

Dehaene, S., Dupoux, E., Mehler, J., Cohen, L., Paulesu, E., Perani, D., van de Moortele, P.-F., Lehe'ricy, S., and Le Bihan, D. (1997). 'Anatomical variability in the cortical representation of first and second language'. NeuroReport 8, pp. 3809-3815.

BACKGROUND

The same group did a previous PET study (Mazoyer et al. 1993) on French monolinguals listening to

- (a) lists of French words
- (b) meaningful stories in French
- (c) distorted stories in French
- (d) stories in a language unknown to the subjects (Tamil?)

"...in addition to regions devoted to single-word comprehension, processing of meaningful stories activates the left middle temporal gyrus, the left and right temporal poles, and a superior prefrontal area in the left frontal lobe. Among these regions, only the temporal poles remain activated whenever sentences with acceptable syntax and prosody are presented."

Perani et al. (1996) failed to find any differences between listening to an L2 and listening to an unknown language

METHODS

Subjects

Eight right-handed male French students between the ages of 21 and 25

[N.B. these are French French, NOT French Canadian subjects]

Children of French parents, not exposed to English before age 7, when they began to learn it in a school setting

None had lived in an English-speaking country for more than one year

English comprehension tested prior to imaging using:

- word translation
- sentence comprehension tests

English comprehension tested during imaging using:

- "difficult factual questions about the stories immediately after each scan"

Materials

French (F) and English (E) versions of the same stories were recorded on digital audiotape by native speakers and digitally cut at sentence boundaries to obtain fragments of 36 seconds each

Three such fragments were alternated with three fragments of a taped story in Japanese, played backwards (B)

Two experimental conditions: F-B-F-B-F-B and E-B-E-B-E-B

English and French versions of the same stories counterbalanced

Five subjects also listened to a replication of these conditions using three independent short stories instead of a single story cut into three fragments

Image Acquisition and Analysis

Subject's head fixed (foam cushions and bands) to limit motion

Scans every six seconds

First three images of each series discarded because magnetization not steady initially

A cluster of pixels was considered active when it consisted of at least three contiguous pixels, each with a correlation coefficient above 0.45

This correlation procedure only allowed within-condition comparisons (i.e. French vs. backwards Japanese and English vs. backwards Japanese, but NOT French vs. English)

Ergo data reanalyzed to allow across-condition comparisons as follows:

[(French minus backwards Japanese) minus (English minus backwards Japanese)]

RESULTS

L1: all eight subjects showed activation in

- left superior temporal sulcus and neighboring portions of
- left superior temporal gyrus and
- left middle temporal gyrus

activation extended forward into

- left temporal pole in four subjects and backward into
- left angular gyrus in four subjects

similar activation in right hemisphere

- right superior temporal sulcus (six subjects)
- right temporal pole (two subjects)

BUT weaker

more variable from subject to subject

no activation in right angular gyrus

six out of eight subjects showed left > right activation of
temporal lobe

outside temporal lobe, only consistent activation near intersection of

- inferior frontal sulcus and
- precentral sulcus

i.e. Brodmann's areas 8, 9, 44, and 6

i.e. superior to Broca's area proper

- six subjects showed this activation in left hemisphere
- three subjects in right hemisphere

L2: six subjects showed activation in

- left superior temporal sulcus and neighboring portions of
- left superior temporal gyrus and
- left middle temporal gyrus

"...but the active pixels showed considerable dispersion contrasting with their tight localisation to the banks of the STS [superior temporal sulcus] when

listening to L1." (p. 3811)

However, volume of left temporal activity "often smaller" in L2 than in L1

AND

Listening to L2 activated additional areas in the RH
(mostly the superior temporal gyrus and sulcus)

Left-right asymmetries in L1 and L2:

	Left STS	Right STS	
L1	1378 cubic mm	456 cubic mm	$p < .004$
L2	666 cubic mm	327 cubic mm	$p < .037$

no activation in

- left temporal pole
- left angular gyrus

two remaining subjects showed activation in the right hemisphere ONLY
(which means they were left-dominant for L1 but right-dominant for L2)
one such subject shown in Figure 2 -

L1 intense activation in

- left superior temporal sulcus
- left anterior temporal region

"some" activation in

- right frontal lobe
- right middle temporal lobe

L2 right hemisphere activation only

- right superior temporal gyrus
- right middle temporal gyrus
- right temporal pole

outside temporal lobe, highly variable patterns of activation in L2

- 6 subjects - as in L1, frontal activation at junction of
 - inferior frontal sulcus and
 - precentral sulcus
- i.e. Brodmann's areas 8, 9, 44, and 6
- 3 subjects - left inferior frontal gyrus (Broca's area)
 - inferior precentral sulcus
- 4 subjects - bilateral anterior cingulate

DISCUSSION

Previous PET studies of L1 comprehension using continuous speech showed activation in:

- (1) left superior temporal gyrus
- (2) left middle temporal gyrus
- (3) left posterior temporal lobe

The higher spatial resolution of this fMRI study showed most such activation concentrated in the superior temporal sulcus

(once activation of primary and secondary auditory cortex is subtracted out)

[N.B. Ojemann does not find essential language sites in sulci, but only on the crown(s) of gyri]

- (4) left and right temporal poles

Instead of robust activation of temporal poles in PET studies, only modest activation of temporal poles seen here

probably caused by loss of signal due to "magnetic field inhomogeneities in the inferior anterior temporal region"

- (5) left inferior frontal gyrus
- (6) left Brodmann's area 8

In this study, activation seen instead at the intersection of the inferior frontal sulcus and the precentral sulcus

Reliably activated temporal network for L1 comprehension not consistently activated in L2 comprehension

Dehaene et al. cite the Kim et al. (1997) fMRI study of silent speech as supporting evidence for "A similar distinction between subregions for L1 and L2 within the same general anatomical area" (p. 3814)

HOWEVER, they fail to point out that the distinction that Kim et al. found was in FRONTAL regions, NOT in TEMPORAL regions

Activation of inferior frontal gyrus and of anterior cingulate bilaterally in some subjects when listening to L2 but not L1 in this study might reflect:

- vocal rehearsal of English sentences (inferior frontal gyrus)
- increased attention to English sentences (anterior cingulate)

The lateralization patterns for L1 and L2 in this study may help to resolve a fraught controversy regarding lateralization in the 2LA literature:

- a) lateralization of activity to the left temporal lobe is reduced in L2
- b) individual subjects show greater variability for lateralization of L2 than of L1

The authors:

- 1) attribute the failure of Perani et al. (1996) to find any differences between listening to an L2 and listening to an unknown language
to the intersubject averaging required in PET, which wipes out intersubject variability
- 2) speculate that the intersubject variability of this study is due to the fact that L2s are taught using different techniques, which might lead to different L2 processing strategies
- 3) point out that variability in language lateralization contributes to variability in L2 representation
- 4) suggest that studies should be done of individuals who achieve high levels of L2 proficiency late in life (see Perani)