



Determination of hemispheric language dominance using functional magnetic resonance imaging and the *Shiritori* (Japanese word chain) task in patients with epilepsy: Comparison with the Wada test

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ABSTRACT

Purpose: The Wada test has been the gold standard for determining hemispheric language dominance (HLD) in the presurgical evaluation of patients scheduled for neurosurgical procedures. As it poses inherent risks associated with intra-arterial catheter techniques and as it occasionally fails to indicate language dominance, an alternative reliable test is needed. We quantitatively assessed the results of functional magnetic resonance imaging (fMRI) using the *Shiritori* task, a Japanese word chain, to identify the threshold for correctly predicting HLD.

Methods: The subjects were 28 patients with intractable epilepsy scheduled to undergo the Wada test and focus resection. We set the region of interest (ROI) on the bilateral Brodmann areas 44 and 45 (BA 44 and 45). To compare the functional activity at both ROIs we calculated the language laterality index (LI) using the formula: $[VL - VR]/[VL + VR] \times 100$, where VL and VR indicated the number of activated voxels in the left and right ROIs, respectively.

Results: As 2 patients were excluded due to the lack of activation in either ROI, the final study population consisted of 26 patients. By the Wada test, HLD was left in 20, right in 3, and equivocal in 3. At a cut-off of LI + 50, the predictive sensitivity and specificity for left HLD were 85% (17/20) and 100%; right HLD was predicted in a single patient (sensitivity 33.3%, specificity 100%).

Conclusion: The fMRI using the *Shiritori* task showed good activation in ROI of BA 44 and 45. At a cut-off of LI + 50, LI of BA 44 and 45 predicted HLD identified by the Wada test with high specificity.

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1. Introduction

To avoid post-operative cognitive and/or language dysfunction, hemispheric language dominance (HLD) must be identified in patients scheduled for neurosurgical procedures and the Wada test has been the gold standard (Wada and Rasmussen, 2009). However, it is invasive and there is the risk of brain ischemia (Dion et al., 1987). Individual variability in the response to anesthetic agents and differences in the area perfused by the internal carotid artery

(ICA) limit the interpretation of the results (Hong et al., 2000). Functional magnetic resonance imaging (fMRI) non-invasively detects the language area based on the visualization of increased regional blood oxygenation that reflects enhanced neural activity (Ogawa et al., 1990). Using fMRI, Desmond et al. (1995) first identified the area in the brain cortex related to language function. This imaging method has since found various clinical applications and a shift from the Wada method to fMRI has been suggested for the lateralization of HLD (Bahn et al., 1997; Binder, 2011).

Several studies compared the results obtained with fMRI and the Wada test in epilepsy patients performing language tasks, e.g. semantic decisions, word generation or word fluency, sentence reading, story listening, rhyme detection, word chains, and their combination (Arora et al., 2009; Baciú et al., 2001; Benson et al.,

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SPM result

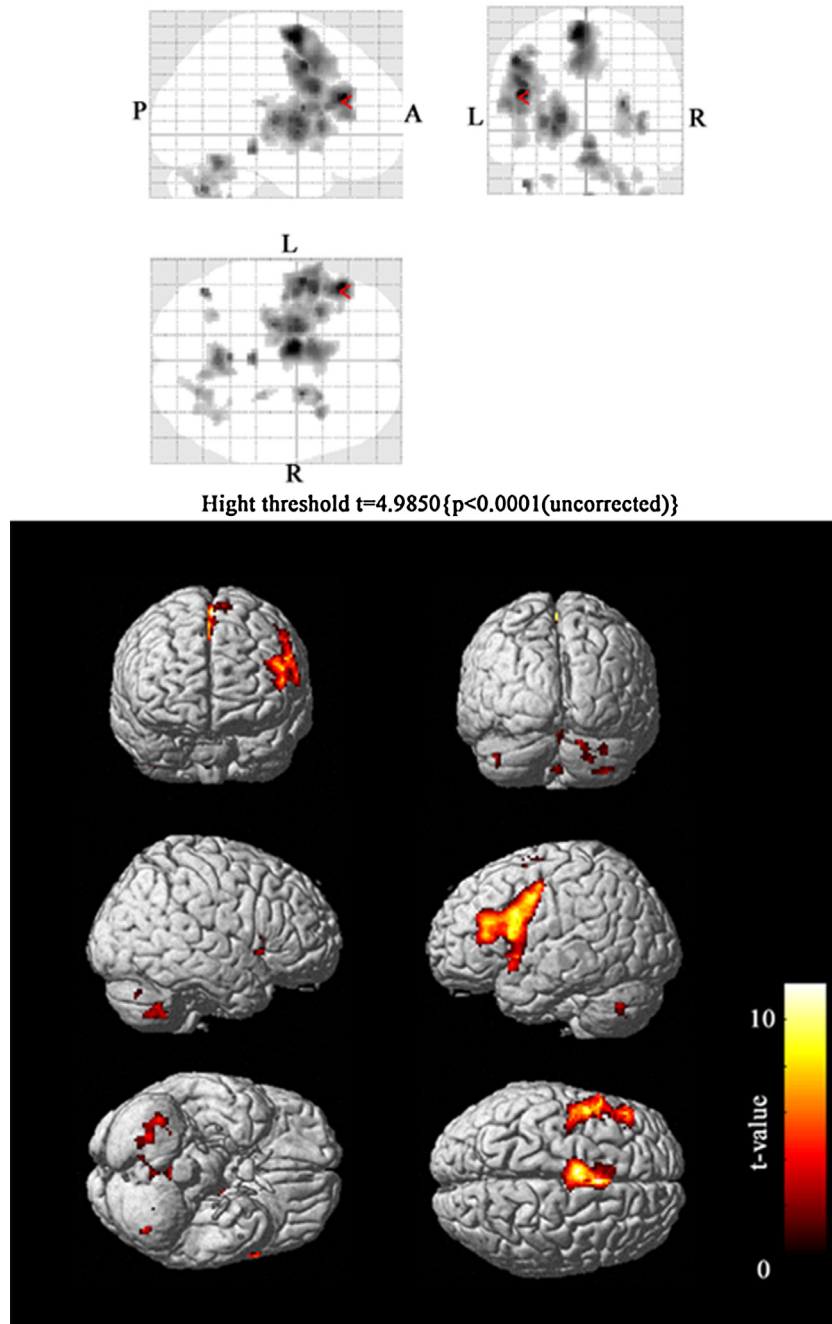


Fig. 2. Group analysis findings.

The Statistical Parametric Mapping activation map (upper) and 3D surface rendering (lower) revealed significant activation in the motor language area (Brodmann areas 44 and 45). Activation in the premotor- and the supplementary motor area, and in the cingulate gyrus in the left hemisphere was also observed.

1999; Chlebus et al., 2007; Deblaere et al., 2004; Gaillard et al., 2002; Wellmer et al., 2008; Wilke et al., 2003; Worthington et al., 1997). However, the fMRI protocols varied across studies. The laterality index (LI), (i.e. $[L - R]/[L + R]$, where L/R are the activated voxels or pixels in the left/right hemisphere, respectively) is a typical numerical evaluation method first reported by Binder et al. (1996). However, its optimal threshold and the region of interest (ROI) have not been standardized (Binder, 2011) because the region and strength of the activation vary with the assigned tasks.

Takayama et al. (2001) used *Shiritori*, a traditional Japanese word-chain- or last-and-first game and f-MRI studies to detect

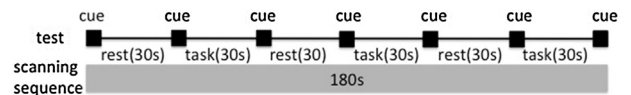


Fig. 1. Task design of our functional magnetic resonance imaging (fMRI) studies. The subjects repeated three 30-s sets of the *Shiritori* task.

language lateralization in Japanese neurosurgery patients. We compared fMRI- and Wada-test findings in Japanese patients performing *Shiritori* to determine the LI threshold on *Shiritori* fMRI

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