

What neural activation patterns are observed in the brain's language regions during silent reading of different text types using functional magnetic resonance imaging (fMRI)?

Silent reading activates distributed language networks with text-specific patterns: metaphoric content engages frontal-temporal regions, technical prose activates visual areas, poetry stimulates cingulate responses, and fiction recruits temporal-frontal circuits.

Abstract

Silent reading of varied text types engages a distributed network of language regions. Mashal and Faust (2010) report that both metaphoric and nonmetaphoric texts activate bilateral posterior and anterior superior temporal gyri—with lower anterior activation for metaphoric texts. Eviatar and Just (2006) show that metaphoric statements drive increased activity in the left inferior frontal gyrus and bilateral inferior temporal cortex, whereas ironic statements stimulate the right superior and middle temporal gyri. Xu et al. (2005) note that moving from random word lists to coherent narratives expands activation from perisylvian regions to include frontal operculum, temporal poles, precuneus, and medial prefrontal cortex. In comparisons of literary genres, Smith et al. (2010) observe that technical prose activates visual areas (areas 17 and 18), while conventional and demanding sonnets evoke stronger cingulate cortex responses and self-chosen poetry recruits autobiographical memory networks. Lin et al. (2019) report that fiction elicits greater intersubject neural synchrony in temporal poles, fusiform gyri, and left inferior frontal regions relative to news articles, and Yao et al. (2011) document that direct speech preferentially activates voice-selective regions in the right auditory cortex. Choi et al. (2014) find that natural text reading engages the canonical language network, whereas pseudo-reading activates attentional circuits. Finally, Kuperberg et al. (2003) demonstrate that anomalies in plausible language differentially engage left temporal and inferior frontal areas (pragmatic anomalies) or bilateral parietal regions (morphosyntactic anomalies). These results support the view that text type and complexity modulate activity in both classical language areas and auxiliary regions involved in semantic, syntactic, and higher-order integrative processes.

Paper search

Using your research question "What neural activation patterns are observed in the brain's language regions during silent reading of different text types using functional magnetic resonance imaging (fMRI)?", we searched across over 126 million academic papers from the Semantic Scholar corpus. We retrieved the 50 papers most relevant to the query.

Screening

We screened in papers that met these criteria:

- **Imaging Method:** Does the study use fMRI as the primary imaging method?
- **Reading Task:** Does the study examine silent reading of connected text (beyond single-word reading)?
- **Participant Health:** Does the study exclusively include healthy adult participants (age 18+) without neurological conditions, learning disabilities, or language disorders?
- **Text Comparison:** Does the study compare different text types (e.g., narrative, expository, poetry, technical)?

- **Brain Regions:** Does the study examine brain activation in established language regions?
- **Original Data:** Does the study report original fMRI data (either as primary research or within a systematic review/meta-analysis)?
- **Reading Mode:** Does the study focus exclusively on silent reading (not oral reading or listening tasks)?

We considered all screening questions together and made a holistic judgement about whether to screen in each paper.

Data extraction

We asked a large language model to extract each data column below from each paper. We gave the model the extraction instructions shown below for each column.

- **Neuroimaging Method:**

Specify the exact neuroimaging technique used. If fMRI, note:

- Type of fMRI (event-related, block design, etc.)
- Specific scanning parameters (e.g., rapid-presentation event-related)
- Any unique methodological approaches to data collection or analysis

Look in the methods section. If multiple details are present, include all relevant information. If information is incomplete, note "insufficient details provided".

- **Text Types and Reading Conditions:**

List all distinct text types/conditions used in the study:

- Specify genre (e.g., prose, poetry, technical writing, fiction, news)
- Note any specific variations within genres (e.g., conventional vs. demanding sonnets)
- Describe any specific reading tasks or instructions given to participants

Extract verbatim from methods section. If multiple text types were used, list them all with brief distinguishing characteristics.

- **Participant Details:**

Record:

- Total number of participants
- Mean age (and standard deviation if provided)
- Gender distribution
- Specific expertise or selection criteria (e.g., literature teachers, skilled readers)

Extract from methods section. If any characteristic is not reported, write "not reported". Use exact numbers/percentages from the text.

- **Primary Brain Activation Regions:**

Identify and list:

- Specific brain regions showing significant activation
- Hemispheric location of activations

- Context of activation (e.g., during specific text type or condition)

Extract from results section. Use exact anatomical terminology as reported in the study. If statistical significance is mentioned, include those details.

- **Comparative Neural Activation Patterns:**

Describe differences in neural activation between:

- Different text types
- Different reading conditions
- Compared to control conditions

Look in results section for comparative analyses. Note specific regions showing differential activation and the nature of those differences (increased/decreased response, statistical significance).

- **Key Study Limitations:**

Extract:

- Methodological limitations explicitly mentioned by authors
- Potential confounding factors
- Suggestions for future research

Prioritize limitations directly stated by the authors in discussion/conclusion sections. If no limitations are explicitly mentioned, write "no limitations reported".

Results

Characteristics of Included Studies

Study	Study Design	Text Types Examined	Brain Regions Studied	Key Findings	Full text availability
Mashal and Faust, 2010	functional magnetic resonance imaging (fMRI)	Metaphoric and nonmetaphoric texts	Bilateral posterior and anterior superior temporal gyri	Both text types activated bilateral posterior and anterior superior temporal gyri; metaphoric texts showed lower activation in anterior superior temporal gyri	Not available

Study	Study Design	Text Types Examined	Brain Regions Studied	Key Findings	Full text availability
Eviatar and Just, 2006	Event-related fMRI	Literal, metaphoric, and ironic statements	Left inferior frontal gyrus, bilateral inferior temporal cortex, right superior and middle temporal gyri	Metaphoric statements activated left inferior frontal gyrus (IFG) and bilateral inferior temporal cortex; ironic statements activated right superior and middle temporal gyri	Available
Smith et al., 2010	fMRI	Technical prose, literary prose, conventional sonnets, demanding sonnets, self-chosen "thrilling" poetry	Visual areas 17 and 18, cingulate cortex, bilateral inferior parietal regions, bilateral precuneus	Prose activated visual areas 17 and 18; sonnets activated cingulate cortex; self-chosen poetry activated autobiographical memory networks	Not available
Xu et al., 2005	fMRI	Random word lists, unconnected sentences, coherent narratives	Perisylvian language areas, frontal operculum, temporal poles, precuneus, medial prefrontal cortex, dorsal temporo-parieto-occipital cortices	Narratives activated extrasylvian areas; right hemisphere increasingly active with contextual complexity	Not available

Study	Study Design	Text Types Examined	Brain Regions Studied	Key Findings	Full text availability
Lin et al., 2019	fMRI	Fiction and news articles, human and machine translations	Bi-hemispheric visual cortex, precuneus, occipito-parietal junction, temporal poles, fusiform gyri	Fiction reading activated temporal poles and fusiform gyri; human translation activated precuneus more than machine translation	Available
Yao et al., 2011	Event-related fMRI	Direct and indirect speech	Voice-selective areas in right auditory cortex, posterior and middle parts of right superior temporal sulcus (STS)	Direct speech activated voice-selective areas in right auditory cortex more than indirect speech	Available
Choi et al., 2014	fMRI	Normal text, pseudoword text, consonant string text	Language network (superior temporal gyrus/sulcus, middle temporal gyrus, angular gyrus, inferior frontal gyrus, middle frontal gyrus), attentional network (anterior/posterior cingulate, parietal cortex)	Natural reading activated language network; pseudo-reading activated attentional network	Available

Study	Study Design	Text Types Examined	Brain Regions Studied	Key Findings	Full text availability
Kuperberg et al., 2003	Rapid-presentation event-related fMRI	Plausible, morpho-syntactically anomalous, and pragmatically anomalous sentences	Left temporal and inferior frontal regions, bilateral medial and lateral parietal regions	Pragmatic anomalies activated left temporal and inferior frontal regions; morphosyntactic anomalies activated bilateral medial and lateral parietal regions	Available
Wehbe et al., 2014	fMRI	Continuous narrative (Harry Potter chapter)	Occipital cortex, temporal cortices, left inferior frontal gyrus, posterior temporal cortex/angular gyrus	Different text features activated distinct brain regions (e.g., word length in occipital cortex, semantics in temporal gyri)	Available
Ferstl et al., 2008	Meta-analysis of 23 neuroimaging studies	Various text types from included studies	Anterior temporal lobes, dorsomedial prefrontal cortex, posterior cingulate cortex	Text comprehension activated anterior temporal lobes bilaterally; coherent text activated dorsomedial prefrontal cortex and posterior cingulate cortex	Available

Analysis of the included studies:

- Study Design: 9 out of 10 studies reported using functional magnetic resonance imaging (fMRI), with 3 of these specifically reporting the use of event-related fMRI. One study was a meta-analysis of 23 neuroimaging studies.
- Text Types: The studies examined reported a wide variety of text types:

- Metaphoric texts were examined in 2 studies
- Narratives and sentences were each examined in 2 studies
- Other text types (prose, poetry, word lists, fiction, news articles, and various forms of anomalous or manipulated text) were each examined in 1 study
- Brain Regions: Multiple brain regions were reported across studies:
 - Superior temporal areas were examined in 4 studies
 - Inferior frontal gyrus (IFG) was examined in 4 studies
 - Precuneus, temporal poles/lobes, cingulate cortex, and parietal regions were each examined in 3 studies
 - Visual areas, middle temporal gyri (MTG), angular gyrus (AG), prefrontal cortex, and superior temporal sulcus (STS) were each examined in 2 studies
- The studies we examined did not report consistent use of specific text types or focus on particular brain regions across all studies, reflecting diverse approaches in investigating brain activity during reading and text comprehension.

Thematic Analysis

Genre-Specific Neural Signatures

The included studies provide evidence for distinct neural activation patterns associated with different text genres and types. This theme explores how the brain processes various forms of written language, from simple word lists to complex narratives.

Poetry vs. Prose Activation Patterns

- Smith et al. (2010) compared neural responses to prose and poetry:
 - Prose passages elicited stronger activation in visual areas 17 and 18 compared to poetry
 - Conventional and demanding sonnets showed stronger activation in the cingulate cortex (areas 23, 24, 31) compared to prose
 - Self-chosen "thrilling" poetry elicited stronger activation in regions associated with autobiographical memory networks, including bilateral inferior parietal regions (area 40) and bilateral precuneus (area 7)

News vs. Fiction Processing Lin et al. (2019) compared neural responses to news articles and fiction:

- Fiction reading elicited stronger inter-subject correlated fMRI signals in:
 - Temporal poles
 - Fusiform gyri
 - Left dorsal lateral prefrontal cortex
 - Left inferior frontal gyrus
 - Right temporal pole
- These regions are associated with:
 - Semantic integration
 - Social cognition

- Executive control
- Language processing

Hemispheric Specialization

The studies provide insights into the relative contributions of the left and right hemispheres during silent reading of different text types.

Left Hemisphere Language Processing

- Eviatar and Just (2006) found that metaphoric statements resulted in significantly higher activation in:
 - Left inferior frontal gyrus (IFG)
 - Left inferior temporal cortex
- Kuperberg et al. (2003) observed that pragmatic anomalies in sentences activated:
 - Left temporal regions
 - Left inferior frontal regions

Right Hemisphere Contributions

- Eviatar and Just (2006) found that ironic statements resulted in significantly higher activation in:
 - Right superior temporal gyrus
 - Right middle temporal gyrus
- Xu et al. (2005) observed that the right hemisphere became increasingly active as contextual complexity increased, with maximal activation at the narrative level
- Yao et al. (2011) reported that silent reading of direct speech, compared to indirect speech, resulted in greater activation of voice-selective areas in the right auditory cortex

Bilateral Activation Patterns

- Mashal and Faust (2010) found that both metaphoric and nonmetaphoric texts activated:
 - Left posterior superior temporal gyrus
 - Right posterior superior temporal gyrus
 - Left anterior superior temporal gyrus
 - Right anterior superior temporal gyrus
- Ferstl et al.'s (2008) meta-analysis confirmed that text comprehension activates the anterior temporal lobes bilaterally
- Lin et al. (2019) observed that both human and machine-translated texts activated:
 - Bi-hemispheric visual cortex
 - Precuneus
 - Occipito-parietal junction

Text Complexity and Neural Response

The included studies provide evidence for how text complexity modulates neural activation patterns during silent reading.

Simple vs. Complex Text Processing Xu et al. (2005) compared neural responses to random word lists, unconnected sentences, and coherent narratives:

- Perisylvian language areas were consistently active across all conditions
- Sentence processing was associated with expanded activation in:
 - Frontal operculum
 - Temporal poles
- Narrative processing showed robust responses in extrasyylvian areas within both hemispheres:
 - Precuneus
 - Medial prefrontal cortex
 - Dorsal temporo-parieto-occipital cortices

Choi et al. (2014) compared normal reading to pseudo-reading of pseudowords and consonant strings:

- Natural reading activated a language network including:
 - Superior temporal gyrus/sulcus
 - Middle temporal gyrus
 - Angular gyrus
 - Inferior frontal gyrus
 - Middle frontal gyrus
- Pseudo-reading activated an attentional network including:
 - Anterior cingulate
 - Posterior cingulate
 - Parietal cortex

Metaphorical vs. Literal Language

- Eviatar and Just (2006) found that metaphoric statements resulted in significantly higher activation in:
 - Left inferior frontal gyrus
 - Bilateral inferior temporal cortex
- Mashal and Faust (2010) reported that metaphoric texts resulted in significantly lower activation than nonmetaphoric texts in the anterior superior temporal gyri
- Ferstl et al. (2008) noted that right hemisphere activations were seen most notably in contrasts testing specific subprocesses, such as metaphor comprehension

Neural Activation Patterns by Text Type

Text Type	Primary Brain Regions	Activation Pattern	Key Features
Prose	Visual areas 17 and 18	Stronger activation compared to poetry	Dense visual input processing

Text Type	Primary Brain Regions	Activation Pattern	Key Features
Poetry (Sonnets)	Cingulate cortex (areas 23, 24, 31)	Stronger activation compared to prose	Emotional and cognitive control processes
Self-chosen Poetry	Bilateral inferior parietal regions (area 40), bilateral precuneus (area 7)	Stronger activation compared to other poetry and prose	Engagement of autobiographical memory networks
Fiction	Temporal poles, fusiform gyri, left dorsal lateral prefrontal cortex, left inferior frontal gyrus, right temporal pole	Stronger inter-subject correlations compared to news	Semantic integration, social cognition, executive control
News	Bi-hemispheric rostral prefrontal cortex	Significant inter-subject correlations	Information integration and evaluation
Direct Speech	Voice-selective areas in right auditory cortex, posterior and middle parts of right superior temporal sulcus (STS)	Stronger activation compared to indirect speech	Auditory simulation during silent reading
Metaphoric Statements	Left inferior frontal gyrus, bilateral inferior temporal cortex	Higher activation compared to literal statements	Semantic integration, figurative interpretation
Ironic Statements	Right superior and middle temporal gyri	Higher activation compared to literal statements	Non-literal language processing, intention inference
Coherent Narratives	Precuneus, medial prefrontal cortex, dorsal temporo-parieto-occipital cortices	Robust responses compared to word lists and unconnected sentences	Situation model building, inference generation
Pragmatically Anomalous Sentences	Left temporal and inferior frontal regions	Increased activation compared to non-violated sentences	Semantic processing, context integration
Morphosyntactically Anomalous Sentences	Bilateral medial and lateral parietal regions	Increased activation compared to non-violated sentences	Syntactic processing, grammatical error detection

Analysis of neural activation patterns by text type:

- We found information on 11 different text types, with poetry and anomalous sentences each appearing twice, and the others appearing once.
- The primary brain regions involved in text processing varied across text types:
 - Temporal regions were most frequently mentioned (4 text types)
 - Prefrontal cortex and inferior frontal regions were each involved in 3 text types
 - Parietal regions and precuneus were each involved in 2 text types

- Other regions (visual areas, cingulate cortex, auditory cortex, STS) were each mentioned for 1 text type
- Key features of text processing also varied:
 - Semantic integration/processing was the most common feature, mentioned for 3 text types
 - Most other features (e.g., visual processing, emotional/cognitive control, autobiographical memory, social cognition) were unique to specific text types
 - We found some overlap in features related to higher-order cognition (e.g., executive control, information integration, inference generation) across different text types
- The studies we examined did not report a consistent pattern of brain activation across all text types, suggesting that different types of text engage distinct neural networks.
- Prose and poetry showed contrasting patterns, with prose activating visual areas and poetry engaging emotional and cognitive control processes in the cingulate cortex.
- More complex text types (e.g., metaphoric and ironic statements, coherent narratives) tended to involve multiple brain regions and higher-order cognitive processes.

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