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Language-associated cortical regions in non-proficient Chinese–English bilinguals with glioma

Han Gao [a], Hongmin Bai [a], Lixin Han [b], Tiandong Li [a], Wei Wang [a], Yibing Liu [a], Jian Lin [a], Xuan Zeng [a], Guoliang Wang [a], Yubao Wang [a], Limin Wang [a], Xiaopeng Zhang [a], Weimin Wang [a, *]

[a] Department of Neurosurgery, Guangzhou General Hospital of Guangzhou Military Command, Guangzhou, China
[b] Department of Magnetic Resonance Imaging, Guangzhou General Hospital of Guangzhou Military Command, Guangzhou, China

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ABSTRACT

In fluent bilingual patients with glioma, brain mapping for the two languages is necessary because the language areas for both languages may not completely overlap. However, whether or not non-fluent bilingual patients with glioma should undergo the same procedure has yet to be determined. In this study, the distribution characteristics of language-associated cortical regions in non-fluent Chinese–English bilinguals (CEBs) with glioma were explored. Six unskilled Chinese–English late bilingual patients with glioma in eloquent cortical regions underwent awake brain surgery. Preoperative blood-oxygen-level dependent functional magnetic resonance imaging (BOLD-fMRI) was performed to position bilingual regions. Direct cortical electrical stimulation (DCES) was conducted for intraoperative positioning of bilingual cortical regions. The identified language-positive regions were protected during tumor resection to preserve language function after surgery, and BOLD-fMRI and DCES results were compared. Results showed that 71 points were stimulated in 6 CEB patients. Three specific language regions (4.2%), including 2 specific English language regions (2.8%) and 1 specific Chinese language region (1.4%), were located in the frontal and temporal lobes. Comparisons between BOLD-fMRI and DCES showed a sensitivity, specificity and consistency of 75.0%, 30.9% and 40.9%, respectively. Non-fluent Chinese–English late bilinguals have specific bilingual cortical regions, and the test for both languages during surgery is necessary. The language region positioning results of BOLD-fMRI cannot replace the position accuracy provided by DCES.

1. Introduction

The term bilingual refers to individuals who can communicate to a certain degree in two languages. On the basis of the differences in degree of mastery, bilinguals can be categorized as fluent or non-fluent. To find out more about the specific underlying brain mechanisms of bilingualism, Penfield (1965) was among the first to apply direct cortical electrical stimulation (DCES) and discovered that bilinguals had specific cortical language areas. Whilst performing epilepsy surgery, he found that the two language areas of bilinguals were not completely overlapping and that a specific language area existed for

* Corresponding author.
E-mail address: weiminwangcn@163.com (W. Wang).

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each language inside the Broca's area and Werinicke's area. Although he hypothesised that learning a second language did not unequivocally require a new area of the cortex, he did not pursue this matter any further. Ojemann and Whitaker (1978) applied DCES in glioma resection and performed mapping of bilingual language areas. They also found that the functional areas of the mother tongue and the second language had some overlap and some separation. In that research they concluded that the shared language areas were in the center of the traditional language cortex, in both frontal and parietal cortex, while the specific language areas were in the periphery. Using blood-oxygen-level dependent functional magnetic resonance imaging (BOLD-fMRI), Kim, Relkin, Lee, and Hirsch (1997) indicated the presence of distinct cortical areas representing native and second languages in bilinguals. He also pointed out that these distinct language areas only existed in the Broca's area, but not the Wernicke's area.

Brain mapping for eloquent areas (which normally means cortical areas for language, motor skills and sensory perception) is highly significant for glioma patients because gliomas infiltrate into the brain tissue and occasionally grow into eloquent areas. Maximum resection of glioma whilst preserving movement and language function is the best approach to deal with these lesions (Duffau, 2011a, 2011b, 2012). Thus, longer overall survival rates can be achieved and postoperative quality of life can be ensured. This procedure is especially important for patients with low-grade glioma (LGG) because some patients can survive over 10 years. As for bilinguals who are equally fluent in both of the languages they speak, brain mapping for each language during brain tumor surgery is mandatory because the language area for the two languages may not be totally overlapping (Bello et al., 2006; Giussani, Roux, Lubrano, Gaini, & Bello, 2007; Kho et al., 2007; Rapport, Tan, & Whitaker, 1983; Roux et al., 2004; Walker, Quinones-Hinojosa, & Berger, 2004).

Fluent bilingual patients may have specific language-associated cortical regions—that is, the cortical regions of the two languages do not complete overlap. Therefore, testing of two language tasks during surgery is necessary to protect the two language areas (Fabbro, 2001; Giussani et al., 2007; Lucas, McKhann, & Ojemann, 2004; Roux et al., 2004). However, some concerns regarding bilinguals whose linguistic skills are not equal between the two languages remain. Given economic developments in China, the number of Chinese individuals with a certain level of English communication skills has grown, and a narrow proficiency gap between the second language and their mother tongue exists. Treating non-fluent bilingual patients with LGGs has become an increasingly common occurrence. These bilingual patients maintain Chinese as their native language and English as their second language. However, for unskilled late bilinguals using Chinese as their mother language and English as their second language, further investigation is necessary to determine the distribution characteristics of language-associated cortical regions and whether the intraoperative dual language task stimulus should be performed. Mapping for both languages is typically avoided in non-fluent bilinguals; instead, checking for L1 is performed by a surgeon. Unfortunately, this method may be insufficient because, although non-fluent in their second language, non-fluent bilinguals may also make use of other functional areas for their L2.

In this article, we attempt to determine whether brain mapping is necessary for non-fluent bilinguals with gliomas harboring in eloquent areas. In this study, six Chinese–English bilinguals (CEBs) who consented to awake brain surgeries to treat their LGGs in eloquent areas in the dominant hemisphere were investigated using BOLD-fMRI and DCES. This study aims to explore the distribution characteristics of language regions in CEBs and the necessity of performing intraoperative dual-language tasks on these patients. We hypothesise that if a difference exists in distribution characteristics exits, then additional tests should be administered to avoid resecting L2 areas even for low-proficient bilinguals in future surgeries.

2. Materials and methods

2.1. Clinical data

Six unskilled Chinese–English late bilingual patients (4 males and 2 females, 21–34 years of age, mean age of 25.2 years) with glioma in language-associated cortical regions were enrolled in this study (Table 1). The patients were admitted to Guangzhou General Hospital of Guangzhou Military Command from January 2007 to December 2012 and underwent awake brain surgery during which language mapping was performed. Three cases of epilepsy and three cases of headache and dizziness were identified. The patients spoke Chinese as their mother language and had obtained a college degree or higher. The English skills of these patients varied, although all of them started to study English as a second language from primary school or junior school. All patients had passed College English Test Grade 6. Two patients had a long history of studying in Europe and the United States, one patient was a college professor specialising in English teaching, and the three remaining

Table 1
Initial data of the six patients who participated in this study.

Name	Pathological diagnosis	Location	Initial
GLC	Astrocytoma	Left parietal	Seizure
XYS	Ganglioglioma	Left frontal-temporal	Headache
JJG	Astrocytoma	Left frontal	Headache
XWL	Astrocytoma	Left frontal	Seizure
YCZ	Astrocytoma	Left temporal-occipictal	Seizure
YJS	Oligodendrocytes	Left temporal	Dizziness