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Philosophy of Mind and Neuroscience. The Case of the Default Mode Network

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Abstract This paper addresses contemporary discussions in philosophy of mind and neuroscience concerning the Embodied Cognition (EC) framework, particularly examining the role of bodily and embodied cognitive processes in shaping linguistic knowledge. It outlines three primary positions regarding semantic embodiment: 1) the Classical Embodied Semantics (ES), which posits that concepts are fully grounded in sensory and motor representations; 2) the Embodied Abstraction (EA), supported by neuroscientific evidence (e.g., fMRI studies), indicating motor-area activations even during metaphor comprehension, thereby suggesting specialized functional networks capable of context-dependent abstraction; 3) Radical Enactivism (the Linguistic Bodies Thesis), asserting linguistic embodiment as a socially and personally navigated process, independent of specific biological or neural mechanisms. This position explicitly rejects cerebral embodiment, placing it in direct conflict with classical EC perspectives, neuroscience, and cognitive science. The discussion highlights theoretical contrasts and implications of these positions in the broader interdisciplinary dialogue. On the contrary, both embodied semantics and embodied abstraction have co-evolved with clearly identifiable neural structures: the former in mirror neurons and the latter in the Default Mode Network (DMN). The functional roles of this latter structure will be discussed extensively in §.3. The argument here is that these two approaches are fully complementary, and their unified interpretation is essential for contemporary philosophy of language.

Keywords: default mode network, embodied cognition, embodied semantic, embodied abstraction

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1. State of the Art

Philosophy of mind and neuroscience constitute two distinct research domains, characterized by their own methodologies; however, their interaction has grown increasingly profound and complex over time. In recent years, there has been a significant intensification of dialogue between these fields, resulting in a rich and dynamic interdisciplinary landscape. This exchange has facilitated the emergence of new theories, critical revisions, and empirical collaborations, thereby contributing to a redefinition of the understanding of consciousness, identity, and the mind-body relationship. In particular, the interactions among neuroscience, cognitive sciences, and philosophy of

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mind now delineate a complex and continuously evolving field of study aimed at elucidating not only the nature of the mind but also cognitive processes, their biological and philosophical foundations, and, with the expansion into cognitive neuroscience, their empirical applications particularly in clinical, economic, and social contexts (De Brigard, Sinnott-Armstrong 2022, Gouveia 2022, Leòn, Zahavi 2023, Lopez-Soto *et al.* 2023, Buccella *et al.* 2024).

In Italy, after a delay of several decades largely due to the influence of the idealistic tradition in the Philosophy of Language (Pennisi 2017), a vigorous debate has recently emerged on a variety of topics surrounding the central relationship between philosophies of mind and neuroscience. This debate has taken an original direction and has quickly led to the international dissemination of these approaches (Pennisi, Falzone 2016, Pennisi, Falzone 2020, Paolucci 2021, Ferretti 2022, Parisi 2019, Plebe, Perconti 2022, Pennisi P. 2023, Pennisi G. 2025, Cardella, Gangemi 2021, Voltolini 2022, Cimatti 2020). In many of these contributions, the theme of language has assumed central importance. Additionally, this tradition has deepened discussions on Embodied Cognition and the role of the body in cognitive systems, oriented in two distinct directions. The first has focused on the notion of interaction, emphasizing the relationships among bodies, brains, empathy, and social interactions: «a bodily paradigm based on relationships» (Gallese, Morelli 2024), anchored in the structure of mirror neurons. The second has emphasized both the constraints and potentials inherent in bodily structures, as well as the central cognitive role of inner language: «a bodily paradigm based on the body» (Pennisi 2021), anchored in the structure of the Default Mode Network (Pennisi 2022, Pennisi 2024).

2. Embodied Language

These different approaches are not in opposition; rather, they appear entirely complementary. The point of overarching unity is their shared commitment to the embodied cognition paradigm, deeply grounded in well-identified biological structures. Mirror neurons embody the neurocerebral foundation of social relationships, while the Default Mode Network, as we shall see, has for the first time enabled the localization of the more subjective and creative aspects of linguistic embodiment within individual autobiographical memory. Additionally, both approaches distance themselves from less corporeal versions of Embodied Cognition, a point to which we will shortly return. It is not coincidental, moreover, that cognitive sciences of language over the past thirty years have distinguished at least two meanings of semantic embodiment.

The first is that of Embodied Semantics (ES), according to which concepts are entirely reducible or grounded in specific sensory or motor representations, rather than being in any way amodal. Within ES, the word itself becomes a metaphor for embodiment. For instance, tactile metaphors – such as "John scratches his chin" or "Mark touches his forehead" – activate the somatosensory cortex, while metaphors involving expressions of movement – such as "John grabs the rope", or "Anna pulls the handbrake" – activate motor areas (Barsalou 1999, Barsalou 2003, Barsalou 2008, Tranel *et al.* 2003, Simmons *et al.* 2007, Gallese, Lakoff 2005, Pulvermüller, Fadiga 2010). ES is sensory in nature, species-specific, tied to the universal biology of individuals, and dependent upon evolutionary history and the biological development of structures.

The second meaning is that of Embodied Abstraction (EA). This was formulated after many researchers verified, through fMRI experiments, that activation of motor areas during metaphor comprehension also occurred when testing expressions of movement or figurative actions (e.g., "grasping the meaning", "seizing an opportunity", or "the audience grasped the idea"). Thus emerged the fundamental hypothesis of the existence of functionally diverse networks integrated through specific structures, which autonomously regulate the appropriate level of abstraction according to use, differing significantly from one individual to another and from one context to another (Binder, Desai 2011, Littlemore 2019, Pelkey 2023). EA is subjective, discursive, autobiographical in nature, tied to the historical cultures of individuals, and dependent upon the evolution of linguistic usage, the individual and collective histories of words.

These dichotomies are inspired by two distinct definitions of the body offered by Husserl in his *Cartesian Meditations* (1931: §34): Körper and Leib. The Körper is the objective structure: *the mere physical body* studied precisely through biology, physiology, and evolutionary history. In contrast, Leib is the subjectively experienced body – *the lived body* (corps vécu), as Merleau-Ponty described it in *Phenomenology of Perception:* the body that perceives, feels, desires, experiences sensations and emotions, studied through psychology.

In European philosophical tradition, at least since Spinoza, it is clear that this distinction serves as a practical schema rather than reflecting an ontological truth. According to Spinoza,

> mind and body are one and the same thing, conceived now under the attribute of Thought, now under the attribute of Extension. Hence it comes about that the order or linking of things is one, whether Nature be conceived under this or that attribute, and consequently the order of the active and passive states of our body is simultaneous in Nature with the order of active and passive states of the mind (Spinoza 1977, trad. ingl.: 280).

Similarly, Husserl himself, in the *Cartesian Meditations,* where he introduces the distinction between the two modes of understanding corporeality, adds: «as perceptively active, I experience (or can experience) all of Nature, including my own animate organism, which therefore in the process is reflexively related to itself. That becomes possible because I «can» perceive one hand «by means of the other, an eye by means of a hand, and so forth a procedure in which the functioning organ must become an Object and the Object a functioning organ» (MC: 97).

In contemporary cognitive science, even methodologically, the distinction between Körper and Leib tends to dissolve. Neuroscience, in particular, absorbs the psychological approach. Who today would not recognize behavioral modifications as alterations in cerebral states? Of course, the peculiar behaviors induced by these states remain objects of study for psychology and related disciplines (psychiatry, psychopathology, neuropsychology, linguistics, neurolinguistics, etc.). Nonetheless, no cognitive scientist today would deny the cognitive unity of psychic processes and the structural dependence of mental faculties on bodily structures. As succinctly stated in a renowned article by philosopher of the mind Daniel Casasanto, *Different Bodies, Different Minds* (2011).

However, this is not the direction taken by certain sectors within Embodied Cognition, especially the enactivism originally founded by Alva Nöe and now independently pursued by Ezequiel Di Paolo, Clare Cuffari, Hanne de Jaegher, and others. Radical enactivism specifically tends to entirely negate the fundamental role of Körper:

> The universal human body does not exist; we should begin to phase it out of our theories. In this, we depart from previous work that has used bodies as universal templates for explaining the mind. Bodies are unfinished, always becoming. Linguistic bodies, particularly so. They are always constituting themselves through their activities in linguistic communities. For this reason, we will pursue a constitutive approach to language, conceiving it not simply as a set of sophisticated skills for communication, expression, and so on, but as defining of humanness (Di Paolo *et al.* 2018: 7).

In this context, linguistic embodiment assumes a third, uniquely contradictory position. Being human means being «linguistic bodies» (*Ibidem*). We might appear to share the first two perspectives on linguistic embodiment described above (ES and EA), but this is not the case. Di Paolo *et al.* (2018) explicitly reject the Aristotelian position on species-specificity of human language. Likewise, they reject a modern ethological perspective; linguistic bodies do not interest them as member of species. To them, being a linguistic body means existing «as a process of navigating and merging social and personal orders (…) constituted by utterances and relationships between utterances» (*Ibidem*). Linguistic bodies are active bodies «as doing things together in the world with a view of language to match this activity, not merely in terms of communication but as structuring practices, thought, rituals, places, and institutions» (id: 14). Here, we enter the domain of performance studies and gender studies: « This is also true of several criticisms coming from feminist and gender studies. Human bodies are no longer universal blueprints, whose very universality is their strong theoretical suit (as in cognitive linguistics), but they are historical, gendered, stylized, politicized, with varying forms of ableness, powers, and sensitivities» (*Ibidem*). Language thus becomes merely a form of power:

> a living stream of activity in the sociomaterial world of practices and history. Language is a field of struggle, transformation, criticism, of human enaction. A guiding assumption is that the problem of understanding language is the problem of explicating the co-emergence of certain patterns of social organization and certain forms of embodied agency (id: 7).

While these positions are legitimate and intriguing in many ways, they align more closely with cultural studies and sociology, clashing epistemologically with neuroscience and cognitive sciences. This radical enactivism creates tensions even within Embodied Cognition itself, which must acknowledge the unity of mind and brain, proposing instead an exclusively functional – not ontological – perspective for the brain. Such epistemological choices, respectable in their own right, remain fundamentally incompatible with cognitive science and neuroscience, as demonstrated by Adams & Aizawa (2008), Colombo *et al.* (2019), Pennisi (2021) and numerous other recent critics. Thus, contemporary cognitive linguistics return to Spinoza, seeking a unified philosophy of body-mind relationships, while Embodied Cognition increasingly diverges from such a perspective.

3. The Default Mode Network

Returning now to the two main lines of research within embodied cognition – one emphasizing interaction (Gallese, Morelli 2024), and the other focusing on constraints and potentials inherent in bodily structures (Pennisi 2021, Pennisi 2024) – we can better appreciate their complementarity rather than their opposition, as we briefly mentioned at the beginning of §2. Both approaches, despite addressing two distinct phenomena related to language – interaction and inner speech – diverge from the enactivist positions previously discussed because they rely on identifying a specific cognitive mechanism localized within the brain. More precisely, these mechanisms are localized not merely in cerebral regions but primarily in neural networks that are today precisely identifiable: mirror neurons and the Default Mode Network (DMN). The complexity of these networks and their dense interconnections reveal for the first time a holistic yet distinctly differentiated unity of linguistic functions. Vittorio Gallese has extensively explored the relational mechanism. Here, I will concisely explain the neuroscientific component of linguistic-semantic embodiment in inner speech: the Default Mode Network, to which I devoted the book *The Eighth Solitude. The Brain and the Dark Side of Language* (2024).

3.1. The essential data

Although our lives seem immersed in continuous interactive activity, the most critical part of the body, the brain, experiences a state of permanent solitude, which individuals encounter daily. It is an involuntary and systematic solitude, within which a large portion of our cognitive activity occurs. This has been confirmed precisely by the neuroscientific discovery of the Default Mode Network.

The DMN refers to the recent identification of a set of brain regions activated in a nearly exclusively complementary fashion; that is, they mutually inhibit each other. When engaged in tasks requiring external attention, part of this network is activated while the other is inhibited. Conversely, during resting states, the opposite occurs. Overlaps are relatively rare. To better understand the DMN's functioning and significance, some preliminary clarifications are necessary.

When neuroscientific research examines the relationship between the brain, cognitive functions, and behaviors, it is practically obligatory to use specific tasks designed to measure neural responses. For example, in the Wisconsin Card Sort test, a patient is instructed to classify shapes and colors shown in various figures. While performing this task, brain imaging devices (usually fMRI, but also Positron Emission Tomography – PET – or other detection systems) indicate activated areas and their intensity. This method provides precise, repeatable control of brain functions, greatly benefiting applied research and clinical practice.

This procedure – the most widely used to date – often implicitly assumes that the brain functions as a neural context-sensitive device, reacting to environmental demands and contextual stimuli. Fortunately, this is true in many instances. For example, we walk smoothly thanks to the predictive nature of spinal cord oscillators that regulate our movements, allowing us to navigate a given path while avoiding obstacles or falls. However, the idea that this model explains all mental functions and related behaviors is unfounded. This assumption seems to echo the old seventeenth-century hypothesis of the reflex arc, ennobled in the nineteenth century by von Helmholtz and made dominant in the early twentieth century through Skinner's stimulus-response theory. Chomsky, in 1956, was the first cognitivist to oppose Skinner, asserting cognition as an internal faculty independent of context. Contrary to behaviorism, we now know that much of our cognitive activity occurs when the brain is not responding directly to environmental stimuli.

This led some researchers to test the brain when it was supposedly doing nothing. Experimentally, this involves monitoring individuals' brains via fMRI as they lie curled up and isolated inside the MRI machine, possibly focusing at most on a small luminous dot. This represents the literal case of cerebral solitude, technically known as intrinsic activity. According to Marcus Raichle, one of the DMN theory's founders, «understanding how the brain works critically depends on the study of its intrinsic activity» (Raichle, Snyder 2007: 1083). What exactly occurs when the brain – detached from contextual tasks – initiates intrinsic activity remains a subject of considerable debate, which we will revisit shortly. It is crucial, however, to understand immediately that this constitutes our brain's default activity, frequently interrupted by interactive tasks but resumed whenever the external world finally leaves us free. Raichle's work initiated extensive debate in theoretical and social neuroscience, cognitive psychology, neuropsychology, and philosophy of mind over the past twenty years. Today, the DMN appears to «have a prominent role in the

overall organization of the brain and hierarchy of functional networks» (Kahali *et al.* 2021: 1).
The central question posed by the DMN is: what occurs in our brain during the resting state? Moreover, is this neural context-free activity measurable using tools typically employed for neural context-sensitive activity? We will attempt to answer these questions by referring to neuroscientific debates and widely agreed-upon data. Due to the difficulty of correlating brain data directly with a clearly defined functional task, understanding intrinsic activity has not been easy. Nevertheless, the ongoing debate allows some firm conclusions. Currently, we can state with certainty that the DMN:

a. Occupies about half our mental time and consumes substantial energy – far more than what solving practical problems or engaging socially requires (Raichle 2006). Paradoxically, our brain consumes more energy the less it seems to do.
b. Has also been identified in monkeys (Ongür, Price, 2000, Vincent *et al.* 2007, Buckner *et al.* 2008, Mantini 2011), cats (Popa *et al.* 2009), rats (Lu *et al.* 2012), and mice (Stafford *et al.* 2014).
c. Exhibits regular topography and high functional organization (Buckner *et al.* 2008, Raichle 2015).
d. Is altered in several psychopathologies, particularly depression and schizophrenia (Pennisi 2022).

Hence, the DMN likely represents a highly energy-intensive evolutionary adaptation stabilized in later species, evidently conferring selective advantages outweighing its high energetic cost. It thus appears central to animal cognition.
Methodologically, the limitation of direct testing has been overcome using subtractive (or comparative) methods, recording brain activity first during specific tasks, then comparing it to intrinsic resting-state activity, as illustrated in Figure 1.

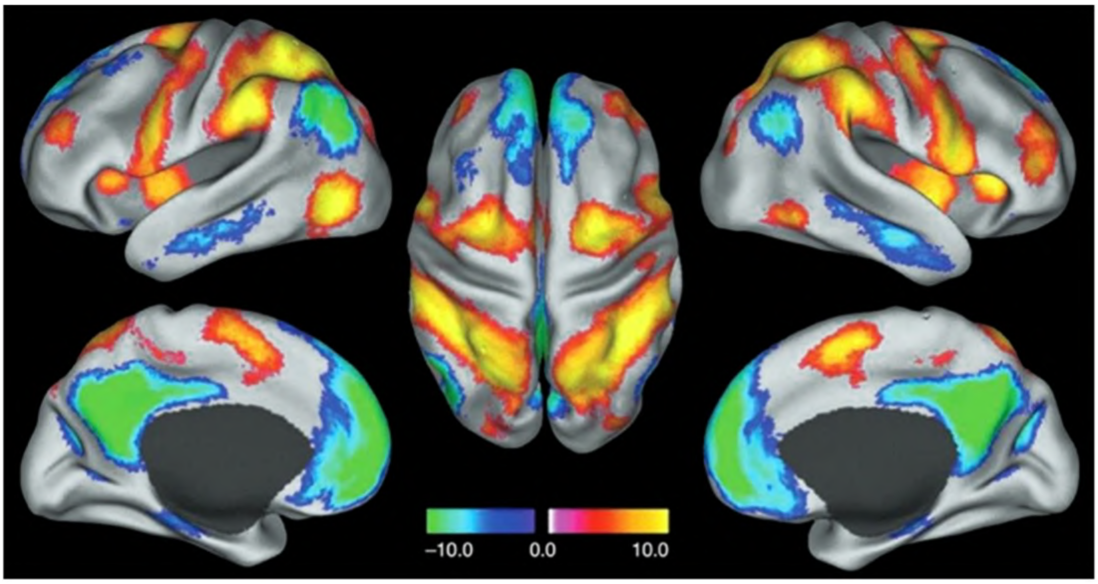

Fig. 1: fMRI images of a resting human brain illustrating the highly organized nature of intrinsic brain activity. Positive correlations indicate increased activity during controlled stimuli responses, negative correlations signify decreased activity under the same conditions. (Left: lateral and medial views of the left hemisphere; Center: dorsal view; Right: lateral and medial views of the right hemisphere) (Raichle 2006: 1249).

The intrinsic neuronal activity demonstrates a coherent distribution within cerebral systems and across individuals and groups of subjects. Specifically, the Default Mode

Network (DMN) is distributed across three primary cerebral systems: the ventral medial prefrontal cortex, the dorsal medial prefrontal cortex, and the posterior cingulate cortex along with the adjacent cuneus to the lateral parietal cortex, corresponding to Brodmann's area 39, or Angular Gyrus. Recent advancements in brain imaging techniques and new experimental methodologies have further revealed contributions of deeper brain structures to the DMN, incorporating the basal ganglia, amygdala, and thalamus into the DMN framework (Alves *et al.* 2019).
Participants in resting-state brain imaging tests were asked after the measurements about their experiences or thoughts during the experiment. Numerous hypotheses have been proposed based on extensive testing. In Pennisi (2022), I summarized ten interpretative hypotheses with detailed bibliographic references; however, I will not analyze all of them here. Instead, four of these hypotheses seem particularly representative:

(a) The «Worry Hypothesis»: Rather than being merely «mind or "daydreaming" as initially described by some researchers, the resting state involves cognitive incursions into daily concerns: «contrary to earlier Freudian notions, spontaneous thought is dominated by typical life events and minimally focused on fantasy» (Andrews-Hanna *et al.* 2010: 322). Eric Klinger described this activity as «current concerns hypothesis» (1971:239 ss.) attributing intrinsic activity with the practical role of organizing emotional demands, structuring past events, and anticipating future occurrences. Experimental evidence suggests participants predominantly think about their immediate past and/or future events, particularly those about to occur or potentially occurring: «pondering over our recent past may allow us to consolidate significant events, whereas envisioning our personal future enable us to entertain plausible future scenarios, "experiencing" them before they happen» (*Ibidem*). Several researchers have also proposed that this intrinsic activity has an adaptive function, facilitating preparedness and prediction of dangers or opportunities (Klinger and Cox 1987).
(b) The «Autobiographical Memory Hypothesis» focused intensively on retrieving semantic information (Spreng *et al.* 2009). Recalling personal memories, rich with emotional and multisensory details, aimed at problem-solving tasks occupies significant resting-state activity. This state of self-reflection, activated without external stimuli, explores embodied impressions from personal memories. It involves intense cognitive work across the temporal axis, shifting between past and future to generate assumptions, anticipations, and expectations – a «Bayesian inference engine designed to generate predictions about the future» (Raichle, Snyder 2007: 1087). This active, dynamic network for meaning-making «integrates incoming extrinsic information with intrinsic prior information over extended temporal scales» (Yeshurun *et al.* 2021).
(c) The «Default Self Hypothesis» relating to cognitive activity generating narratives, self-narratives, and mental imagery of the self (Pennisi 2021). It appears that a common intrinsic activity is narration and self-narration. Some researchers even suggest that the default self entirely overlaps with resting-state activity observed in the DMN. Davey *et al.* (2016) highlight semantic self-processing in the DMN: «left-sided IPL has a role in retrieving and integrating complex semantic information and its involvement in the network suggests that such processes make an important contribution to the sense of self» (Davey *et al.* 2016: pp. 395-396). During resting-state conditions, detailed mental imagery of the body might replace one's bodily schema, possibly explaining certain psychologically resistant pathologies, such as eating disorders (anorexia, vigorexia, etc.) and extreme cases like xenomelia (Pennisi 2021, Pennisi, Capodici 2021, Capodici *et al.* 2022a, Capodici *et al.* 2022b, Capodici *et al.* 2023).
(d) The «Social Cognition and Theory of Mind Hypothesis»: During resting states, activities requiring mental simulation, alternative perspectives, imagined scenarios, such

as moral decision-making and predictions, occur sequentially (Yeshuran *et al.* 2021). According to this hypothesis, during resting states, different components of the DMN selectively interact with brain systems involved in embodiment and mentalization, including the mirror neuron system. The goal of these interactions is generating cognitive maps suitable for socio-cognitive tasks. Simulation theory suggests we understand others by internally simulating potential behaviors in specific social situations; similarly, understanding oneself involves observing others' social behaviors closely (Yeshurun *et al.* 2021).

In summary, consensus exists regarding the DMN's cognitive function of integrating memory, language, and semantic representations to construct an internal narrative suitable for handling individual issues and experiences. According to Menon (2023: 2469): «this narrative is fundamental for constructing a sense of self, shapes how we perceive ourselves and interact with others, might have ontogenetic origins in self-directed speech during childhood, and forms a vital component of human consciousness».

3.2. The linguistic nature of the intrinsic activity

The key that unifies these diverse cognitive functions lies fundamentally in the linguistic nature of the intrinsic activity occurring within the DMN. At first glance, this assertion might appear contradicted by the presence of the DMN in some species evolutionarily close to humans yet lacking articulated language. Moreover, intrinsic brain activity has been recorded under general anesthesia in humans, monkeys, and rats. These cases suggest that intrinsic activity might also reflect non-conscious mental activity – a more general evolutionary feature of neural organization limited to visual, emotional, sensorimotor processes, or any other form compatible with animal brain evolution in non-contextual situations. In Homo sapiens, however, the intensity of these processes manifests as inner language. Thus, it's crucial to differentiate the human DMN from that of other species, particularly regarding anatomical elements distinguishing the human brain from other primates.
The most significant anatomical-functional difference involves Brodmann's area 39, present within the human DMN but absent or significantly less developed in other primates, such as macaques. Nevertheless, as Raichle notes:

> Regardless of anatomical details, if we accept that a default mode network is an integral part of the mammalian brain – which remains to be precisely established – it seems clear that the mental states of rats and humans, not to mention non-human primates, differ substantially (Raichle, 2015: pp. 441-442).

According to Brodmann's classification, area 39 corresponds to the angular gyrus, extending around the posterior end of the superior temporal sulcus, particularly its caudal portion. Practically, it forms an extension of Wernicke's area (parts of 22 and 40) and is functionally connected to the auditory cortex (41 and 42) and memory areas (37).
As is widely known, Brodmann's cortical areas are defined based on cellular structure: one tissue type transitions into another at clearly identifiable cellular boundaries. In Fig. 2 these areas are indicated solely by their numerical labels in parentheses. Despite continuous advancements in neurohistology leading to frequent modifications of these area definitions, the fundamental approach of distinguishing brain tissues by neuronal and fiber composition has endured over a century, with current research shifting its interest toward inter-area connectivity. These cortical areas process information and interact with distant cortical and subcortical regions via long nerve fibers (axons).

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The areas depicted in Fig. 2 communicate through intermediate pathways; some, however, connect directly – for example, Broca's area (45) directly connects with Wernicke's area (40) via the arcuate fasciculus (identified by Geschwind, 1970) and similarly connects with the angular gyrus (39).
Given the bi-directional nature of these connections (ab-ba), Broca's area and the angular gyrus directly exchange cognitive adjustment information that, indirectly, reaches and influences other areas in real-time. On the other hand, Broca's area lacks direct connections with prefrontal motor areas, hence it doesn't directly control oro-facial musculature involved in articulated verbal activity.

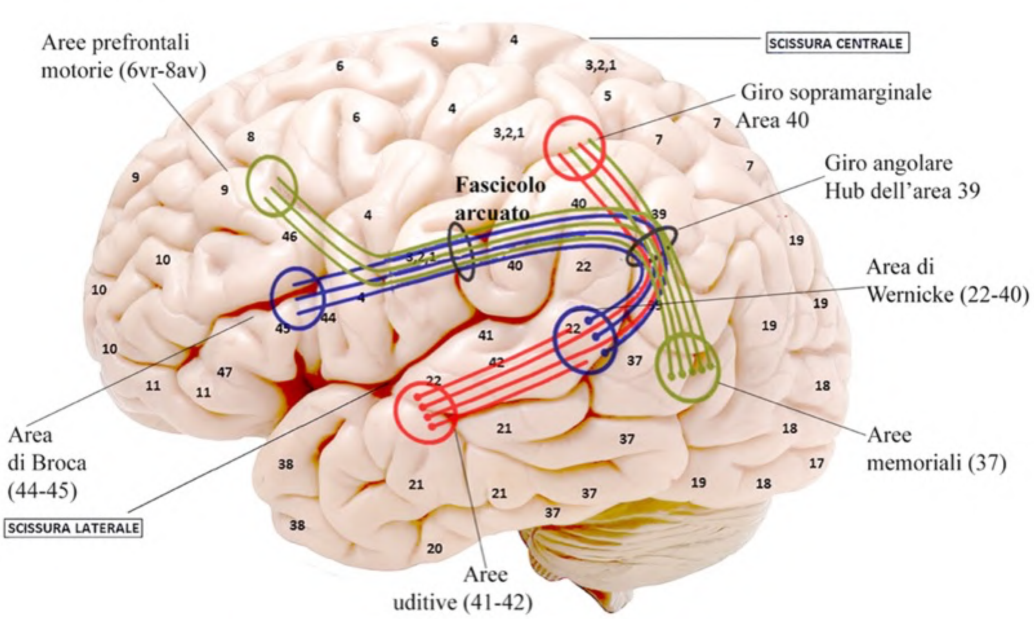

Fig. 2: Schema of connections among language areas (Petrides 2013).

Instead, advanced articulatory functions typically access indirectly via area 44, which governs certain prefrontal motor areas (e.g., 6VR and 8AV) involved in phonological activation. Area 44 also directly connects with the supramarginal gyrus (area 40), considered critical in phonological processing – thus acting as a transitional zone between purely motor systems and prefrontal semantic-cognitive systems.
This connectivity pattern among linguistic areas becomes particularly compelling when examining DMN activity. What remains of these connections when subjects undergo resting-state fMRI using the previously described method? The findings, depicted in Fig. 3, are striking and indicative of significant innovation introduced into neurolinguistics by DMN research.

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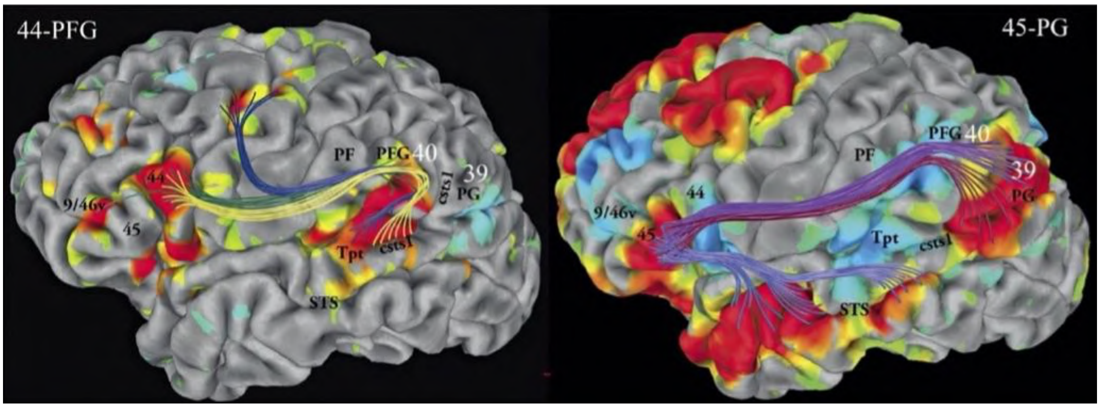

Fig. 3: (44-PFG-40) Resting-state connectivity in the left cerebral hemisphere of a human brain showing positively correlated activity (indicated in red) between area 44 and the posterior part of the supramarginal gyrus (area PFG-40), as well as the adjacent posterior part of the superior temporal gyrus (area Tpt). Note the negatively correlated activity (indicated in blue) in the angular gyrus (area PG-39). Superimposed on this image are the fascicles known to connect these regions (yellow and blue, branches of the arcuate fasciculus; green, third branch of the superior longitudinal fasciculus).

Fig. 3: (45-PG-39) Resting-state connectivity in the left cerebral hemisphere of a human brain showing positively correlated activity (indicated in red) between area 45 and area PG-39 in the angular gyrus, as well as the superior temporal sulcus and adjacent cortex on the superior and middle temporal gyri. Note the negatively correlated activity (indicated in blue) in the posterior supramarginal gyrus (area PFG) and the posterior part of the superior temporal gyrus (area Tpt). Superimposed on this image are the fascicles known to connect these regions (dark purple, second branch of the superior longitudinal fasciculus; red, arcuate fasciculus; light purple, extreme temporofrontal capsule fasciculus) (Petrides. 2013. Adapted).

Subjects in a resting state alternate activation between direct connections from Broca's area (45) to the angular gyrus (39) or from area 44 to area 40. Thus, when the cognitive-semantic reflection circuit (45/39) activates, the motor circuit (44/40) deactivates, and vice versa. This phenomenon explains why the region formed by the precuneus and angular gyrus has been termed a «high-level cortical hub» (Fernandino *et al.* 2016, Fernandino *et al.* 2022), primarily engaged during resting-state connections. Functionally, area 39 is immediately identifiable as processing auditory words, preserving and manipulating conceptual data for which words serve as audible markers – a kind of superprocessor of cognitive processing, linking physical sound to conceptual memory storage.

Area 39 is undoubtedly multifunctional. Seghier's meta-analysis (2013: 47) lists at least twenty-three experimentally tested tasks implicating area 39 through fMRI, including visuo-spatial and verbal numerical retrieval; memory control; self-referential processing; theory of mind tasks (story-based and otherwise); subjective, episodic, autobiographical memory; visuo-spatial navigation; and prospective tasks. Linguistically, it plays a decisive role in phoneme discrimination, semantic processing, recall, and distinguishing between concrete versus abstract concepts.

Thus, within the human DMN, area 39 plausibly plays a vital role in non-contextual thought, managing intrinsic activity as inner language that brings forth emotional states, creative processes, stored information, autobiographical memories, everyday concerns underlying potential actions or ethical and cognitive choices, simulations, and proactive anticipations. This critical cognitive activity occupies almost half of our waking lives (Klinger, Cox 1987, Killingsworth, Gilbert 2010). Its independence from immediate environmental stimuli echoes Chomsky's identification of language's unique species-specific trait (1966): the power of language to represent objects in absentia.

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3.3. The embodied semantic system

Binder, Desai, *et al.*'s crucial meta-analysis, encompassing over 520 functional neuroimaging studies focusing on semantic processing, observes: «the semantic system identified here is also strikingly similar to the human brain *default network*» (2009: 2781). Further studies affirmed that task-unrelated processes are essentially semantic, activated by acquired world knowledge processing. Binder initially projected semantic activation results from the meta-analysis (Fig. 4), then mapped complementary brain networks processing internal (red), external (yellow), or overlapping (green) information (Fig. 5).

Fig. 3: In orange the one hundred thirty-five activation foci published by the included studies projected onto a three-dimensional cortical surface (Binder 2009: 2771).

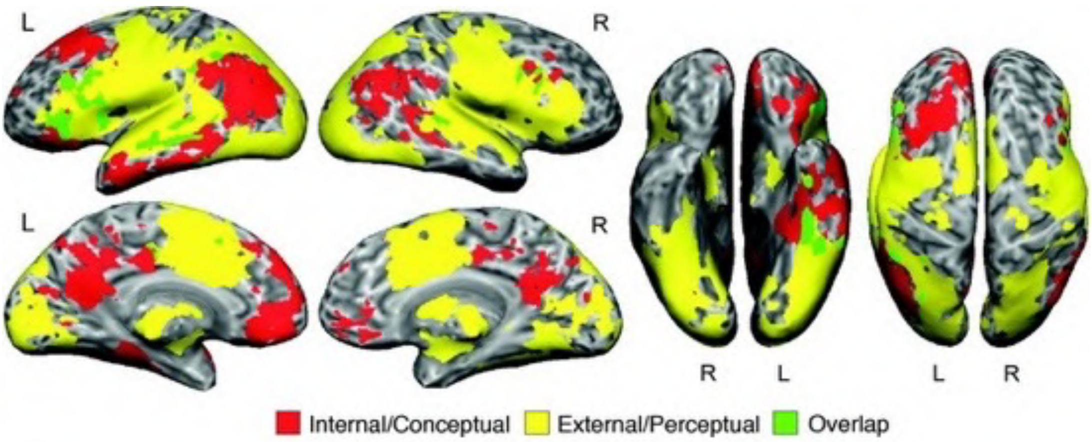

Fig. 4: Composite map of complementary human brain networks to process internal and external sources of information. Red = Internal semantic network; Yellow = External semantic network; Green = Overlaps (Binder 2009: 2781).

These results confirm the hypothesis of a DMN revealing complementary components. Overlaying lateral and medial left-right images (Figure 6) clearly shows semantic activation clustering around Brodmann's area 39.

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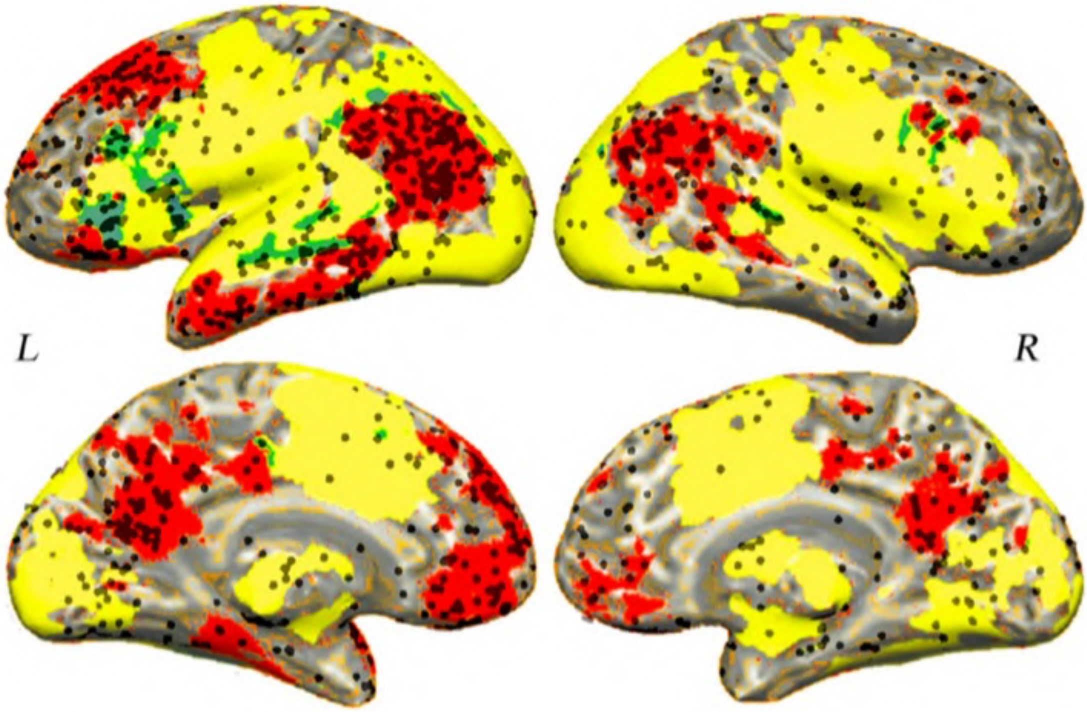

Fig. 5: Semantic processing occurs mainly in non-contextual areas (red). The intensity of the processing foci (dark points in figure) are concentrated in red areas. The areas of auditory understanding that correspond to Brodmann's 39-40 stand out in particular, but also involve the area of the auditory cortex (Binder 2009. Elaborated).

Specifically, the DMN engages brain regions uniquely specialized in semantic word recognition, activating stored conceptual knowledge. Without external stimuli, the human brain inherently becomes linguistic, processing thought through words. However, intrinsic DMN activity extends beyond abstract conceptualization, incorporating autobiographical memory, self-recognition semantics, social anticipation, and personalized, subjective reflections – transforming language into deeply individualized cognition. Recent studies have increasingly linked the core semantic knowledge of worldly objects, persons, actions, and events with language comprehension involving DMN's angular gyrus, emphasizing its role as a multimodal semantic abstraction hub integrating first-level sensory circuits. Binder and Desai coined «embodied abstraction» to describe this cognitive DMN process, suggesting semantic knowledge as multi-level abstractions from sensory-motor-affective inputs selectively activated by context, frequency, familiarity, and task demands:

> we suggest that the current evidence is most compatible with a view we term "embodied abstraction" briefly. In this view, conceptual representation consists of multiple levels of abstraction from sensory, motor, and affective input. All levels are not automatically accessed or activated under all conditions. Rather, this access is subject to factors such as context, frequency, familiarity, and task demands. The top level contains schematic representations that are highly abstracted from detailed representations in the primary perceptual-motor systems. These representations are "fleshed out" to varying degrees by sensory-motor-affective contributions in accordance with task demands. In highly familiar contexts, the schematic representations are sufficient for adequate and rapid processing. In novel contexts, or when the task requires deeper processing, sensory- motor-affective systems make a greater contribution in fleshing out the representations (Binder, Desai 2011: 531).

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This conceptualization of semantic knowledge to stand in opposition both to traditional computationalist hypotheses – following Fodor – which view meaning attribution as a purely amodal procedure, and to proponents of radical models of embodied semantics (Barsalou 1999, Gallese, Lakoff 2005) already described in the discussion of ES in §2. Nevertheless, Desai, Binder, and others (2011) established through fMRI experiments that motor areas become active during metaphor comprehension, even when testing figurative expressions of movement or action such as «grasping the meaning », «seizing an opportunity », or «the audience grasped the idea», as previously discussed in the description of EA in §2. Thus emerged the core hypothesis of functionally diverse networks integrated by specialized structures that regulate abstraction levels differently across individuals and contexts.

Solutions resembling this hypothesis have always been envisioned by great thinkers, from Aristotle to Vico, from Heidegger to Wittgenstein, as well as numerous other philosophers of language. However, the persistent problem has always been understanding how and where this intense semantic activity could occur in a biologically functioning animal organism. Indeed, higher-level representations can become so abstract and removed from concrete sensorimotor inputs that the notion of universal schematic processing becomes untenable. Memory and the lived experience of words can help unravel this mystery. The relationship between words and world knowledge displays remarkable flexibility: memory shapes individual histories of word usage. The angular gyrus (area 39) emerges here as the linguistic device capable of anchoring meanings to the world, not via a stable referent but through a semantic history – an uninterrupted succession of individualized enrichments and clarifications tied to a single lexical anchoring.

Recent DMN studies have further highlighted the extreme specialization of this mechanism. «We found – write Kuhnke *et al.* (2023: 273) – «that the Angular Gyrus is consistently deactivated under non-semantic conditions». This finding aligns closely with observations previously presented in Fig. 3. This implies that within the DMN system, the angular gyrus activates not only during resting states (independent of external stimuli) but specifically when lexical retrieval or semantic disambiguation is required – processes naturally varying according to each individual's linguistic encyclopedia. Additionally, analyses by Binder suggest potential functional lateralization, with almost all researchers agreeing that semantic processing primarily involves the left angular gyrus. Recent meta-analysis by Jackson (2021) further supports this hypothesis.

The anatomo-functional evidence suggests conclusively that «in semantic processing, we propose that left AG acts as a *multimodal hub* which binds different semantic features associated with the same concept, enabling efficient retrieval of task-relevant features» (Kuhnke *et al.* 2023). Further refinements currently under study propose that the angular gyrus could be subdivided into distinct cytoarchitectonic regions: the anterior subregion (Pga) and the posterior subregion (Pgp). Functionally, the anterior may generate semantic representations following the embodied abstraction model, while the posterior selectively retrieves (controlled processing) these representations (Anderson *et al.* 2019). This function, critical for human cognition, begins ontogenetically very early. Myelination of this area progresses from the 27th to the 31st gestational week (Dubois *et al.* 2008), and three-month-old infants already show strong left-angular-gyrus activation in fMRI when hearing their mother's voice (Dehaene-Lambertz *et al.* 2002).

Finally, it is crucial not to conflate the angular gyrus's role with that of the temporal lobe in semantic processing. The temporal lobe houses, among other areas, the primary auditory cortex (Brodmann areas 41 and 42) and Wernicke's area (area 40). As previously discussed, the latter connects to Broca's area (44-45) via the arcuate fasciculus, playing a fundamental role in language comprehension starting from early childhood learning.

Generally, the anterior temporal lobe is considered the semantic hub responsible for abstract meaning processing. The critical difference between the temporal lobe and the angular gyrus is that the former serves as an «amodal» hub, whereas the latter is a «multimodal» hub (Kuhnke *et al.* 2023). This distinction is significant. The temporal lobe integrates semantic features into highly abstract representations that retain no modality-specific information, operating primarily in contextual situations. Conversely, the angular gyrus embodies abstraction, anchoring semantic representations within a quiet, autobiographical memory elaboration and pragmatics, binding diverse semantic features associated with a word while maintaining individualized modality-specific information.

4. Conclusions

The human DMN is neither vague nor indefinite. It is effectively a dense communication network linking clear linguistic areas (Broca's and Wernicke's) and more obscure areas like the angular gyrus hub, which embeds meanings within our lived experience, memories, and emotions, thus transforming abstract concepts into individually lived experiences. Subsequently, these enriched concepts re-enter the clear linguistic circuit, becoming abstract notions shared again with others, enhanced through personal elaboration. This continuous and energetically costly intellectual activity occurs independently of conscious choice, automatically triggered regardless of the mundane or profound problems troubling our daily lives – from writing a chapter of *Being and Time* to paying tomorrow's electricity bill. As soon as external tasks are completed, our default state immediately returns to reflection and self-reflection.
With the DMN, the mystery surrounding language's subjective dimension begins to clarify. The brain area responsible for inner speech filling our solitude during rest (the angular gyrus hub, area 39) does not exist – or is minimally developed – in other animal species. It truly represents a species-specific cognitive trait rooted in human biology, philosophically prefigured by Chomsky's early *Cartesian Linguistics* (1966), but now instantiated within a clearly identifiable and empirically falsifiable neurocerebral network. Thanks to recent DMN studies, we now recognize that alongside traditional Broca's and Wernicke's areas – where sound is encoded and decoded, syntax structured, and semantics organized – there exists an area dedicated to rethinking meanings, re-embodying words within individual biographies, thus constituting a place where words become ontology. It is indeed the house of being, as Heidegger famously called it: language inhabits not just humanity in general but each specific human being, each specific history of linguistic use. Thus, the DMN emerges as the missing link capable of reconnecting biological objectivity with individual subjectivity in the complex puzzle of human cognition.

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