Selective alteration of native, but not second language articulation in a patient with foreign accent syndrome

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The present study deals with a right-handed female polyglot suffering from a Foreign Accent Syndrome (FAS) which affects her native language (L1), but not her other languages learnt since the age of 12. She had a small infarct in the left corona radiata as the result of a carotid occlusion. Her L1 was Spanish, but she also had a good command of French, English and Catalan (L2). Aphasia tests did not reveal any other significant alteration in any language. Analyses of pre-morbid and post-morbid voice recordings revealed that FAS affected Spanish dramatically, but no important changes were observed for French. Results were interpreted as showing that different brain areas control articulation of L1 and L2 learnt after a critical period. *NeuroReport* 15:2267–2270 © 2004 Lippincott Williams & Wilkins.

Key words: Bilingualism; Foreign accent syndrome; Speech articulation control

INTRODUCTION

This paper presents a case study of a stroke patient with foreign accent syndrome (FAS) resulting from a right carotid occlusion. The fundamental feature of this case was that the pathological symptoms of a foreign accent were noticeable in her first language (Spanish), but not in the other languages she had learnt after the age of 12 (French, English and Catalan), and which she spoke fluently with a Spanish accent. The learning of a second language once the so-called critical period of 12 years is over, produces varying degrees of foreign accent, depending on the first language, which is maintained for many years and is easily detectable by a native [1]. The selective alteration in the articulation of the first language seems to suggest a different cerebral control for languages learnt after the critical period.

FAS is a strange disorder characterised by slight alterations in native speech as regards articulatory and prosodic features, without necessarily showing aphasic or apraxic symptoms [2]. In most cases, FAS emerges during recovery from non-fluent agrammatic aphasia. This disorder can be distinguished from the segmental and prosodic speech production impairments often observed in Broca's aphasia, from dysarthria, and from pure dysprosodia. In contrast to these disorders, in all previous reports of FAS the native speaker-listeners have described hearing a foreign accent.

Previous cases of FAS have shown a range of languages, accents and lesion sites, and considerable variation in the associated symptomatology. Of special relevance to our study are the nature and mechanisms underlying the disorder. Different reports have concluded that FAS does not reflect the acquisition of a determinate foreign accent [2–5], but a generic foreign accent because the changes in accent do not characterize the phonetic characteristics of any particular language. These changes are probably due to a prolongation of speech (i.e. vowel production, word duration, excessive pausing between words, or long latencies of speech onset) which, combined with a reduced verbal fluency, gives the listener the impression of a foreign accent [5].

Also relevant is the heterogeneity in the localization of lesions that has provoked the appearance of FAS. Both lesions in the left basal ganglia and the motor cortex predominate in the mere 20 cases published [6] though it has also been observed after cortical lesions in the left hemisphere without apparent subcortical damage [7,8]. However, recent reports have shown that the neural basis of the FAS is actually largely unknown [3,9]. Specially relevant is the patient with FAS caused by tiny areas of damage in peripheral brain areas of the frontal lobe, the left inferior frontal corona radiata and the left thalamus.

Little is known about the cerebral bases of the native accent, though theoretical proposals highlight the role of the basal ganglia and their connexions to the motor areas in the control of articulation, coarticulation and the rhythm of speech [10,11]. Although less studied, different subcortical zones seem to participate in the control of second language articulation [12,13]. All these data support current models that hypothesize a different participation of procedural and declarative memory systems depending on age of acquisition, and proficiency [14,15]. If L1 and L2 are acquired early in natural contexts and to a high level of proficiency, their phonology and morphosyntaxes are stored in procedural memory systems. However, learning of L2 after the critical

period, along with limited proficiency in production, seems to involve the declarative memory system to a greater extent.

The present study is the first report focused on the manifestation of FAS in a polyglot patient whose L1 was Spanish, but who was able to speak other languages like French, English and Catalan. Our objective was to investigate if the deviation in the articulation from normal native language observed in FAS also affected second languages learnt after the critical period. To this end, we were fortunate to have available premorbid recordings of our patient speaking in Spanish and French. Then, we compared premorbid and postmorbid recordings of both languages in order to study whether FAS affected L1 and L2, or only L1.

PATIENT AND METHODS

Clinical history: This study is based on a right-handed 51-year-old woman who suffered mild trauma to her neck, which initially caused total muteness and right hemiparesis. She progressively recovered from both the hemiparesis and muteness, but a FAS disorder remained. MR angiography revealed an obstruction of the right internal carotid artery secondary to a spontaneous dissection. MRI showed an infarct on the right temporal lobe and a small lesion in the left inferior frontal corona radiate not relevant for clinicians (Fig. 1). In keeping with the previous report [3], we have attributed symptoms of FAS and right hemiparesis to the small infarct in the left hemisphere since (1) small infarcts in the corona radiate may cause transient motor deficits [16], and (2) the onset of motor and speech problems was simultaneous.

Neuropsychological description: The patient's first language was Spanish, but she was also fluent in French, Catalan, and English. She had learnt all these second languages after the age 12. She began French when she was 12 years old and she normally uses this language to speak to her husband. She started learning English at the age of 13, and became very fluent. She started to study Catalan at 30. General language in Spanish and French was assessed by the Boston Diagnostic Aphasia Examination, the Token Test, and the Boston Naming Test. Results showed that diverse language functions such as reading, naming, writing, and repeating words and sentences were within normal limits. As in previous cases of FAS, vocal volume was diminished. Thus, dominant complaints were in motor difficulties with the speech in Spanish, but not in French. She was, as is common in such cases, fully aware of her speech production difficulties. Importantly, she repeatedly reported that she felt better speaking in French, English and Catalan than in Spanish. These symptoms had been observed for more than 2 years.

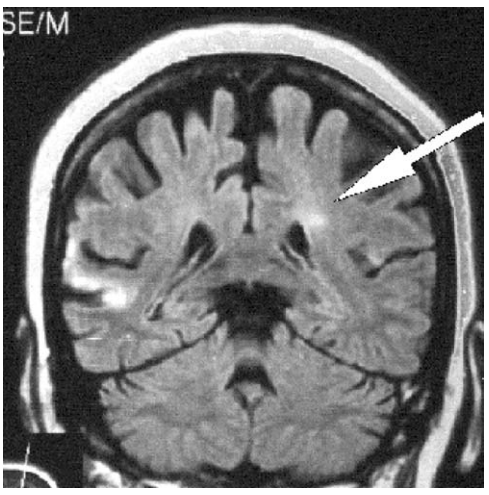

Fig. 1. MRI after onset of FAS showing a small lesion of left corona radiate and a lesion on the right temporal lobe (left hemisphere is on the right side).

Methods: Recorded speech material from patient and control subjects was obtained in two languages, Spanish and French, from spontaneous speech, repetitions of words and sentences, and reading of two paragraphs. We chose French from all possible second languages because we had premorbid recordings in this language. All speech samples were recorded in DAT (Sony TCD-D8), and converted to wav files.

The foreign accent in Spanish was evaluated using 84 speech fragments: 12 of the patient obtained from a home video recording made before the lesion; 12 obtained after the lesion; 12 obtained after the lesion and masked with background noise from the original video recording; 24 of 4 native Spanish women (12 masked with background noise); and, finally, 24 of 4 native French women (12 masked with noise). All the masked conditions were at 0 dB S/N. Native female French speakers were used because, in a preliminary study, 50% of the listeners had stated that accent of our FAS patient sounded French. A total of 16 native Spanish listeners evaluated the speaker's accent in the 84 fragments using a four-point scale: 1=native Spanish accent; 2=mild foreign accent; 3=moderate foreign accent; and 4=strong foreign accent; including the option of not responding.

A second identical experiment was carried out with fragments in French, using 36 fragments of our patient (12 premorbid), 24 fragments of 4 native French women, and 24 fragments of 4 Spanish women with a good command of French. A total of 16 French listeners evaluated the speaker's accent using the same scale (only changing native Spanish accent by native French accent). Samples of fragments may be obtained from authors.

FAS speech is characterized by both segmental and suprasegmental deficits [2–5]. Two kinds of auditory and acoustic analyses were performed on the patient's speech. First, impressionistic observations were made on spontaneous samples of pre and post-morbid speech in Spanish and French, independently by two native Spanish listeners and two native French listeners, respectively. Second, a number of acoustic measurements were taken of properties of interest reported in previous research.

Segment and pause durations were taken from samples of pre- and post-morbid spontaneous speech in French and Spanish language. Durations also were taken from a sentence-repetition task in Spanish and French (24 sentences of 8–12 words in each language). Temporal measures were also obtained from 4 Spanish native women and 4 French native women who participated as controls in this task. Voice-onset-time (VOT) was used for exploring the production of voicing in initial stop consonants [p t k b d g], by means of a repetition task of 24 disyllabic Spanish words.

Each word contained an initial stop (4 words x 6 stops) and was read three times. Fundamental frequency (Fo) patterns were measured in 24 Spanish sentences repeated by our patient and three subjects control (women aged 25–45 years).

RESULTS

Evaluation by native listeners: The analyses of evaluations of fragments of spontaneous speech made by native Spanish listeners showed that our FAS patient did not have a foreign accent in Spanish before the lesion, in contrast to the strong foreign accent which she displayed after it (Fig. 2, $t(14)=33.16$, $p<0.001$). Premorbid accent was not different from that of the native Spanish control subjects ($p>0.10$), whereas after the lesion it sounded more foreign than that of the actual foreigners ($t(14)=7.35$, $p<0.001$).

Evaluations made by native French listeners failed to show any change in her French before and after the lesion (Fig. 2; $p>0.10$). Compared with the French native group, our patient had a stronger foreign accent ($t(14)=12.80$, $p<0.001$), but compared with other Spanish natives, she had a better French accent ($t(14)=9.82$, $p<0.001$).

Acoustic analyses: As observed in previous patients with FAS, the post-morbid speech in L1 (Spanish) showed segmental and suprasegmental deviations from native performance that affected articulation, utterance and segmental duration, and prosody. These impairments were not evident in French, English and Catalan (L2). Comparing mean phoneme durations (excluding pauses) of pre- and post-morbid spontaneous speech in Spanish and French, the data revealed an overall slowness of the rate of articulation in post-morbid Spanish (Fig. 3). Importantly, this effect was specific to her native language, only appearing in Spanish ($t(116)=0$ 7.34, $p<0.0001$), but not in French ($t(36)=0.57$, $p=0.570$). Difficulties in proper sequencing and connecting of native speech movements were patent in a sentence-repetition task (Fig. 4). Relative duration of between-word pauses was much longer in post-morbid Spanish (12.04% of sentence duration) than in post-morbid French (2.55%; $F(1,44)=21.45$, $p<0.0001$). Compared with control speakers that read the same text, pauses were much longer than controls in Spanish, but not in French.

Auditory and acoustical analyses revealed articulatory impairments in the Spanish consonants apico-alveolar tap /r/, vibrant /r/, fricatives /θ/ and /s/, and the affricate

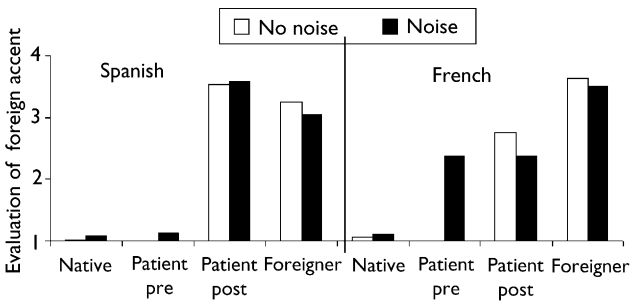

Fig. 2. Evaluations of degree of foreign accent in Spanish and French for voice recordings of our FAS patient (pre-morbid and post morbid), native speakers and foreign speakers. 16 Spanish natives and 16 French natives evaluated the degree of foreign accent of a total of 84 voice fragments.

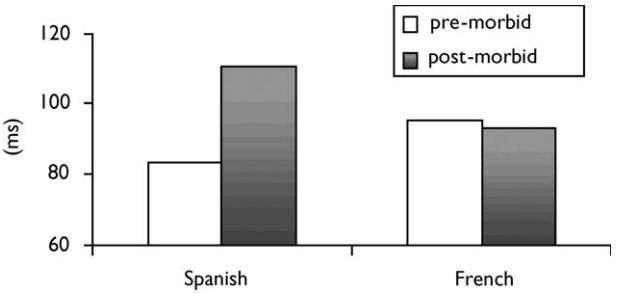

Fig. 3. Mean phoneme durations in ms (excluding pauses) pre- and post-morbid spontaneous speech in Spanish and French.

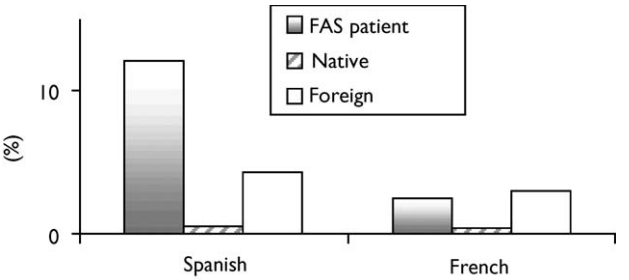

Fig. 4. Percentage of time for pauses in Spanish and French of our patient (post-morbid) and control subjects in a sentence-repetition task.

/tʃ/. Impairment especially arose in the ability to sequence speech movements when several of these sounds were included in the same word (e.g. 'zanahoria'/θanaoria/ [carrot], 'cereza' /θereθa/ [cherry]). Her Spanish was grammatical and perfectly intelligible, but she showed difficulties in linking certain sounds across words in connected speech, particularly the final /s/ of plural articles preceding vowels (e.g. 'los árboles'/los-árboles/[the trees]). No significant impairment was found for French as evaluated by 10 French native speakers.

Impressionistically, the prosodic pattern of her spontaneous speech sounded slightly deviate from native Spanish, with inappropriate pitch excursions in some intra -sentence words. Comparative analyses with control subjects of fundamental frequency contours in a sentence-repetition task showed that our patient roughly preserved the normal overall pattern in statements, questions, and compound sentences, but she introduced changes in word- and syllable-level contours. In this task, her speech also showed some vowel shifts and a deviation from the normal rhythmic-temporal pattern of Spanish. In this language, accented vowels are on average longer than unaccented vowels [17,18]. Control participants exhibited normal duration differences ($t(336)=2.62$, $p<0.01$), but our patient did not ($t(336)=0.23$, $p=0.817$). Finally, distribution of VOT of Spanish occlusives was normal, allowing a correct distinction between voiced and voiceless consonants.

DISCUSSION

This report shows the first case of a bilingual patient with FAS that included an extensive analysis of two languages. Consistent with a previous report [3], a small infarct

observed in the left corona radiata would be responsible for the observed symptoms (FAS and hemiparesia). As in previous cases [2,3], the present report would suggest that FAS syndrome is caused by mild disruption of white matter fibres connecting brain areas responsible for speech production.

What is really relevant is that language deficits were observed for L1 but not for any of the L2s, even though she showed a high level of proficiency in them. Fortunately, we have available premorbid recordings of L1 and one of her L2. From our analyses, we have contrasted changes observed after the lesion in both languages. The main result was that whereas no change in degree of foreign accent was observed in L2, L1 suffered a dramatic change from native to strong foreign accent. Nevertheless, it might be argued that the degree of foreign accent in French (L2) did not change because our FAS patient already had a Spanish accent when speaking in French. This would be a fair interpretation if we consider the FAS to be an acquisition of a determinate foreign accent, but not if we interpret it as a deviation from normal language due to a prolongation of speech that gives the impression of a generic foreign accent [5].

Against the possibility that differences between Spanish and French were due to the Spanish accent in French, there are several relevant issues included in the results section: (1) although our patient had a mild Spanish accent when speaking in French, it did not change in degree after the lesion; (2) she manifested repeatedly for 2 years her preference for speaking in French rather than in Spanish; (3) her pauses in Spanish were longer than in French (and longer than other foreign speakers); (4) articulation rate slowed post-morbidly in Spanish but not in French; and (5) she only had problems with some Spanish phonemes, but with no French phonemes. Overall, an important amount of data obtained from analyses of relevant changes typically observed in FAS [5] supports the idea that the dramatic change in Spanish accent was not observed in French.

As far as we know, this is the first case in the literature that involves the selective alteration of the native language accent, and which serves to demonstrate a different motor control of the native language from other languages learnt after the critical period. The slow down in the rate of articulation and the increase in pauses seem to suggest that our patient used a less automated system for articulating Spanish. In sum, data give support to the idea that the native language may be learned and used implicitly, relying upon cerebral mechanisms more automated than L2. By contrast L2, particularly if learned after the critical period, is probably learned and used explicitly, relying upon more conscious mechanisms.

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