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A Cross-linguistic study of vocal pathology: Perceptual features of spasmodic dysphonia in French-speaking subjects

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Bionotes

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ABSTRACT

Clinical characterisation of Spasmodic Dysphonia of the adductor type (SD) in French speakers by Klap and colleagues (1993) appears to differ from that of SD in English. This perceptual analysis aims to describe the phonetic features of French SD. A video of 6 French speakers with SD supplied by Klap and colleagues was analysed for frequency of phonatory breaks, pitch breaks, harshness, creak, breathiness and falsetto voice, rate of production, and quantity of speech output. In contrast to English SD, the French speaking SD patients demonstrated no evidence pitch breaks, but phonatory breaks, harshness and breathiness were prominent features. This verifies the French authors' (1993) clinical description. These findings suggest that phonetic properties of a specific language may affect the manifestation of pathology in neurogenic voice disorders.

Key words: cross-linguistic, voice, spasmodic dysphonia

INTRODUCTION

Spasmodic dysphonia (SD) is a chronic neurogenic voice disorder affects the central motor control of the vocal cords causing action-induced spasms. During speech the otherwise normal cords contract inappropriately, causing abnormal movements and muscle spasms producing a range of vocal abnormalities. SD has been the subject of growing research literature with the development of a successful treatment with botulinum toxin (BTX) injections in the past decade (see Whurr and Moore, 1996 for review). The overwhelming majority of investigations into perceptual and acoustic aspects of the vocal pathology caused by SD and its clinical characterisation to date have been carried out on English-speaking patients (e.g. Blitzer, Brin and Fahn, 1988; Whurr, Lorch, Fontana, Brookes, Lees, and Marsden, 1993; Whurr, Lorch, and Nye, 1997).

The present study represents an effort to rectify this Anglo-centric bias by addressing the question: How do language-specific phonetic features interact with this laryngeal disorder as manifested in the speech of SD speakers? The focus of this cross-linguistic investigation is French, a language that has phonetic features involving voicing which are quite distinct from those evident in English (e.g. Ryalls et al, 1995). This paper presents a perceptual analysis of the speech production of six French speakers with SD of the adductor type.

The perceptual vocal symptoms of SD for English speakers include the presence of pitch breaks, phonatory breaks, and a strangled/strained quality. Surprisingly, one characterisation of SD in French speaking subjects that appeared in the English literature identified a somewhat different set of diagnostic vocal symptoms: voice stoppage, laryngealisation,

tremor, and breathy phonation (Chevrie-Muller, Arabia-Guidet and Pfauwadel, 1987). In a more detailed description of SD in French speakers published in French, Klap and colleagues (1993: 282) described their speech as follows: '*Les dysphonies spasmodiques...en adduction pure, elle est responsable d'une voix saccadée avec des arrêts vocaux fréquents et une incoordination pneumophonique*'. In this article, the authors provide a translation of the abstract in English which includes this description of SD: 'adductor form with a jerky voice, pitch breaks, vocal arrests and pneumophonatory incoordination' (Klap et al., 1993: 281). It is notable that these two descriptions are not identical. In the French text, the diagnostic features emphasised are frequent phonatory breaks *(avec des arrêts vocaux fréquents*), while the English translation includes the symptom of pitch breaks, which is not mentioned in the French. The authors go on to state:

> *'Les dysphonies spasmodiques en adduction pure (la plus fréquente) sont caractérisées par une voix étranglée, forcée, ponctuée d'arrêts vocaux, avec des spasmes respiratoires en inspiration ou en expiration lors de la voix conversationnelle et une mauvaise coordination pneumophonique. On note par ailleurs un forçage vocal, des difficultés d'attaque du son et des désonorisations intermittentes sur un rythme irrégulier et lent*'. (Klap et al, 1993 : 282)
>
> [Spasmodic dysphonia of the adductor type (the most frequent) is characterised by a voice that is strangled, forced, punctuated by phonatory breaks, with respiratory spasms on inspiration or expiration during conversational speech and poor pneumophonatory coordination. Vocal effort, difficulty with voice onset and intermittent devoicing in irregular and slow speech rhythm are notable. (*translated by ML*)]

These discrepancies in characterisation of SD speech in Francophones call into question how phonetic properties interact with laryngeal gestures in SD speech. The aims of this perceptual analysis are 1) to verify the discrepant characteristics of the French description of SD speech in the study by Klap and colleagues highlighted above, 2) to describe and illustrate the phonetic features of SD in these French speakers using criteria developed in the

characterisation of the vocal impairment in English (Whurr et al., 1993; Whurr and Moore, 1996) and 3) to compare and contrast the findings for these French speaking subjects with the present characterisation of SD in English speakers (Ludlow et al., 1988).

Perceptually, voice quality is an accumulative abstraction, which involves laryngeal and supralaryngeal features contributing to voice quality. According to Laver (1980), voices can be described by perceptually distinguishable components, and the articulatory, acoustic and physiological correlates of these components can be specified. The descriptive system developed by Laver (1980) was based on principles of phonetic analysis for normal/healthy voice. When applying this system to the description of pathological voice the number of distinguishable components is necessarily reduced. The salient vocal features that are the focus of the present analysis are: 1) phonatory breaks, 2) pitch breaks, 3) harshness, 4) creak, 5) breathiness and 6) falsetto as characterised in Laver, 1980.

Phonatory breaks are created by a sudden contraction of the laryngeal muscles which are erratic in occurrence and over which the patient has no control. (They are also referred to as vocal fry, voice breaks or laryngealizations.) Phonatory breaks occur both within and between syllables, and produce the impression of a jerky and staccato delivery of speech.

It should be noted that while phonatory breaks are considered pathological in English-speaking SD patients, this is distinct from the glottal stop which does exist as a common allophone in some forms of English (e.g., glottal stop [?] as an allophone for /t/ is quite prominent in some varieties of English as in [∪βε?↔] as a variant of /∪βετ↔/ for the word

'better'). In contrast, the glottal stop does not appear in Standard French pronunciation and is rarely found in regional variants of French than in variants of English (Malecot, 1980). Based on this cross-linguistic phonological distinction, the present study will treat all productions of phonatory breaks as pathological in French rather than as a possible allophonic regional variant.

Pitch Breaks are abrupt changes in the fundamental frequency of vocal cord vibration due to changes in vocal cord length resulting from spasm. This will be perceived as irregularity (and/or aperiodicity) in vocal pitch.

Harshness and Creak. Harshness is distinguished from creak as an irregular rather than periodic noise with a modal fundamental frequency. Harshness gives an impression of effortful production with a strained-strangled voice quality. In extreme cases of harshness there is evidence of tension in the neck muscles sometimes even extending to the upper body. Creak 'refers to a vocal effect produced by a very slow vibration of only one end of the vocal cords and ... very low pitch level' (Crystal, 1985: 80). In the present data analysis, creak was generally applied to the description of the quality of an individual segment while harshness was applied to voice quality over longer speech events.

Although it is generally considered to be an abnormal vocal quality, creak may be used paralinguistically in English Received Pronunciation to express disparagement (Crystal, 1985) or in conjunction with a low falling intonation, as a signal of completion of their turn as a speaker when yielding the floor to the listener (Laver, 1980). The paralinguistic use of creak is similar in French, and some people would naturally use this as a phonatory setting.

Breathiness and Whispery Voice. In instances of breathiness, the vocal cords are vibrating, but there is also a significant amount of air escaping through the glottis, causing turbulence. Breathiness is actually a subcategory of whispery voice but breathiness is the more typically used perceptual descriptor (Crystal, 1985). Whispery voice will be used in the present study to refer to instances which affect individual segments while breathiness will be used to refer to this quality in longer speech events.

In the voice of SD speakers, spasms of the vocal cords causing the phonatory breaks and creak/harshness require more medial compression than modal voice. (The term 'modal' will be used here to refer to the premorbid voice of the subject or of a healthy voice generally.)

Whisper is a vocal register used in French and English, as in many other languages, to indicate secrecy. Abnormal breathiness may be manifest in a variety of contexts in French: aspiration of consonants which is not otherwise a phonetic feature of French, lower than usual intensity or weak phonation, or devoicing of the voiced fricative consonants.

Falsetto. When producing a falsetto voice the vocal cords are stretched tightly so the resulting vibrations can have over twice the frequency that a speaker can produce using modal voicing. The use of falsetto in SD patients is seen in some cases as a form of compensatory strategy. The functional consequence of the pathology might be such that when the vocal cords are closer together and therefore producing a high pitch less spasm may occur. Falsetto is a vocal feature which can only be rated as being present or absent, rather than degree of speech affected, as it is an overriding characteristic of a speaker's production.

Without an objective measure of the fundamental frequency of the subject's premorbid voice, the degree of pitch change that had occurred in compensation for the symptoms of SD can not be judged.

METHOD

SUBJECTS: Klap and colleagues, authors of the 1993 paper referred to above, provided a videotape of clinical interviews carried out at the Oto-Rhino-Laryngology Service, Foundation A. Rothschild, Paris for this study. Six individual cases were assessed in that clinic with fibreoptic laryngoscopy, videostroboscopy, acoustic analysis of voice, neurological and neurophysiological techniques by a Neurologist (Marion), Otolaryngologist (Klap) and a Phoniatrist (Fresnel-Elbaz). All patients were diagnosed as having Spasmodic Dysphonia of the adductor type with no other language, speech or voice disorder evident. Although some of the cases did demonstrate evidence of dystonias affecting other parts of the body, none had a history of generalised motor control problems, tardive dyskinesia, vocal cord surgery or other neurological symptoms affecting speech production. All were middle aged and were native speakers of French. There were 5 women and 1 man. Table 1 below provides general information about the subjects' clinical histories ascertained through the interviews. (Subjects are referred to by pseudonyms to retain anonymity.)

Insert table 1 about here

There was variability in the number of injections received by the subjects. Two had never been treated with BTX injections, while two additional subjects had received their previous injections quite a long time before recording was made and were probably in a refractory period. No information about treatment was available on one subject, while another had received a recent (failed?) injection but had returned for additional treatment.

Whurr and colleagues (1993) reported that English SD speakers follow a typical pattern of vocal effects post injection: on average patients experienced 10 days of breathy voice, followed by approximately 2 months of improved voice, followed by a reappearance of some of the vocal symptoms exhibited pre-injection. The authors noted that in this refractory period, although voice quality did deteriorate, it nonetheless was maintained at a level above initial (i.e., pre-injection) baseline measures. In consideration of this point, it may be expected that subjects coming for their first injection may differ in severity to those who have received injections but are now in a refractory period.

MATERIALS

The analysis was based on the video recording provided by the clinic of Dr. P. Klap, Dr. M-H. Marion, and Dr. E. Fresnel-Elbaz at the Oto-Rhino-Laryngology Service, Foundation A. Rothschild, Paris. In these video sessions, the same clinician conducted each of the semi-structured interviews. The interviews did not follow a fixed protocol, but very similar questions were asked of each subject. The reflective quality of the subjects' responses suggests that the answers were spontaneous even if some of the patients may have been asked the same questions on previous occasions in the course of previous clinical interviews.

Unfortunately, the quality of the sound on the video recordings was poor and there was a great amount of background noise.

IPA transcriptions were made by a native speaker of French who was trained in phonetics (MP). For each of the 6 samples, transcriptions were created with the following format:

Line 1 -- the French utterance;

Line 2 -- a translation into English;

Line 3 -- the phonetic transcription of modal speech from a healthy control subject;

Line 4 -- the phonetic transcription of the subject's speech.

Due to the semi-structured nature of the interviews, there was considerable variability in amount of speech produced by each subject. Therefore, a sample text of one hundred syllables was selected from each subjects' responses to the interviewer. The creation of this corpus of 6 speech samples provides a fair representation of the range of linguistic phenomena present in their speech, and afforded the opportunity to make quantitative comparisons.

ANALYSIS and RESULTS

Analysis 1: Perception of Severity and Distribution of Pathological Vocal Features.

Rating categories and measures were initially validated on another sample of French SD speakers as well as English speaking SD samples. These samples were judged independently by a native Francophone with training in phonetics (MP) and 2 non-native French speakers

with long experience of speech pathology (ML and RW). Inter-rater agreement was approximately 85%. Discrepancies were reviewed collectively and agreement on measures and ratings was reached. Perceptual analysis on the 6 SD subjects was carried out by MP. In order to establish intra-rater reliability, the ratings were made a second time on all samples after an interval of 3 months. The second set of ratings showed a high degree of correspondence with the first.

Determination of the characteristics of the speech of the 6 SD speakers of French in terms of features typically described in English speaking patients must take into account the variability of the presence of symptoms which is typical of clinical disorders. Subsequently, the relative preponderance of individual features-- i.e., phonatory breaks, harshness, breathiness, and falsetto was judged for each subject. The severity rating scale was as follows: 1 = very mild, 2 = mild, 3 = moderate, 4 = pronounced, 5 = severe. The results of this analysis are displayed in Table 2 below.

In a recent study of French speaking dysphonic subjects (of varied etiologies not of the spasmodic type) Revis and colleagues (1999) found that perceptual ratings on connected speech correlated highly with those for sustained vowels produced under experimental conditions. They found that the most reliable and valid judgements were given on ratings of global severity, roughness (i.e. harshness) and breathiness.

Insert table 2 about here.

Phonatory breaks were found to be present in the speech of four of the six subjects: Anne, Christophe, Diane and Francine.

Pitch breaks. No pitch breaks were noted in the speech of any of the subjects analysed. This is a remarkable finding. It verifies the characterisation of SD in French as reported in Chevrie-Muller et al., 1987 and Klap et al. 1993 discussed above which does not include pitch breaks in the symptomotology.

The English literature has consistently noted the prominence of pitch breaks in SD from both perceptual and acoustic measures. The first diagnostic reference to pitch breaks was Aronson, 1968. Over the past 20 years pitch breaks have continued to form one of the diagnostic features of SD (e.g., Blitzer, 1998; Ludlow, 1988; Whurr et al, 1993). Most recently, Sapienza, Walton and Murry (1999: 127) carried out an acoustic analysis SD English speech and reported that 'During reading, frequency shifts [i.e. pitch breaks] were the predominant acoustic event, followed by phonatory breaks and aperiodicity'.

Harshness and creak**.** Five subjects produced voices with harshness. There were no instances of creak recorded on individual segments. It is possible that the presence of other pathological features such as phonatory breaks and falsetto may have been confounding factors which prevented the determination of creak (or pitch breaks) in individual segments.

Breathiness. (For this analysis breathiness was coded for all instances including those involving individual segments. An analysis that separates these two categories is given below in Table 3.) Interestingly, this feature is typically associated in the literature on English

SD speakers as an early post-injection side effect of BTX, which weakens the adductor muscles of the larynx (Blitzer et al., 1988; Brin, Blitzer and Stewart, 1998; Whurr et al., 1993;). In the present group of French SD speakers, breathiness was found in all cases, although 2 had never been injected with BTX and 3 other treated subjects were beyond the period of time in which these physiological side effects are expected to occur.

Falsetto was observed in three of the cases.

As can be seen from Table 2 above, the presence of phonatory breaks and harshness were the most prevalent features for these French SD speakers. Furthermore, when either phonatory breaks and/or harshness were present, these pathological features appear to contribute to a perception of greater severity of disorder overall. This perception could be due to the fact that these two features are not typically present in healthy speakers of French (or English) voices whilst harshness (and creak), breathiness (whisper) and falsetto may be used to create paralinguistic effects by healthy speakers of both of these languages as noted above.

The more pronounced cases of breathiness came from the two subjects who presented only one other SD feature. This could suggest that either harshness is not easily compatible with more than one perceptual feature or, more likely, that the presence of more than one other feature overrides the perception of breathiness.

To summarise, the voice quality of each of the 6 SD subjects can therefore be described as

-Anne: very slight breathiness, moderately harsh voice, with phonatory breaks

-Barbara: harsh, with breathiness

-Christophe: very slight breathiness, harsh, falsetto, with phonatory breaks

-Diane: breathiness, with phonatory breaks

-Elise: very slight breathiness, harsh, falsetto

-Francine: slight breathiness, moderately harsh, falsetto, with phonatory breaks

Analysis 2: Frequency of Pathological Vocal Features.

A quantitative analysis of the pathological vocal features-- phonatory breaks, harshness and breathiness, was carried out on the corpora created from the 100 phonetic syllable samples extracted from each patient's interview. The aim of this analysis was to investigate the proportion of the patients' speech affected by these various pathological features. The figures represent the percentage of affected syllables out of 100 phonetic syllable texts. See Table 3 below.

Categories of data analysis are as follows:

A = those **Phonatory breaks which occur at a syllable boundary** and therefore did not affect the production of a given segment;

B = a **Phonatory break which disrupted a segment** resulting in silent articulation or erroneous voice onset.

C = Harshness is calculated from the number of syllables recognised as harsh on transcription.

D = the observation of the **Breathiness** from low intensity.

E = individual sounds affected by **Whispery voice**--devoicing of fricatives, aspiration, silent articulation.

F = the **Total Number of Disordered Features**.

G = The **Total of Phonetic Syllables Affected**.

H = **Ratio of Features per Affected Syllable** was calculated as the total number of disordered features divided by the total of phonetic syllables affected.

N.B. The difference between the frequencies reported in Columns (F) and (G) is due to the fact that any one syllable may be affected by more than one feature, e.g., breathiness + harshness.

Insert table 3 about here.

Phonatory breaks. As can be seen in Table 3, the proportion of phonatory breaks affecting speech is varies considerably across subjects. This could be due to the fact that the sample of 100 syllables may be too small a window of observation for such a variable feature. Phonatory breaks may also be more or less prevalent depending on the individual and the given discourse context. In addition, some subjects may be more successful in accommodating their speech production to compensate for the frequent and disruptive occurrence of these phonatory breaks. For example, it was notable that Francine's production was marked by the manner in which speech was produced as distinct; separate syllables rather than a fluent speech stream.

Breathiness. The proportion of breathiness affecting speech is fairly variable in these subjects.

Total and Ratio of disordered features. Although the ratio of features per syllable varies (from 1.06 for Elise to 1.38 for Barbara) the order of prevalence remains the same.

Comparison of subjective severity ratings and quantitative analysis of pathological features.

In Table 2, Anne, Diane and Francine were rated as most severely affected by the presence of phonatory breaks in their speech. The results of the quantitative analysis reported in Table 3 would appear to present a conflicting picture to this assessment as, in Francine's case there are 41 instances of phonatory breaks, while Anne and Diane had relatively fewer with 24 and 26 instances respectively. However, on examination of the frequencies given in columns (A) and (B) one can see that Anne and Diane have a much greater proportion of phonatory breaks affecting their production. This may be due to the fact that the listener is more likely to notice phonatory breaks when they disrupt a segment rather than occurring at a syllable boundary.

With regard to harshness, the severity rating appears to match the frequency figures. Anne and Francine were estimated at severity 3, and display similar proportions (20 and 22 respectively) while Christophe and Elise were rated as 4 for severity of harshness and produced a greater number of instances of harshness (27 and 31 respectively).

A severity rating of 3 for phonatory breaks relates to an occurrence of around 14, whilst the same rating of severity of harshness relates to a greater proportion, just above 20 instances. Thus, phonatory breaks appear to contribute to a greater perception of vocal impairment with fewer actual instances. Again, it should be noted that harshness could be a paralinguistic feature of healthy French-speakers' repertoire, while phonatory breaks are not present in the

phonetic inventory for most French speakers. This may account for the impact that phonatory breaks have on the listener.

There seems to be little evidence to support the strong perceptual impression of breathiness or whispery voice for Barbara (severity rating of 4) as only 27 instances were recorded, in comparison with 45 for Diane. In the interview, Barbara herself affirmed having a greater problem with breath than with the harshness of her voice. Her difficulties with breath support appear to be part of the symptomotology of SD (e.g., pneumophonatory incoordination) and not from any other respiratory pathology.

Surprisingly, Barbara and Diane were rated highest in severity for breathiness although neither of them had received any previous injections. In the English-speaking SD literature, breathiness is typically noted solely as a temporary post-injection side effect. For example, mild breathiness post-injection of BTX was noted to last approximately 1 week by Blitzer and colleagues (1998) in a study of 901 patients over a period of 13 years 6,300 injections.

It is notable that a perceptual severity rating of 4 for the feature whispery voice is obtained with 45 instances in the case of Diane, as compared to much lower frequencies for the feature harshness (e.g., a severity rating of 4 with 27 instances in Elise's case). This may be due to our familiarity with whisper and whispery voice as non-pathological paralinguistic forms of expression. When more than half the instances of whispery voice elements are considered as affecting the patient's production it is only given the severity 4, as compared to higher perceptual severity ratings for phonatory breaks with less than half the instances being affected. When whispery voice is observed in affected syllables the perception of this feature

appears to be more pronounced. Elise and Francine have similar proportions of whispery voice, but the greater proportion of affected sounds differentiates these occurrences for Francine who was given a severity rating 2.

Overall, the relatively greater presence of phonatory breaks, rather than harshness or breathiness, appears to contribute most towards the subjective impression of severity in this study of French SD speakers. This may be at odds with the study by Wolfe, Fitch and Martin (1997) comparing acoustic measures of different SD voice types with perceived severity in English SD. They reported that 'the most useful measure for the prediction of [perceptual] severity across voice types was noise-to-harmonic ratio' i.e., harshness and breathiness (Wolfe et al., 1997: 292). Critcher and Pannbacker (2000) reviewed the use of perceptual and acoustic measures for a variety of vocal disorders and concluded that perceptual judgements are the critical tool for identifying a number of aspects of speech impairment, particularly with respect to phonatory breaks, pitch perturbation and breathiness.

Analysis 3: Overall Intelligibility of Speech

In this section, the issue of overall intelligibility was investigated with the aim of determining which features of vocal pathology present in speakers with SD most hindered the listener's understanding of SD speech production. It should be noted that this rating of intelligibility was not based on a single word discrimination/identification task typically used to assess accuracy of articulation. Rather, it is derived from the notion of intelligibility, as originally defined by Darley, Aronson and Brown (1975), applied to the speech of SD by Blitzer, Brin, Stewart, Aviv and Fahn (1992). This view of intelligibility includes other subjective impressions of understandability, acceptability and effort required on the part of the listener.

Each subject was rated for overall intelligibility using a scale of 1 to 5: 1 = fully intelligible, 2 = fair, 3 = difficult, 4 = poor, 5 = not intelligible.

The results of this analysis are:

Anne = 3; Barbara = 2; Christophe = 3; Diane = 4; Elise = 2; Francine = 4.

These ratings mirror the perceptual ratings for overall severity displayed in Table 2. The two patients who were judged to be most easily understood (Barbara and Elise) are those who do not produce phonatory breaks. This finding again underscores the observation that phonatory breaks are the vocal feature which produce the greatest disruption to communication for the listener.

Anne's intelligibility was judged to equal a rating of 3 (difficult to understand). Anne's speech was in fact comprehensible on the whole although erratic. It is true that her speech contained both phonatory breaks and harshness but this was coupled with very clear well-articulated consonants. Although Christophe produced fewer phonatory breaks than Anne the intelligibility of his speech was also given a rating of 3. This may be due to the presence of falsetto in Christophe's case. In addition, his rate of speech was quite rapid (see the section on rate below) and the feature of harshness is rather pronounced.

Diane and Francine were judged to be the most difficult to understand. Both had a large proportion of phonatory breaks. It appears that the intelligibility rating for Diane might be somewhat inflated as she only presented with two features of vocal pathology. However, Diane produced the largest proportion of segments affected by whisper (column E, table 3) as

well as a relatively high proportion of phonatory breaks affecting individual sounds. A whispery voice requires well-articulated consonants to make it intelligible.

It is not surprising that Francine, who presented all of the vocal features of SD pathology, should be one of the most difficult to understand. Having had SD as a chronic condition, it would appear that this subject might have developed particular compensatory strategies. Her speech production gives the impression of being very staccato because of the presence of phonatory breaks, but also because she speaks in discrete words rather than continuous speech. This may be a strategy adopted in anticipation of phonatory breaks. It was also noted that this subject had long latencies before responding to questions, which may reflect additional planning time.

In most cases, phonatory breaks occurred sporadically enough for the listener to work out from context what the missing sound was. They can however happen in inopportune places and hinder intelligibility; the following sentence from Anne highlights this problem:

ε βφE) Z(ε)? κ⁄ο μA) σ(?ε) α Eτρ Zε νε0

ε βφE) Zε κο μA) σε α Eτρ Zε νε

Eh bien, j'ai commencé à être génée...

(Well, it started to bother me...)

Because the phonatory break occurs at the end of the verb 'commence' the tense markers are difficult to discern causing some ambiguity. There are three equally plausible intended utterances:

present tense: *'je commence à être génée'*

present perfect: *'j'ai commencé à être génée'*

imperfect: *'je commençais à être génée'*

In such cases only context can be of help and in the example offered above it was obvious that the present perfect was intended.

Phonatory breaks may also occur successively within a single utterance. When this happens, the listener may not receive enough information to reconstruct the sentence. In the conversational interviews analysed here, three instances of phonatory breaks occurred in utterances that could not be reconstructed from context. In those instances, it not was possible to determine what was said despite the context provided by the question and the rest of the response uttered. In contrast to English, French does not permit phonetic reduction in unstressed syllables. As vocal spasm in SD can alter the production of speech sounds through changes or loss of voicing, it would seem that the overall intelligibility might be more affected in French than in English.

The speech of low volume which sometimes accompanies a breathiness or whispery voice is easily understood in the soundproof recording room but will be compromised in environments with a good deal of background noise interference. Denes and Pinson (1993: 57) provide a possible explanation for the avoidance of increased volume in SD speakers:

> 'In loud speech and shouting the vocal cords open and close more rapidly and remain open for a smaller fraction of a cycle; this increases the amplitude of the higher harmonics and gives the sounds a harsher quality'.

These various points taken together suggest that, although SD does not affect articulation in any major sense, the vocal pathology does indirectly have a great impact on intelligibility, understandability and acceptability of speech communication.

Analysis 4: Rate of Speech

Rate of speech was a feature of interest but given that the speech samples were produced in an informal interview measurements are not as robust as under controlled conditions. Table 4 displays the number of words in the sample and the production time in seconds, along with a calculation of rate given in number of words per minute.

Insert table 4 about here.

The SD speakers' rate of speech production ranged from 105 words per minute to 222 words per minute. When these results are taken together with those reported above it, can be seen that the rate of speech generally tends to decrease with an increase in the number of pathological features present in the SD speech (see column (E) Table 3). No one specific feature can be seen to directly correlate with reduction in the rate of speech. In the case of Elise, moderate harshness combined with a slightly whispery voice does not suffice to slow the rate of speech.

Cannito, Burch, Watts, Rappold, Hood and Sherrard (1997) reported on the contribution of speech disfluencies, speaking rate, temporal acoustic measures of inter-word duration, and articulation time in defining SD for English speakers. They found statistically significant differences in individuals with SD and non-dysphonic controls. Their conclusion was that

although slow speaking rate was not a defining feature of SD it contributed to the overall impression of the severity of the disorder. SD speakers' subjective experience of effortfulness in speech production may give rise to reductions in fluency and speaking rate. As a sequelae, they may also make a conscious strategy to increase listener comprehension and/or to avoid the likelihood of having to repeat.

Analysis 5: Quantity of Speech Output.

The complete transcripts of the conversational interviews were analysed to establish whether SD affected the speakers' quantity of output. Mean length of utterance (MLU) and mean length of response (MLR) to an interviewer question, i.e. length of turn, were calculated for each speaker. Responses to all 'yes/no' questions were excluded from this analysis. The proportion of monosyllabic responses was calculated from the corpora in order to assess whether SD speakers were using a discourse strategy to avoid experiencing production difficulties. The results are presented in Table 5 below.

Insert table 5 about here

The four SD speakers who had a similar ratio of MLU also had similar proportions of monosyllabic responses. Christophe had the greatest quantity of output and used the smallest proportion of monosyllabic responses. While Diane who was the speaker with the least output used the greatest proportion of monosyllabic responses.

Diane, who was visibly distressed by her condition, showed very clearly that the difficulty of communicating could have a considerable effect on the expression. Indeed, it was evident

that she answers questions with the shortest possible formulas. For example, when asked if she had children she nodded and added '*petits-enfants*' (children) followed by '*grands*' (big) and a gesture of the same signification. The shortest usual response expected might have been something like '*oui et des petits-enfants qui sont déjà grands'* (yes, and children who are already grown-up). The creation of a one hundred syllables sample text was in her case quite difficult as the longest sentence she produced was only ten syllables long; her thirteen longest sentences had to be used to make up her corpus. It is undeniable that Diane (consciously?) limits her speech to the absolute minimum. The mean length of response matches the mean length of utterance in her case because each answer only contained one sentence.

Barbara's answers were the second longest of the group but the number of words per sentence is at the same level as those of Anne, Elise and Francine. The breathing difficulty mentioned earlier is probably responsible for this; she cannot sustain the breath support for long utterances.

A study by De Langen (1996) on a German speaking SD patient suggested that vocal pathology was evident primarily in propositional speech, in particular at the end of an expiratory phase, while non-propositional, automatic speech was not affected. Moreover, Whurr and Moore (1996) observe that in English speaking SD patients laryngeal spasms affect respiratory patterns during speech, using quick inspirations to terminate long or intense adductor spasms. This suggests there may be discourse level consequences such as reduced sentence length and reliance on monosyllabic responses as a compensatory strategy in some SD speakers.

Analysis 6: Triggering phonetic environments.

A further analysis was carried out to investigate whether there were particular phonetic environments that 'trigger' pathological productions in SD French speakers. The phonetic environment was determined for each phonatory break and each instance of harshness in the 100-syllable corpus for all six of the cases. Consonants were analysed with respect to syllable type, i.e., CV, C + semivowels /φ/, /ʃ/ and /w/, and consonant clusters, and according to voice, place and manner. The frequency of vowel environments was also calculated.

Insert table 6 about here

Phonatory breaks. Of the consonant clusters produced, 58% contained a phonatory break. Phonatory breaks also occurred in 64% of environments containing a consonant + semi consonant. There was no difference in the occurrence of phonatory breaks with regard to the voice, place and manner of the consonant in canonical CV syllables. No difference was found with regard to the particular vowel target environment in which the phonatory break occurred, or with regard to the presence of nasal vowels. These results suggest that consonant clusters may provide a triggering phonetic environment for the occurrence of phonatory breaks in SD French speakers.

In French, consonant clusters are less frequent and less complex both in syllable initial and syllable final position when compared to English. The syllable structure in English is quiet

complex, while the potential for consonant clusters is much more restricted in French (Gil, 1986). In English the pattern is (C) (C) (C) V (V) (C) (C) (C) (C) while in French only (C) (C) V (C) (C) is possible. This phonotactic difference suggests the prediction that there would be a greater occurrence of phonatory breaks in the English SD speakers when compared directly to French SD speakers due to the language specific differences in the phonetic environments the two languages possess.

Harshness. The relative percentage of vowels that were perceived to be affected by the quality of harshness were as follows:

/□/ 55%; /A)/ 48%; /E/ 41%; /E)/ 39%; /□)/ 33%; /ɑ/ 32%; /o/ 29%; /ɛ/ 25%; /ψ/ 22%; /ʊ/13%; /↔/ 11% and /I/ 10%. There were not enough instances of the sounds /A/, /↵/ and /O/ were available to draw reliable conclusions.

Of all the vowels produced by the SD speakers affected by harshness, 74% of them were preceded by a voiced consonant; 18% of them were preceded by an unvoiced consonant; and that the remaining 8% were vowels in isolation. Of the vowels unaffected by harshness 41% followed a voiced consonant; 45% followed an unvoiced consonant; and 14% were in isolation.

It was noted by Rees (1958) that harshness on vowels is perceptually judged to increase with the openness of the vowel; to be greater when the vowel occurred in a voiced environment; and more marked on vowels in isolation when initiated with a glottal stop than with a 'soft', 'aspirated' beginning' (cited in Laver, 1980).

English has a phoneme inventory that is comprised of 27 consonants and 13 vowels with a C/V ratio of 2.08. French has a phoneme inventory which is comprised of 21 consonants and 16 vowels with a C/V ratio of 1.31 (Gil, 1986). This comparison suggests that as vowels are proportionally more frequent in French than in English syllables, and as harshness is noted to affect vowels, a French SD speaker will have a potentially greater problem with harshness than an English SD speaker. It should be pointed out that both these C/V ratios are considerably lower than the average of 3.52 calculated over a large number of Subject Verb Object (SVO) languages in Gil, 1986. This typological fact suggests that while French has higher sonority than English and therefore provides a greater potential for harshness than English, both of these languages have greater sonority than is typically the case.

In Delattre's (1965) comparative study of the frequency of occurrence of phonemes in French and English (and German) it was observed that the French open-mid and open vowels (including the nasal vowels) represent 45% of the vowels used in conversational speech. In contrast, the English open-mid and open vowels represent only 25% of the vowels used (or 32.5% if diphthongs /ai/ and /au/ are included). The source of the reduced occurrence of open vowels in English can be attributed to the process of unstressed vowel reduction. For example 'territorial' is pronounced [$\bar{\tau}$εριτ□$\bar{]}$ριλ] such that the vowels in the unstressed syllables become the neutral vowels /↔/ and /I/. In French, all vowel sounds are maintained whether they occur in stressed or unstressed syllables. The identical word 'terratoriale' would be pronounced [τΕριτ□ρφαλə]. Therefore, because open vowels are more affected by

harshness than closed ones, and because of the high frequency of occurrence of open vowels in French, French is likely to be harsher than English.

One further phonetic characteristic of note should be mentioned. In the French SD speech samples there was some evidence of voicing and devoicing of consonants. So far it has been assumed that these were due to the presence of other features, especially voice breaks and whispery voice respectively but the possibility of the VOT (voice onset time) playing a part in this change from normal elocution cannot be ignored. Indeed, some research has been done on VOT of French and English speakers with aphasia which reinforce this consideration. This could be an important point in the comparison of French and English SD speakers as Ryalls notes: ‘‘Since voiced stops are typically produced with a negative VOT (i.e., ‘voicing lead’) in French, while they are typically positive in English (i.e., ‘voicing lag’) there is a much greater average VOT difference between voiced and voiceless pairs in French than there is in English’’. As the quality of the tape did not allow technical measuring we can only mention the point and leave it for future studies.

CONCLUSION

The discrepancy between the characterisation of vocal symptomotology in English speaking SD individuals and the description provided by Klap and colleagues (1993) for French speaking SD individuals has been upheld in these 6 cases. A feature that is considered to be central to the description of SD in English, that of pitch breaks, was not evident in any of the productions of our subjects. Two perceptual features of voice quality that are not considered to be central, i.e. harshness and breathiness, appeared to be quite prominent in these French-speaking subjects.

These findings can only be indicative due to being based on a small number of speakers and perceptual rather than acoustic analysis. However this study does highlight the need to consider the interaction of language-specific phonetic properties with speech pathology. Diagnostic criteria developed in a given language may not be exhibited in another due to cross-linguistic variables. Therefore, clinicians working within the international community must be aware that the characterisation of pathology in English speaking patients may not coincide with the manifestations of the same pathology in speakers of other languages.

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Table 1: Subject Variables

Subject	Length of Illness	Other Dystonias	History of Injections	Timing of Interview/ Treatment
ANNE	42 years	Torticollis, segmental	unknown	Unknown
BARBARA	1 year	none	none	Coming for first injection
CHRISTOPHE	a few years	none	3 previous injections	8 months post injection
DIANE	10 years	none	none	coming for first injection
ELISE	5 years	Blepharospasm	4 previous injections	4 weeks post injection
FRANCINE	30 yrs.	Segmental	2 previous injections	4 months after last injection

Table 2: Severity and Distribution of Vocal Features

	Overall Severity	**Phonatory breaks**	**Harshness**	**Breathiness**	**Falsetto**
Anne	3	5	3	1	-
Barbara	2	-	5	4	-
Christophe	3	3	4	1	✓
Diane	4	5	-	4	-
Elise	2	-	4	1	✓
Francine	4	5	3	2	✓

1 = very mild, 2 = mild, 3 = moderate, 4 = pronounced, 5 = severe.

✓ = present, - = absent

Table 3: Frequency of Pathological Vocal Features

Subjects	**Phonatory breaks** (A)	(B)	**Harshness** (C)	**Breathiness/ Whispery voice** (D)	(E)	**Total & Ratio** (F)	(G)	(H)
Anne	15	9	20	2	2	48	45	1.07
Barbara	0	0	45	19	8	72	52	1.38
Christophe	13	1	31	7	0	52	47	1.11
Diane	20	7	2	23	22	74	55	1.35
Elise	0	0	27	11	0	38	36	1.06
Francine	40	1	22	8	4	75	57	1.32

Table 4: Rate of Speech

Subjects	**Sample words**	**Time Secs**	**Rate words/min**
Anne	80	29	165
Barbara	86	30	172
Christophe	67	33	121
Diane	90	51	105
Elise	74	20	222
Francine	72	40	108

Table 5: Parameters of Verbal Production

SUBJECTS	**MLU (words)**	**MLR (seconds)**	**Percentage of Monosyllables**
Anne	11	17.3	44%
Barbara	11	36	40%
Christophe	15.5	59.3	28%
Diane	5.5	5.5	72%
Elise	10.6	18.5	35%
Francine	10.5	17	38%

Table 6: Phonetic Environment of Pathological Vocal Productions

	Anne	**Christophe**	**Diane**	**Francine**
CC	10/16	6/14	3/6	6/7
CsemiC	4/8	3/5	14/19	6/10
single V		1	1	2
VV	1	1		3
Unvoiced+V	4	2	3	11
Voiced+V	5	1	6	13
A	*2*		*3*	*7*
E/OE	*4*	*2*		*11*
O				
I			*3*	*2*
U				
NASAL	*2*	*1*	*3*	*4*
SCHWA	*1*			
TOTAL	24	14	27	41