Greater syntactic impairments in native language in bilingual Parkinsonian patients

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J Neurol Neurosurg Psychiatry 2004;**75**:1678–1681. doi: 10.1136/jnnp.2003.018507

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Received 9 May 2003
In revised form
10 December 2003
Accepted
23 February 2004

Objective: To investigate the presence of syntactic impairments in native language in Parkinson's disease. **Methods:** Twelve bilingual patients, with Friulian as their first language (L1) and Italian as their second (L2), with Parkinson's disease and 12 normal controls matched for age, sex, and years of schooling, were studied on three syntactic tasks. **Results:** Patients with Parkinson's disease showed a greater impairment of L1 than L2. **Conclusions:** These findings provide evidence of greater basal ganglia involvement in the acquisition and further processing of grammar in L1 v L2 possibly due to a major involvement of procedural memory in representing L1 grammar.

Language deficits ranging from mild to moderate are often observed in Parkinson's disease (PD). Besides speech (articulation of sounds) disruption, PD patients may show morpho-syntactic^{1,2} (grammatical) impairments. Recent findings³ suggest that resource limitations (mainly working memory impairments) could account for some aspects of sentence processing deficits in PD.

Converging evidence from bilingual aphasia studies^{4,5} and neuroimaging^{6,7} investigations suggests that the basal ganglia are involved in procedural acquisition and further processing at the morpho-syntactic level in the native language (L1), while declarative learning of the grammar of a second language (L2) and the lexical-semantic level of both L1 and L2 are mainly subserved by the temporal cortex and temporo-parietal areas.

To our knowledge, however, no clinical studies specifically addressing grammatical impairments in L1 v L2 in bilingual patients with PD have been conducted so far. Patients with PD might be expected to show greater morpho-syntactic impairment in L1 than in L2.

METHODS

We studied 12 right-handed patients with PD (seven females) (mean (SD) age 58.8 (6.9) years) and 12 right-handed healthy controls, strictly matched for age (mean (SD) age 58.2 (7.5) years), sex, and years of schooling (8.7 (4.1) years in both groups). All were Friulian native speakers (L1) and had learnt standard Italian (the national language; L2) at school by the age of 6.

Friulian is a regional language of the raetho-romance family⁸ spoken in the north-eastern region of Italy. As frequently happens for non-national languages, Friulian is usually used in an unofficial context. However, it is worth noting that it is very frequently used in daily oral communication.

Friulian differs from standard Italian in three main aspects: phonetics and phonology (larger number of vocalic and consonantal phonemes in Friulian than Italian), morpho-syntax, and lexicon. Two main morpho-syntactic differences are relevant to our investigation. In contrast to Italian and similarly to English, pronominal subjects must be overt in Friulian, even if a nominal subject is present (for

example, in Italian "*Lui* [He] *sposta* [pushes away]", in Friulian is "*Lui* [He] *al* [pronominal subject] *pare vie* [pushes away]"). Besides, as in English and in contrast to Italian, Friulian presents with (masculine) nouns composed of the root of the word and a zero suffix (Ø) (for example, in Friulian "*Frut*+Ø—read *Frut*", in English "*Boy*+Ø—read *Boy*", and in Italian "*Bambin*+o—read *Bambino*", for a singular masculine noun, and in Friulian "*Frut* (root)+s—read *Fruts*", in English "*Boy*+s—read *Boys*", and in Italian "*Bambin*+i—read *Bambini*", for the corresponding plural). Finally, we might mention the high frequency of phrasal verbs in Friulian (as in English) which are very rare in Italian.⁹

Disease onset ranged from 1 to 6 years. Severity of the disease was measured by the Unified Parkinson's Disease Rating Scale, part III (scores ranged from 6 to 17). On testing, patients were on levodopa (L-DOPA), dopaminergic agonists, Monoamine oxidase-B (MAO-B) inhibitors, and anticholinergic agents with individually guided therapies (drug selection and dosage) to obtain maximum control of PD motor symptoms.

Patients received a short baseline neuropsychological examination that assessed their general cognitive functioning (Mini Mental State Examination, MMSE), visuo-spatial problem-solving skills (Coloured Raven Progressive Matrices), and executive functions, namely categorisation ability (that is, number of categories sorted on the Wisconsin Card Sorting Test, WCST), cognitive flexibility/strategy shifting (that is, percent of perseverative errors on the WCST), and the ability to make predictions (Brixton test¹⁰).

Patients with PD and controls received three syntactic tests of sentence processing both in L1 and L2. The testing order in the different languages was counterbalanced across subjects: 50% of patients with PD and 50% of controls were assessed on L1 first.

Sentence comprehension

The first test consisted of a multiple choice sentence comprehension test in which subjects were requested to

Abbreviations: BAT, Bilingual Aphasia Test; MMSE, Mini Mental State Examination; PD, Parkinson's disease; WCST, Wisconsin Card Sorting Test

Figure 1 Performance of patients with PD and healthy controls in the syntactic comprehension task.

match an orally presented sentence (for example, “*Lei* [She] *li* [them, plural masculine] *bagna* [wets]” with the corresponding picture among a group of four (for example, the target, “*Lei lo bagna*”—She wets him, “*Lei la bagna*”—She wets her, and “*Lei le bagna*”—She wets them [plural feminine]). Each correct match was scored as one. The test consisted of 87 sentences. Different types of sentences were used: standard (for example, *The boy pushes the girl*), pronominal (for example, *He holds her*), passive (for example, *The boy is pushed by the girl*), topic-manipulated—subject or object topicalised (for example, *It is the girl that pushes the boy*, or *It is the boy that the girl pushes*, respectively), negative (for example, *The boy doesn’t push the girl*), and finally, sentences with a reversible noun phrase construction (for example, *Show me the mother’s baby*).

Sentence judgement

The second test was a syntactic judgement test consisting of 52 sentences. Subjects were asked to judge the syntax of single sentences presented orally and to decide whether they were “correct” or “incorrect” (50% of the sentences were syntactically correct) (for example, “*Le sedie della cucina è rotta*”—The chairs of the kitchen is broken). Each correct response was scored as one. Along with the syntactically correct sentences, we presented sentences with one morpheme omission, or substitution, or addition.

Sentence judgement plus correction

The third test was a syntactic judgement plus correction test consisting of 29 sentences. Subjects were asked to accept or reject the syntactic feature of an orally presented sentence (for example, “*La* [“the” feminine] *leone* [“lion” masculine] *è vecchio* [is old]), and then to correct errors, if present (66% of the sentences were syntactically incorrect as the primary aim of the task was to assess the ability to appropriately correct syntactically wrong sentences). Error detection and error correction were scored separately as one. Sentences of the same type as in the previous test were used.

The length and the syntactic complexity of the sentences used in the three tests were comparable across languages. In fact, to avoid any spurious effects across languages, the sentence comprehension test was taken from the Bilingual Aphasia Test (BAT) devised by Paradis¹¹ and rigorously adapted in almost 70 different languages. The syntactic judgement test was also taken from the BAT and we added 42 more sentences taken from an Italian aphasia battery¹² (we adapted these 42 additional sentences to Friulian). Finally, the syntactic judgement plus correction test was taken from the BAT and we added (in both Italian and Friulian) 19 newly created sentences. In order to address the length effect, we classified sentences as short (no more than six words), long (7–10 words), or very long (11 words or more). Each of

the three groups, short, long, and very long, included equal numbers of sentences across languages.

Given the skewed distribution of results towards the high range of scores, raw data were transformed following the arcsin procedure. Transformed data were entered into three separate ANOVAs for repeated measures, one for each task, with group (patients with PD and controls) and language (L1 and L2) as main factors. Post hoc comparisons were carried out by means of two-tailed paired *t* tests when differences in performance across languages were to be contrasted in each group. Bonferroni’s correction was used when necessary. We ran Spearman correlation analysis between measures of executive functions and performance in the three linguistic tests.

RESULTS

Six patients showed mild to moderate deficits of general cognitive functioning (overall, the patients’ scores ranged from 20 to 29 on the MMSE). All patients scored above the cut off (18) on the Coloured Raven Progressive Matrices test. Four patients showed no deficits of executive functioning, while the others presented with one or more dysexecutive impairments (defective categorisation prediction ability and perseverative behaviours).

Sentence comprehension

The language main factor was significant ($F_{1,22} = 8.89$, $p < 0.01$) (better performance on L1) while the group main factor was not ($F_{1,22} = 0.74$, $p > 0.40$). The language $\times$ group interaction was significant ($F_{1,22} = 4.56$, $p < 0.05$) (fig 1). Post hoc analysis of the language $\times$ group interaction showed that patients with PD performed comparably across languages ($t_{1,11} = 0.53$, $p > 0.60$), while healthy controls performed significantly better in L1 ($t_{1,11} = 4.23$, $p < 0.001$).

Syntactic judgement

The language main factor was significant ($F_{1,22} = 6.35$, $p < 0.02$) (better performance on L2) while the group main factor was not ($F_{1,22} = 0.86$, $p > 0.36$). The language $\times$ group interaction was significant ($F_{1,22} = 15.92$, $p < 0.001$) (fig 2). Post hoc analysis of the language $\times$ group interaction showed that patients with PD scored lower on L1 ($t_{1,11} = 3.69$, $p < 0.005$) and that healthy controls scored comparably across L1 and L2 ($t_{1,11} = 1.56$, $p > 0.14$).

Syntactic judgement plus correction

Both the language main factor ($F_{1,22} = 13.43$, $p < 0.001$) (better performance in L2) and the group main factor ($F_{1,22} = 4.52$, $p < 0.05$) (higher scores in the healthy controls’ group) were significant, while the language $\times$ group interaction was not ($F_{1,22} = 1.20$, $p > 0.28$) (fig 3).

Figure 2 Performance of patients with PD and healthy controls in the syntactic judgement task.

Figure 3 Performance of patients with PD and healthy controls in the syntactic judgement plus correction task.

Correlation analysis between executive and linguistic tests

The number of categories sorted in the WCST directly correlated with performance in the sentence comprehension test both in L1 (stronger correlation) and L2 (weaker correlation). The percentage of perseverative errors on the WCST inversely correlated with performance in the sentence comprehension test in L1. No other significant correlations were found (table 1).

Error analysis

We addressed the language effect across all different types of sentences. In the sentence comprehension test, we found that control subjects made less errors on pronominal sentences in L1 than in L2 ($\chi^2_1 = 6.28$, $p < 0.02$), while PD patients only showed a tendency to significance ($\chi^2_1 = 3.67$, $p > 0.055$), and that both PD patients and control subjects made less errors in L1 on topic-manipulated—object topicalised—sentences ($\chi^2_1 = 6.68$, $p < 0.01$, and $\chi^2_1 = 4.05$, $p < 0.05$, respectively). In the sentence judgement test, PD patients made less errors in L1 ($\chi^2_1 = 5.5$, $p < 0.02$), while controls did not ($\chi^2_1 = 0.81$, $p = \text{NS}$) in sentences with a morpheme substitution error. In the sentence judgement plus correction test, PD patients made more errors in L1 than in L2 ($\chi^2_1 = 4.33$, $p < 0.04$) in sentences including a morpheme omission error, while control subjects did not ($\chi^2_1 = 0.45$, $p = \text{NS}$). Finally, control subjects made more errors in L2 short sentence ($\chi^2_1 = 18.01$, $p < 0.0001$) compared with L1, while PD patients almost made more errors in L1 ($\chi^2_1 = 3.67$, $p > 0.055$). No language effects were found across all the other types of sentences.

DISCUSSION

These results are consistent with a greater impairment of syntactic processing in L1 with respect to L2 in PD patients.

Firstly, consistent with previous findings,¹³ when the access to syntax required implicit pathways (procedural grammatical knowledge) such as in the sentence comprehension test, there was a facilitative effect for L1 in control subjects but not in PD patients. Secondly, when the access to

syntax was based more on declarative meta-linguistic pathways (judgements tests), L2 drove better performance (group effect on both tests) and PD patients had lower scores in L1 with respect to L2 only in the sentence judgement test and not in the judgement plus correction test, where meta-linguistic knowledge is especially required.

Therefore, PD patients seemed to be more impaired in accessing procedural knowledge of L1 (see findings in the sentence comprehension test), while access to the declarative knowledge of L1 grammar seemed more preserved, at least to a considerable extent (see findings in the judgement plus correction test).

Consistent with previous studies,^{14, 15} eight out of 12 PD patients showed dysexecutive impairments. We correlated measures of frontal executive functioning and performance in linguistic tests. The dysexecutive impairment turned out to parallel the impaired performance of PD patients in the sentence comprehension test in L1 while only a weaker correlation was found for L2. These findings seemed to suggest that maximally the most implicit grammatical operations in L1 might be sensitive to the basal ganglia-prefrontal cortex network dysfunctions.

Error analysis failed to show consistent clear-cut dissociations across languages in most of the syntactic parameters considered (standard, passive, and topic manipulated—subject topicalised—sentences in the sentence comprehension test, correct sentences and sentences with a morpheme omission or addition in the sentence judgement test, correct sentences and sentences with a morpheme substitution or addition in the sentence judgement plus correction test, and finally, in long and very long sentences). In addition, if present, the language effect (L1 advantage) was inconsistent. We found it in control subjects but not in PD patients in comprehension of pronominal sentences, in both groups in comprehension of topic-manipulated—object topicalised—sentences, in PD patients but not in control subjects in judging sentences with a morpheme substitution error, and in control subjects but not in PD patients in processing short sentences. By contrast, we found L1 disadvantage in PD patients but not in control subjects when required to judge and correct sentences with a morpheme omission error. In conclusion, error analysis did not help that much to disentangle the possible language effect in the groups considered.

It is worth mentioning that our findings cannot be attributed either to the syntactic complexity of the sentences used or to sentence length across languages as we checked for these variables in preparing testing materials in Friulian and Italian.

Overall, patient performance was quite consistent across all individuals. In fact, variability was rather small (standard deviations were within 15% of the values of mean scores).

The patients were using Friulian in their everyday life, while Italian was limited to more formal contexts. Therefore, Friulian was used more often than Italian on a daily basis. This, along with the fact that Friulian is their first language,

Table 1 Correlation analysis between executive and linguistic tests

	Rho coefficient					
	Comprehension (Friulian)	Comprehension (Italian)	Judgement (Friulian)	Judgement (Italian)	Judgement plus correction (Friulian)	Judgement plus correction (Italian)
Brixton test	0.409	0.279	0.052	0.346	0.452	0.298
WCST number of categories	0.817**	0.582*	0.298	0.479	0.369	0.189
WCST % perseverative error	-0.717**	-0.417	0.007	-0.337	-0.004	-0.022

* $p < 0.05$; ** $p < 0.01$.

suggests a stronger neurofunctional representation of Friulian with respect to Italian. It might be predicted that, consistently with neurolinguistic findings on the patterns of language recovery in bilingual aphasics,¹⁶ the weaker language—in this case, Italian—should be more affected by pathological mechanisms. This was not observed in our patients. Therefore, we suggest that the linguistic deficits we assessed may be specific to Parkinson's disease in that they primarily affect subcortical structures.

Our study seems to give some support to the assumption of greater impairment, in PD patients, of L1 grammar as compared to a second language learnt later during childhood. Our findings are in line with the theory of language learning in polyglots^{17,18} whereby native language grammar is acquired implicitly with principal involvement of neural systems related to basal ganglia that are already mature at birth, and syntactic skills in the second language are learnt by using declarative memory which mainly relies upon memory systems related to temporal areas that complete their functional maturation in later infancy. That syntactic deficit found in our PD patients is more evident for L1 (the Group main factor was significant only on the syntactic judgement plus correction task) significantly extends previous reports of syntactic deficits in PD patients tested only in their native language.^{1–3}

Besides the theoretical interest, these findings are also relevant for clinical practice. In fact, polyglot patients with PD should be assessed in all their languages, or at least in the languages that they use most often as their linguistic deficits might be language specific. This might have important consequences for speech therapy (that is, definition of the priorities and rehabilitation in each language).

Finally, it is worth mentioning that further experimental studies on bilingual PD patients might be useful to provide further and consistent evidence in support of the theoretical framework of implicit *v* explicit processing of grammar features, and to investigate with larger neuropsychological batteries whether impairment in processing syntactic features of native language might correlate with some other cognitive operation.

ACKNOWLEDGEMENTS

We thank two anonymous referees for valuable comments in improving a previous version of the manuscript.

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This work was supported by a grant from the Italian Department of Health to IRCCS "E. Medea" (Current Research Project 2001)

Competing interests: none declared

REFERENCES

- 1 **Lieberman P**, Friedman J, Feldman LS. Syntax comprehension deficits in Parkinson's disease. *J Nerv Ment Dis* 1990;178:360–65.
- 2 **Skeel RL**, Crosson B, Nadeau SE, *et al*. Basal ganglia dysfunction, working memory, and sentence comprehension in patients with Parkinson's disease. *Neuropsychologia* 2001;39:962–71.
- 3 **Grossman M**, Cooke A, De Vita C, *et al*. Grammatical and resource components of sentence processing in Parkinson's disease—an fMRI study. *Neurology* 2003;60:775–81.
- 4 **Fabbro F**, Paradis M. Differential impairments in four multilingual patients with subcortical lesions. In: Paradis M, ed. *Aspects of bilingual aphasia*, vol. III. Oxford: Pergamon, 1995:139–76.
- 5 **Fabbro F**. *The neurolinguistic of bilingualism*. Hove: Psychology Press, 1999.
- 6 **Dehaene S**, Dupoux E, Mehler J, *et al*. Anatomical variability in the cortical representation of first and second language. *Neuroreport* 1997;8:3809–15.
- 7 **Weber-Fox CM**, Neville HJ. Maturation constraints on functional specialisation for language processing: ERP and behavioural evidence in bilingual speakers. *J Cogn Neurosci* 1996;8:231–56.
- 8 **Haiman J**, Benincà P. *The rhoeto-romance languages*. London: Routledge, 1992.
- 9 **Fabbro F**, Frau G. Manifestations of aphasia in Friulian. In: Paradis M, ed. *Manifestations of aphasia in different languages*. Oxford: Pergamon, 2001:171–95.
- 10 **Burgess PW**, Shallice T. *The Hayling and Brixton tests*. Bury St. Edmunds: Thames Valley Test Company, 1997.
- 11 **Paradis M**, Libben G. *The assessment of bilingual aphasia*. Hillsdale: Erlbaum, 1987.
- 12 **Miceli G**, Laudanna A, Burani C, *et al*. Batteria per l'analisi dei deficit afasici—BADA. Rome: CEPSAG, 1994.
- 13 **Green DW**, Rice C. Functional imaging in the study of recovery pattern in bilingual aphasia. In: Green DW, ed. *The cognitive neuroscience of bilingualism*. *Bilingualism Lang Cogn* 2001;4:191–201.
- 14 **Dujardin K**, Defebvre L, Grunberg C, *et al*. Memory and executive function in sporadic and familial Parkinson's disease. *Brain* 2001;124:389–98.
- 15 **Saltzman J**, Strauss E, Hunter M, *et al*. Theory of mind and executive functions in normal human aging and Parkinson's disease. *J Int Neuropsychol Soc* 2000;6:781–88.
- 16 **Fabbro F**, ed. *Advances in the neurolinguistics of bilingualism*. Udine, Italy: Forum, 2002.
- 17 **Paradis M**. Neurolinguistic aspects of implicit and explicit memory: implications for bilingualism and SLA. In: Ellis NC, ed. *Implicit and explicit learning of languages*. London: Academic Press, 1994:393–418.
- 18 **Ullman MT**. The neural basis of lexicon and grammar in first and second language: the declarative/procedural model. *Bilingualism Lang Cogn* 2001;4:105–22.