

IN monolinguals, not only cortical areas but also specific subcortical structures are crucial for language and speech processing. While the role of the left basal ganglia in monolingual aphasia has been defined, its relevance in bilingual and polyglot aphasia is still unknown. Data have now been obtained on a patient who, following an ischaemic lesion not involving cortical structures and mainly confined to the left basal ganglia, showed severe impairments in mother tongue production, with significantly better performance in her hardly spoken second language. This dissociation remained stable for over a year and was observed both in spontaneous speech and in translation tasks. This pattern of linguistic performance, which has never been described in relation to subcortical lesions, suggests that the left basal ganglia play a relevant role in the output of a highly automatized language.

Key words: Bilingual aphasia; Subcortical lesions; Implicit and explicit memory

Paradoxical selective recovery in a bilingual aphasic following subcortical lesions

Salvatore Aglioti¹ and Franco Fabbro^{2,CA}

¹Istituto di Fisiologia Umana, Università di Verona; ²Istituto di Fisiologia, Università di Trieste, Via Fleming 22, 34127 Trieste, Italy

CA Corresponding Author

Introduction

Aphasic syndromes and recovery patterns in bilinguals with cortical lesions to the dominant hemisphere and data obtained by means of electrical cortical stimulation support the hypothesis that languages are functionally independent systems and that they are subserved by different neural substrates at the macro-anatomical and/or the micro-anatomical level.^{1–3} Electrical stimulation and cerebral regional blood flow studies carried out on normal and aphasic monolinguals reveal that the left basal ganglia and the left thalamus are involved in language organization.^{4–6} In monolinguals, a lesion to the left basal ganglia with or without involvement of the adjacent white matter, provokes impairments in the speech and language output system, which are characterized by disturbances in speech rate and volume and by transcortical motor aphasia.^{7,8} Moreover, recent studies have shown that basal ganglia along with other subcortical structures and circumscribed neocortical structures are involved in *implicit* memory, i.e. in the learning and memorization of skilled, automatized functions which are acquired through many repetitions and not accessible to conscious introspection, whereas they are not involved in *explicit* memory, i.e. when learning and memorizing knowledge which can be acquired from a single exposition and which individuals are aware of and may voluntarily recall.^{9–11}

Paradis¹² suggested that since an individual's mother tongue (L1) is generally acquired in conversational settings with unconscious learning strategies typical of implicit memory, it should be anatomically and neuro-functionally organized in cortical and subcortical structures that differ from those subserving the second language (L2), which is generally learned in formal settings with conscious, metalinguistic learning pro-

cedures typical of explicit memory. Therefore, it would be reasonable to suppose that a lesion to the left basal ganglia should mainly impair L1, while sparing L2. Yet, not a single case of bilingual or polyglot aphasia due to subcortical lesions has so far been reported in the literature. We present the study of a remarkable case that provides evidence of a double dissociation between first and second language following subcortical lesions mainly involving the left basal ganglia.

Materials, Methods and Results

E.M. is a 70-year-old right-handed housewife who, in November 1990, presented a mild right sensory-motor hemisindrome with a period of mutism lasting about two weeks. According to the description delivered by the patient and her relatives, the main residual impairments consisted in a slowing down of movements and a remarkable speech deficit characterized by the fact that the patient was no longer able to speak Venetan (Veronese dialect), which was her mother tongue and the language she had been using all her life, whereas she suddenly could resort to standard Italian, although her relatives and the medical staff addressed her in Venetan. Venetan is a Romance language spoken in northeastern Italy: it includes the dialects spoken in Venice (Venetian), Verona (Veronese), Treviso (Trevisan), and Padua (Paduan), which are predominantly oral dialects.¹³ During the first 3 months from the brain insult the patient's mother tongue was so severely impaired, that she could hardly interact linguistically with her family and friends. In October 1991 the patient applied to the speech therapy service in Verona, asking to be re-educated in the comprehension and production of her mother tongue. E.M. grew up and had always lived in a family environment where

only Venetan (L1) was spoken; she had attended only 3 years of elementary school in Italian (L2). She usually watched Italian TV and read Italian magazines, but she hardly ever spoke in her second language (2–3 times in a year, according to E.M. herself), and if so with great effort and several borrowings from her L1.

A neurological examination one year after the stroke revealed a slight tendon hyperflexia of the right upper limb along with severe verbal-motor inertia. In the Wechsler Adult Intelligence Scale (administered in L2) E.M. scored 92 (Verbal IQ = 94, Performance IQ = 90). No signs of ideational or ideomotor gestural apraxia were observed. Magnetic resonance was performed in April 1992 (Fig. 1).

E.M. spoke spontaneously only in Italian (L2). Her speech production was non-fluent, slow and characterized by a low voice, with foreign-accent syndrome in L2.^{14,15} The foreign-accent syndrome was judged by a group of 26 professors and medical students (20 males and 6 females) whose mother tongue was Italian. They listened to recordings of E.M.'s speech production in Italian and were simply asked to say whether the voice belonged to an Italian native speaker, and if not to tell what kind of accent they could detect. Twelve of them judged E.M.'s accent to be Italian-sounding but none said that the speaker had a typical accent of the region

of Veneto, whereas 14 held the speaker for a foreigner indicating different accents (German-, Slovenian-, English-, and Arabian-sounding) to a varying degree (for 6 judges it was only slight, for 5 it was moderately strong, for 2 it was very strong). In her mother tongue E.M. did not produce spontaneous speech and only on request could she, after a great effort, produce a few words, again with a low voice and foreign accent. By means of a language test (Italian version of the Aachener Aphasia Test)¹⁶ a slight Broca's aphasia was assessed. The same test was partially administered in Venetan, so as to assess the patient's linguistic competence in both production and comprehension of L1. In an object naming task E.M. scored 29/30 in L2 and 12/24 in L1 ($\chi^2 = 15.88$, 1 d.f., $p < 0.0001$), errors in L1 consisted of 4 semantic paraphasias, 1 anomia and 7 correct words uttered in L2 instead of L1. In the description of pictures she scored 28/30 in L2 and 3/30 in L1 ($\chi^2 = 41.71$, 1 d.f., $p < 0.0001$). No significant difference between languages was found in comprehension tasks (Token test: L2 = 36/50, L1 = 35/50; oral comprehension of words: L2 = 27/30, L1 = 14/15; comprehension of oral description of events: L2 = 9/10, L1 = 8/10). E.M.'s relatively good performance in language comprehension in both L1 and L2 may be due to the fact that the cortical structures of

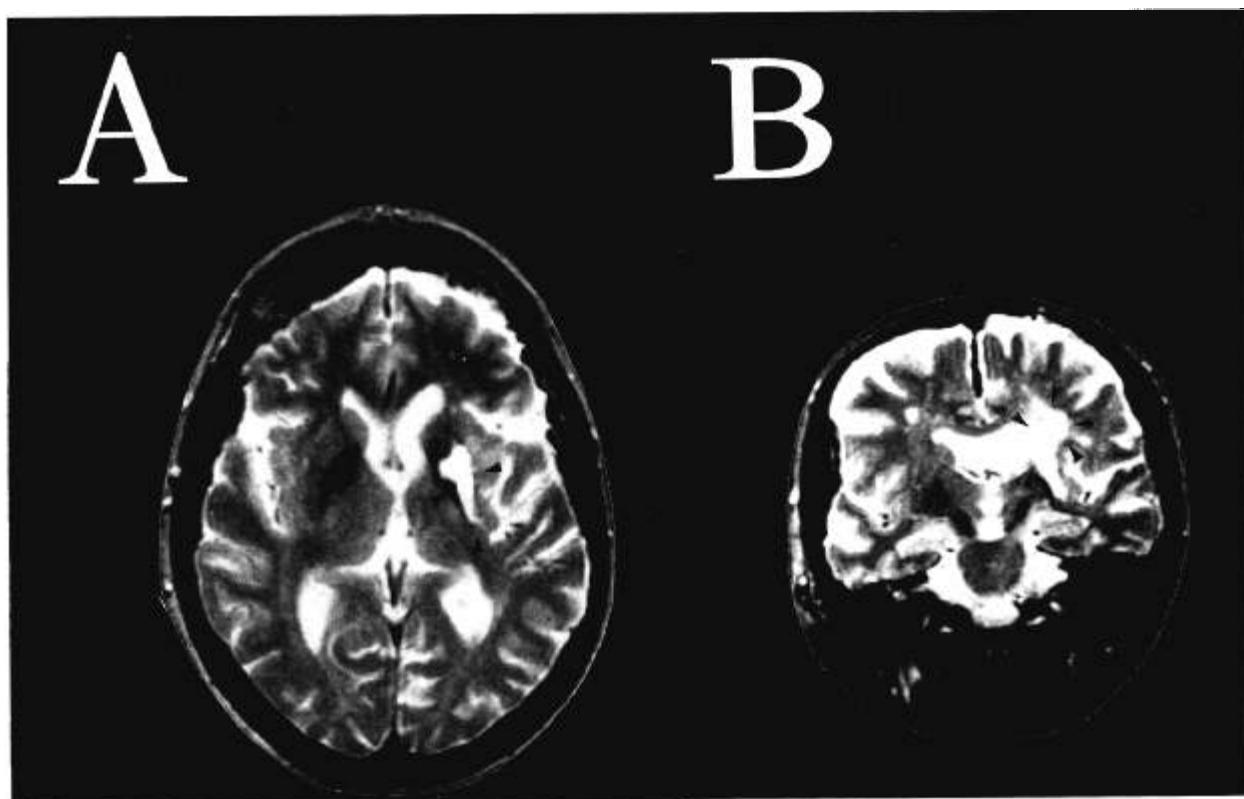


FIG. 1. Magnetic resonance image (MRI) through basal ganglia showing E.M.'s lesions in transverse (A) and coronal section (B). The images are T2 weighted: damaged areas appear white. The left hemisphere is represented on the right. The lesions have been reconstructed by two neuroradiologists who did not know about the patient's clinical history and symptoms. The extent of the lesions was assessed according to Damasio and Damasio.²³ Black arrows highlight a subcortical infarction area involving the left basal ganglia. Small bilateral infarctions in the para- and supra-ventricular frontal white matter can also be seen. Since the patient presents only extremely slight contralateral paresis, the internal capsule must be at least partially spared.

Table 1. E.M.'s performance in different spontaneous speech tasks

| | Number of words | | χ^2 df = 1 | <i>p</i> | Number of utterances | | |
|--------|-----------------|---------------|--------------------|----------|----------------------|--------------|-------------|
| | L1 | L2 | | | L1 | L2 | Mixed |
| Task 1 | 654 42.8% | 874 57.2% | 631.31 | < 0.0001 | 51 23.6% | 89 41.2% | 76 35.2% |
| Task 2 | 121 10.3% | 1059 89.7% | | | 4 2.5% | 113 69.3% | 46 28.2% |

Task 1: dialogue with the examiner in Venetan (L1). Over a period of 40 min of voice tape-recording (4 sessions in total) the patient's utterances account for 21'12" (53.3%), with 1528 uttered words and a fluency of 72.07 words per minute. **Task 2:** dialogue in Italian (L2). Over a period of 30 min of voice tape-recording (4 sessions) the patient spoke for 14'50" (49.01%), producing 1180 words with a verbal fluency of 79.55 words per min. This table shows on the left the number of words and on the right the number of utterances produced in tasks 1 and 2.

both hemispheres, which are more involved in language comprehension, were not affected by the lesion.

The rather uncommon dissociation in language production between L1 and L2 observed in E.M. was systematically evaluated by analysing spontaneous speech performance in both languages and word and sentence cross-language translation tasks.¹⁷ All words and sentences administered in these tasks had been previously chosen from the Veronese-Italian dictionary.¹⁸ When choosing the words and sentences for the translation tests, two main criteria were followed: (1) only words and sentences with exactly corresponding meaning in the two languages but different lexical stems and syntactic structures were chosen, (2) very common words were used. Since all sessions had been video recorded, scoring was checked with the help of the film sequences. All tests were administered by a Venetan/Italian bilingual speech therapist. During spontaneous speech sessions only one of the languages was used all the time the examiner and the patient were together. During the sessions where only Venetan was allowed, the patient was reminded to speak Venetan several times, because she would inadvertently switch to Italian, thereby violating instructions. Independent of the language to be used in each spontaneous speech task (either L1 or L2), the patient would produce most

Table 3. Patient's (E.M.) and control's (A.B.) results in sentence translation tasks

| Stimuli | from → to | Correct responses | χ^2 df = 1 | <i>p</i> |
|----------------|-----------|-------------------|--------------------|----------|
| E.M. (patient) | | | | |
| Sentences | L1 → L2 | 19/20 | 32.4 | < 0.0001 |
| Sentences | L2 → L1 | 1/20 | | |
| A.B. (control) | | | | |
| Sentences | L1 → L2 | 18/20 | 2.1 | 0.14 |
| Sentences | L2 → L1 | 19/20 | | |

Task 1: Translation from L2 (Italian) into L1 (Venetan): out of 124 words uttered by E.M., 119 were in L2 and only 5 in L1. **Task 2:** Translation from L1 into L2: 121 words were uttered by E.M., all of them in L2. A.B. did not show any mixing phenomenon: all words in task 1 (122) were in L1, and all words in task 2 (114) were in L2.

utterances in L2 (Table 1). In the repetition of words and sentences E.M. did not show any paraphasia. Errors in repetition tasks in L1 were mainly due to the patient's tendency to give a partial translation in L2 of the stimuli presented in L1, instead of simply repeating them (spontaneous translation). On the contrary, when speaking spontaneously the patient made several word errors: 20 neologisms, 28 phonemic paraphasias, 3 verbal paraphasias and 1 semantic paraphasia. Since the patient mainly spoke in L2, the majority of mistakes were in this language.

In word translation tasks (Table 2) the patient performed significantly quicker and better from L1 into the L2 than from L2 into L1, thus showing better results in what is considered to be the most difficult task between the two.^{2,19,20} The same was true for sentence translation tasks (Table 3). Here again the patient performed significantly better in what is assumed to be the most difficult translation version (from L1 into L2). E.M.'s husband (A.B.), a 67-year-old bilingual (L1 = Venetan, also Veronese dialect; L2 = Italian) right hander with eight years of schooling in Italian acted as control subject to match translation performance. As regards direction of translation, no significant difference was found in the control subject, both in word and sentence translation tasks (Tables 2 and 3).

Table 2. Patient's (E.M.) and control's (A.B.) results in word translation tasks

| Stimuli | from → to | Correct responses | χ^2 df = 1 | <i>p</i> | MEAN RT (s) | S.D. |
|-----------------------|-----------|-------------------|--------------------|----------|-------------|-------|
| E.M. (patient) | | | | | | |
| Words | L1 → L2 | 52/75 | 11.89 | < 0.0001 | 7.47 | 6.64 |
| Words | L2 → L1 | 31/75 | | | 10.91 | 11.05 |
| A.B. (control) | | | | | | |
| Words | L1 → L2 | 68/75 | 2.95 | 0.08 | 2.08 | 2.3 |
| Words | L2 → L1 | 73/75 | | | 1.88 | 2.1 |

Errors in translation into L1 were non-responses, whereas 13 out of 23 errors in translation into L2 were either pertinent circumlocutions or semantic paraphasias (e.g. 'ràpola' [wrinkle in L1] translated into L2 as 'vecchiaia' [old age]). Reaction times (RTs), reported on the right side of the table, were recorded for each item by means of a manually activated stop-watch. E.M.'s RTs were significantly longer in translation tasks from L2 into L1 than from L1 into L2, whereas no significant difference in translation direction was found in the control subject. Analysis of variance (ANOVA) on RTs with completely randomized design evinced $F(3,220) = 29.39$; $p < 0.0001$. Multiple comparisons (Newman-Keuls) also showed significantly slower performances of E.M. as opposed to A.B.

Discussion and Conclusion

Studies on monolingual aphasics with lesions to the left basal ganglia showed that these subcortical structures participate in the process of coordination and selection of language items that precede verbal production.⁸ In bilinguals and polyglots, the selection of a set of items belonging to one language is a crucial step towards correct production without code mixing. Moreover, switching from one language set to another language set is a typical, effortless behaviour in normal bilinguals. Since cerebral lesions generally reduce the amount and variety of behavioural sets, several neurologists have tried to explain some peculiar aspects of aphasia in polyglots, such as differential or selective recovery, in terms of an impairment of the ability to switch from one language to another. An alteration in

the switching mechanisms was thought to be the cause for the permanent 'tuning' on one language only.²¹ Other authors suggested that the unrecovered language was not lost but only inhibited.¹

These explanations, however, do not account for the reason why a cerebral lesion impairs one specific language more than another. Several hypotheses have been suggested in the past: the native language was thought to be more resistant than the languages which have been acquired later (Ribot's rule); the most familiar language was said to be more resistant (Pitres' rule); written languages were supposed to be less liable to brain damage than oral languages, whereas other authors^{1,2,22} stressed the importance of psycho-social factors influencing language resistance to brain damage. However, some clinical pictures peculiar to bilingual or polyglot aphasia can be both explained and predicted in terms of most recently developed concepts. These include the distinction between implicit and explicit memory, which are subserved by different neurofunctional and anatomical substrates, and the hypothesis that in certain types of bilingualism L1 is organized through implicit memory, whereas formally acquired L2 predominantly relies on explicit memory.

Since basal ganglia are among the most relevant structures for implicit memory,^{11,12} and since implicit memory is related to one's mother tongue, this might explain why a lesion to the basal ganglia of E.M.'s dominant hemisphere impaired access to the mother tongue but did not impair production in L2 to the same extent. Our findings clearly indicate for the first time that in bilinguals the basal ganglia of the dominant hemisphere are essential subcortical nodes in the neural

network for correct output in the mother tongue, or any automatized language which has been acquired as a habit.

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