473
<i>Different set</i>		
Fragmentation 1 PW1 into n PW2		
Total	2,316	5,110
G1	217	477
G2	404	887
G3	387	832
G4	246	528
G5	1,062	2,386
Fragmentation 1 PW2 into n PW1		
Total	1,501	726
G1	132	65
G2	196	96
G3	349	167
G4	259	125
G5	565	273
Recombination of x PW1 into y PW2		
Total	483	533
G1	39	47
G2	72	84
G3	93	87
G4	50	53
G5	229	262
Same segmentation extent, different nucleus position		
Total	249	249

Table 4

The percentage of PW that had initial and final satellite words are given in column 2 and the percentage of the overall disfluencies these included are given in column 3. Columns 4 and 5 give the percentages of PW that were excluded due to two exclusion criteria given in the text. Results are given for the common set (top section) different set according to PW1 (middle section) and PW2 (bottom section)

	PW with initial satellite (%)	Disfluencies in the selected material (%)	Excluded because disfluency on satellites following the nucleus (%)	Excluded because disfluency on initial satellites and nucleus (%)
<i>Common</i>				
G1	47.51	67.86	0.00	2.05
G2	55.90	71.70	0.19	1.13
G3	61.18	84.87	0.00	1.53
G4	60.79	77.49	0.00	1.86
G5	54.05	75.86	0.05	3.09
<i>PW based on content words as nuclei (PW1)</i>				
G1	70.70	83.19	0.33	3.72
G2	72.38	87.73	0.59	1.84
G3	70.04	89.15	0.31	1.09
G4	68.66	89.71	0.47	0.81
G5	70.76	84.82	0.36	3.84
<i>PW based on stressed words as nuclei (PW2)</i>				
G1	45.41	59.37	0.32	1.58
G2	46.45	62.64	0.00	0.45
G3	53.43	66.67	0.09	0.53
G4	60.47	69.01	0.13	0.66
G5	53.38	68.09	0.40	1.10