Common Network Supporting Narrative Comprehension

David A. Robertson (Georgia Inst. of Technology) & Morton Ann Gernsbacher (UW-Madison)

ABSTRACT

We used fMRI to investigate narrative processing. Written, spoken, or picture narratives were alternated with non-narrative materials.

Regions showing increases for narratives:

- remarkably similar across the three modalities
- did not include left-hemisphere regions typically thought to support language comprehension
- bilaterally in the precuneus and the junctions of the parietal, temporal and occipital lobes, and right middle temporal gyrus.
- More right than left hemisphere in temporal regions.

Psych. of Narrative Processing

Comprehending narratives, understanding the situations described in the narrative, requires linking concepts between sentences, drawing various kinds of inferences, and forming a representation of the situation. General cognitive processes are thought to support narrative comprehension. Performance on comprehension tests is highly correlated for written, spoken, and picture narratives (Gernsbacher, Varner, & Faust, 1990). Additionally, many of the phenomena observed in text comprehension are also observed in picture-story comprehension (Gernsbacher, 1985). In this research we examine the neuroanatomy supporting narrative comprehension across the three modalities.

Previous research

Two previous experiments contrasted written and picture narratives with two different comparision conditions (Robertson, Gernsbacher, & Guidotti, 1999). One comparison task was a simple fixation control task; the other comparison condition presented sentences or pictures that did not make up stories but otherwise were similar to the narrative materials.

The findings for the contrasts between narrative and non-narrative materials were remarkably similar for picture and written stories. The regions included bilateral precuneus, and the junction of the parietal temporal and occipital lobes, as well as right prefrontal/frontal pole, and right superior temporal sulcus.

Method

Task Design

We wanted to be certain subjects were understanding narratives as narratives. So the task we assigned them required them to indicate anytime a sentence or picture was presented that didn't fit the evolving narrative. As a control task, subjects read unrelated sentences or viewed pictures, and indicated when a sentence or picture contained an anomaly.

Materials

Picture Narratives were scanned from a series of books by Mercer Mayer. The books present stories about a boy and various animal friends of his, most notably a mischievous frog. (See Fig. 1)

Written/Spoken Narratives were created by writing sentences (18-20 syllables) for each picture.

Non-narrative pictures were taken from a variety of sources that displayed scenes, but were unrelated to each other. Some of the scenes had objects inserted that ordinarily wouldn't be seen in the situations (e.g., a grand piano in a gas station). (See Fig 2)

Non-narrative sentences were generated to be of similar length and complexity as the narrative sentences, but they did not form a coherent story.

Procedure

Visual materials were presented via fiber-optic goggles. Spoken materials were recorded, digitized, and presented over in-ear headphones. Sentences and pictures were presented one per 5.5 sec.

Subjects indicated by squeezing a squeeze-bulb when an oddball stimulus was encountered. An oddball was defined as a sentence or picture that did not fit the story during the narrative condition. During the non-narrative condition, oddballs were pictures or sentences with semantic anomalies.

Narrative and non-narrative materials were alternated in 45 second blocks, while epi data were collected. Each block was preceded by a warning screen.

Scanning Protocol & Data Analysis Functional images were collected in the coronal plane using a gradient echo, epi sequence (TE/TR=50/3000 ms, FOV=24 cm, slice/gap = 7/1 mm, 23 slices, 64X64 matrix) 145 images per run, 6 runs per subject, modality order was counter-balanced across subjects. Data were analyzed using SPM, and in-house code that fit a delayed box-car & 1-degree polynomial.

Figure 1: Narrative pictures (and an oddball)

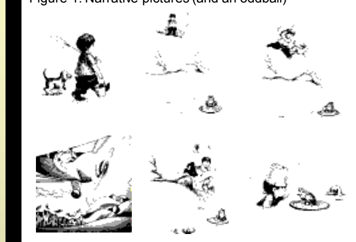


Figure 2: Picture Judgment Task Stimuli

Table 1: Example Written Stimuli

Example Narrative Sentences:

One summer day, a boy and his dog set out with a net and pail, looking for frogs.

The boy and the dog spotted a frog sitting on a lily pad in the pond.

I'd just be brave and sneak quietly into the attic with my lasso ready. *

The boy and dog eagerly ran down the hill to the pond where the frog was.

However, they didn't notice a large branch, and they tripped and fell down the hill.

The boy and the dog tumbled head over heels, splashing down right next to the frog.

Example Non-Narrative Sentences:

It was Ann's 18th birthday and the surprise party made her feel very happy.

Bob had a toothache, so he called a dentist to schedule an appointment.

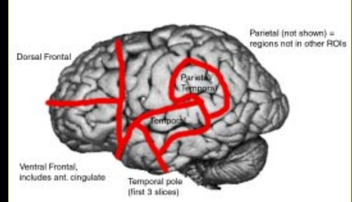
As grandpa got older a pacemaker was needed to repair his failing heart.

Although her parents were average height, Lois was taller than most girls her age.

They hurriedly drove to the international airport to catch the aspirin.*

* = oddball stimulus item.

Figure 3: Schematic of Regions of Interest



Results (See Fig 4 & 5)

Signal increases during Written Narrative vs. Sentence Judgment task were observed bilaterally in the precuneus and at the junction of the parietal, temporal, and occipital lobes, extending along the right superior temporal sulcus, replicating the previous experiments. The results for picture and spoken narratives were similar to written. Spoken trials resulted in less activation overall, as well as greater error rates, perhaps due to difficulty hearing. Picture narratives in this experiment, but not the previous experiments, resulted in left temporal activation as well. Frontal lobe activation was observed for all three modalities, typically in middle frontal gyrus (BA 8), but was not as robust, nor as stable across modalities as the posterior regions.

Tests of Hemispheric Assymetry were conducted by using anatomical underlays to define regions of interest for each subject. Regions were selected based on results of previous experiments. (See Fig. 3) Activation was calculated by taking the proportion of voxels in each region surpassing a threshold (t>2.0), and multiplying by the mean t-value of active voxels in the region, thus encorporating strength and spatial extent.

These values were submitted to repeated measures ANOVA (Narrative/non-narrative X Hemisphere X modality X gender), treating subjects as random factors. No interactions with sex, or modality were detected.

Figure 5 presents a graph of the results. More right than left activation was observed in the temporal lobe and temporal poles, while more left than right activation was observed in superior parietal areas.

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Figure 4 Rendered views showing regions of increase during narrative processing

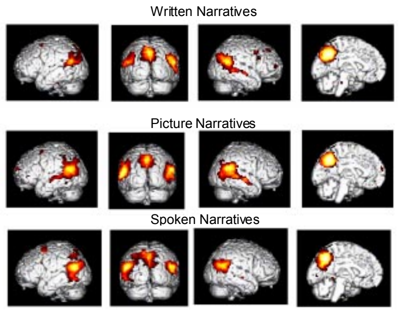
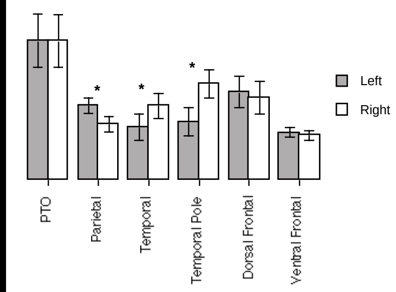


Figure 5

Activation Values in Left and Right Anatomical Regions of Interest



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