Neurogenic Foreign Accent Syndrome:
Articulatory Setting, Segments and Prosody in a Dutch speaker.

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ABSTRACT

Foreign accent syndrome (FAS) can be defined as a motor speech disorder in which patients develop a speech accent which is notably different from their premorbid habitual accent. This paper aims to provide an explicit description of the neurolinguistic and phonetic characteristics of a female speaker of Belgian Dutch who suffered from neurogenic FAS in which she developed a French/German foreign accent after a left hemisphere stroke. A detailed phonetic analysis of the speaker's pronunciation errors revealed problems at both the segmental and suprasegmental level. At the segmental level a wide variety of pronunciation errors were observed which are consistent with a tense articulatory setting: creaky voice, strenghtening of fricatives into stops and more carefully articulated consonants and vowels. The perception of the French accent mainly resulted from a combination of speech pathology features and unaffected regional pronunciation characteristics of the patient's Standard Dutch.

In contrast to the traditional view in the literature that FAS represents a primary dysprosodic disturbance, a detailed analysis of the speaker's intonation contours by means of the stylisation method revealed the entirely correct implementation of the most common pitch contours of Standard Dutch. This unique finding shows that FAS does not by definition follow from disruption of prosodic processing. However, the frequency of occurrence of the different types of pitch contours was clearly deviant since the patient very frequently used the Dutch continuation rise. It is hypothesized that this represents a deliberate strategy of the speaker to stay in control of the speaking situation by keeping the speaking turn which she is at continuous risk of losing as the result of long and frequent pausing.

Keywords

Foreign Accent Syndrome, Prosody, Intonation, Neurogenic Disorder

1. INTRODUCTION

Foreign Accent Syndrome (FAS) can be defined as a motor speech disorder in which patients develop a speech accent which is notably different from their premorbid habitual accent. This phenomenon was described for the first time in the context of speech and language pathology by the French neurologist Pierre Marie (1907): he reported the case of a Parisian speaker who developed a different French regional accent (Alsatian) after recovering from anarthria following a left hemisphere stroke. Since this first description a number of well-documented cases have been reported. A thorough consideration of the literature suggests that it is possible to distinguish different types of FAS. In *Neurogenic FAS* the change of accent is related to damage to the central nervous system. A landmark case is the Norwegian Astrid L. who developed a German accent after incurring head trauma during the Second World War (Monrad-Krohn, 1947): she sustained extensive damage to the left fronto-temporo-parietal region. Monrad-Krohn (1947) identified the main pronunciation problem to be a fundamental alteration of the patient's speech prosody. As to its neuroanatomical substrate, neurogenic FAS typically follows from etiologically different – mostly vascular - lesions affecting the motor speech areas of the language dominant hemisphere, including the precentral and middle frontal gyrus, the anterior insular region, the inferior parietal region and the adjacent subcortical regions. The most recent research further indicates that the cerebellum may also be crucially implicated in the development of FAS particularly in Mariën, Verhoeven, Engelborghs, Rooker, Pickut, & De Deyn (2006), Mariën & Verhoeven (2007) and Cohen, Kurowski, Steven, Blumstein, & Pascual-Leone (2009). Besides an *acquired* type of neurogenic FAS, a *developmental* variant has recently been identified by Mariën, Verhoeven, Wackenier, Engelborghs, & De Deyn (2009) who described FAS in the context of developmental apraxia of speech and specific language impairment.

The second type of FAS is a purely *psychogenic* variant in which the foreign accent of the patient is grounded in underlying psychological issues. This is exemplified by Verhoeven, Mariën, Engelborghs, D'Haenen, & De Deyn (2005) who described a Dutch patient with an outspoken French foreign accent. In this speaker, in-depth neurological assessment did not reveal any damage to the central nervous system, but her psychological profile was entirely consistent with conversion disorder. Reliable reports of similar patients are Van Borsel, Janssens, & Santens (2005), Tsuruga, Kobayashi, Hirai, & Kato (2009) and Haley, Roth, Helm-Estabrooks, & Thiessen (2009).

The third type of FAS can be considered of a *mixed* nature: in these cases the cause of the foreign accent is originally *neurogenic*, but the psychological effect of the change of accent on the patient's own personality perception is such that the patient attempts to achieve a better match between the newly acquired accent and his/her own self by further developing the accent to create a more 'believable' personality (Laures-Gore, Contado Henson, Weismer, & Rambow, 2006).

In *neurogenic* FAS the accent change is commonly related to a combination of segmental and suprasegmental pronunciation characteristics which deviate from what can be expected on the basis of the speech community to which the speaker belongs. At the segmental level, the most common problems are articulation errors pertaining to the degree of articulatory constriction in consonants and vowels with overshoot being more common than undershoot. Errors relating to various aspects of articulation such as the diphthongisation of monophthongs or wrong secondary articulations (clear l > dark l) occur less frequently as well as errors pertaining to place of articulation with backing being equally frequent as fronting of the place of articulation.

At the suprasegmental level, neurogenic FAS has often been noted to have a fundamental change of speech rhythm which is described as slow (Ardila, Rosselli, & Ardila, 1988), different (Christoph, de Freitas, dos Santos, Lima, Araujo, & Carota, 2004), isosyllabic (Berthier, Ruiz, Massone, Startkstein, & Leiguarda, 1991), staccato (Berthier et al, 1991), scanning (Mariën et al., 2006) or syllable-timed (Mariën & Verhoeven, 2007). In addition to changes in speech rhythm, occasional problems with word stress placement are sometimes observed (Gurd, Bessell, Bladon, & Bamford, 1988). Furthermore, fundamental changes in F0 and intonation are often reported and mention is made of deviant prosodic patterns (Avila, Gonzàlez, Parcet, & Belloch, 2004), dysprosody (Villaverde-González, Fernández-Villalba, Moreno-Excribano, Aliás-Linares, & Garciá-Santos, 2003; Bakker, Apeldoorn, & Metz, 2004) and anomalous pitch (Denes, Trumper, Maddalon, & Romito, 1995). In addition, it is stated that intonation is 'strange' (Gurd et al., 1988), 'monotonous' (Berthier et al., 1991) or 'impaired' (Moen, 1990) with 'abnormal' F0 patterns (Berthier et al., 1991) and F0 excursions which are either 'too small' (Berthier et al., 1991) or 'exceptionally large' (Gurd et al., 1988). It is regretful that many of these statements are based on impressionistic observation and are mostly left unsupported by acoustic measurements. Even in those cases where prosody was analysed acoustically, the conclusions are not unequivocal. Blumstein, Alexander, Ryalls, Katz, & Dworetzky (1987) concluded that their speaker used inappropriate terminal rises instead of falls and unusually large and frequent F0 excursions, while Ingram, McCormack, & Kennedy (1992) documented quite flat overall F0 and the use of exaggerated falls on the last syllable of phrases. Furthermore, Moen, Becker, Günther, & Berntsen (2007) found that their speaker was not able to correctly implement the Norwegian word accent distinctions. Kurowski, Blumstein, & Alexander (1996), however, found that their speaker's speech prosody was normal. 'Despite (…) long pauses, the fundamental frequency patterns of the sentences appeared to be normal. There were appropriate continuation rises at the ends of phrases within the sentence as well as appropriate terminal falling contours." (Kurowski et al. 1996: 19). They further argue that there was an overall continuity in the intonation contours, even in the presence of long pauses between phrases.

The above-mentioned contradictions about the involvement of intonation in FAS were taken as a starting point for a thorough analysis of speech intonation in a female speaker of (Belgian) Dutch who suffered from neurogenic FAS in which she developed a French/German foreign accent after a left hemisphere stroke. This intonation description will be carried out against the background of a thorough analysis of the patient's neurolinguistic and segmental phonetic characteristics. For a discussion of the possible underlying pathophysiologic mechanisms of FAS in this patient, we would like to refer the reader to Mariën et al. (2006).

2. CASE REPORT

The patient was a 53-year-old woman who presented with acute speech problems and a paresis of the right hemicorpus. On admission to the hospital she was well-oriented, alert and fully co-operative. Neurological examination revealed verbal mutism with intact auditory-verbal comprehension, normal spelling and intact written language comprehension. A moderate right hemiparesis and central facial nerve palsy were found. Sensory examination was normal. On confrontation no visual field defects or visuo-spatial neglect phenomena were encountered. No evidence was found for oral apraxia. Medical history was unremarkable. The patient had worked as a technician in a medical laboratory and had an education level of 14 years. For ten out of ten unimanual tasks a strong and consistent right hand preference was observed (Oldfield, 1971). On admission a computerized tomography (CT) scan of the brain was normal. A repeat CT, three days after admission, disclosed an infarction in the left fronto-parietal region. Magnetic resonance imaging (MRI) of the brain confirmed CT findings demonstrating a lesion which involved the inferior frontal gyrus, the precentral gyrus, the anterior insular cortex, the postcentral gyrus and he supramarginal gyrus of the left hemisphere (figure 1).

INSERT FIGURE 1

Neurocognitive and neurolinguistic examinations were carried out in the acute phase (day 11) and the lesion phase (day 27) of the stroke. **Neurocognitive** investigations were based on a selection of standardized tests. These consisted of the Mini Mental State Examination (MME) (Folstein, Folstein, & McHugh, 1975), the Progressive Matrices (Raven, 1938), the Wechsler Adult Intelligence Scale (WAIS) (Wechsler, 1970), subtests of the Hierarchic Dementia Scale (HDS) (Cole & Dastoor, 1987), the Wechsler Memory Scale-Revised (WMS-R) (Wechsler, 1981), the Rey-Osterrieth figure, the Wisconsin Card Sorting Test (Grant and Berg, 1993), the Stroop Colour-Word test (Stroop, 1935), the Right-Left Orientation test, the Visual Form Discrimination test and the Judgment of Line Orientation Test (JLO) (Benton, deS Hamsher, Varney, & Spreen, 1983). These test results showed above average general, verbal and performal intelligence levels and above average visuo-spatial cognition, orientation, memory, gnosis and praxis.
The **neurolinguistic** test battery consisted of a selection of tests including the Dutch version of the Aachener Aphasie Test (AAT) (Graetz, De Bleser, & Willmes, 1992), the Boston Diagnostic Aphasia Examination (BDAE) (Goodglass & Kaplan, 1983), the Token Test (De Renzi & Vignolo, 1962), the Boston Naming Test (BNT) (Kaplan, Goodglass, & Weintraub, 1983; Mariën, Mampaey, Vervaet, Saerens, & De Deyn, 1998), a phonological and semantic verbal fluency task (unpublished norms) and subtests of the Dutch version of the Psycholinguistic Assessments of Language Processing in Aphasia (PALPA) (Bastiaanse, Bosje, & Visch-Brink, 1995). The results on these tests revealed that the patient’s oral-verbal output was most markedly characterized by speech apraxia: speech was slowly articulated and hesitant. In addition, effortful articulatory struggles, which particularly affected consonant

clusters, vowel and consonant prolongations, decreased stress and a general flattening of voice volume. The perception of speech rhythm was isochronous and scanning. Though the articulatory distortions affected speech rather inconsistently, errors predominantly consisted of phonemic substitutions. Articulatory groping and struggling which induced sequential errors and mostly unsuccessful efforts to self-correction alternated with 'islands of error-free speech'. Errors increased with word length and were not task dependent. No improvement was found when the patient recited, repeated, cursed or read aloud. Apart from this selective impairment of speech movements, no accompanying aphasic or dysarthric disturbances were found: auditory-verbal and written comprehension, expressive and receptive syntax, word-finding, written confrontational naming, and dictation writing did not disclose any structural linguistic deficits.

3. THE DIAGNOSIS OF FOREIGN ACCENT SYNDROME

In order for a speech disorder to qualify as neurogenic FAS, Whitaker (1982) states that at least 4 clinical criteria should be met. In the first instance, the accent has to be considered by the patient, by acquaintances and by the investigators to sound foreign. Next, the accent should be unlike the patient's native speech before the insult. It should further be clearly related to central-nervous-system damage and there should be no evidence in the patient's background of him/her being a speaker of a foreign language. It can be confirmed that the patient fulfilled all these criteria: the patient herself as well as her direct acquaintances mentioned that her speech sounded odd as if she had a French accent. The investigators perceived her speech as French in some utterances, as German in others. In addition, comparison of the patient's speech with a recorded sample of her speech before the stroke revealed substantial differences which will be reported below. As described earlier, the disorder is related to ischemic damage of the fronto-parietal region of the language dominant hemisphere so that the speech problems are related to damage of the central nervous system. Although the patient was quite fluent in French, she only used this language occasionally.

In order to obtain more objective information about the patient's foreign accent, a sample of her speech was presented to 127 native speakers of Dutch in a perception experiment in which a speech sample was embedded between that of 4 other FAS speakers, 5 speakers with a real foreign accent and 5 native speaker controls. The listeners from the listening panel were asked to freely assign the perceived accent to the speech samples. From the results, it appears that the patient's speech was attributed a French accent by 47.79 % of the listeners, while 7.08 % identified her accent as German. In addition the patient's speech was correctly recognized as (Belgian) Dutch by 37,17 % of the participants in the listening test. The remaining accents that were assigned were Danish, Eastern European, English, Moroccan and South European (Total= 6.94%).

4. PHONETIC ANALYSIS

The phonetic analysis in this paper is based on two recordings of the patient's speech. The first speech sample is a video recording of the patient dating back to a few weeks before the stroke: it consisted of three short prayers which were read in church on the occasion of a wedding anniversary. Consequently, the language register and the speaking situation are rather formal. This recording has a duration of 25 seconds and consists of a total number of 61 words.

The second recording was made in the acute phase of the stroke, i.e. 11 days post-onset of speech symptoms and consisted of a short informal conversation between the patient and one of the authors of this paper. This recording has a duration of 2 min 40 seconds and has a total number of 206 words. In the remainder of this paper, the first recording will be referred to as *prestroke* while the second recording will be referred to as *poststroke*.

For both recordings, an orthographic transcription was made by both authors of this paper who worked independently of each other. The degree of correspondence between both transcribers was calculated as Cohen's Kappa (Cohen, 1960). For both the prestroke and poststroke speech samples Kappa amounted to 1.00, i.e. there was full agreement between both transcribers as to the words that had been said by the patient.

On the basis of this inventory, both investigators subsequently indicated for each word in the poststroke speech sample whether the pronunciation conformed to the native speaker norms. Calculation of Kappa revealed an interrater agreement of 0.95, i.e. there was agreement on the pronunciation of 195 out of 206 words of the poststroke speech sample. In the subsequent phonetic analysis, only those words from the poststroke speech sample were taken into account on which both researchers agreed that they had deviant pronunciation characteristics.

In the next stage, the poststroke recording was analysed auditorily in great detail by an experienced phonetician and a detailed phonetic transcription was made. On the basis of this transcription all the deviant speech patterns were inventorized concerning four speech production processes described in Laver (1994), i.e. initiation, phonation, articulation and co-ordination. Whenever possible the prestroke recording was used as a reference sample.

4.1 Initiation

This speech production mechanism refers to the airstream which provides the energy for speech. All speech sounds in the poststroke speech sample were produced on the basis of a pulmonic egressive airstream and that is what can be expected in Standard Belgian Dutch.

4.2 Phonation

The mechanism of phonation relates to laryngeal activity in speech: it is mainly associated with voicing of speech sounds and voice quality. With respect to the voicing distinction, the patient’s speech was characterized by a quite strong general tendency to devoice stops and fricatives in word-initial and intervocalic position (stops and fricatives in word-final position in Dutch are always voiceless). The poststroke speech sample contained 10 devoiced stops and 6 devoiced fricatives, i.e. 22.2% and 19.35% of the respective total number of voiced stops and fricatives in the sample. In all these instances, devoicing could not be accounted for by natural phonetic processes such as assimilation of voice. It should be mentioned that the proportion of fricative devoicing has to be considered as the most conservative estimate, since the total number of instances of fricative devoicing was actually 15, i.e. 48.48%. However, 9 cases were instances of devoicing the velar fricative [V] and our own research on (Belgian) Standard Dutch suggests that there is a strong general tendency for the voiced velar fricative to be devoiced by a very significant proportion of speakers (Verhoeven & Hageman, 2007). This ‘natural’ devoicing tendency does, however, not apply to the labio-dental [v] and the alveolar [z] fricatives.
In the context of devoicing, three interesting patterns of voice assimilation were seen. In Dutch, sequences of a voiceless and voiced segment normally invoke progressive assimilation: the voiced segment becomes voiceless. The exception to this rule is

when the second segments are [b] and [d]: in this case, assimilation is regressive resulting in voicing of the first segment.

[Ob d´] > [Op t´] {on the}

[sIndzdin] > [sIntstin] {since}

In order to ascertain that this phenomenon did not represent an idiosyncratic feature, a comparison was made with the prestroke speech sample which contained three instances where regressive assimilation is expected: all these instances were correctly realised with the appropriate transfer of voicing from the second segment to the first:

[v´rdridb´zOrV´] {cause grief}

[OndbrAk] {was missing}

As far as the voice quality of the patient is concerned, it appears that many of the vowels were realised with creaky voice: 29 of the 237 vowels (12.23%) had clear perceptual creak. In order to confirm this perceptual impression, the first 50 vowels from both speech samples were analysed with respect to jitter and shimmer. The terms ‘jitter’ and ‘shimmer’ refer to the amount of microperturbation in cycle duration and cycle amplitude respectively. In order to measure this microperturbation the vowels were visualised on the broadband spectrogram in PRAAT (Boersma & Weenink, 2005). In each case the middle third portion of the vowel was selected since the influence of the surrounding consonants in this area can be considered minimal. Subsequently, a voice report was generated (Boersma, 2004). In the prestroke speech sample, average jitter amounted to 0.87%, while poststroke jitter was 1.43%. A t-test indicates that this difference is significant ($t(98) = 15.30$, $p = 0.0002$). The analysis of shimmer provides an average value of 8.0% in the prestroke speech sample and 12.11 % in the poststroke speech sample. A t-test reveals that this difference is significant ($t(98)=16.92$, $p < 0.0001$).

4.3 Articulation

As far as the process of articulation is concerned, Laver (1994) distinguishes between the dimensions of manner, place and aspect of articulation.

In terms of manner of articulation a total number of 18 errors were observed. 15 errors involved the replacement of a fricative stricture type by a stop stricture and thus involves overshoot of the active articulator, i.e. [V > g], [x > k] and [h > /]. The most consistent error was the replacement of the glottal fricative by a glottal stop: this

change occurred in 13 out of 14 potential cases (92.95%). Besides overshoot, 2 instances of undershoot of the active articulator were noted in which a stop was replaced by a fricative: [k > x], [t > s].
Regarding the place of articulation, a comparison of the patient's speech with the prestroke speech sample revealed that the speaker consistently replaced the alveolar trill by a uvular trill. In itself, this replacement is not problematic in that both types of trill occur in Standard Dutch and both are regarded as equally acceptable: they are free variants. This replacement nevertheless is quite spectacular in that it involves the change from a relatively anterior to a distinctly posterior place of articulation. In addition, speakers generally only use one type of trill throughout their life and they are often unable to produce the other trill accurately.
As far as aspect of articulation is concerned, 2 errors were noted. One had to do with the conformational central/lateral aspect where a central fricative was replaced by a lateral approximant ([v > l]) and one in which the voiced bilabial stop was replaced by a voiced bilabial nasal ([b > m]). The first error may be considered as a perseveration: [V´vYlt] > [V´lYlt] {filled}. The second one may be the result of a regional colloquial realisation of the auxiliary verb [hEb´] as [hEm´].

4.4 Co-ordination

The phenomenon of co-ordination has to do with a number of aspects relating to the transition between segments. As far as co-ordination is concerned, two phenomena have to be mentioned. The first one relates to the affrication of voiceless stops. In colloquial Dutch, the word-final voiceless stops [p, t, k] are released with considerable (phonetic) affrication only if the word occurs in prepausal position; in other instances these stops remain unreleased and they do not have significant aspiration or affrication. In the poststroke speech sample, the largest majority (80.48%) of word-final voiceless stops were realised with strong homorganic affrication. Average duration of the affrication phase amounts to 114 msec. In other positions in the word, no significant aspiration or affrication was found, which is entirely in agreement with the pronunciation characteristics of Standard Dutch.
The second observation has to do with the onset of vowels: all word-initial vowels were realised with substantial glottal attack and this is not characteristic of the patient's prestroke speech.

4.5 Vowel features

The poststroke speech sample contained a total of 237 monophthongs and 6 diphthongs: only 37 of all vowels (15.61%) were regarded as problematic. Careful auditory analysis revealed that on the front-back dimension 9 vowels were realised too anterior, 7 too central and 3 too posterior. On the open-close dimension 9 vowels were too open and 7 too close. Only 2 vowels were regarded problematic in terms of lip rounding.

In a separate analysis, the patient's poststroke vowels were analysed acoustically and compared against a set of female reference measures in Belgian Standard Dutch (Verhoeven & Van Bael, 2002). Although an acoustic comparison with the vowels in the prestroke recording would have been interesting, it appeared that not all Dutch vowels were present in the prestroke recording. The acoustic analysis was done by means of PRAAT (Boersma & Weenink, 2005) on the basis of analyis conditions appropriate for female voices. On the basis of visual inspection of a broadband spectrogram, the formant values were measured as an average of the middle third portion of each vowel. These Hz-values were numerically normalized by means of a z-score transformation (Lobanov, 1971) in order to minimize the impact of anatomical differences between speakers while preserving pronunciation differences (Adank, 2003).

INSERT FIGURE 2

From figure 2 it appears that the patient's vowel space is considerably smaller in comparison to the reference values for Standard Belgian Dutch. This restricted vowel space can be partly explained by differences in the way the vowel data were elicited. In the reference set, the vowels were read as part of a carrier phrase which placed the vowel in accented focus position. As a result, they represent values for carefully articulated speech. The patient's vowels, however, were taken from a spontaneous, informal conversation averaging over different prosodic contexts. Nevertheless, there seems to be a notable difference as to the way in which the vowel space is shaped with respect to the reference vowels: all the front vowels as well as [a] and [A] have substantially lower F1 values, which is indicative of a raised articulation. The result of this raised articulation of the front vowels is that the vowels [i], [I] and [e] are hardly distinguished acoustically. In the back vowels, however, it is mainly F2 which is affected: this suggests a general fronting in the articulation of the back vowels.

4.7 Segment duration

Regarding the duration of the speech segments a comparison was made between the vowels in both speech samples as well as a comparison between the consonants. The durations of consonants and vowels in both speech samples were measured by means of PRAAT on the basis of visual inspection of a broadband spectrogram that was time-aligned with the speech waveform in the time domain. Segment durations were analysed statistically by means of a 2-way analysis of variance (ANOVA) with the TYPE of speech segment (vowels vs. consonants) and CONDITION (pre or poststroke) as independent variables and segment duration as the dependent variable. This analysis indicates a significant effect of the variable CONDITION ($F(3, 381) = 43.47$, $p < 0.0001$), while the interaction between the two independent variables was not significant. This means that both the vowels and consonants were significantly shorter in the prestroke speech sample with respective durations of 82 and 89 ms. In the poststroke speech sample the durations of vowels and consonants amounted to 128 and 137 ms.

4.8 Prosodic characteristics

4.8.1 Speech rate

Speech rate in the poststroke speech sample was quantified as speaking rate and articulation rate (Verhoeven, De Pauw, & Kloots, 2004). Speaking rate can be expressed as the number of syllables per second inclusive of pauses and interjections, while articulation rate is expressed as the number of syllables per second excluding pauses. Speaking rate in the poststroke speech sample was 1.96 syll/sec while articulation rate amounted to 2.80 syll/sec. Both values are considerably lower than the values for Standard Belgian Dutch with a speaking rate of 3.98 syll/sec and an articulation rate of 4.23 syll/sec (Verhoeven et al., 2004). In the patient’s prestroke speech sample, the average speaking rate was 4.55 syll/sec and articulation rate was 4.65 syll/sec both values being slightly faster than the reference values for Standard Belgian Dutch. On the basis of this it can be expected that the patient’s actual speech rate before the stroke is likely to have been faster still, since conversational speech is generally faster than a prayer read aloud in church.

4.8.2 Rhythm

From a perceptual point of view, it was observed that the patient's speech sounds more syllable-timed and isochronous than the normal stress timing in Standard Belgian Dutch. In order to establish a more objective measure of speech rhythm, a pairwise variability index (PVI) (Low, Grabe, & Nolan, 2000) was calculated for the prestroke and poststroke speech samples. This index is based on the idea that durations of vowels in stress-timed languages vary widely while these in syllable-timed languages show less durational variation: this gives rise to a relatively large PVI for stress-timed languages and a relatively small PVI for syllable-timed languages. The PVI for the prestroke speech sample was 56.8, while that for the poststroke speech sample amounted to 44.3. The relatively smaller PVI for the poststroke speech sample is entirely consistent with the auditory impression of greater syllable-timing in this sample. It should be pointed out that this difference in PVI is unlikely to have been caused by the difference in text styles in that the prestroke prayer was one that had been written by the patient herself and it was more conversational than poetic is nature.

4.8.3 Intonation

Several aspects of the patient's intonation in the poststroke speech sample were analyzed. On the one hand, a number of acoustic dimensions of the pitch contours were quantified. On the other hand, the general shape of the intonation patterns was analysed on the basis of the so-called stylisation method that was developed by 't Hart, Collier, & Cohen (1990).

As far as the acoustic dimensions are concerned the analysis focused on the speaker's mean pitch level, the pitch range and declination. Mean F0 in the speaker's utterances was measured by the standard autocorrelation algorithm in PRAAT (Boersma & Weenink, 2005) which was optimised for intonation analysis. In the prestroke speech sample mean F0 was 183 Hz, while mean F0 in the poststroke speech sample amounted to 140 Hz.

The pitch register of the speaker can be expressed as the difference between the lowest pitch and the highest pitch in an utterance. These values were established for all individual utterances. In the prestroke speech sample, the lowest pitch was 93 Hz on average, while the highest pitch was 293 Hz on average: the pitch register (F0max

– F0min) amounts to 200 Hz or 19.86 semitones. In the poststroke speech sample the average minimal pitch is 109 Hz, while the maximal pitch amounts to 198 Hz. Thus, the pitch register amounts to 89 Hz (or 10.33 semitones). These figures indicate that the pitch register of the patient has been reduced by about 50% after the stroke.
Besides the pitch register the declination of individual utterances was measured. Declination can be defined as the natural tendency of the speaker's pitch lowering gradually over utterances. In order to quantify declination the pitch was measured in the middle of the first unstressed syllable and the middle of the last unstressed syllable of each utterance. Taking into account the time span between these two measuring points, the average declination for the prestroke speech sample amounted to 0.60 semitones per second, while that of the poststroke sample amounted to 0.16 semitones per second.

The general shape of the intonation patterns was analysed by means of a stylisation procedure developed by 't Hart et al. (1990): on the basis of visual pitch information and auditory information the actual pitch contours are replaced by a stylized contour. In experimental practice, the procedure of stylization involves the replacement of the actually observed pitch contours by a set of straight lines which are perceptually equivalent to the original contours. This procedure does not only filter out microprosodic effects, but also provides an insight into the internal structure of pitch contours in terms of their constituting pitch movements. This stylization procedure was applied to the data by the two researchers who worked independently of each other. After the procedure, the stylisations were compared and in cases of disagreement, a consensus stylisation was sought. The stylisations were obtained were made by means of GIPOS, which is dedicated software developed specifically for this purpose at the former Institute of Perception Research, Eindhoven (the Netherlands).
On the basis of the stylisations, it was found that the patient used four different intonation patterns which can be regarded as the most elementary contours of Standard Dutch. In the first pattern, the sentence accent is realised by means of an accent-lending rising pitch movement (1) which is immediately followed by an accent-lending falling pitch movement (A) on the same syllable. The pitch excursions on the syllable with which they are associated render this syllable more prominent than the others in the same utterance. The general shape of this contour is illustrated in figure 3.

INSERT FIGURE 3 HERE.

This (1-A) intonation pattern occurred 6 times in the poststroke speech sample and was always associated correctly with the most prominent syllable of the utterance.
An important variant of this elementary contour is the (1-Ø-A) pattern, in which the rising and falling pitch movements are associated with two different accented syllables: the two movements are connected by means of a stretch of high declination. The distribution of this contour is restricted to the last two accented syllables in utterances. This contour is illustrated in figure 4.

INSERT FIGURE 4 HERE

This contour occurred 11 times in the poststroke speech sample: in all instances the contour was well-formed and conformed to the distributional requirements.
In another variant of the (1-A) contour, the first accent is realised as a prominence-lending rising pitch movement (1), while the last accent is realised by means of a prominence-lending fall (A). The intervening accents are realised by means of half-falls (E) as a result of which a terraced contour arises. This is illustrated in figure 5.

INSERT FIGURE 5 HERE.

This contour was used twice by the patient and in both cases the contour was well-formed with respect to the location of the sentence accents.
The last contour was the (1-B) pattern in which the sentence accent is realised by means of a prominence-lending rise (1) after which the pitch remains high. At some point, the pitch is reset to a lower level to mark a syntactic boundary. This is the standard continuation contour that is used by speakers to indicate that the they want to hold on to their speaking turn. This contour is illustrated in figure 6.

INSERT FIGURE 6 HERE.

This contour occurs most frequently in the poststroke speech sample: 35 or 64.48 % of all contours have this shape. A detailed analysis of the contour location reveals that this pattern does not always coincide with major syntactic boundaries, but that it is also used on words within a bigger syntactic unit.

The frequency of the pitch contours used by the patient was compared with frequency information about pitch contours in spontaneously spoken Dutch (Blaauw 1995). On the basis of a perceptual analysis of so-called instruction dialogues of 5 unimpaired native speakers, it was found that the (1-A) contour was most frequent (32.9%), followed by (1-B) which occurred in 19.50% of the cases. (1-E) had an occurrence of 8.39%. In comparison with the frequency of the pitch contours in the poststroke speech sample there are important differences. In the first instance, the frequency of the (1-B) pattern (64.8%) is extremely high, while the frequency of the (1-A) pattern (11%) is rather low. The frequency of (1-E) (3.70%) is a fraction lower than what can be expected on the basis of the reference information in Blaauw (1995).

Finally, it should be mentioned that all prominence-lending pitch movements were placed correctly by the patient, i.e. on syllables carrying word stress. In addition it has to be noted that all contours confirm with the general principle of Dutch intonation that a falling pitch movement has to be preceded by a rising pitch movement. In contrast to other languages, combinations of two falls are not acceptable in Dutch.

5. DISCUSSION

FAS is a clinical condition in which the speech of a patient is not perceived as a motor speech disorder but as a noticeable change of (regional/national) accent. In neurogenic FAS the foreign accent impression results from a misinterpretation by listeners of speech markers which are in fact indicative of speech pathology as markers of regional/national affiliation. This has important consequences for the patient, i.e. a sudden impact on identity because the speaker is no longer recognized as a member of the same speech community as before, which may lead to severe psychological and social distress (Miller, Lowitt, & O'Sullivan, 2006).

Following a stroke in the fronto-parietal region of the language dominant hemisphere, this patient presented with neurogenic FAS after a brief period of anarthria. Repeat neurolinguistic investigations in the acute and lesion phase of the stroke additionally disclosed AoS but no aphasia symptoms. Formal neuropsychological testing did not reveal any cognitive deficits.

A thorough auditory/acoustic analysis of the phonetic characteristics of FAS in this patient revealed a substantial number of pronunciation problems at the segmental level with respect to the mechanisms of phonation, articulation and co-ordination.

As for the mechanism of phonation, the voice quality of the patient was investigated and it was found that many vowels (12.23%) had clear creaky voice. This was confirmed by an acoustic analysis of jitter and shimmer: compared to the prestroke speech sample both jitter and shimmer were significantly higher after the stroke. Significant changes in voice quality in FAS patients have been reported previously (Dankovicova, Gurd, Marshall, MacMahon, Stuart-Smith, Coleman, & Slater, 2001; Gurd et al., 1988; Ingram et al., 1992; Verhoeven et al., 2005): in all these cases there was a change towards creaky voice, which is the result of a tense laryngeal setting with a strongly increased medial compression of the vocal folds as well as an increased adductive tension on the arytenoids (Laver, 1984).

Further to voice quality, the mechanism of phonation is also actively involved in voicing of speech sounds: the patient showed a tendency to devoice fricatives and stops which could not be accounted for by a natural process of assimilation. This is in agreement with previous studies which have reported devoicing of stops and fricatives (Whitacker, 1982; Ardila et al.,1988; Gurd et al., 1988; Ingram et al. 1992; Kurowski et al., 1992; Munson & Heilman, 2005; Nielsen & McKeown,1961; Roth, Fink, Cherney, & Hall, 1997; Van Borsel et al., 2005). We would like to point out that devoicing can be regarded as an articulatory simplification of the target sound: especially in fricatives the aerodynamic conditions to achieve vocal fold vibration are more complex than in other speech sounds (Verhoeven & Hageman, 2007). The reverse process in which voiceless sounds are realised as voiced does not occur in this patient, although this phenomenon has been observed occasionally in other FAS-speakers (Whitaker, 1982; Gurd et al., 1988; Berthier et al., 1991; Roth et al., 1997).

In addition to devoicing, it was observed that the patient’s pronunciation showed a number of wrong assimilations in which there is progressive assimilation instead of regressive. These mistakes are probably not due to defective processes of assimilation, but can be the result of the more general trend of devoicing speech sounds.

The articulation of speech sounds was investigated with respect to manner and place of articulation as well as additional aspects of articulation. As far as the manner of articulation is concerned it was found that the majority of pronunciation errors resulted from articulatory ‘overshoot’ of the active articulator, i.e. fricatives were realised as stops. This pertains particularly to the velar fricatives which are pronounced as velar stops and the glottal fricative which is almost consistently realised as a glottal stop in word-initial position. This ‘overshoot’ is no doubt an important factor in the perception of a French accent because these are typical mistakes which are frequently made by French learners of Dutch (Hiligsmann, 2006). On only one occasion a stop is realised as a fricative which is an example of ‘undershoot’. This is in agreement with previous research which suggests that ‘overshoot’ is generally more frequent than ‘undershoot’ (Berthier et al., 1991; Avila et al., 2004; Carbary, Patterson, & Snyder, 2000; Dankovicova et al., 2001; González-Álvarez et al., 2003; Ingram et al., 1992; Moen, 1990; Monrad-Krohn, 1947 and Ryalls & Reinvang, 1985). The relative underrepresentation of undershoot may have to be explained by the fact that the patient may be relying more heavily on proprioceptive feedback in the production of her speech and therefore possibly changes speech sounds with less proprioceptive feedback (fricatives and resonants) into sounds with clearer proprioceptive feedback (stops).

Besides manner of articulation we also investigated place of articulation. The most important conclusion here was that the alveolar trill was systematically pronounced as a uvular trill by the patient. This is also a typical feature of French learners of Dutch. In addition, there were occasional errors regarding other aspects of articulation such as the central/lateral and oral/nasal aspect. Regarding the latter it is not clear whether this is related to speech pathology or non-affected regional accent of the patient.

In connection with the vowels, an acoustic investigation revealed a substantially smaller vowel space and less acoustic differentiation between [i], [I] and [e]. This probably also contributes significantly to the perception of a French accent: in French there is no phonemic difference between [i] and [I] and the loss of this contrast is also a typical feature of French learners of Dutch (Hiligsmann, 2006).

At the suprasegmental level, this paper investigated the duration of speech segments, speech rhythm and intonation. Regarding the duration of vowels and consonants it was found that both classes of sounds are about 35% longer than in the prestroke speech sample. This is compatible with a generally slower speech rate which is 57% slower than the reference values in Verhoeven et al. (2004). This observation is consistent with the literature in which problems with speech rate are regularly mentioned (Blumstein et al., 1987; Berthier et al., 1991; Avila et al., 2004; Ardila et al., 1988; González-Álvarez, 2003; Kurowski, 1996; Pick, 1919). However, it should be noted that there have also been many patients the speech rate of whom was explicitly mentioned to be very fluent (Critchley, 1964; Dankovicova et al., 2001; Edwards, Patel, & Pople, 2005; Fridriksson, Ryalls, Rorden, Morgan, George, & Baylis, 2005; Hall, Anderson, Filley, Newcombe, & Hughes, 2003).

As far as the analysis of speech rhythm is concerned, both the auditory and acoustic analyses indicated a more syllable-timed speech delivery: the pairwise variability index in the poststroke speech sample is significantly lower than in the prestroke sample. This is consistent particularly with Miller et al. (2006) who also reported a lower vocalic PVI in their FAS patient.

The analysis of intonation revealed that the patient's pitch register was substantially reduced in the poststroke speech sample. In addition to this, the patient's mean utterance pitch was observed to be substantially lower in the poststroke speech sample. Furthermore, declination was found to be smaller after the stroke. Taken together, all these factors indicate that the patient's speech melody was generally flatter in the poststroke speech sample and leaves a distinctly monotonous impression. Furthermore, the patient's intonation patterns were analysed by means of the stylisation method. This analysis reveals a rather limited inventory of intonation patterns with a remarkably frequent occurrence of the (1-B) pitch contour: this pattern consists of a prominence-lending rising pitch movement on a syllable with sentence stress, followed by a stretch of high declination and terminating in a non-prominence lending pitch reset associated with a syntactic/prosodic boundary. This pattern is typically used by speakers as a continuation marker. The high frequency of this contour in the patient's speech probably reflects a strategy of the patient to keep in charge of the speaking turn. As a result of her slow speech rate and the sometimes long pauses between individual words in utterances, the patient is in constant danger to lose her speaking turn. However, by using the (1-B) intonation pattern the patient indicates that her speaking turn is not finished yet and that there is more information to come. The excessive use of continuation rises has been reported previously by a.o. Berthier et al. (1991) who reported rising pitch contours at terminal elements.

The intonation analysis suggests a flatter speech melody which leaves a monotonous impression and the correct useage of the intonation patterns of Standard Dutch. This conclusion deviates from widespread reports in the literature about abnormal speech melody (Avila et al., 2004; Berthier et al., 1991; Cristoph et al., 2004) and ill-formed intonation patterns (Blumstein, 1987; Lippert-Gruener, Weinert, Greisbach, & Wedekind, 2005; Reeves & Norton, 2001) as an inherent feature of FAS. Although FAS is often described as a fundamental 'ataxia of the prosodic faculty' (Monrad-Krohn, 1947: 411), the intonation analysis of this patient shows that this does not necessarily have to be the case. Indeed, it seems that FAS speakers in the presence of the motor speech disorder adapt the prosody of their utterances to their communicative needs.

Regarding the underlying mechanisms of FAS in this patient, a diagnosis of isolated FAS with AoS was made. Motor speech planning disorders as FAS and AoS create a greater need to remain in control over pronunciation. This leads to a relatively slow speech tempo, a tense articulatory/laryngeal setting and probably also articulatory simplification which is illustrated by the devoicing of stops and fricatives and articulatory overshoot in fricatives which are often realised as stops.

The impression of the foreign accent in this patient is probably caused by two processes which are fundamentally bases on misinterpretation of speech markers by listeners. In the first process pronunciation errors in the patient which are the result of speech pathology are misinterpreted by listeners as markers of a foreign national identity. Strong cues in this misinterpretation process in this patient are the use of uvular-r instead of the alveolar-r, the replacement of word initial /h/ by a glottal stop and the occasional pronunciation of velar fricatives as velar stops: these are very common amongst French learners of Dutch (Hiligsmann, 2006). In addition, there is a generally slower speech rate which may be typical for speakers of Dutch as a foreign language and a more syllable-timed rhythm which refers to French as a mothertongue. In the second process, above-mentioned misinterpretation triggers another misinterpretation at another level: a number of pronunciation characteristics of the patient which are regionally determined are no longer interpreted as regional characteristics by listeners because they happen to be consistent with the interpretation of a French accent and thus they may reinforce this 'foreign' perception. The most important feature here is the minimal difference between /i/ and /I/ in the patient's Antwerp/Campine regional Dutch. This regional characteristic which is not affected by speech pathology is probably re-interpreted as indicative of a French accent. Thus, the originally regional pronunciation characteristics reinforce the perception of the foreign accent.

6. CONCLUSION

The phonetic analysis of a (Belgian) Dutch patient with neurogenic FAS and AoS following a left fronto-parietal ischemic stroke revealed pronunciation problems at mainly the segmental level. These errors are consistent with a tense articulatory setting and articulatory simplification of speech sounds. At the suprasegmental level, a more monotonous rendering of intonation was found. Although the general implementation of the patient's intonation patterns was entirely well-formed, an overfrequent use of the continuation contour in Dutch was found: this seems to suggest that the speaker uses this as a deliberate communicative strategy to stay in control over the speaking turn. However, linguistic analysis of the intonation patterns in this patient did not confirm the general view in the literature that FAS primarily represents a dysprosodic disturbance.

It is possible to trace the origins of the foreign accent back to a misinterpretation on behalf of the listener of the patient's markers of speech pathology. This may trigger the misinterpretation of other speech markers which have not been affected by speech pathology. The result of this is that both misinterpretations reinforce each other to establish a coherent interpretation of the speaker's accent as foreign.

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Legends:

Legend to table 1:
Table 1: Lesion phase neurocognitive test results.

Legend to table 2:

Table 2: Acute phase (day 11) and lesion phase (day 27 poststroke) neurolinguistic test results

Legend to Figure 1

Figure 1: Brain MRI axial (A-B) and coronal (C-D) T1-weighted slices showing a left hemisphere ischemic lesion involving the inferior frontal gyrus, the precentral gyrus, the anterior insular cortex, the postcentral gyrus and the supramarginal gyrus.

Legend to Figure 2

Figure 2: Comparison of the acoustic characteristics of the patient's poststroke vowels and a reference set of 20 female speakers of Standard Belgian Dutch. F1 and F2 values were intrinsically normalized to z-scores (Adank, 2003).

Legend to Figure 3

Figure 3: Illustration of the pointed hat intonation pattern. Sentence gloss: 'Yes, I still know it'.

Legend to Figure 4

Figure 4: Illustration of the flat hat intonation pattern. Sentence gloss: 'That I have a strange accent'.

Legend to Figure 5

Figure 5: illustration of the terrace intonation pattern. Sentence gloss: 'And then my husband found me'.

Legend to Figure 6

Figure 6: illustration of the continuation rise. Sentence gloss: 'I have two … weeks … ago …