
‘Cerebral organization for language in deaf and hearing subjects: Biological constraints and effects of experience’.


BACKGROUND

Lesion evidence on the representation of sign language in the brain suggests that is as left-lateralized as spoken language, despite its heavy reliance on spatial processing, ordinarily a predominantly right-hemisphere function

METHODS

Subjects

1) normal hearing, monolingual, native speakers of English with no knowledge of ASL

2) profoundly, congenitally, genetically deaf individuals with late exposure to English (“school age”) without the advantage of auditory input

3) normal hearing (of deaf), bilingual native speakers of English/signers of ASL

All subjects were right-handed

Experimental Design/Stimulus Material

fMRI scans of English and ASL sentence processing

Material presented in four different counterbalanced runs (two of each language)

Each run consisted of alternating 32-second blocks of sentences and a baseline condition

English runs: alternating blocks of simple declarative sentences vs. consonant strings, presented one word/string at a time at a rate of 600 msec per item

ASL runs: alternating blocks of filmed sentences of ASL produced by a native signer vs. nonsign gestures similar to ASL signs

No stimuli repeated Practice runs of each type included

Behavioral Tests

After each run, subjects were shown six sentences and six consonant strings or six non-sign gestures, and asked to indicate whether these had appeared in the previous run (half had been presented and half were new) about all conditions
MR Analysis

Not all subjects were able to participate in the requested two scanning sessions, one for each hemisphere.

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<th>both hemispheres</th>
<th>LH only</th>
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<td>8</td>
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RESULTS

Behavioral

- Subjects were better at recognizing sentences than nonsense strings.
- All subjects performed equally well in remembering English sentences and consonant strings.
- Hearing subjects were at chance recognizing ASL sentences and nonsense signs.
- Deaf and hearing of deaf subjects performed equally well on ASL stimuli.

Imaging

English

- Hearing: left inferior frontal gyrus (Broca’s area)
- left superior temporal sulcus (STS, including Wernicke’s area)
- left angular gyrus
- left dorsolateral prefrontal cortex (DLPFC)
- left inferior precentral gyrus

- Deaf: no reliable asymmetrical left hemisphere activation
- right middle and posterior temporoparietal areas

- Hearing of deaf: left anterior lateralization
- left posterior lateralization present but weaker

ASL

- Hearing: no differential activation between the two conditions
- Deaf: left hemisphere activation in Broca’s and Wernicke’s areas
- plus DLPFC and anterior superior temporal sulcus activation
- right superior temporal lobe
- right angular gyrus
- right inferior prefrontal cortex
Hearing of deaf: Broca’s area
Wernicke’s area
left angular gyrus
left DLPFC
left precentral sulcus
"right hemisphere activation similar to that of the
dead subjects (all group effects NS)"

DISCUSSION

Lack of complete consistency in results for processing English in temporal lobe
of hearing and hearing of deaf subjects "suggests that language experience
may more strongly influence the development of posterior language areas." (p. 926)

"...whereas the activations were uniformly bilateral or larger in the right
hemisphere for the deaf subjects, over anterior areas they tended to be
larger from the left hemisphere in the hearing native signers. This pattern
suggests that the early acquisition of oral/aural language influences the
organization of anterior areas for ASL." (p. 928)

"The ERP research, in line with the present study, also points to extensive
right hemisphere activation in early learners of ASL and supports the
proposal that activation within parietooccipital and anterior frontal
areas of the right hemisphere may be specifically linked to the linguistic
use of space." (p. 927)

What about the lesion evidence (indicating left lateralization of ASL)?

This may "point to areas that may be necessary and sufficient for particular
types of processing."

while neuroimaging data "index[es] areas that participate in processing
in the neurologically intact individual." (p. 927)

"In the present study, as in previous studies, the right hemisphere effect
was variable in extent and was observed in about 70% of deaf subjects." (p. 927)

"The hearing native signers (bilinguals) displayed considerable individual
differences during sentence processing of both English and ASL. These
results are reminiscent of recent reports of a high degree of variability
from individual to individual and area to area of language activation
in hearing, speaking bilinguals who learned their second language after
the age of 7 years (Kim et al. 1997; Dehaene et al. 1998)." (p. 928)