

Recovery from aphasia as a function of language therapy in an early bilingual patient demonstrated by fMRI

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Abstract

Knowledge about the recovery of language functions in bilingual aphasic patients who suffer from left-hemispheric stroke is scarce. Here, we present the case of an early bilingual patient (German/French) with chronic aphasia. Functional magnetic resonance imaging (fMRI) was used to investigate neural correlates of language performance during an overt picture naming task in German and French (a) 32 months after stroke to assess differential recovery of both languages as a function of the preceding language therapy that was provided exclusively in German and (b) after additional short-term intensive (German) language training. At the first investigation behavioral performance confirmed selective recovery of German naming ability which was associated with increased functional brain activation compared to the French naming condition. Changes in behavioral performance and brain activation pattern as disclosed by fMRI after an additional experimental treatment were confined to the trained (German) language and indicate bilateral neuroplastic reorganization. No generalization to the untrained (French) language was observed. The present case results demonstrate use and/or training-dependent differential recovery of expressive language functions and an enhanced pattern of brain activation as a function of the rehabilitation efforts that were focussed exclusively on the patient's German language abilities.

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1. Introduction

“Multilingualism” means the mastering and frequent use of two or more languages in everyday life and does not imply a specific degree of proficiency in one or the other language. According to this definition more than half of the world population might be considered multilingual (Fabbro, 2001a). Accordingly, neurological conditions (e.g., stroke, tumors) leading to language disorders may affect more than one language in this population.

Little is known about the recovery of language in multilingual patients suffering from aphasia after neurological injury like cerebrovascular stroke. Former theories of enhanced recovery

of the “most used language” (Pitres' Rule) or “the native language” (Ribot's law) have not been confirmed (Fabbro, 2001a; Pearce, 2005). Rather, the recovery from aphasia in multilinguals appears to be more complex than these early theories have suggested. For example, Paradis (1987) described six patterns of recovery of aphasia in former bilingual patients. The most frequent are parallel recovery (simultaneous recovery of two or more languages), selective recovery (only one language is recovered) and successive recovery (one language improves before the others). In a more recent study, Paradis (2001) found parallel recovery of both languages in 65% of patients in a sample of 20 former bilingual patients. Greater impairment of the first acquired language was found in 20% of the cases, the opposite pattern was observed in the remaining 15% of the patients. Therefore, a highly variable pattern of recovery is to be expected in bilingual aphasics. Possible influences might be age of acquisition, proficiency and daily use of each language before neurological damage and the training provided following the insult (Marrero, Golden, & Espe-Pfeifer, 2002).

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Moreover, the question whether rehabilitation efforts are transferred from one language (the trained) to the other (the untrained) language deserves further elaboration. While it has been claimed that rehabilitation efforts usually tend to transfer from the trained to the untrained language to some degree (Fabbro, 2001b; Filiputti, Tavano, Vorano, de Luca, & Fabbro, 2002; Fredman, 1975; Gil & Goral, 2004; Watamori & Sasanuma, 1978), the improvement in the trained language is usually more pronounced than in the untrained language. For example, Junque, Vendrell, Vendrell-Brucet, and Tobena (1989) found more enhanced improvement of naming performance for the trained language in a sample of 30 Catalan–Spanish bilingual aphasics. On the other hand, there are studies that could not demonstrate transfer of treatment efforts from one language to the other: Galvez and Hinckley (2003) investigated a Spanish–English bilingual aphasic patient whose native language was Spanish but rated himself equally proficient in his later acquired English. A naming treatment that included a hierarchy of semantic and phonemic cues or the repetition of target words was provided consecutively in both languages. Improvements were found after each training session for the trained language but no transfer to the untrained language was observed. A possible explanation for the lack of or less pronounced generalization in treatment studies (even in early bilinguals with equal language proficiency) has been provided by Laganaro and Overton-Venet (2001): the authors suggest, that treatment only generalizes when common computational processes (i.e., a task requires the same strategies in both languages) are targeted. This is in line with studies that found more pronounced recovery and enhanced transfer of treatment gains across languages during picture naming treatment for cognates (i.e., words that overlap in form and meaning in different languages) but not for non-cognates (Detry, Pillon, & de Partz, 2005; Kohnert, 2004; Lalor & Kirsner, 2001; Roberts & Deslauriers, 1999). Moreover, Edmonds and Kiran (2006) investigated transfer patterns of a semantic naming treatment that was consecutively provided in English and Spanish in two English–Spanish bilingual aphasics. Transfer from one language to the other was only found in the patient with balanced language skills (i.e., equal premorbid skills for both languages) while no transfer was observed in the (unbalanced) English dominant patient. The authors suggested that for patients who are equally proficient in their language abilities before neurological damage it may be sufficient to treat only one language.

Even though the above cited studies addressed treatment outcome and generalization across languages, to our knowledge the neural concomitants of treatment effects and potential generalization across languages have never been scrutinized by means of functional imaging techniques (e.g., functional magnetic resonance imaging, fMRI). The present study sought to provide such evidence by investigating a 35-year-old early bilingual (German/French) individual with premorbid balanced language skills, who had suffered from a left-hemispheric stroke 32 months ago and was in the late chronic stage of aphasia. After the stroke standard language rehabilitation had been offered which focussed exclusively on the German language abilities.

Functional magnetic resonance imaging (fMRI) during an overt picture naming task using a temporal sparse sampling procedure (Hall et al., 1999) served to monitor cortical activation of verbal responses during scanning. In a first fMRI scan, naming of visually presented objects was required in German and French in order to investigate cortical activation accompanying word-retrieval as a function of the long-term rehabilitation efforts. Then, the patient participated in a 2-week intensive (German) language training (Meinzer, Djundja, Barthel, Elbert, & Rockstroh, 2005; Pulvermueller et al., 2001). Special emphasis was given to word-retrieval in this training. Functional MRI was repeated for both languages after the training period to explore neuroplastic changes, i.e., concomitants of improvement of function, and potential transfer of training to French.

1.1. Case history

CQ,¹ a highly educated (Ph.D.) right-handed 35-year-old man was raised as the son of a German father and a French mother in France until the age of 3. The primary language during the first 3 years of his life was French, but he became fluent in German by the age of 3 when the family moved to Germany where he visited a German Kindergarten and spent most time with his grandparents who only spoke German. The primary language with his parents was French. Therefore, both languages were used on a daily basis during his early childhood. According to the patient and his parents language skills for each language were comparably good. Until he graduated from high-school both languages were equally prominent in his everyday life, German at school and French at home. Later in life the patient continued to use both languages on a daily basis at home and at work, since he was employed at an international law firm.²

At the age of 32 CQ suffered from an ischemic cerebrovascular stroke of the left middle cerebral artery following dissection of the internal carotid artery. Two weeks later decompressive craniectomy was performed since additional intraslesional bleeding was encountered during computer tomography and a left frontal ventricular catheter was introduced. An additional 2 weeks later the catheter was removed and the site of trepanation was closed by a palakosplastic. The remaining lesion involved large parts of fronto-temporo-parietal lobes of the left hemisphere. The anterior portion of the middle and superior temporal lobe, the inferior frontal gyrus and rolandic operculum, pre- and postcentral regions, the posterior portion of the insula and putamen and parts of the superior and inferior parietal lobe (determined from Talairach & Tournoux, 1988) were affected. The posterior portion of the superior and middle temporal lobe and inferior temporal regions remained largely spared (see Fig. 1 for details of the lesion).

In the acute phase, CQ's (German) language disorder was diagnosed as global aphasia. According to CQ and his parents,

¹ Initials were changed in order to guarantee confidentiality.

² Later in life, during high-school education and at university, the patient also acquired English and Italian. We do not report on his other languages, since they were not acquired at an early age.

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