Quantification fMRI methods for assessing hemispheric dominance for language by using a phonological and a semantic task. Preliminary results.

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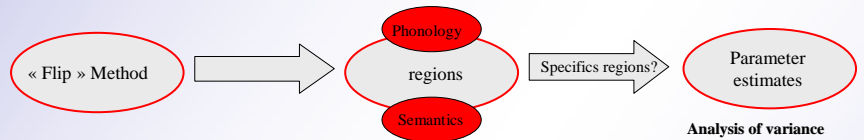[2] INSERM IFR n° 1, RMN Biomédicale, Unité IRM 3T, CHU de Grenoble, France

Background

The hemispheric predominance assessment of language is necessary in epileptic patients presenting focal and drug-resistant epilepsy before surgery. The neurosurgeons are interested not only in knowing which hemisphere is predominant for language but also in mapping language operations such as phonology and semantics. Before testing patients, the inter and intra-hemispheric representation of language should be determined in healthy subjects.

Aim

a. To quantify the hemispheric predominance for language
b. To assess specific regions activated by phonology and semantics

« Flip » Method → Phonology / regions / Semantics → Specifics regions? → Parameter estimates

Analysis of variance

Material and methods

Participants
• 11 healthy, right-handed (Oldflied, 1971) male volunteers gave their informed consent to this study which was approved by the local ethic committee.
• performed a rhyme detection (phonological) and a "living" categorization (semantic) tasks.

Stimuli
• *Rhyme detection*– legal pseudo-words, , half rhyme with /é/ , 3 orthographic shapes were used (*i.e.* « é », « er » and « ée »)
• *« Living » categorization*– Medium and high frequency French words, half designed objects and half designed plants and animals
• *Visual control items*– constituted by printed « words » of unreadable characters written in white Karalyn Pattersen font

barlié (i)   cheval (ii)
rupau (i)   lampe (ii)
ɔʞɕʌɔʅ (iii) ɔʞɕʌɔʅ (iii)

Rhyme detection (i)

« Living » categorization (ii)
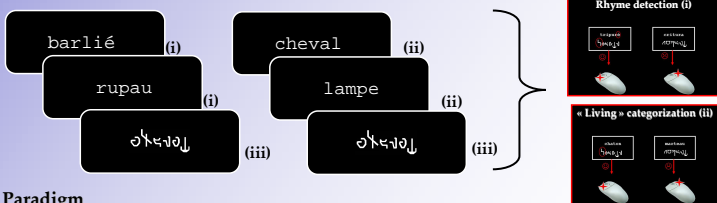
Subjects had to judge:

(i) if the pseudo-words rhymed with « é » (Rhyme detection task)

(ii) if the word belonged to the living category ("living" categorization)

(iii) if one character was overshot (visual task: KP, for the two tasks)

Paradigm
• A pseudo-randomized ER fMRI paradigm was used with three conditions: rhyme (48 Items), non-rhyme (48 Items), control (48 Items) during rhyme detection task and living (48 Items), non-living (48 Items) and control (48 Items) during living categorization; 33 null-events per session for both tasks

MR acquisition
• Whole-body 3T MR scanner (Bruker MedSpec S300).
• Whole brain volume, 41 slices, 3 mm thickness, TR = 2.5 sec

Data processing
• General linear model (Friston *et al.*, 1995) for event-related designs in SPM2 (Wellcome Department of Imaging Neuroscience, London, UK, www.fil.ion.ucl.ac.uk/spm)
• Random-effect group analysis
• Hemispheric predominance assessment :" flip" method (Baciu *et al*, 2005) : for each 8 sessions: 4 "right-side images" sessions (2 phonological and 2 semantics) and 4 "mirror images" sessions. The mirror images were the same original sets but flipped horizontally in the left-right direction.

➔ *Right-side" set vs. "Mirror" set = dominant (p) hemisphere for language*

• Phonological and semantic specificity : extraction of parameter estimates in ROI : Broca's area (BA 44, 45), inferior frontal cortex (BA 47), supramarginal gyrus (BA 40), Wernicke's area (BA 22); premotor cortex (BA 6), lingual gyrus (BA 19), precuneus (BA 7) and their homologue.
• ANOVAs on parameter estimates

Results

A. Hemispheric predominance assessment
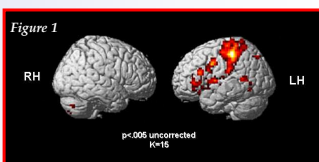
Figure 1

RH   LH

p<.005 uncorrected K=15

Figure 1 shows regions provided by the random group analysis (N=11) and by using the flip method. The activation (p<.005 uncorrected and k=15) was obtained by contrasting all « right-side » images of all semantic and phonological sessions vs. the « mirror » images resulting from the original « right-side » set, flipped horizontally in the left-right direction.
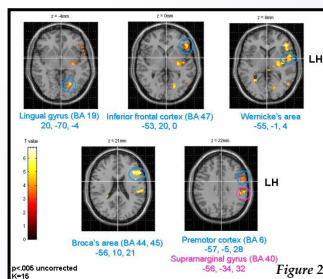
z = -4mm   z = 0mm   z = 4mm

LH

Lingual gyrus (BA 19)   Inferior frontal cortex (BA 47)   Wernicke's area
20, -70, -4   -53, 20, 0   -55, -1, 4

z = 21mm   z = 22mm

LH

Broca's area (BA 44, 45)   Premotor cortex (BA 6)
-56, 10, 21   -57, -5, 28
                            Supramarginal gyrus (BA 40)
                            -56, -34, 32

p<.005 uncorrected K=15   *Figure 2*

Figure 2 shows activated regions underlined by using colored circles from which we have extracted the parameter estimates.

B. Specificity (phonological or semantic) assessment

Figure 3

Legend: ■ Phonology in left ■ Semantics in left ■ Phonology in right ■ Semantics in right

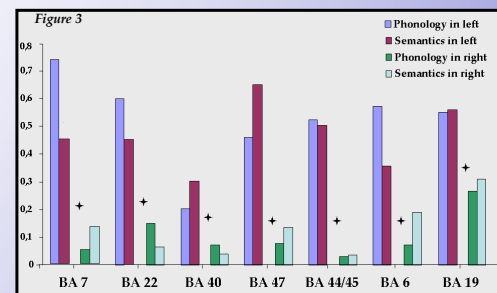(bar chart with categories: BA 7, BA 22, BA 40, BA 47, BA 44/45, BA 6, BA 19)

Figure 3 shows results provided by ANOVAs conducted on parameter estimates for two variables:
1. Hemisphere (Left vs. right)
2. Phonology vs. semantics
Only a principal effect for the hemisphere was observed, no specificity for the tasks

Conclusion

• The « flip » method is reliable for assessing the hemispheric predominance for semantics and phonology in healthy subjects
• No region of interest was significantly more activated for one task with respect to the other, although a tendency could be observed for Wernicke's area and premotor cortex (phonological task) and inferior frontal cortex (semantic task).
• We expect increasing the statistical significance of our results by including a supplementary number of subjects.

References
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• Friston, K. J., Frith, C. D., Frackowiak, R. S., & Turner, R. (1995). Characterizing dynamic brain responses with fMRI: a multivariate approach. *Neuroimage, 2*(2), 166-172.