The Role of the Left Angular Gyrus in Lexical Semantic Processing

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Abstract

The left angular gyrus represents an important semantic processing region identified by language cognitive neuroscience research. Its specific role in lexical semantic processing remains without unified understanding, constituting a hotly debated topic and focal issue among researchers. Structurally, the angular gyrus is situated at the junction of the temporal, occipital, and parietal lobes, and features extensive white matter fiber tract connections, which predisposes it to cross-regional information integration functions. This region shows activation during high-level semantic representation, joint representation of modality and feature information, semantic relationship representation, and semantic integration processing, potentially serving as an information "convergence zone" for semantic representation and processing. However, functional controversies persist regarding the left angular gyrus across three domains: the semantic representation hub, semantic executive control processing, and semantic processing within the default mode network. Future research must comprehensively consider the anatomical structural foundation of the left angular gyrus and its characteristic extensive connectivity with other brain regions, and conduct in-depth and detailed investigations into the functional properties of angular gyrus subregions.

Full Text

The Role of the Left Angular Gyrus in Lexical-Semantic Processing

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Abstract
The left angular gyrus (LAG) is a critical brain region for semantic process-

ing identified in the cognitive neuroscience of language. However, its specific function in lexical-semantic processing remains a topic of intense debate and research focus. Anatomically, the angular gyrus is situated at the junction of the temporal, occipital, and parietal lobes, featuring extensive white matter fiber bundle connections that enable potential cross-regional information integration. The LAG is activated during high-level semantic representation, conjunctive representation of modality and feature information, semantic relationship representation, and semantic integration processing, suggesting it may serve as an information "convergence zone" for semantic representation and processing. Nevertheless, controversies persist regarding its role as a semantic representation hub, its involvement in semantic executive control processing, and its function in semantic processing within the default mode network. Future research should comprehensively consider the anatomical structure of the LAG and its connectivity with widespread brain regions to conduct in-depth investigations of subregional functions.

Keywords: left angular gyrus, semantic representation, semantic processing, convergence zone
Classification Number: B842

1 Introduction

The left angular gyrus has been identified as a crucial brain region for semantic processing, supported by extensive evidence from studies of brain-damaged patients [**?**], neuroimaging research (see review by [**?**]), and virtual lesion studies using neuromodulation techniques [**?**, **?**]. Researchers have approached the function of the angular gyrus from different perspectives, including semantic representation, semantic access, semantic control, and semantic processing in the default mode network, leading to divergent interpretations of its role. Consequently, elucidating the function of the left angular gyrus in semantic processing has become a prominent focus of investigation.

Anatomically, the left angular gyrus is located at the junction of the temporal, occipital, and parietal lobes and possesses extensive white matter fiber bundle connections, which likely enables cross-regional information integration. On one hand, the LAG is adjacent to occipitotemporal and parietal regions involved in visual, auditory, somatosensory, and spatial information processing, and maintains widespread structural connections with these sensorimotor cortices. Specifically, the LAG connects to temporal regions processing visual, auditory, and manipulative information via the arcuate fasciculus, and to parietal cortex involved in manipulative information processing through part of the superior longitudinal fasciculus [**?**]. On the other hand, the LAG exhibits rich structural connectivity with other language-processing brain regions [**?**, **?**]. For example, it forms dorsal connection pathways with frontal regions via the superior longitudinal fasciculus [**?**, **?**], ventral pathways to frontal cortex through the inferior longitudinal fasciculus [**?**, **?**], and connects to the middle and inferior frontal gyri via the arcuate fasciculus [**?**, **?**]. These connections constitute the

structural basis for the LAG's involvement in frontoparietal networks that play a vital role in semantic control [?]. Moreover, the LAG demonstrates extensive structural connectivity with temporal regions, linking to the middle temporal gyrus and anterior superior temporal gyrus through the arcuate fasciculus [?] and connecting to the temporal pole and posterior temporal regions responsible for semantic representation and storage via the middle longitudinal fasciculus [?, ?, ?]. Additionally, short-range U-shaped fibers connect the LAG to adjacent temporal, parietal, and occipital cortices, including the superior temporal gyrus, superior and middle occipital gyri, supramarginal gyrus, and superior parietal lobule, which contribute to semantic processing of visual stimuli [?].

These extensive structural connections with language-processing brain regions likely determine the core role of the left angular gyrus in semantic processing. Activation of the LAG has been observed in cross-modal, cross-neural network multidimensional information aggregation and integration processes, suggesting its function may be that of an information "convergence zone" for lexical-semantic processing.

2 The "Convergence Zone" Function of the Left Angular Gyrus in Semantic Representation

The concept of a "convergence zone" was proposed in models of how the brain creates and represents concepts, with multimodal cortices such as the left angular gyrus considered convergence zones for perceptual, motor, and emotional modality information [?]. Numerous neuroimaging studies have demonstrated that the neural basis of conceptual representation includes not only primary cortical regions for perception and action [?, ?] but also high-level multimodal cortices. These modality-specific and high-level multimodal regions collectively store the actual content of semantic knowledge [?]. The left angular gyrus is activated across cross-modal information processing, manifesting high-level semantic representation [?] while also participating in cross-modal semantic integration [?, ?] and showing significant activation in semantic relationship processing [?], establishing it as a crucial region for semantic representation and processing [?].

2.1 The Left Angular Gyrus as a High-Level Semantic Representation Area

Extensive research indicates that the left angular gyrus is an important region for lexical-semantic representation. Functional neuroimaging studies have found stronger activation in the LAG during semantic tasks compared to other tasks. For instance, in visual studies, semantic tasks elicited greater activation in the LAG and other semantic regions than non-semantic tasks (including phonological tasks, perceptual judgment tasks, and lexical decision tasks) [?, ?]. Similarly, in auditory research, semantic tasks activated the LAG more than non-semantic tasks [?, ?]. This pattern suggests that regardless of presentation modality, the

LAG consistently shows greater activation during semantic tasks, reflecting its role in high-level semantic representation.

Additional studies have found stronger activation in the LAG for real words compared to pseudowords [**?**, **?**] and for high-frequency versus low-frequency words [**?**], suggesting this region's involvement in lexical-semantic representation. Because real words possess lexical-semantic representations and high-frequency words allow easier access to these representations, they elicit greater activation in semantic representation regions such as the LAG. Recent research has also found that different types of concepts activate the LAG. For example, when participants processed proper nouns referring to people or places and common nouns, both word types activated the left angular gyrus [**?**].

The LAG also shows heightened sensitivity to semantically feature-rich words, as evidenced by imageability and concreteness effects. Semantic imageability refers to a word's capacity to evoke mental imagery. High-imageability words produce greater LAG activation than low-imageability words, demonstrating a robust imageability effect across lexical decision [**?**, **?**], semantic tasks [**?**, **?**], reading tasks [**?**], and naming tasks [**?**]. Neuromodulation studies using transcranial direct current stimulation (tDCS) have provided causal evidence for this sensitivity: cathodal stimulation inhibiting LAG activity significantly reduced the imageability effect in reading tasks [**?**]. Furthermore, the LAG shows greater activation for concrete than abstract words [**?**, **?**]. The processing advantage for high-imageability and concrete words is thought to relate to their richer semantic feature information, with LAG activation potentially reflecting sensitivity to such rich semantic features.

Overall, LAG activation demonstrates high consistency and reliability across numerous studies employing different stimuli and semantic tasks. Binder et al. [**?**] conducted a meta-analysis of 120 semantic processing studies using strict semantic contrast criteria, excluding studies where activation could be explained by attention or working memory demands or where stimuli were not matched for orthographic or phonological properties. This analysis revealed stable activation in the LAG. Collectively, these findings suggest that the LAG, activated across diverse semantic tasks and meaningful stimuli, may serve a high-level semantic representation function within the semantic processing network.

2.2 The Left Angular Gyrus and Cross-Modal Semantic Conjunctive Representation

As a high-level semantic representation area, the left angular gyrus may function to connect and integrate multimodal feature information from perception and action, playing a crucial role in forming complete semantic representations by integrating multiple feature types [**?**].

Evidence from brain-damaged patients provides strong support for the LAG's involvement in multimodal semantic representation. Patients with LAG damage typically exhibit difficulties in semantic processing across auditory and

written language modalities, showing multimodal semantic deficits in picture-word matching, picture naming, synonym tests, and word classification tasks [**?**, **?**, **?**, **?**]. For example, in picture description tasks, these patients cannot identify object colors or sounds or retrieve action-related knowledge, demonstrating cross-modal features of semantic impairment [**?**].

By manipulating semantic modality dimensions, researchers have found that LAG activation is modulated by perceptual-motor modality information, likely corresponding to a cross-modal semantic conjunctive representation function. Bonner et al. [**?**] observed LAG activation for both concrete words from specific modalities (visual, auditory, manipulative) and abstract words, suggesting that the LAG serves as a high-level cross-modal representation area that aggregates multiple modality information for concepts. Subsequently, Fernandino et al. [**?**] collected brain activation patterns for 900 English nouns and ratings of their perceptual-motor semantic attributes (color, shape, visual motion, sound, manipulation). While peripheral cortical regions were associated with the sensorimotor system and sensitive to one or more attributes, the LAG correlated with all five lexical semantic attributes. These findings indicate that the LAG represents multiple modality types and may possess cross-modal conjunctive representation functions.

Further evidence links the LAG to cross-modal semantic information integration. Studies have found that the LAG is activated during explicit semantic judgment tasks for both action-feature and sound-feature words, showing sensitivity to cross-modal semantic features [**?**]. Functional connectivity analyses by Kuhnke et al. [**?**] revealed that high action-feature words increased functional connectivity between the angular gyrus and action-feature representation regions (including left primary motor cortex and right posterior superior temporal sulcus), while high sound-feature words enhanced connectivity with sound-feature representation regions (including left anterior cingulate cortex, right inferior parietal lobule, bilateral dorsomedial prefrontal cortex, and thalamus). These results suggest that the left angular gyrus is a high-level convergence zone for multimodal semantic information, potentially integrating semantic information from modality-specific association cortices to form complete conceptual representations.

Recent representational similarity analysis (RSA) techniques have provided further support for the LAG's cross-modal information representation mechanism. Fernandino et al. [**?**] found that concepts in the angular gyrus and other regions are represented based on experiential feature information from perception, action, emotion, and spatiotemporal domains. Tong et al. [**?**] constructed a conceptual experience model based on 65 experiential dimensions (perceptual, motor, emotional) to predict neural similarity structures for 522 lexical concepts, detecting semantic similarity structures for lexical concepts in the angular gyrus and other cortical regions, demonstrating that these areas encode multimodal experiential information about concepts.

2.3 The Left Angular Gyrus Processes Semantic Relations

The LAG's semantic information convergence function is also manifested in its sensitivity to semantic relations, which constitute key elements of semantic space. Semantic relations can be organized into taxonomic systems based on semantic feature similarity (e.g., dog-bear) and thematic systems based on co-occurrence in events or scenes (e.g., dog-bone) [**?**].

Patients with LAG damage often produce thematic relation errors in picture naming [**?**] and show impaired ability to identify thematic relations between objects [**?**]. Functional MRI studies in healthy participants also support the LAG's sensitivity to thematic relations [**?**], with evidence from neural adaptation paradigms [**?**], semantic relatedness judgments [**?**, **?**], and picture-word interference naming tasks [**?**].

The LAG also shows sensitivity to categorical processing of concepts. Comparisons of biological and non-biological concept activation have revealed greater LAG activation for biological concepts [**?**]. A recent RSA study found that the LAG is sensitive not only to contextual distributional features of words but also to semantic category similarity [**?**]. Additionally, tDCS studies applying anodal or cathodal stimulation to the LAG have shown significantly reduced response speeds in semantic categorization tasks compared to sham stimulation [**?**], indicating sensitivity to semantic category processing. Since concepts within the same category share more features, they require greater feature integration. For example, biological concepts share more common features and thus show higher inter-concept similarity, whereas non-biological concepts tend to have more distinctive features and lower similarity. The greater similarity among biological concepts makes them more difficult to discriminate, potentially requiring more complex semantic feature integration [**?**].

The LAG's sensitivity to both thematic and taxonomic relations can be unified by its unique anatomical structure and function as a semantic convergence zone. Binder [**?**] analyzed how high-level semantic hub regions including the LAG process categorical and thematic relations, proposing that the angular gyrus functions as a high-level cross-modal convergence zone. From a connectionist perspective, thematic relations can be operationalized as features, with researchers suggesting that thematic and categorical relation processing differ only in the semantic features they depend upon: categorical relations relate more to visual features like shape and color, while thematic relations associate more with functional, spatial, temporal, and action features [**?**, **?**]. Representations of both relation types originate from information integration across multimodal systems, with concepts sharing category or thematic relations showing greater feature similarity than unrelated concepts. The enhanced LAG activation for both relation types compared to unrelated conditions may thus reflect integration of overlapping semantic feature information.

Several findings demonstrate LAG activation associated with both thematic and categorical relation processing. Semantic aphasia patients exhibit difficulties

across semantic tasks, making errors in both category judgment/matching and thematic association retrieval [?]. Virtual lesions of the LAG using transcranial magnetic stimulation impair performance on both category- and thematic-based picture-word matching tasks [?]. Zhang et al. [?] used neuroimaging data from natural story listening to build predictive models of cortical representations for semantic categories and relations, finding angular gyrus activation across multiple semantic category and relation processes. Additionally, magnetoencephalography studies have shown similar LAG activation for both relation types [?], while RSA research found that although the LAG was sensitive to category information, it also showed sensitivity to thematic information after controlling for category differences [?].

2.4 The Role of the Left Angular Gyrus in Lexical-Semantic Integration Processing

The left angular gyrus serves a convergence function for high-level semantic information in conceptual representation, which may correspond to semantic integration during access. At the lexical level, this manifests as integration from orthographic form to semantic representation, while at the larger scale of phrase integration, it involves combining multiple semantic information sources.

At the word level, the angular gyrus is thought to mediate transformation between word form and corresponding meaning. This view initially received support from brain-damaged patient studies [?], with direct evidence coming from neuroimaging research on Chinese character reading. Chinese characters' ideographic properties provide a unique opportunity to investigate neural mechanisms underlying orthography-to-semantics mapping. Neuroimaging studies of Chinese reading have found LAG activation during both semantic and orthographic processing, suggesting its function in mapping orthography to semantics [?]. A subsequent meta-analysis revealed greater LAG activation for Chinese character processing than alphabetic scripts, which both convey meaning and sound but require more orthographic analysis for Chinese characters. This led researchers to propose that LAG activation in Chinese character processing reflects orthography-to-semantics mapping [?].

At the phrase level, the left angular gyrus likely participates in semantic composition—the ability to combine individual words into complex meanings. Several studies have identified the LAG as part of a compositional processing network that supports integrating individual concepts into coherent semantic combinations [?, ?, ?]. For example, Price et al. [?] found greater LAG activation for meaningful phrase combinations ("tiny radish") than meaningless ones ("fast blueberry"), with activation unaffected by the modifier's sensorimotor information type. Recent research has also shown that posterior angular gyrus exhibits stronger activation for both meaningful and meaningless phrases compared to pseudoword phrases in auditory input, displaying stable activation across implicit and explicit tasks. This suggests posterior angular gyrus is sensitive to the amount of semantic information and relates to semantic

richness, reflecting automatic semantic composition [**?**]. Causal evidence for the LAG's role in conceptual combination comes from high-definition tDCS studies showing that anodal stimulation of the LAG facilitates faster identification of meaningful phrases [**?**].

3 Further Research on Left Angular Gyrus Functions

The left angular gyrus's extensive anatomical connections with widespread brain regions may enable its participation in multiple cognitive processing networks simultaneously. This characteristic has raised questions about the region's specific function in semantic representation and processing, complicating functional interpretations.

3.1 The Left Angular Gyrus and Anterior Temporal Lobe Semantic Hub Functions

As a high-level semantic convergence zone, the angular gyrus has been proposed as a hub region for semantic processing and representation. This view primarily derives from Binder and Desai's [**?**] embodied-abstract theory of semantic processing, which associates the LAG with event concept representation and integration of information from perceptual and motor modality regions. In contrast, the hub-and-spokes model of semantic representation posits that the sole cross-modal hub for semantic representation resides in the bilateral anterior temporal lobes, with semantic processing emerging from interactions between modality-specific information sources (spokes) and the anterior temporal hub [**?**, **?**].

Recent attempts have been made to unify these two hub regions within a single theoretical framework. Kuhnke et al.'s [**?**] hybrid model of semantic representation proposes that semantic processing involves different hierarchical levels of high-level hubs, with the angular gyrus and anterior temporal lobe playing distinct yet complementary roles. Conceptual processing depends on a hierarchical neural architecture progressing through modality-specific regions, multimodal regions, and finally amodal regions. The angular gyrus functions as a multimodal region that integrates low-level modality-specific information while preserving concept-related modality information, whereas the left anterior temporal lobe represents a higher-level amodal region that integrates semantic modality information into abstract representations without retaining modality-specific details. This model emphasizes that both modality-specific and multimodal regions participate flexibly in concept processing in a task-dependent manner, selectively responding to task-relevant conceptual features, while amodal regions completely abstract modality-specific sensorimotor information into highly abstract conceptual representations that are insensitive to modality information.

The functional contributions of the left angular gyrus and anterior temporal lobe to semantic representation and processing remain active research questions. Investigators have examined the functions of these two regions across different

linguistic levels (words, phrases, sentences) and in relation to various language processing components such as semantic integration and grammatical processing [**?**, **?**, **?**]. However, no consensus has emerged regarding their respective functional contributions, necessitating further in-depth research.

3.2 The Left Angular Gyrus in Semantic Control Processing

Semantic processing requires collaboration between semantic representation and semantic control systems, with semantic control defined as the flexible ability to access and manipulate semantic information. Some studies propose that the left angular gyrus is part of the semantic control network [**?**, **?**]. A review of brain-damaged patient studies, fMRI research in healthy participants, and TMS studies identified key regions for semantic control, including the left inferior frontal gyrus, posterior middle temporal gyrus, and dorsal angular gyrus/intraparietal sulcus [**?**]. Stroke aphasia patients with damage to left frontal and temporoparietal regions (including the angular gyrus) do not show loss of semantic knowledge but rather deficits in flexibly using and manipulating semantic information, exhibiting executive control impairments that suggest these cortical networks support semantic control processing [**?**]. Patients' semantic deficits vary with task control demands, showing better performance when retrieving common knowledge about objects and dominant meanings of ambiguous words but impaired retrieval of uncommon knowledge and subordinate meanings. This pattern suggests the LAG may be involved in semantic executive control, manipulating semantic information to generate task-appropriate responses [**?**, **?**].

However, debate persists regarding whether the left angular gyrus participates in semantic executive control processing in normal adult fMRI studies. A meta-analysis of 53 fMRI studies by Noonan et al. [**?**] found greater activation in the left anterodorsal angular gyrus for high-control-demand semantic tasks compared to low-control-demand tasks, indicating LAG involvement in semantic control processing. Yet this function has been challenged by other researchers. Jackson [**?**] employed improved meta-analytic techniques to re-examine the semantic control network but found no evidence for LAG involvement in semantic control; instead, angular gyrus activation appeared in the semantic cognition network (semantic tasks vs. baseline, meaningful vs. meaningless stimuli), leading the author to conclude that the angular gyrus is a semantic representation region rather than a control region. Furthermore, according to the activation profile of semantic executive control regions, the LAG should show stronger activation in more difficult tasks, yet a recent fMRI study demonstrated weaker angular gyrus activation in harder tasks [**?**]. Thus, whether the left angular gyrus participates in semantic executive control processing remains a contentious issue.

3.3 The Left Angular Gyrus in Default Mode Network Semantic Processing

Previous research has shown overlap between semantic processing networks and the default mode network (DMN) [**?**, **?**]. The DMN is a brain system that shows deactivation during goal-directed tasks relative to rest or passive baseline states, comprising the medial prefrontal cortex, posterior cingulate cortex, lateral and medial temporal cortices, and posterior inferior parietal lobule/angular gyrus [**?**, **?**]. These regions work cooperatively within the DMN to form a functional network involved in semantic and social knowledge processing, episodic and autobiographical memory retrieval, introspection, and memory. As a core DMN region, the left angular gyrus has been interpreted from three distinct perspectives regarding its function within this network.

One view proposes that the angular gyrus within the DMN serves as a semantic processing hub. Binder et al. [**?**] suggested that semantic processing constitutes an important component of cognitive activity during rest. Comparing resting state, tone perception, and semantic tasks, they found DMN activation during rest was higher than during tone perception but equivalent to semantic task activation, indicating semantic processing occurs during rest. Relative to resting state, the LAG shows significantly less deactivation during semantic than non-semantic perceptual or phonological tasks [**?**, **?**, **?**], and even displays positive activation when semantic processing demands exceed those of rest [**?**]. Xu et al. [**?**] found that a semantic processing network overlapped with core DMN regions, with most regions in this network being multimodal semantic convergence zones, further supporting DMN involvement in semantic processing.

A second view denies a semantic processing role for the angular gyrus within the DMN, attributing semantic effects to difficulty differences [**?**, **?**]. Researchers manipulated stimulus difficulty in semantic relatedness judgment and visuospatial tasks, finding no semantic task effect in the angular gyrus; instead, it showed a deactivation pattern across both tasks, with easier conditions producing less deactivation than difficult conditions [**?**]. A recent study similarly found greater deactivation in the left angular gyrus for difficult than simple conditions in both semantic and non-semantic tasks [**?**]. Consequently, researchers argue that activation differences in semantic > non-semantic or real word > nonword contrasts may reflect greater negative activation for more difficult tasks or items [**?**, **?**]. This difficulty hypothesis is supported by Graves et al. [**?**], who found that the typical activation difference between real words and nonwords in the angular gyrus was driven by stimulus difficulty, with activation patterns reversing such that nonwords activated the angular gyrus more than real words when using difficult-to-identify low-frequency words.

A third multifunctional view suggests the angular gyrus may support both semantic and non-semantic processing. Some researchers found that DMN regions including the angular gyrus remained activated even after controlling for demand differences between semantic and control tasks [**?**], leading to suspicion

that DMN involvement in semantic processing is not merely due to general difficulty differences. For example, Kuhnke et al. [?] found dissociable effects of task difficulty and semantic processing in the angular gyrus: stronger activation for semantic than non-semantic tasks (sensitivity to semantic information) alongside decreasing activation with increasing difficulty in both conditions (potential involvement in general difficulty processing). Moreover, recent research has revealed functional dissociations between angular gyrus subregions, with ventral angular gyrus showing social semantic effects and dorsal angular gyrus showing sensitivity to task difficulty [?]. Thus, the angular gyrus may simultaneously support semantic processing and general task difficulty processing.

4 Possible Explanations

The diverse functions and ongoing controversies surrounding the left angular gyrus in lexical-semantic processing may stem from several factors. One possibility is the existence of structurally and functionally distinct subregions within the angular gyrus. Cytoarchitectonic studies have divided the angular gyrus into separate anterior and posterior subregions [?, ?] that exhibit distinct structural and resting-state functional connectivity patterns with other brain regions [?, ?, ?]. Tractography studies have revealed different connectivity patterns for these subregions: anterodorsal angular gyrus connects via the superior longitudinal fasciculus to ventral premotor cortex and posterior inferior frontal gyrus, while posteroventral angular gyrus connects via the inferior longitudinal fasciculus to the parahippocampal gyrus [?]. Resting-state functional connectivity analyses have similarly shown differential connectivity, with anterodorsal angular gyrus showing stronger connections to ventral premotor cortex and ventrolateral prefrontal cortex, and posteroventral angular gyrus connecting more strongly with medial prefrontal cortex, posterior cingulate cortex, precuneus, and hippocampal gyrus [?, ?]. These findings reveal the complex structural and functional connectivity of angular gyrus subregions, implying distinct functional roles.

Indeed, researchers have proposed functional subdivisions of the angular gyrus [?, ?, ?]. Some studies suggest that posteroventral angular gyrus is associated with semantic representation, whereas anterodorsal angular gyrus participates more in semantic executive control. A neuroimaging meta-analysis found that dorsal angular gyrus activation increased with semantic task executive demands, while ventral angular gyrus showed greater activation in semantic versus phonological tasks but was insensitive to control demands [?]. Similarly, Jefferies [?] proposed that dorsal angular gyrus participates in semantic executive control while ventral angular gyrus handles semantic integration. However, a recent study found anterodorsal angular gyrus showed domain-general processing difficulty effects, but with a negative correlation between activation and difficulty (activation decreased as task difficulty increased), leading researchers to conclude that anterodorsal angular gyrus is not involved in semantic executive control [?]. Seghier et al. [?] directly compared DMN and semantic process-

ing networks, identifying three angular gyrus subregions. The middle region where the two networks overlap showed stimulus-driven deactivation across all stimulus types, with deactivation level positively correlating with semantic association level, suggesting involvement in semantic association processing for various stimuli. Dorsal and ventral subregions adjacent to this overlap both showed significant activation in semantic tasks compared to fixation baseline, indicating involvement in stimulus-driven semantic processing. The functional distinction lies in dorsal angular gyrus showing greater activation than baseline for both semantic and non-semantic perceptual judgment tasks, suggesting it performs semantic retrieval for all visual stimuli regardless of explicit meaning. In contrast, ventral angular gyrus activated during semantic judgment tasks but deactivated during perceptual judgment tasks, suggesting its involvement in conceptual identification of visual input [**?**]. While these studies have examined subregional functions, the contributions of angular gyrus subregions to semantic processing remain unclear, requiring more precise localization in future neuroimaging research.

Another explanation is that the angular gyrus functions as a cross-system connector supporting multiple aspects of semantic processing. This aligns with Xu et al.'s [**?**] tri-network neurocognitive model of semantic processing, which divides the semantic system into three subsystems: a multimodal experience-based semantic representation system, a language-supported semantic representation system, and a semantic control system. The model identifies the left angular gyrus as a central hub connecting these three semantic subsystems, suggesting that semantic information processing involves connection, transformation, and integration through the angular gyrus. The model further proposes that internal hubs for these three modules reside in angular gyrus subregions with distinct functional divisions: anterior angular gyrus participates in language-supported semantic representation, posterior angular gyrus supports multimodal experience-based semantic representation, and dorsal angular gyrus is involved in semantic executive control [**?**, **?**]. Additionally, the angular gyrus's central position in the DMN supports its function as a cross-system connector, as the DMN is associated with broad cognitive functions including semantic and social knowledge processing, episodic and autobiographical memory retrieval, introspection, and memory [**?**]. As a hub connecting different semantic systems, the left angular gyrus maintains close interactions with each network, suggesting its function in semantic processing may depend on interactions with other brain regions. Future research examining how different angular gyrus regions interact with other core semantic brain regions could provide network-level insights into angular gyrus function in semantic processing.

5 Conclusion

In summary, the left angular gyrus plays an important role in lexical-semantic processing. Current research has explored the "convergence zone" function of the LAG in semantic processing, yet debates persist and no consensus has been

reached. Future studies require deeper investigation into the functions of the angular gyrus in semantic processing.

Author Contributions

ZHANG Xiangyang: Research conceptualization, manuscript drafting;
WANG Xiaojuan: Research conceptualization, manuscript revision;
YANG Jianfeng: Research conceptualization, manuscript revision.

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