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NEUROANATOMICAL BASES OF SEMANTICS AND DETERMINANTS OF MEANING

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NEUROANATOMICAL BASES OF SEMANTICS AND DETERMINANTS OF MEANING

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ABSTRACT

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NEUROANATOMICAL BASES OF SEMANTICS AND DETERMINANTS OF MEANING

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Both neuroscience and linguistics study semantics, yet often in separation. Their independent pursuits may be experimentally productive, but prescribe their inability to fully predict or explain how language triggers meaning. Advances in neuroscience identify instances of lateralized language and frequently attribute word meaning retrieval to the temporal lobe, yet these findings are inevitably accompanied by the understanding that this type of cognitive ability is a result of neural interconnectivity. Meaning itself is associative, dependent on multiple neural bases to conceptualize, integrate, and coordinate information. That said, meaning is not a sole result of mental operation: external features such as the context, precedence, and conceptual frame in which a word is situated predispose the type of neural response and structural progression used to understand it. For instance, metaphors and implicatures require an alternate method of association compared to that of literal language. Establishments of the neural mechanisms that underlie semantic ability should account for these linguistic factors; reflectively, linguistic constraints that model semantic patterns should account for the neural bases of word association.

INTRODUCTION

What part of our brain is responsible for understanding the meaning of words? This is an impractical question: neither a word nor a single neural structure is very effective at producing meaning on its own. Meaning, in a broad semantic understanding, is the conceptual result of indication—a compositional state containing several possible paths to something else. Therefore, it would be contradictory to study the mechanisms behind meaning within a single discipline. The study of meaning should reflect the associative nature of semantics and integrate foundational theories from both neuroscience and linguistics.

To back up, this question about the neural and linguistic methods of modeling semantics was not a question that simply dropped into my head one day unaccompanied. It was more a question I found beneath several more abstract questions I had been asking, such as: how does literature, constructed of sole words, remain eternally relevant and impactful? How can a sentence dissolve the fabric of our routine thought? How are words able to catalyze complex and unfamiliar feelings, dismantle our line of logic, and even shift our state of consciousness? Why are our brains so willingly defenseless against the influence of a sound or a cluster of letters? (Or, on the other hand, how does the refusal to process them help the brain cope?) These questions intrigue me, and I think their seemingly lack of concrete explainability is what led me to pursue them through neuroscience and linguistics: subjects that make the abstract concrete and translate feeling into structure. However, instead of an answer to my questions, I found that neuroscience and linguistics are not fields frequently in combination, especially when it comes to the discussion of word meaning.

In the sole application of the word "meaning," it seems meaning could refer to everything possibly associated with or cued from any linguistic unit. Predictably, this definition bleeds too far into other linguistic subfields to remain an exclusively semantic concern. Thus, the semantic frame narrows to theories where meaning, more often, refers to an object of concept. The holistic object becomes a shortcut that reveals patterns of its linguistic indication, demonstrating an instance where denotative constraints are productive and unrestrictive within their own domain, yet inevitably denotes meaning myopically. In terms of its specific neuroanatomical location, an object is too complex to look for without separating its perceptive parts (Barsalou, 2017).

Perhaps it seems clearer to start with previously identified language areas of the brain, yet without an application of linguistic theories to distinguish them, this approach also results in unproductive overlaps. To demonstrate, Gazzaniga & Miller (2009) locate language, as a whole, predominantly in the left hemisphere of the brain. If the entirety of language can be localized to this extent, it seems logical that words, a part of language, could be localized to a neural structure within the left hemisphere. However, this logic too readily disregards the foundation of Gazzaniga & Miller's (2009) results, which are more accurately an effect of lost inter-hemispheric communication than they are the typical nature of language modularity. This exhibits, as Anderson & Lightfoot (2002) and Jackendoff (1994) identify, that left-lateralized language occurs primarily in right-handed adult males; this localization is not equally true for all humans. Further, the inexact location of semantic comprehension could partly be because what the word "meaning" refers to can easily vary across contexts. Several sources locate semantic comprehension within the temporal lobe (in both hemispheres), often in the anterior (or front) portion, yet commonly agree that semantic comprehension necessarily involves outside structures (Hickok, 2009; Patel et al., 2023; Price et al., 1998; Rice et al. 2015; Soshi, 2023). Other sources seek to determine the role of those outside structures, and in turn find that areas in the parietal lobe are essential to understanding language functionally, in particular with concept integration and motor-theories of language (Coslett & Schwartz, 2018; Esopenko et al., 2012), while areas in the frontal lobe are essential to differentiating lingual representations and responses, in turn determining the structures used to process meaning (Flinker et al., 2015; Reilly et al., 2011). Additionally, words activate the neural structures capable of representing the perceptive features of its indicated meaning (Barsalou, 2017), and, reflectively, Yap & Balota (2015) found that people recognize words faster when they contain several types of sensory information. Collectively, this evinces that semantic comprehension, the ability to link language to meaning, is a neural function, but is not exclusively localized to a particular neural structure.

Perhaps the inconclusiveness of what meaning refers to, and therefore where it is located, is not a result of a vague definition, but rather an inconsistent focus on the parameters of its presentation. For example, if we defined meaning as an encompassment of perceptions elicited by language, each localized to the sensory system brought to our consciousness by a lingual element, and studied them as individualized neural functions, maybe there would be more concrete findings of their localization. Maybe, hypothetically, everything responds simultaneously but separately: the auditory cortex exclusively processes sound, the hippocampus retrieves memories, the angular gyrus creates a general connective framework, and all the relevant information becomes consciously accessible on the cortical level, whose unification is really an interpretation of concurrency. However, this hypothesis still disregards several linguistic constraints—such as a conceptual, top-down process in which an idea initially arises in combination, or how our capacity to process information is not equally distributed across stimuli, but limited to the first part of what we hear.

Common explanations for how words indicate meaning are often discipline bound, appearing like entirely different studies with coincidentally similar vocabularies. Perhaps an attempt to understand language-and-meaning simultaneously through neural localizations and linguistic constraints is counterproductive, yet to disregard their common factors would bring about an inevitable falsity to the human mechanism of semantic understanding. The linguistic method of determining factors that create and constrain semantic association becomes more functionally multidimensional when applied to its neuroanatomical bases; reflectively, the interconnectivity between neural structures increasingly exemplifies through the linguistic patterns of intrinsically combinational language.

Semantics: The study of meaning

Semantics is the linguistic sub-field concerned with meaning (Arul, 2017). Sub-fields of linguistics distinguish themselves based on the way they dissect language. For example, the word “apple” is dissectible in multiple ways: through its adaptable part of speech (ex. *apple* versus *apple tree*), the letters that make it plural, its pronunciation, how context effects its representation (like how “apple” means something different in the Garden of Eden versus in Snow White, or for Isaac Newton versus a phone company). The semantics of “apple” would focus on how the word refers to the actual thing, or our conception of it. Like the thing you would point to if someone shouted, “point to an apple!” Semantics deals with how language translates to, and from, reality.

A word, simplistically, is a unit of language (but not every unit of language is a word). In regard to the ability to simply identify that a word is a word, its meaning is somewhat unnecessary knowledge. For instance, simply by looking at each cluster of letters isolated by a space on either side, you could identify that this self-referential sentence has twenty-nine words. These are orthographic words—they distinguish themselves visually (Arul, 2017). We can identify orthographic words by their spacing: however, we add spaces in between words to separate them, which means the word existed before the space, which means a word is more than an observable chunk of letters. Evidently, we speak in continuous sound-streams of words without spaces in between (Jackendoff, 1994). Spoken words are phonological words: they exist in sound (Arul, 2017). Both orthographic and phonological words consist of smaller lingual units; sort of like the five levels of organization within an organism. A sentence is maybe more like an organ-system, making words like organs. A word is composed of morphemes like an organ is composed of tissue, a tissue is composed of cells like a morpheme is composed of graphemes (orthographic) or phonemes (phonological). However, a lot of what distinguishes these linguistic units is their meaning (Urban, 1951). For example, the words “I” or “a” are simultaneously a word and a morpheme and a grapheme.

Ferdinand de Saussure, a Swiss linguist, developed a model in 1907-1911 in which a word is an example of a sign containing the signifier and signified (Arul, 2017). Reda (2016) identifies Saussure as having a predominantly synchronic, or non-historical, approach towards language meaning yet it seems suspicious that this model coincidently reflects the etymology of the word “semantic” as derived from Greek sēma and sēmainein: sign and signified (Oxford, 2023). Regardless, Saussure models an underlying structure where the stimulus and response, the indication and indicated, the representation and meaning, are held within a word (Arul, 2017). He claims we subconsciously recognize the phonetic cues of a written word and the image concept that its morphological components link to. His model identifies a compositionality to word meaning, indicating that word processing is a function requiring processing across multiple spheres, providing further reason it is not localized to one specific region of the brain.

Despite the straightforward definition of semantics within the linguistic domain, the interdisciplinary relevance of the term calls for a clarification. “Semantic” refers to something slightly different in neuroscience than it does in linguistics. In both cases “semantic” refers to a type of something—in linguistics, it refers to a type of study; in neuroscience and psychology, it more often refers to a type of memory. Semantic memory is a subtype of declarative (or explicit) memory—information that can be expressed through language (hence declare). Declarative memory is distinct from procedural memory, which is the implicit memory of how to do things like walk or draw (Basham, 2022). Semantic memory and episodic memory are the two main types of declarative memory: episodic memory is recall of events and experience—information useful for knowing how to act or what to do in everyday situations (Senkfor, 2002); semantic memory refers to knowledge of meaning, such as knowing the definition of a word: the meaning we have, for lack of a better word, memorized (Patel et al., 2023). As the definitions might indicate, the premise of semantic memory and linguistic semantics uncoincidentally share several common terms. For an example of a theory combining the two, Hickok (2009) proposes that the neural structures responsible for declarative memory could be the same structures responsible for word comprehension. Hickok (2009) finds that people with Parkinson's and Huntington's disease (of which a prominent symptom is deterioration of motor ability, indicating more damage to procedural memory than declarative memory) have greater difficulty in processing grammar in contrast to people with Alzheimer's disease (of which a prominent symptom is a deterioration of cognition and memory, indicating more damage to declarative memory than procedural memory), who have greater difficulty processing individual words. Conversely, children with spinal muscular atrophy acquire grammar, but struggle with word-meaning (Sieratzki and Woll in press, as cited in Anderson & Lightfoot, 2002). At minimum, these studies indicate that syntax and semantics can be somewhat separately functional—that syntax is computation, while semantics is retrieval.

I. NEUROANATOMICAL BASES OF SEMANTICS

If a brain function is localized, it means that a certain part of the brain is responsible for performing it. For example, people will often refer to a teenager's poor decision-making skills by saying they have an undeveloped frontal lobe. This common attribution is based off the evidence that decision making and impulse control are functions localized in the frontal lobe of the brain (Jawabri & Sharma, 2023). However, the idea that certain functions are localized to a specific region in the brain is somewhat controversial because, typically, no part of the brain is detached from the other.

One way that neuroscientists link specific functions to certain regions in the brain is through scans such as MRIs and EEGs. MRIs (magnetic resonance imagery) detail brain anatomy: they identify oxygen-rich blood in the brain, and therefore identify where blood is flowing. EEGs (electroencephalogram) show brain activity: they identify neural activity across a period of time, yet are less accurate in showing where activity is happening in comparison to an MRI (Jackendoff, 1994). When used together, these scans show where neurons increase their firing rates, more rapidly exchange chemicals, and compare the area of activity to specific anatomical locations and examine the localized consistency.

The other prominent determinant of localized brain function are the observable effects of regional brain damage. The abilities a person loses after damaging a particular part of their brain often evidences what that part of the brain did. Language disorders resulting from brain damage are called aphasias. For example, anomic (or amnestic) aphasia is a word-finding deficit. Anomic aphasia is not localized, but can result from damage to nearly anywhere in the left hemisphere (Yorganov et al., 2015). Anderson & Lightfoot (2002) present a study further identifying a non-localized semantic mechanism, where scientists would stimulate specific cortical areas in epileptic patients, which they found could disrupt their semantic naming-ability, but the neural areas whose stimulation resulted in this disruption was inconsistent across subjects.

The way linguistic analysis divides language into separate parts of phonology, morphology, semantics, syntax, or pragmatics is not necessarily reflectively mapped onto certain parts of the brain. Certainly, our brains can identify all these linguistic sub-fields as distinct, evidenced by their sole existence and continued study. Anderson & Lightfoot (2002) clarify that their claim of modularity refers to this existent separated nature of linguistic concepts, not to the physical separation of structures perceiving them. They write, “various aspects of linguistic knowledge are logically and functionally independent of one another, yielding the full complexity of human language through the interaction of individually rather simple systems” (p. 23). However, these linguistic domains are not truly separate from each other, which is not contrastive of but mimetic of the mind that separates their patterns. The inability to exclusively divide the parts of language occurs alongside the inability to exclusively localize their function to a specific neural structure.

However, maybe different neuroanatomical structures produce different semantic functions (Pulvermüller, 2013). Maybe this arises from their location relative to other structures, or maybe the mechanism of semantic association is dependent on a processing sequence whose pathway reflects a precedence-caused predetermination of meaning. To how small of a structure could specific semantic functions be determined? The research I use to answer this question evinces 1) semantic comprehension is a function of the brain, and 2) “semantics” encompasses different presentations yet is consistent as a concept of meaning. My method is to identify neural structures underlying semantic ability and categorize their individual roles based on consistencies in research—it is also through these consistencies that I progressively narrow the scope of neural structures and meaning.

Cerebrum and cerebellum

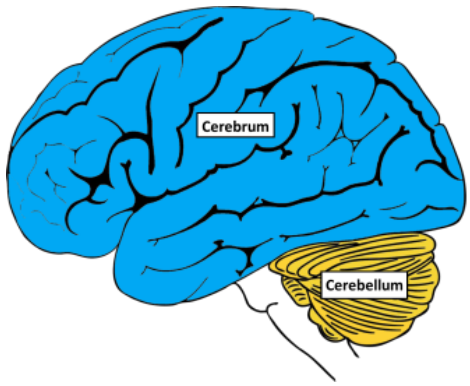

*Figure 1***.** Cerebrum and Cerebellum (Source: NINDS, 2023).

The cerebrum makes up most of the brain's surface area, consisting of both the outer layer of brain, the cortex, and the tissue below the cortex (Figure 1). The cerebrum encompasses the frontal, temporal, parietal, and occipital lobes— all of which generally distinguish themselves based on their roles in sensory perception (Jawabri & Sharma, 2023). The cerebrum is responsible for most of our conscious functions: our awareness of the outside world, our ability to think, our behavior, personality, and memory (Jawabri & Sharma, 2023). The outer layer—the cerebral cortex—is responsible for the majority of our higher-order cognitive functions (Eckhoff & Holmes, 2015), and the communicative networks across the cortex have a substantial role in our conscious thought (Tononi & Laureys, 2009). Concurrently, researchers often place the cortex as the general structure underlying language. However, Lieberman (2000), in addition to clarifying the inability to localize language, proposes its overlooked existence in the basal ganglia: a structure in the heart of the brain, which, compared to the cortex, is distinguishably not concerned with cognition. Lieberman (2000) frames language as repurposed system of neural structure whose origins controlled motor-based adaption. Could the physical locations of language give further evidence for its function or purpose, indicated by the primary or paralleled functions and purpose of similar neural areas in other species?

Most of the brain is made up of the cerebrum, yet the brain stem and cerebellum are vital to our unconscious functions. The cerebellum is the structure at the bottom of the brain and top of the spine, and it functions to control and refine movement (Figure 1). The cerebellum is also what makes the world seem right-side-up. Basham (personal communication, 2023) explains that you can wear goggles that flip your vision upside-down, which is disorienting at first, but after about an hour, your cerebellum will flip your vision again, so everything looks normal with the goggles on. If you then take off the goggles, everything will seem upside-down until the cerebellum re-adjusts. This orientational function of the cerebellum indicates it could have a role in visual letter (and word) recognition. In line with Lieberman's (2000) motor-language theory, recent research may evidence the cerebellum is important in understanding language, and further hypothesized to have a role in syntactic sequencing (Mariën & Manto, 2016).

Left and right hemispheres

The brain is an interconnected system, bound together by circuits and reciprocation and neural correspondence, but what happens when it splits? Gazzaniga & Miller (2009) observe this in patients with a severed corpus collosum, the body of fibers that connect the two halves of the brain. (Severing the corpus collosum is a last-resort treatment for seizures.) When the left and right hemisphere lose their physical communication network, they become separately functional. However, this does not create two conflicting consciousnesses that the patient is aware of. The reason why is likely because the function of the brain's ability to interpret its experience is localized within the left hemisphere (Gazzaniga & Miller, 2009). To be clear, there is an observable disconnect in the left and right hemisphere in "split-brain" patients; they will carry out automated actions dictated by the right hemisphere without communicating to the left hemisphere. This is not confusing to patients, however, because their left hemisphere will interpret these actions after they have occurred, creating an explanation that makes sense of their unexplained experience (Gazzaniga & Miller, 2009). The separation of neural circuits (that would have been involved in hemispheric communication) does not result in broken pathways or open channels for neurons to fire into the emptiness of where the corpus collosum once was. When the corpus collosum is completely removed, so is its ability to sense its own absence. Gazzaniga & Miller (2009) note that this would not be the case if the collosum was damaged, rather than completely removed, because its presence is what enables its detection of its own injury. In the case of the removal, the two halves of the brain simply function independently, becoming separately interconnected, separately bound, separately conscious. But again, if this is the case, why do these patients not express having two consciousnesses? Perhaps it is a matter of defining the levels of consciousness; the right hemisphere is conscious to the extent that it can sense, process, and respond to information, but compared to the left hemisphere, significantly lacks ability to reflect, interpret, and express itself (Gazzaniga & Miller, 2009). These functions are left hemisphere dominated, which uncoincidentally, is also the hemisphere in which Vigneau et al. (2006) find the language abilities of "motor representation of the mouth and phonological working memory areas" as functions exclusive to the left hemisphere.

Vigneau et al. (2006) and Vigneau et al. (2011) separate the parts of language rather than localizing it as a whole, supporting the non-localized basis of language as an entirety. Their research evinces multiple separate structures underlying syntactic abilities (Vigneau et al., 2006). Vigneau et al. (2011) explain that the right hemisphere, as Gazzaniga & Miller (2009) might predict, does not respond to phonological information and responds significantly less to words compared to the left hemisphere. However, Vigneau et al. (2011) explain that the right hemisphere is highly responsive when it comes to understanding context, which is essential to determining the relevance of word meaning.

According to Gazzaniga & Miller (2009), the right hemisphere would recognize the separate action-performances of sketching and painting, yet the left hemisphere would be able to explain *I'm sketching an outline for the picture I'm going to paint*. Of course, language is a complex behavior, and the common view negates that it can completely localized to a specific anatomical structure (Lieberman, 2000). Although the left hemisphere has shown substantial superiority for speech production and written language (Gazzaniga & Miller, 2009), as well as the "interpreter" which is capable of unifying information and integrating a continuous narrative of the self, this lateralization of functions only occurs when the corpus callosum is split—so while brain functions may be localized, the brain's interconnectedness alone allows it to communicate across local spheres. Further, the left-hemisphere dominance of language is most prominent in male, right-handed adults (Anderson & Lightfoot, 2002; Jackendoff, 1994). Lateralization is less prominent in children, and some studies suggest also in women (Anderson & Lightfoot, 2002). Also, the Broca's and Wernicke's areas in female brains are more consistently interrelationally structured across hemispheres, which could be the reason why their language appears less lateralized (Anderson & Lightfoot, 2002). Some left-handed people show an opposite lateralization of language (Anderson & Lightfoot, 2002). Further, hemispheric localization of language occurs differently in right-handed adults with no left-handed relatives compared to children and adults with left-handed relatives (Jackendoff, 1994). Is it that right handedness—the dominance of the right hand over the left—causes dominance of the left brain over the right? If motor processing is a form of spatial processing, is this processing also paralleled within the visual field? Moreover, Jackendoff (1994) presents the idea that the communication-dominant hemisphere of the brain is a result of input, a hypothesis evidenced by deaf people's increased sensitivity and discriminatory abilities towards visual stimuli compared to auditory communicators. Eckhoff & Holmes (2015) identify that the communication between the left and right hemisphere is a connection essential to enabling language; that parts of the brain *do* monopolize low-order perceptive skills, but language is a result of their reciprocal connection. Accordingly, Eckhoff & Holmes (2015) explain that this inter-structure communication adapts to damage and injury, and is capable of forming new connections. Similarly, Lieberman (2000) identifies how alternative structures become the basis for language function in children with brain injury in areas deemed essential to language. This is a result of neuroplasticity (Doidge, 2007).

Ventral and Dorsal Streams

There are two central pathways or two sequences of localized brain activation used to process information: the dorsal stream and ventral stream. The term “ventral” is an example of an anatomical directional term that identifies a position relative to other areas of, in this case, the brain. “Ventral” is often synonymous with “front,” but technically means “towards the stomach” (contrastive of “dorsal” which means “towards the back”), so in this context “ventral” refers to an under-part of the brain. The ventral stream is the “what” stream: it controls recognition of both speech and visual objects (Hickok, 2009). It involves areas in the superior temporal lobe and some parts of the middle temporal lobe in both hemispheres. Hickok (2009) elucidates that the presence of the ventral stream in both hemispheres could be a reason why people remain capable of speech recognition despite damage to the temporal lobe in a single hemisphere. The dorsal stream is the “where” stream: it underlies auditory-motor integration, converting sound information into instructions for producing speech (Hickok, 2009). The dorsal stream involves area Spt (a fissure between the parietal and temporal lobe) and the posterior frontal lobe, and mainly in the left hemisphere—perhaps why “production deficits are prominent sequelae of dorsal temporal and frontal lesions” (Hickok, 2009). The dorsal stream is responsible for informing our actions from visual cues, the ventral stream is responsible for establishing our familiarity with those visual cues (Van Polanen & Davare, 2015). In language, the ventral stream is responsible for connecting sound to meaning; dorsal for sound to articulation (Saur et al., 2008). This connects to the motor theory of lateralization—that our speech comes from the ability to produce distinct syllables from fine motor control.

Temporal lobe

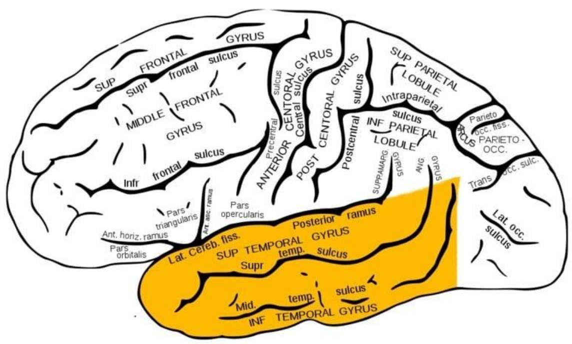

Figure 2. Temporal Lobe

The temporal lobe is a region on the sides of the brain—from a profile view, it is located at the bottom-center of the brain, sitting behind the frontal lobe and above the cerebellum (Figure 2). Its cognitive functions associate mainly with hearing, as its outer layer comprises largely of the auditory cortex, and memory, as the hippocampus lies in the inner-region of the temporal lobe. Although Patel et al. (2023) note that it is difficult to truly attribute cognitive functions to any isolated region of the brain due to its interconnectivity, they locate semantic processing in the ventral temporal lobe.

Anterior temporal lobe

Anterior means front (contrastive of posterior, meaning back), so the anterior temporal lobe (ATL) is the area of the temporal lobe closer to the front of the brain (or closer to the forehead). Damage to the outer layer of this area, the anterior temporal cortex, results in semantic dementia (Patel et al. 2023, Hickok 2009, Soshi 2023), which Hickok (2009) uses to evidence the anterior temporal lobe's role in processing words and their meaning. Additionally, people with semantic dementia have difficulty understanding word-indicated objects on a conceptual level, supporting the idea that the anterior temporal lobe is also involved integrating sensory memory (Hickok, 2009). Perhaps this is also why Hickok (2009) also notes that ATL damage affects syntactic processing. Soshi (2023) agrees on the ATL's consistent involvement in understanding word meaning, but that conceptual-semantic information involves outside cortical regions. They found that the sole act of consciously processing word meaning increased the communication between right temporal and frontoparietal regions, and that after their initial connection, these regions continued to concurrently process semantics explicitly.

A type of aphasia called deep dyslexia is a condition of inconsistencies in word representation yet a consistency in meaning—a person with deep dyslexia will be unable to repeat a given word, but will respond with a synonym or a related word (Jackendoff, 1994; Price et al., 1998). Although Jackendoff (1994) and Price et al. (1998) cannot localize a particular neuroanatomical structure whose damage results in this condition, partly because of its rarity and small sample-sizes, Price et al. (1998) note common differences in word-processing compared to the typical structural activation in two deep dyslexics. Both their subjects have substantial injuries in their left hemispheres, but interestingly, rather than a diminished activation of the anterior temporal cortex and left posterior temporo-parietal cortex, areas heavily involved in semantic processing, they show increased activation of both these areas (Price et al., 1998).

Superior temporal lobe

Research of the superior temporal lobe (superior meaning top-part of) exhibits its involvement in the production of speech sounds, such as articulation and speaking in a pattern (Hickok, 2009). Speech production contrasts speech recognition, which is more associated with verbal short-term memory (Hickok, 2009), perhaps because the ability to produce speech necessitates the working memory of both what you said and are going to say. The predominant structures in the superior temporal lobe are the superior temporal gyrus and superior temporal sulcus. The term “gyrus” refers to a bump or raised part of the brain, a “sulcus” is an indent or crevice. A structure called the planum temporale is located on the superior temporal gyrus, and is involved in speech and spatial hearing (Hickok, 2009). The posterior part of the left planum temporale includes a structure called area Spt (which stands for Sylvian parietal temporal)—the back part of the Sylvian fissure (which divides the parietal and temporal lobes). Area Spt is important for integrating sense and motor instruction that enable the articulatory tasks of speech (Hickok, 2009).

Damage to area Spt is associated with conduction aphasia[1], in which the main symptoms are frequent mispronunciation and difficulty repeating sentences (Jackendoff, 1994). However, people with conduction aphasia retain the ability to produce fluent and meaningful speech—as they are often able to recognize words and their meaning—their errors may only become noticeable in longer sentences. For this reason, it is somewhat unclear what exactly conduction aphasia impairs—some identify a disruption of articulatory instruction, others with verbal working memory (Hickok, 2009). Hickok (2009) also presents the hypothesis that conduction aphasia results from cortical dysfunction, which would evidence the further role of the left auditory cortex in producing language.

The superior temporal sulcus (on both hemispheres) is involved in phonological processing (Hickok, 2009), which is different than speech processing because it requires a person to break down speech-sounds in order to understand language, rather than immediately

[1] Conduction aphasia is also associated with the arcuate fasciculus, a subcortical connection running though temporal, parietal, and frontal lobes (Hickock, 2009).

processing speech on the surface as a comprehensive whole (Wagner & Torgesen, 1987). However, damage to the superior temporal sulcus does not significantly impair phonological processing, which could be explained by it functioning on both hemispheres, but further, the impairments to phonological processing appear to not be a result of damage to the superior temporal sulcus, but an effect of an impaired ability to processes word-meaning (Hickok, 2009). The superior temporal sulcus is also involved in processing faces and language, as well as producing speech and motion. It is also linked to the Theory of Mind, which is the theory of being able to metaphorically inhabit another person's mind (like the ability to feel like you are in a character's head when reading a book). This is likely because the temporoparietal cortex is partly responsible for understanding spatial relations relative to one's physical body (Vogeley & Newen, 2002).

However, the lingual star of the superior temporal cortex is a structure in the superior temporal gyrus called Wernicke's area. Carl Wernicke was a neurologist who discovered that damage to the top of the back temporal lobe resulted in the inability to demonstrate meaningful language comprehension. Effectively, his name became the name of both the area and the aphasia. People with Wernicke's aphasia can often speak with grammar and flow, what they are saying often seems to not make any sense (Jackendoff, 1994). By the method of damage-determined localization, Wernicke's area is responsible for accurately associating word meaning through its lingual representation.

Carl Wernicke proposed that Wernicke's area, because of its proximity to the auditory cortex, underlies long-term phonological memory of word meaning (Jackendoff, 1994). In other words, his idea is that that Wernicke's area is a semantic storage site for auditorily-cued words. While acknowledging the logic in Wernicke's idea, Jackendoff (1994) ultimately finds this explanation inadequate because understanding meaning in language extends beyond lexical-semantic retrieval. Even so, to consider Wernicke's argument, why would it intuitively seem the auditory memory of words also holds the meaning of them, but pronunciation does not? Is it the difference between perceiving and producing language?

Medial temporal lobe

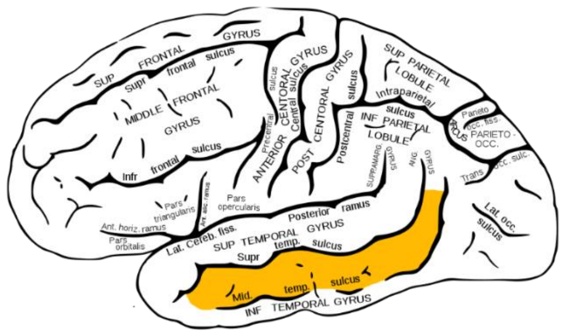

Figure 3. Medial Temporal Lobe

"Medial" is another example of a directional term: it refers to structures in the middle, relative to "lateral" structures, which are located closer to the outside. However, in contrast to anterior and posterior, medial and lateral operate on a west-east, or horizontal, or latitudinal plane. For example, both eyes are outside the nose, so they are lateral to the nose (and medial to the ears). The eyes are also on the outside of the brain, but they are not lateral to the brain because they are not comparatively further from the latitudinal center; rather, the eyes are anterior to the brain because they are in front of it.

Quiroga et al. (2005) located neurons that respond to concepts in the medial temporal lobe (Figure 3). They found single neurons that respond invariably to different representations of a single concept: in one case, different photos and drawings of Halle Berry's face, even seeing her name written, all catalyzed the same neuron. Another subject had a neuron that responded identically to different depictions of the Sydney Opera House (and even buildings that looked like it), another to Jennifer Anniston. This does not mean we all have neurons devoted to Halle

Berry and the Sydney Opera House and Jennifer Anniston—the concepts themselves were variable across subjects—this means we have neurons devoted to concepts. Sajjad et al. (2022) additionally identify single neuron responses to lexical concepts. The reason a concept neuron responds identically to varying depictions of a single concept is because rather than responding to the depictions, it responds to the idea behind them. Further, Quiroga et al. (2005) propose that "neurons in the MTL might have a fundamental role in learning associations between abstract representations" (p. 1106).

The existence of concept neurons indicates that the human brain is predisposed to recognize concepts but that the content of these concepts is individualized, indicating subjectivity's role in conceptualization. Particular concepts exist within individuals because of their resonance, creating an interesting loop of forming concepts from our own self-concept (Timmermans et al., 2012). This subjectivity in concept-resonance makes the phenomenon of single neuron recognition and response increasingly puzzling and complex.

The middle temporal gyrus is a prominent site for retrieving declarative knowledge. Patel et al. (2023) explain that the posterior part of the medial temporal gyrus retrieves conceptual memories, while the anterior part retrieves knowledge represented explicitly, such as facts that come after those *did you know?* blurbs in textbooks. Patel et al. (2023) write that the inferior and middle temporal cortex is "a general semantic binding sight between words and their meaning" (Patel et al., 2023). Further, Hickok (2009) identifies the role of the middle temporal gyrus in understanding both auditory information and word meaning.

Inferior temporal lobe

A few cases demonstrate that damage to the inferior temporal lobe results in semantic impairment (Hickok 2009, Price et al. 1998). Additionally, Price et al. (1998) identify that the inferior temporal cortex underlies visual recognition of words and their phonological retrieval.

Hippocampus

The hippocampus is a structure within the subcortical (beneath the cortex) medial temporal lobe (Raslau et al., 2015). The hippocampus is responsible for memory storage and recall, which makes Ekstrom et al.'s (2003) finding of neurons that encode spatial location in the hippocampus interesting. Originally found in rats, these neurons increase their firing rate as the rat navigates its environment (these regions also respond to visual stimuli). Yet it remains unclear whether these neurons encode location and fire within familiar space so that the rat can navigate, or if the rat's sensory navigation signals these neurons to fire. The parallel hippocampal areas in humans also fire in response to visual information, which could indicate that these neurons respond to concepts. Another instance in which spatial processing seems to be intertwined with memory is the "loci method:" an effective mnemonic device of associating information with a place (M. Basham, personal communication, 2023). For example, if you are trying to memorize the names of neurotransmitters using the loci method, you could mentally place each one in an area of an imagined house, such as placing serotonin on the stairs, dopamine in the kitchen, etc. When a person places information within a mentally constructed space, it increases their ability to memorize and recall that information.

Occipital lobe

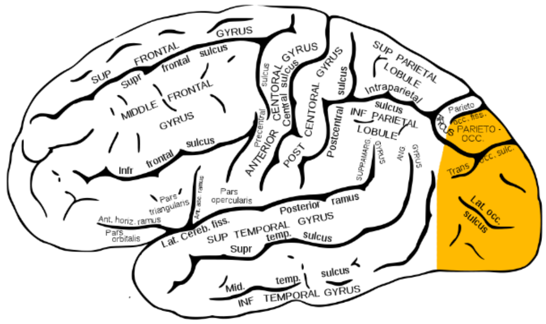

Figure 4. Occipital lobe

The occipital lobe is not frequently associated with language-related research unless it concerns the visual system, as with reading and writing (Figure 4). Pinker (2012) clarifies that written language does not actually exist; language refers to the spoken act, whereas writing is an imitation of language. However, the difference in the spoken versus written representation of a word could influence its semantic processing, or the other way around, that semantic processing influences visual word recognition. Yap & Balota (2015) explain the latter: people comprehend written words faster when they can understand the word in a variety of different ways—or can translate though multiple sensory representations. Yap & Balota (2015) identify that the level of depth with which we understand a word is a result of semantic features, proposing words themselves contain a level of semantic depth. In other words, they view words as compositional. A few of Yap & Balota's (2015) examples of semantic features are "imageability" (mental imagery), "number of senses," and "body-object interaction" (p.14). The evidence that the quantity and depth of these features predict the speed of visual word recognition identifies an instance where comprehension precedes recognition. Another instance of this seemingly perceptive inversion is the word superiority effect, which demonstrates that we more easily recognize letters within an actual word than in a nonsense word (Yap & Balota, 2015).

Compared to the amount of time humans have communicated with language, reading is a relatively new ability (Hanson, 2022). Our ability to communicate infinite meaning through written language is dependent on our ability to continually recognize each letter, each composing of just a few lines positioned in a certain way—it is these particular line formations that make our brain pay attention (Hanson 2022; Yap & Balota 2015). Yap & Balota (2015) explain a neural response to horizontal, vertical, diagonal, and intersecting lines. While it may seem puzzling that something as simple as a line stimulates neuronal attention, it makes sense considering that these definite lines rarely appear in nature. Both Yap & Balota (2015) and Dehaene (2009) add that letter-recognition is a receptive quality of neurons in the cortex, and Dehaene (2009) further adds that the number of lines in a letter is proportionate to the increments of visual processing.

Yap & Balota (2015) also present two interesting types of dyslexia—surface dyslexia, where people can pronounce fake words and words with irregular pronunciations, and phonological dyslexia, where people can pronounce real words and with regular pronunciations. The two cases present a completely different binding to meaning and pronunciation.

Parietal Lobe

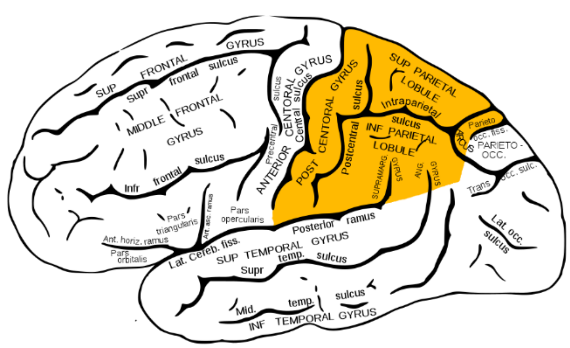

Figure 5. Parietal lobe

The parietal lobe underlies the somatosensory system—somato meaning body—which includes all of the information we receive through having a body, such as texture, temperature, pressure, proprioception, etc. (Jawabri & Sharma, 2023). This is to say that the parietal lobe is what enables and understands our interaction with the physical world (Figure 5). Perhaps this is why Huth et al. (2016) find that the lateral parietal cortex and medial parietal cortex activate in response to words expressing social concepts—which would necessarily be associated with a reference base and experiential interaction with the physical world. Although the nature of experiential comprehension might seem to be more a function of episodic memory, this is the process of integrating of shifting experiences into a consistent concept, which Coslett & Schwartz (2018) clarify is the initial format of semantic memories.

Bottini et al. (1994) also find that sentence processing activated the parietal cortex and the precuneus, a structure within the medial parietal lobe, which could be an effect of using spatial and movement cues to comprehend syntax.

Anterior parietal lobe

The anterior part of the parietal lobe responds to body and feeling related functions (Jawabri & Sharma, 2023). It contains the primary sensory cortex, which does what it sounds like it does—it underlies most of our sense conceptions (Jawabri & Sharma, 2023). Hickok (2009) identifies that this area simultaneously conceives of and integrates sense and motor functions, and he gives the example that this enables grasping. Esopenko et al. (2012) use the term somatotopic-semantics to reference when words contain information regarding movement initiate a response from the parietal-frontocentral network. They note a dual neural response to somatotopic-semantics of both lexical cortices and areas that encode information from the particular body part that the word indicated (Esopenko et al., 2012). Esopenko et al. (2012) also clarify that response from the indicated motor cortices occurs after the conceptual structures by about 0.2 of a second. Uddin et al. (2007) also note the role of frontoparietal areas in distinguishing physical space and relativity through motor function and interaction, and self-recognition.

Posterior parietal lobe

The posterior part of the parietal lobe has an increasingly integratory role of sense and function, and is therefore responsible for things like initiating movements (Jawabri & Sharma, 2023). Coslett & Schwartz (2018) note that relevant research frequently identifies the temporoparietal cortex as actively involved in language tasks, such as in Vogeley & Newen's (2002) explanation of temporoparietal cortex forming a mental egocentric reference frame, which allows us to understand language in a complex, immersive state.

Within the posterior parietal lobe is a structure called the angular gyrus, which Jawabri & Sharma (2023) identify to be involved in spatial function. It seems the angular gyrus' function in integrating multiple domains of information needed to comprehend and navigate space are involved in understanding a single meaning from a variety of representations. Further, Wernicke (1874) and Freud (1891) both claimed our concepts are held within the angular gyrus (as cited in Coslett & Schwartz, 2018).

Frontal lobe

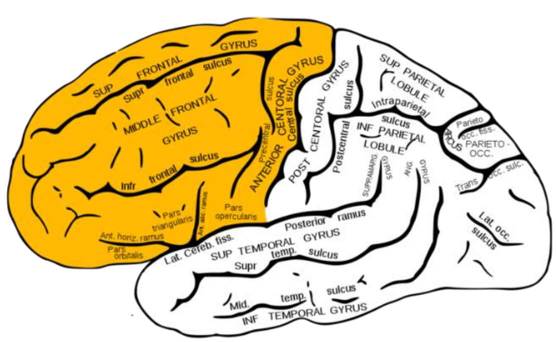

Figure 6. Frontal lobe

The frontal lobe is likely best known for its role in executive functioning, which involves things like decision making, behavior regulation, organization, and planning (Jawabri & Sharma, 2023; Figure 6). Thus, its function is significant to determining sensory representations and responses, and therefore enables a large part of semantic processing and comprehension.

Prefrontal cortex

The prefrontal cortex is involved in self-perception (Tononi & Laureys, 2009), forming complex and thoughtful associations (Deacon, 1997), and phonological working memory (Gruber, 2002). Deacon (1997) identifies that humans have a larger prefrontal cortex compared to other species, yet also claims that damage to the prefrontal cortex does not significantly affect language abilities. Both Deacon (1997) and Tononi & Laureys (2009) identify the prefrontal cortex's role in precepts and predetermining meaning, which reflects in its involvement in new experiences: when the brain is not pulling from what it already knows, it requires a greater awareness and organizational abilities from the prefrontal cortex (Stein, 2007). Interestingly, Stein (2007) and Seger et al. (2000) find that the left prefrontal cortex responds to typical combinations of nouns and verbs, yet atypical noun-verb pairings activated the right prefrontal cortex. Additionally, Miyamoto et al. (2021) identify the anterior lateral prefrontal cortex is involved in determining probability.

Broca's area

Broca's area is named after Paul Broca, a physician with a patient named Louis Leborgne who kept repeating the same word (Figure 7). After he died, Broca discovered a clear injury to a particular area of Leborgne's brain (Mohammed et al., 2018).

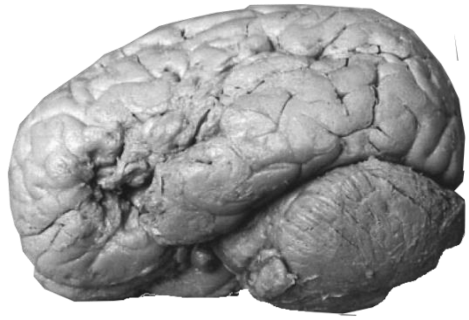

Figure 7. Leborgne's brain (Source: Auditory Neuroscience, 2023)

Located in the left (inferior) frontal lobe, damage to Broca's area results in "agrammatism:" the loss of flow and the inability to connect words into a sentence, however people with Broca's aphasia still make sense because they can answer questions accurately, evidencing their ability to understand meaning (Jackendoff, 1994). If damage to a particular area consistently results in a lost ability, it means that particular area is likely responsible for that ability. Because of its damage consistently resulting in agrammaticism, Broca's area is responsible for establishing flow, connection, and structure in speech. Although people with Broca's aphasia struggle to produce grammatically sound language, they are often still able to evaluate the well-formedness of grammar (Hickok, 2009). Hickok (2009) identifies Broca's area as a seat of grammar and syntax whose deficit could indicate that grammar is a function of working memory.

However, Flinker et al. (2015) notice that Broca's area is not significantly active in the same moment a person is speaking. In a revolutional hypothesis, Flinker et al. (2015) propose that Broca's area is not responsible for speech ability, but is an intermediary that determines articulatory information from language representation. It makes sense that Broca's area, located the frontal lobe responsible for executive function, would have a pre-speech executive role in determining relevant stimuli and responses. Reilly et al.'s (2011) findings could support this as they note the role of the inferior frontal cortex in the left hemisphere in conceptual sematic memory and their retrieval. Perhaps similar to Broca's aphasia, atrophy of the (left) inferior frontal cortex results in progressive non-fluent aphasia, which Reilly et al. (2011) explain results in a disrupted ability to remember the names of things and access concepts over several semantic categories.

Mirror Neurons

Mirror neurons were first discovered in the ventral premotor cortex, an area in the brain activated in response to motor action in relation to objects, such as tearing a piece of paper (Uddin et al., 2007). Sensory mechanisms can define motor agency based on a person's interactions with the outside world—occurrences in the brain reveal an aspect of perceived identity based on how it differentiates its own intent and actions from others. Mirror neurons demonstrate a phenomenon of neurological indistinguishability of motor recognition from one brain to another. Certain neurons will release in a person's brain to conceptualize their actions. For example, if a person sees their hands holding a piece of paper, if they feel them pull it in different directions, if they hear ripping, these neurons activate to identify their intent of tearing this piece of paper. Remarkably, the exact same neurons fire in the person simply watching them. Both people simultaneously and subconsciously identify the single intent. Mirror neurons can respond to recognized multimodal input to immediately understand (often referred to as mind-reading) and conceptualize the intent of another person as they carry out a certain task.

What gets spooky is that these neurons are capable of firing as if they are recognizing someone else when in reality are responding to their own being (like a dog barking at itself in a mirror). This is evidenced by MRI scans showing the similarity that mirror neurons have in response to self-perception (such as when a person sees themself in a mirror) in relation to frontoparietal areas previously established to correlate with self-recognition (Uddin et al., 2007).

In other words, these neurons physically overlap with structures involved in recognizing and perceiving the physical self and motor action.

These neurons release in response to motor actions specifically if the motor action is "goal oriented" (Uddin et al., 2007). If these neurons respond to actions specifically when they know the future of these actions, they must be, to some extent, proactive in conceptualizing the end outcome before it happens. In other words, the predominant function of mirror neurons is not to reflect on an event after it has already happened, but to determine the intent behind an action. Mirror neurons must recognize visual or auditory information and remember the larger scene it is linked to, yet they must not only recognize but predict, construct possibilities and pre-determine the probability of the most-likely outcome.

In order to determine probability, a person must consider an array of different outcomes; this seems to happen immediately or almost subconsciously. The effects of mirror neurons represent multimodal function, but also necessarily the ability to distinguish: both to unify the parts and separate them, to conceptualize and decipher. Considering this way of functioning, it is not a coincidence that mirror neurons have been linked with metaphor comprehension. The cognitive tasks of distinguishing and organizing information can be further examined from the absence of mirror neurons. For example, Acharya & Shukla (2012) report on the reduced presence of mirror neurons in autistic brains, which leads to further hypotheses about the function of these neurons. Based on the effect of their relative absence, mirror neurons are hypothesized to correlate with abstract thinking, language, self-identification, and metaphor comprehension (Acharya & Shukla, 2012).

What contributing neural structures say about language

An attempt to localize the entirety of language to a single neural structure is futile, but perhaps less so when localizing language in parts. The left hemisphere explains while the right hemisphere identifies; the anterior temporal lobe lights up during semantic retrieval while the hippocampus retrieves memories of concepts that the parietal lobe can understand. Damage to a certain structure may result in a predictable deficit to a part of language, such as Wernicke's area resulting in semantic deficits yet preserving grammatical production, yet these deficits do not occur without reducing the quality of other language functions, even mildly (Anderson & Lightfoot, 2002). Even when their functions seem separate, the parts of language fail to abandon the interconnectivity they originate from. Contributing neural structures evidence that language does not have a single neural basis, and reflectively the mechanism behind meaning-production is integrative. Separate modules necessarily inform and differentiate the same concept.

II. DETERMINANTS OF MEANING

Meaning exists as an indicated concept, which is further capable of indication itself. While meaning may be measured as a state of information, it necessarily is composed of several possible movements to something else. Perhaps part of the compulsion to know, to find meaning, comes from the recognition of not knowing—from the prevalence of its absence. The multitude of connotations and uses of the word "meaning" reflect the factors that determine it. Meaning results from somewhat unconscious matters of representation, recognition, or resonance, yet also from prediction, cognitive construction, and conceptual and contextual framing. To move from a stimulus to an indication, internal mental structures function synergically. The way in which these perceptive processes are so strongly intertwined without creating inevitably convoluted thoughts must be attributed, at least in part, to the grounded external structures of language. Linguistic patterns constrain possibilities of indication, serving as attentional anchors towards meaningful patterns.

The conscious subject as an analogy of meaning

Meaning results from the movement of the signifier to the signified—thus meaning cannot occur as a representation alone, for it necessitates an association. In the same line, the existence of an individual consciousness depends on the perception of something other than itself. To frame this idea in Descartes' (1637) famous quote, "I think, therefore I am," he asserts that the reality of individual existence is evidenced by its ability to think, claiming that thinking is only possible within a contained consciousness—something to think *from* (Damasio, 1994; Vogeley & Newen, 2002). This idea of consciousness necessitating a reference point could serve as a parallel model to meaning, for our relativity within a contextual sphere determines our comprehension of relevant meaning and establishes our concepts. Our consciousness separates our meanings; if consciousness was unbound, we would not need to continually determine meaning because meaning itself would be unbound; nothing would be separate from a single perspective because there would be nothing to differentiate from, no way to become aware of subjectivity. In other words, if everything were already known, there would be no reason to think and nothing to think of; there would be no ability to know that there is an unknown, because the moment a consciousness recognizes an existence beyond its knowledge it becomes bound, separated from the external. Consciousness is bound in the sense of being contained from the external world, yet similar to the possible grammatical basis, the neurological basis of consciousness demonstrates how boundedness is also about internal connection. Consciousness functions not only by what it is bound from, but how it is bound together.

A sort of extreme assertion could be that the information we perceive is solely a result of ourselves, and our relative positioning in the world results in an inevitable subjectivity, entirely preventing our access to objectivity. Subjectivity (as it may have a double meaning, as its referral to the subject in a sentence and as the opposite of objectivity, or these might mean the same thing because they are both identifying *where* something is coming from) binds consciousness from the external; it distances the self from objective reality. Damasio (1994) argues that the self is "a perceptually re-created neurobiological state" (p. 99), asserting that the self is not only a function of perception, but also of dynamic re-creation. Damasio (1994) uses this subjectivity to evidence consciousness. He claims that part of what distinguishes the individual is its perceptive inaccuracy; the way in which our reality is distorted or our memories flawed is what makes them our own. We can know an experience is ours because of its subjectivity. Perhaps this also applies to our capacity to recognize meaning—that our understandings are somewhat dependent on how much an association resonates with the individual subject. This may be variable, but not necessarily unpredictable.

To some extent, a person's consciousness, specifically their individual consciousness, may be cognitively controlled, yet with Damasio (1994), there is definitely an extent to where our consciousness, and therefore our semantic processing, is beyond our conscious efforts. Our ability to determine meaning is invaded and created by memory and interpretation and subjective perception. Damasio's (1994) explanation implies another possible error with Descartes (1637). Instead of thinking, maybe it is closer to "I feel, therefore I am." If thinking is a reaction, if the process of it is similar across separate identities, perhaps the self is evident not for its ability to think, but its ability to feel. Does the claim that feeling precedes thinking make a similar assertion to the claim that the physicality of being precedes thinking? How exactly do we conceptualize complex ideas from the information we receive through our senses? Potentially, the self is enabled, defined, by its physical existence. This is often the central argument of Descartes' (1637) opposition. Instead of "I think, therefore I am" maybe it is "I am, therefore I think." Damasio (1994) argues the latter through analyzing the neuroanatomical structures and chemical processes that enable thinking. Our being is physical, but what about our knowledge of being? Could Damasio's (1994) claim be true, but similar to a conceptual inversion of processing information, could our consciousness, and therefore our ability to determine meaning, occasionally be metaphysically outsourced from language?

Descartes (1637) did not say "I know, therefore I am," perhaps because the phrase seems to contradict itself; "knowing" is not an act of intention and it fails to demonstrate individual will; the pure presence of knowledge in the mind could evidence the contrary: that knowledge is the acceptance of external information as truth which contributes to the indistinguishability of the individual. Although an individual may know "I am," how could they differentiate to know what "I am not" without their own thought? However, Descartes' (1637) word choice was not what established his assertion. Descartes (1637) really made his claim before he even said the word “think.” The anchor of consciousness, the center-most spoken or written evidence of self-reflective cognition, awareness, and existence are held within the “I.”

The use of “I” indicates the simultaneous experience and perception of the internal, production and recognition: the inner state from which one experiences the external, and a removed external view constructed to perceive the possibilities of the internal state. The outward effect of the “I” implies the presence of a metaphysical self that is sustained by the thought of it, which we are reminded of by its stagnant representation in language. This co-existence serves to separate between what is “I” and what is “not I.” It is true that infinitely adaptable self-identification is crucial to language communication, yet the self-reflection required for “I” may evidence a higher level of awareness than needed to simply communicate. The meaning of “I” on its own seems more complex than how “I” is used in a sentence to identify the subject in relation to something else. Well, does “I” mean anything on its own? Is it a complete thought? If the “I” is like consciousness, it would depend on its relation to something external; it would need to be bound. But “I” is not bound, at least not grammatically. It is a pronoun: it stands in the place of something else, refers to it, yet can function on its own. What does “I” stand in place of in the quote “I think, therefore I am”? Are these “I’s” mutual reciprocals? Do they reflect themselves like two mirrors gazing through the other, and upon recognition gain consciousness? The anaphor, unlike the free pronoun, must be bound as it is defined by its referral to something prior. Common examples of anaphors are reflexive pronouns, which are often pronouns that end in –self (a morpheme displaying the characteristic of boundedness at a different level), such as *herself, himself, themself, itself,* or reciprocals such as *each other* or *one another*. For a word to be defined grammatically based on its referral to something prior, it necessarily assumes that that something prior exists. If pronouns represent nouns, and nouns represent reality, pronouns must also represent reality, but from increasing distance. Is this distance-by-reference from reality something that separates us from the external? In order to refer, the same concept must be held within different places of thought. When a thought occurs within another thought it is called recursion, which, in theory, enables us to be aware of separate points of reference simultaneously, and thus how to distinguish them (Acharya & Shukla, 2012).

The recursive self-narrative involves reflection and interpretation; it asks the question *how do I exist within the external?* In other words, it requires a person to embed themselves within a surrounding conception. Could there be such a thing as interpretive embedding? If recursion is defined by a thought being embedded within another, could the thought be embedded within another at the cognitive level, or does recursion simply refer to thoughts as they are written? A possible answer can be constructed from the difference between syntactic embedding and "perspective embedding," which is the awareness of mental states other than, and in addition to, our own (Whalen et al., 2012). For example, if you know that someone else knows something, you are embedding your understanding of that person's mind within your own (this is the basis of the Theory of Mind). The extent to which perspective embedding can be infinite can be displayed syntactically, such as, *I know that you know that she knows that they know that he knows that she knows*...and so on. This example shows that syntactic embedding and perspective embedding may be closely related—but is there more content happening cognitively than displayed in the words? Despite the disorientation that may result from excessive perspective embedding, the sense of self seems to remain stable. How do we stay so securely anchored to a single perspective, despite being able to embody a multitude of them? This is likely also a result of precedence—here, *who am I* is really a question of *when am I*.

Damasio (1994) asserts that we cannot think beyond what our physical capacity enables: that existence precedes essence, that the state of being, as it is physical, is presumptively substantiated, and is the place from which thinking can occur. Perhaps this is also the case with invariable constraints such as precedence—that meaning only exists in response to the (conceptually) physical bounds; the signified exists because of the signifier.

Consciousness, cognition, and meaning without language

Language represents our perception of sensory input, and in doing so, it extends the presence, and accessibility, of that information in the mind. Further, language enables us to be conscious of sensory input and interpret our perception of it. We consciously perceive and interpret language itself, but we remain largely unaware of how we do that. In other words, we can think without language, yet it seems logical that language requires thinking. Albert Einstein was clear when he said, "the words or the language, as they are written or spoken, do not seem to play any role in my mechanism of thought" (as cited in Damasio, 1994, p. 107). This idea is echoed by Deacon (1997), who explains that we can calculate without knowing how, which evidences our cognition does not require our consciousness. For this reason, it seems possible to interpret meaning without being conscious of doing so. Do we subconsciously have language memorized, or are we always subconsciously decoding it? Jackendoff (1994) argues for the latter, distinguishing language from basic cognition. He asserts, "the language we hear in our heads while talking is a *conscious manifestation* of the thought—not the thought itself, which isn't present is consciousness" (p.187). The central argument is that thought itself is unconscious (Mateosian, 2013). By *conscious manifestation*, Jackendoff (1994) likely means that the awareness we have of our thoughts is a linguistic representation of our actual, innate thoughts. However, the placement of the word *conscious* before *manifestation* enables the interpretation that the act of manifesting—of translating pure thought into language that we can recognize as thought—is a conscious process.

I do not really think this is what Jackendoff meant, but his phrasing revealed an interesting gap in the argument: the ability to sense that we are thinking despite not being able to express it in language, even to ourselves, or even the inability to immediately find words to express, indicates our consciousness of sub-lingual thought. In other words, the state of 'looking for the words' identifies an awareness without them; the feeling that we do not have the right words to express something identifies consciousness, to some extent, beyond language. However, Jackendoff (1994) further argues for unconscious thought by how it enables intuition. Stein (2007) explains the neurological basis of this feeling, calling it "uncontrolled thinking" (p.100). Usually, our sense of controlled thinking comes from the prefrontal cortex calling upon other regions of the brain; however, this can also occur in the reverse order; outside cortices can signal the prefrontal cortex (Stein, 2007). When the temporal cortex signals the prefrontal cortex with memories, we get those aha! moments—seemingly which happened beyond our conscious recall (Stein, 2007).

Even cognition itself exists on different levels. Although it seems easily agreeable to claim it is possible to think without language, the idea that it is possible to be conscious without language depends on how you define both thinking and consciousness, or rather to what level of consciousness to refer to. Urban's (1951) theory that "calculation is no longer 'actively conscious thought'" (p.319) implies that language is necessary for us to be *aware* of our thinking. Urban's (1951) idea is that we have both conscious thought, in which we are active participants, and mechanisms of unconscious cognition. For example, a person may have a subconscious awareness of their breathing, yet when you point it out to them, they now have a conscious awareness of their breathing. If you ask them how they breathe, they now become conscious of the separate actions needed to inhale and exhale. If you ask them how they know how to perform those separate actions, they become aware of how they pull on muscles to expand and contract their diaphragm, which ends up sucking air in or pushing it out of their nose, perhaps like a giant pipette. If you ask them how they know they are the one breathing, they may tell you it is a feeling, they may attack you, or they may turn into Descartes.

This opposes a single definition of consciousness. How the definition is approached depends on what consciousness is referring to, which seems to change with the discipline. For example, Tononi & Laureys (2009) make the argument that babies and animals are conscious, basically because it would be weird to say otherwise, yet babies and animals do not produce language, which evidences that consciousness is not rooted in language.[2] The claim made, to some extent, is that consciousness either is there or is not there; something is conscious in the sense that it is not unconscious and that it is simply aware of the external world. Deacon (1997) presents a counter-point: "few would be willing to say that the consciousness of a dog or a cat is of the same sort that we ascribe to humans" (p.439). In contrast to Tononi & Laureys (2009), Deacon (1997) proposes that consciousness exists on different levels. In essence, plants technically could be conscious because they sense their surrounding environment, but on a higher level, a person can be conscious *of* something, where they must direct their awareness to something specific; therefore, they must have the ability to control their own cognition. (Deacon, 1997). Deacon's (1997) claim supports the idea that consciousness is either present or absent, but its presence exists on different levels of what he calls "information holding capacity" (p. 439). The centrality of this argument is the effect of language on consciousness—which Deacon links to three phenomena of our consciousness that science struggles to explain. The first is the binding problem, the ability we have to connect separate features despite there being, seemingly no perceivable connection. For example, we know that barking is coming from a dog even

[2] Jackendoff (2019) similarly uses animals to evidence that consciousness is not solely a result of language, yet more specifically to claim that syntax is not the basis of thought.

though sound is delayed from the visual information. Deacon (1997) further identifies the binding problem to factor into our continuous sense of self. The second is the grounding problem: how representations of thought connect to the reality of their conception (Deacon, 1997). The third is the problem of agency, which, as a reactant to our sense of self, is the ability to identify thought and action as a product of the self, and therefore attribute the source of intent. It is a perception of the self's control of both the internal and external, necessitating a continuous explanation to establish the connection from the produced cognition or behavior to the self.

Concept

To define a concept seems like a contradictory task—it asks the exact bounds of a characteristically abstract and context-dependent encompassment of subjective associations. Maybe an easier way to think about concepts is how we process them; for example, instead of identifying a person's eyes and nose and ears and mouth as separate features before recognizing their whole face, we go the other way: we recognize faces first, and if need be we can dissect its parts after. This demonstrates that the face is a concept: we see the encompassment of facial features before we see the features individually (even the term "facial features" shows this sequence). On a sequence of unification-processing, concepts are where the end idea presents before its parts; a percept that predetermines meaning before other sensory systems have a chance to process new information. A concept is an inversion of analysis: perceiving before sensing, knowing before solving, it sees the culmination before the components. As Deacon (1997) writes, the human mechanism of thought is often "preoccupied with ends" (p. 433).

Take the concept of water, for example. Water is not what fills oceans, not what falls from the sky or turns to ice. Water is a word, a common point of reference that solely represents the real substance. The physical presence of water is absent from the word, yet when we hear "water" (or see it written), we immediately know its meaning even though the meaning of "water" is substantially multifaceted. Water is the stuff in a river, fast, too cold to jump in, dripping from a faucet, leaking from a roof, precious in the heat, mundane to order; it cleans off dirt, ruins paper, destroys landscapes, saves others from drought. A single word simultaneously represents a single thing and many different things, all distinguished from context. The word represents the concept of its meaning. In addition, although we have a common understanding of water, our conception of it may vary. Meaning is dependent on context; what we associate with something is categorized based on its relevance. The word, however, is a variable, capable of being separated from a fixed environment and inserted into another. Is it this ability to "free" concepts from a context that enables abstract thought? Or perhaps abstract thought is a result of the opposite: that no word or thought or concept is truly separable from its associative features and inevitable activation of relevant meanings, and therefore our abstractive, creative, problem-solving abilities are a result of our hyper-connective concept storage and pattern seeking hardware. Yet an attempt to determine our mechanism of semantic conceptualization through a model where *word input=definition output* seems an unrealistic and over simplified approach, especially across all people and all time. Like structures of the brain, words are rarely isolated. Meaning itself is dependent on context, as is the meaning of word. We do not know the meaning of words; we know the concept that words indicate and interpret their meaning based on their context.

Metaphor

Metaphor comprehension is somewhat a paradox of abstraction and focus. Arguably, metaphor comprehension involves a similar method of thinking to prediction; making the correct decision is like interpreting the correct link between the objects of a metaphorical comparison (Hu, 2023). Stein (2007) writes, "the process of elaboration by metaphor, some brain scientists think, underlies all thought" (p. 243). This idea is related to Reddy's (1979) explanation of the *conduit metaphor*. The conduit metaphor proposes that words (and language in general) are like containers that we use to transfer our thoughts to each other. It identifies expressions like "*empty* words" or a "poem *full* of emotion" as having a literal basis. This idea is also apparent in Jespersen's (1965) model of how we transfer our thoughts:

Speaker: notion—function—form
Hearer: form—function—notion (p.57)

This model shows that our communication occurs at a common meeting point of form, the syntactic equation our minds can take and decode. Upon deconstructing the form, we recognize how the received thought functions within our own neural systems, which finally enables us to conceptualize the meaningful notion. Both Reddy's (1979) and Jespersen's (1965) similar models are theoretical, yet they seem consistent with the Saussurian *signed* and *signified* notion of meaning (Arul, 2017), illustrating its active process.

Similarly, the ability to interpret metaphors necessitates the ability to organize information by meaning: to determine what different things have in common, to create categories, understand patterns, and identify an end purpose. For example, the common metaphor of saying someone is "an open book" equates two things, the person and an open book, to convey meaning that is not explicitly in the words. To understand this, we identify the commonality between what both a person and an open book consist of. The way in which an open book is different than a closed book parallels how an open person might be different than a closed person. Considering the low probability this is meant to literally describe a person physically, as in the open or closed skin of a cadaver, may be a result of determining probability, understanding context, or how this understanding becomes less relevant to the "book" part. A person can read an open book, and a person can also be metaphorically easy or hard to read, but how could a human be readable? The capacity for abstraction allows a person to draw further parallels of how reading could connect to human interaction, how a person reflects on their own mental processes when reading and when talking to another person; then, alas, the similarity of gaining information. If someone is an open book, they are easy to know.

Thankfully, our ability to understand everyday metaphors is not dependent on our ability to compare extensive subject-characteristic lists until we find a similarity. We would not get anywhere because of how engrained they are in human communication—metaphors are so prevalent we struggle to even distinguish them from literal language. We are accustomed to "grasp" meaning "understand" —this metaphor belongs to a category referred to by Lakoff & Johnson (1980) as "experiential metaphors" —one of many categories of metaphors that are so prevalent in our daily language they go unnoticed as metaphors. To give another example, Lakoff & Johnson (1980) name another category "orientational metaphors." These include sayings such as "wake up," "get up" or "I fell asleep," of which operate under the metaphor that *consciousness is up* and *unconsciousness is down*. His explanation as to why we naturally perceive consciousness as up and unconsciousness as down is because of the physical patterns of each—if a person is asleep, they are lying *down*, if a person is awake they are standing *up*. However, these orientations may conceptualize from a point deeper than our observations. Do you ever close your eyes, start to fall asleep, and suddenly find yourself plummeting off a skyscraper? This is a hypnagogic hallucination, a common falling-asleep-falling-sensation; even more common is the hypnic jerk, which is a physical reaction to this sensation, yet can happen without the actual feeling of falling (M. Basham, personal communication, 2023). The neural bases of hypnagogic hallucinations and hypnic jerks remain vague, but perhaps our metaphorical notion of falling is rooted in a deeper subconscious concept-network than our pure visual observations.

Another example of an orientational metaphor Lakoff & Johnson (1980) give is: *happy is up*, *sad is down*. Lakoff & Johnson (1980) give several examples: “My spirits *rose*. You’re in *high* spirits...I’m feeling *down*...I *fell* into a depression. My spirits *sank*.” Similar to how they explain conscious and unconscious states, Lakoff & Johnson (1980) align these phrases with the physical basis of posture that reflect a person’s mood, like how we more often see someone slumped over, looking at the ground, and think *sad*—or see someone in a direct marketing prescription commercial laughing at the sun with outstretched arms and think *happy*. Lakoff & Johnson (1980) identify several categories of metaphors we use that reveal our understanding of ourselves, others, things in relation to time and space, but we do not recognize this level of metaphor when we use them. How do we just *get* what they mean?

We often use the word “grasp” metaphorically to mean “understand” (as in *I couldn’t grasp what he was saying*). The reason we make this comparison, and naturally understand it, is possibly from the common experience of being able to better examine something if it is literally in your hand (Lakoff & Johnson, 1980). The action of grasping also elicits a response from mirror neurons—grasping is a goal-oriented action because we cannot really grasp without grasping *for* something (or intending to). Is it a coincidence that when someone watches someone grasp something, neurons fire in their brain as if they were the one grasping, and the word “grasp” is used so frequently as a metaphor for understanding? I think not! Both show how a person understands through embodiment. In the metaphor, *grasp* embodies *understanding*; in the literal sense, grasping something increases our proximity of embodiment to that thing; in the brain, we understand that someone else is grasping something because our neurons embody the same action. Uddin et al. (2007) write, that during recognition (both of self and other) “the perceived self is mapped onto the perceiving subject's motor repertoire” (p.154). This seems to show that in order to understand something, we need to *be* the thing we are trying to understand.

Embodied cognition

Embodied cognition is a broad term encompassing a large range of arguments and interpretations, which are often distinguished based on the extent it contrasts foundational understandings of computational cognition. The common critique of computational cognition is its isolated focus on the brain and disregard for the body's role in influencing cognition. Gallagher (2011) presents five theories of embodiment—one which might seem most relevant to the term itself is biological embodiment, whose argument seems to be based on a matter of sequencing. While our brain controls our motor movements, the movements it controls are limited by the physical capacity of muscles and joints. What came first: the muscle or the intended movement? This is reflected at all levels of perception; for example, our brain processes what we see, but only from the information it gets from our eyes, which is determined from where our eyes are located. A potential argument to this could acknowledge that we do not notice the blind spots within our field of vision because our brain fills in the visual information that our eyes do not actually see (Brooks, 1991). However, this instance of the brain filling in visual information does not necessarily determine the sequence of processing. Lakoff (2004) references a blind-spot study by professor at UCSD named Roman Candron, who conducted an experiment where he flashed a green circle with a yellow center right as the yellow center lined up with the blind spot in the retina—the result is that the subjects did not see any yellow, only green. Lakoff (2004) explains that this evidences a sequence of detection from outside to inside, and that this sequence of retinal detection is what is "filling in that inner part of our brains." By "inner" he is likely referring to the layers of the brain—potentially implying that the evidence of sensory movement from outside to inside precedes the brain-to-eye movement, therefore exposing an eye-to-brain process of filling in visual information. Lakoff (2004) does not claim this explicitly—he actually claims somewhat the opposite: that meaning is located in the brain, and that our image schemas are dependent on our brain structure. Either way, this phenomenon of visual perception preceding visual sense identifies another instance of precept-processing.

The placement of eyes, or really any organ sensing the outside world, is largely discussed to determine and "preprocess" the brain's cognitive capacity from the logic that their location in space situates their perspective of that space (Gallagher, 2011). This idea creates further implications for how our understandings of the physical world are reliant on our spatial relation to it. Gallagher (2011) gives an example: "if our eyes were located on our knees, for example, it would not only change our spatial perspectives, it would create differences in our conceptual associations" (p. 6). If our eyes were on our knees, maybe we would think dogs were terrifying and we would not have them as pets, maybe soccer would be considered a cruel and unusual punishment, maybe we would think the earth swings back and forth instead of rotating like a head. However, perhaps this is a silly and unrealistic example; surely an organ serving as the biological basis of language is not comparable to a knee, or any other body part whose damage is inconsequential to language abilities for that matter (Anderson, 2002). The fundamental logic of embodied cognition is that our physical experience is necessary for our conceptual knowledge. For example, think about your concept of dark compared to your concept of infrared wavelengths, or your ability to detect that something is magnetic versus detecting a magnetic field. Would we have concepts of molecules and atoms if we never saw them through microscopes?

This idea that our concepts form around the reference point of our physical being and from our individual sensory experiences seems to intuitively associate with an idea that concepts themselves are too uniquely personal to be predictable. However, in this case, variability does not equal unpredictability. True, the word "red" would likely mean something different, associate with a different hue, for someone with colorblindness from someone with the typical single type of red-sensing cone (559) from someone with an additional type of cone—resulting in tetrachromacy—and capable of sensing more types of red (Basham, 2022). However, the logical explanation that people have different conceptions of what "red" means does not necessarily indicate that a consistent meaning of "red" is non-existent. More precisely, it indicates that the meaning of "red" consistently responds to its perceptual constraints. (N. Myklebust, personal communication, 2023). The meaning may be variable, but not unpredictable. Perhaps, like language, we determine meaning from a sequence of constraints: our biology constrains sensation constrains perception constrains meaning. Contrary to the connotation of "constrain," these constraints enable meaning—perhaps meaning is simply a response to constraints. Similarly, Jackendoff (1992) explains our ability to be aware of our thoughts, and further to communicate them, requires multiple levels of translation. That we first recall our thoughts as concepts, and our brains must translate them into different representations of increasingly structured formats up until the once non-lingual concept becomes a set of clear articulatory information.

Our ability to understand meaning necessarily involves movement—like in the way certain localized brain functions are distinguished in relation to other parts of the brain, or lexical and grammatical functions are distinguished in relation to other syntactic positions, self-identification and contained consciousness is distinguished in relation to the outside world. Similarly, our ability to create meaning results from the shift in our attention—from cognitively positioning our consciousness to regard the movement into another embodied perspective—our ability to hold both forms of existence at once and connect them allows us to extract the common purpose.

Context

Context is perhaps the largest determining factor in terms of signifying the relevance of meaning. The context determines which representations and information are necessary to be aware of, so although a word's connotations may appear inconsistent, the variability lies in the context and features that cue the most relevant connotation. The study of context, regarding language, is called pragmatics (Lakoff, 2004). The context serves to both encourage the pursuit of certain information and discourage other information (Jackendoff, 1994). Deacon (1997) calls this the primary property of what underlies the commonality of "neural templates" (p. 339), to recognize what is important to respond to. The meaning of a word is variable and somewhat unpredictable due to its dependence on context, but perhaps the mechanism that looks for the features of a context to emphasize the relevant meaning is a consistent feature of the adaptive human brain. A feature's relevance to meaning increases its resonance in the brain.

Memory is adaptive; effectively, language production is adaptive. Memory is often prioritization of important information that arises from circumstance. The brain remembers information it needs to know to survive a particular situation based on what was relevant in the past, which is often inextricable from the location. For example, if a person learns how to build a fire outside in the cold, their future ability to recall the steps and materials needed to make a fire will come with greater ease when they are outside in the cold, compared to in a heated indoor space. The extent to which knowledge is environmentally dependent echoes throughout all learned information; an associated relevancy to necessary knowledge and the location in which it was acquired is naturally inseparable. This indicates that intelligence, and language, are adaptive abilities.

Ability is not a stagnant quality of an individual; a person experiences moments of genius, identity, or creativity because our cognition and semantic awareness is in a state of continuous shift (Portanova et al., 2016). This is functional, as prior knowledge can be interruptive in novel situations. This does not mean knowledge or abilities must be bound but it provides evidence that knowledge and ability is not static in the mind, rather an association that can be exercised and strengthened to flexibility in varying situations and environments, so ability can become more predictable and reliable, therefore this stabilization of self-perceived ability across environment and situation enables the knowledge itself, now internalized, to become a source of and self-capability. The adaptive nature of knowledge supports the frame that our way of determining meaning is an active response to the contextual indication, that understanding meaning is not a task of knowing disembodied meanings, but of drawing meaning from a given indication. This is the nature of implication, formally studied as implicatures (N. Myklebust, personal communication, 2023). Lakoff (2004) gives the example that if someone says "it's hot in here," we convert the literal definition to mean, functionally, "open the window."

Maybe the way a person associates language is similar to how a person associates knowledge with environment because like environment, certain contexts trigger related ideas. If a person is asked to describe a fire, they'll say words like "hot" before "cold," "orange" before "green," or "smoke" before "rain;" their descriptions are based on previous associations. Perhaps our associations are conditioned memorization, or maybe the presence of an internalized lexical environment, which, mimetic of a physical environment, triggers associated thought.

However, these associations might not necessarily come from real life experience, but from what Jones (1966) calls situational vocabulary. Relating to organization and storage, and therefore recall and creation, Jones (1966) proposes a lexical-semantic categorization as organized by a "highest common factor" or "lowest common multiple"—a root form and meaning at the base of related expressions—which he further taxonomizes into simplicity in open and closed situations, positioned and un-positioned syntactic arrangement. (Echoed by

Savic et al., 2023). Jones's (1966) theories of an innate semantic taxonomy, a vocabulary (and therefore linked idea) storage system relates to Jackendoff's assertion that "the number of sentences we are capable of using is just too large to store them individually" (p. 11)…"The way the brain seems to achieve expressive variety is to store not whole sentences, but rather words and their meanings" (p. 12). This point about words being primarily understood with their associated meanings gives evidence that the ideas that individual words are associated with have the potential to trigger different associated words, and therefore more ideas. Loopingly, language becomes context for itself. Lingually-expressed contextual constraints preemptively limit possibilities of lexical meaning (Bruhn, 2018).

Using information from past experience to survive the present is not a uniquely human trait. An example of Deacon's (1997) claim, how past knowledge can interfere with problem solving in the present, is seen in an experiment conducted by Pavlov's laboratory by Vasutro involved showing a chimpanzee named Rafael how to put out a fire by getting water from a faucet and how to build a bridge from a raft (Maruzewski, 1975). They then put ignited materials in Rafeal's raft, and Rafeal reacted by building a bridge to the faucet, filling up a mug, walking back to the raft, pouring the faucet-water on it, and continuing these steps until the fire was out. Maruszewski (1975) notes that a human in this situation would likely use the lake water the raft was on to put the fire out, establishing a higher adaptability to novel experiences. Language enhances human adaptability in novel situations. Maruszewski (1975) claims that this is because communication allows an individual to acquire generations of knowledge and to gain experience beyond an individual's physical capacity. This is true, but could it also be true that the human brain's sole ability to produce language accustoms it to abstraction, and pre-disposes it to problem-solve?

Regardless of the answer, the representational characteristic of language organizes information without us having to think too much about it. This allows for a greater cognitive capacity to operate above perception; the ability to reference entire concepts in a word frees up storage, and we can reference several in a sentence—rather than understanding *the water from the faucet puts out fire* we can separate the concept of water to recognize *water puts out fire*. This seems automatic, but this ability comes from recognizing patterns. Maruszewski (1975) argues the high human capacity for knowledge is probably not something we acquire through our own discovery, but through communication over time. This does not make sense without our ability to interpret *why* this is the case. It makes sense because we fill in the gaps.

The components of sign and signified exist outside the lingual sphere (Urban, 1951). Deacon (1997) gives the example of a sign as the smell of smoke signifying something burning. He claims this is a learned association by method of "repeated correlation" (p. 78). Further, he explains that this method underlies a majority of our associations—which translates back to our knowledge of indicated word-meanings (Unger et al., 2020).

Parallel subfields informing semantics

Semantics is a sub-focus of linguistics that deals with meaning–however it cannot be completely separated from other linguistic domains of phonology, morphology, syntax, or pragmatics, as all influence how a person associates meaning with a word. The general distinguishing factor between these fields is their unit size. For this reason, images that depict their relation often represent them in a hierarchy, and while this serves to orient and is helpful in its intent of illustrating levels of linguistic analysis, it presents a potentially misleading assumption of sequence in terms of cognitive processing. Semantics, for instance, is fundamentally concerned with meaning, so while it deals with relatively large units of phrases and sentences, it is also concerned with individual words, even individual sounds. The study of speech sounds is called phonetics, and phonology studies the systems and patterns of those sounds (Blohm et al., 2021). Jackendoff (2019) identifies instances where meaning is solely coded through phonological emphasis, proposing a direct relationship between phonology and semantics. Demonstrably, the tone with which someone says something distinguishes how the hearer will perceive its meaning. Blohm et al. (2021) use the term sound iconicity, how sounds pair with innate meanings, to explain the phenomenon that "m" or "n" sounds often have a negative association, while "p" or "d" sounds often have a positive association (Blohm et al., 2021, p.14).

Morphology

Morphology studies how a word is formed by morphemes: parts of language reduced to the smallest they can be and still have meaning (Myklebust, 2023). Here, "meaning" refers to a definition or reference to something rather than a sound. For example, while oxymorons or sound-communications like "ugh" communicate meaning, they do not reference a constant definition, such as "re-" which means "again" or "-ing" which indicates the progressive tense. There are two types of morphemes: free and bound (Myklebust, 2023). "Re-" and "-ing" are examples of bound morphemes: in order to work, they need something else to attach to (one indication of this is the dash showing where they attach to words). Think of affixes and root-words. Free morphemes are words that cannot be further divided into affixes and roots but have standalone meaning, such as "word" or "run." These are free because they do not need to be part of a bigger word in order to be, well, a word. Words themselves belong to an open or closed class depending on a morpheme's ability to attach to them. An open class word means it is accepting of morpheme additions. Sajjad et al. (2022) name nouns as primarily open-class and articles as closed-class words. For example, a noun like "table" is easily pluralized with the bound pluralizing morpheme "s" to become "tables," but an article like "the" cannot use the same morpheme to become “thes.” Jespersen (1965) defines morphology is as the study of how a word’s meaning develops from its form. Lexical semantics is likely the semantic domain most proximate to morphology; morphology studies word formation, lexical semantics studies how meaning forms within the word. *Lexical* is the adjective form of *lexicon*, (the vocabulary of a language) which is composed of *lexemes*: a set of forms within a single word, each form is a *lemma*, which automatically indicate a specific meaning (Hickok, 2009). For example, *write, writing, written,* and *wrote* are all different lemmas or lexical items, but they are all part of one lexeme because they all indicate the same well-defined concept. Hickok (2009) proposes a mental “lexical stage,” where we can identify a word by its meaning and syntactic position, but not by how it sounds. [3]

Syntax

Syntax focuses on how words function in combination with each other. It is generally synonymous with grammar, as it is definably concerned with phrase and sentence structure. Some linguists claim that a word’s semantics is nearly entirely derived from their syntactic position; others claim the opposite, that grammatical structure is constructed from meaning. Lakoff (2004) makes an argument for the latter with the following example of a technically grammatical sentence whose underlying structure is rooted in semantic, rather than syntactical constraints: “*John invited you’ll never guess who to you’ll never guess what kind of party for God knows for what reason on wasn’t it last Tuesday...*” Lakoff (2004) explains that the constraint here is exclamations, that because the phrases are exclamatory, they make sense despite not adhering to a regular syntactic structure. However, one could also argue that this sentence is really a combination of separate syntactically correct phrases. Perhaps our

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[3] Hickok (2009) notes, “in some cases there is no single lexical item to express a concept: there is no word for the top of a foot or the back of a hand; these concepts need to be expressed as phrases” (p. 2).

understanding of this phrasal substitution can apply to Deacon's (1997) idea that a person's ability to use a word in an unfamiliar context evidences they understand the word's individual meaning. Jackendoff (2019) argues against the formalist-semantic view of syntactically-constructed meaning in his theory of conceptual semantics. (Within the field of semantics, there are a few sub-fields, and several sub-theories, discerning the relationship between language and meaning; conceptual semantics is one of them.) Rather than understanding syntax as a vehicle that translates thought into meaning, he explains that the original purpose of language was to indicate meaning, and doing so innately contains the mechanism of thought behind it (Jackendoff, 2019). This contrasts Chomsky's (1986) idea of a language organ: an organizational structure underlying innate syntactic abilities in all humans.

Precedence

Precedence is, for lack of a better word, the dominance of the beginning on the end within a surface-level succession. In other words, precedence is why the start of a sentence is the important part to pay attention to; simply by the beginning being located at the front-end of the sentence, it determines and limits the possibilities of the ending. For example, if someone turns to you and says, "What..." just from the first word, you already know they are about to ask a question. This indicates that when we communicate, we do not determine the meaning of every word individually. If we had to recall all of the possible meanings of a word and then calculate which meaning best fits in relation to all of the other words in sequential proximity and all of their possible meanings just to understand a sentence, conversations might as well be calculus. Instead, the first word of a phrase, the first sound of a word, starts to narrow the scope of meaning—a phenomenon called chunking (N. Myklebust, personal communication, 2023). Rather than responding to a linguistic stimulus as its own entity, we respond to the future it indicates and whose meaning we already know. Our perception of language is largely a perception of our predictions. In other words, language, in its objective production, is not the source of information, but rather a cue to retrieve the information we already have. [4] Language, in terms of what it represents, is not objective because our perception of it changes. The indicated meaning of language changes because the indication we hear changes.

To spiral further down our inescapable self-circuit, Brown et al. (2015) explain that even precedence itself is perceptual in the sense that the first sound information we receive is determined by our spatial distance from the sound (and reflectively, space determines precedence). In a way, grammar literally informs our orientation within physical reality.

This ability of instantaneous categorization parallels Chomsky's (1972) theory of innate grammar—that the structure of language is inborn and understood simply through hearing it. By hearing language, having input, the brain is able to recognize the patterns of subject-object agreements, conjunctions, the order of nouns and adjectives, the phrasing of questions, etc. Interestingly, he refers to the mental processes that naturally, innately, occur in the human brain as interpretive. Interpretation is not a display of learned knowledge, but of how the brain works. Just as innate operations enable a retina to absorb photons and signal color to the brain, innate operations enable interpretation. There could be a similarity in need to distinguish the correct part of a metaphor and distinguish the correct grammar for communication; he claims that we learn language by sorting language input into a language frame; a function of finding which pre-existing structure matches the information we receive (Chomsky, 1972). We do not invent, we determine. Language learning is not the creation of communication but a task of organization, of

[4] A possible interesting exception to this exhibits in kids with Williams Syndrome, whose predictably low scores on tests of seriation (sequencing) and conservation (understanding consistencies despite presentation) would logically predict a correlative low score on grammatical ability (Anderson, 2002). However, this is not the case; kids with Williams Syndrome acquire grammar despite their deficits in its supposed foundation (Anderson, 2002).

recognizing patterns and distinguishing categories. Although tasks of organization seem like they would require a substantial amount of intention, it can occur, and does occur in regard to language, on a subconscious level.

In a computational model of precedence, Karpathy et al. (2015) found that Long Term-Short Memory (LTSM) cells, responsible for processing sequential data, on some level have innate interpretive responses to data in regard to recognizing the sequential progression of a sentence. To clarify, while neurons are cells in biology, in computer science LTSM cells are composed of a layer of neurons, and “cell” in this context refers to a state of information rather than a physical unit, hence the word “memory.” The response of these LTSM cells is strongest at the beginning of a line and, as it continues to process that line, its response weakens until the next new line (Karpathy et al., 2015). Sajjad et al. (2022) clarify this by framing LTSM cells as a model of deep NLP (Natural Language Processing). They reference Karpathy et al. (2015), explaining that in order for cells to predictably respond with higher activation at the beginning of a line, they necessarily would need to recognize a word’s positioning within the sentence.

The reason I bring up these studies is because they operate around the same central question: how can a neuron interpret? Here, “interpret” is more synonymous to “recognize” or “predictably respond to” rather than what people do when discussing contemporary art (by that I mean the ability to draw similarities from seemingly unrelated concepts in order to understand meaning). To reiterate the findings of the above studies, there is a link between the part of a sentence, i.e. beginning, middle, end, and the responsiveness of a neuron. Perhaps this is because the beginning of a sentence initializes the stimulus; for example, if you are walking in a parking lot and suddenly a car alarm goes off next to you, you would probably react more to the first BEEP than to the continued beeping after five minutes. Could this have something to do with electrical versus chemical synapses? Do neurons react more electrically at the beginning of the sentence compared to the end? Probably not really; this is a fault of the car-alarm example because the beginnings of sentences do not usually scare us (hopefully), which is often the function of electrical synapses (Eckhoff & Holmes, 2015).

Certain words do carry implied ordering, such as in "prosiopesis," which is the absence of the start of a phrase. Jespersen (1965) gives an example of prosiopesis: if someone says to you "morning," you know that they are saying "good morning" rather than practicing their vocabulary for times of the day. Jespersen (1965) claims that this is because of the inherent placement of "morning" in the phrase, for it to be isolated implies what it began with: the "good." In contrast, if someone came up to you and said "9am" the message is substantially more confusing and somewhat ominous, likely because "9am" has less of an inherent sentence placement, both grammatically and in how commonly we use it to express a repeated meaning. Perhaps sequential-processing neurons and semantic-recognizing neurons work together, or maybe the word signals its own grammatical placement: it seems that if meaning is dependent on placement, and these neurons recognize a word for its meaning, that they would also, at some level, inherently interpret the placement of a word to recognize its meaning. However, this is more likely a result of predicting or recognizing a word's typical position rather than the semantics of a word signaling its syntactic position apart from where it actually occurs in a sequence. Further, a word's precedence status matters in terms of its relation to the rest of the sentence, not in terms of its individual meaning.

Neural responses to semantic-stimuli

Functional modifiers

In addition to word order, Li et al. (2016) found intensification or sentiment neurons and neurons that respond to negation (as cited in Sajjad et al., 2022). These neurons are named for their response to the semantic quality, or the meaning, of words rather than their response to a word's relative position in a sentence.

Intensification neurons react to words that, sensically, intensify the given message. These are somewhat in the same category of sentiment neurons, which are neurons that react to words or phrases that emphasize the speaker's opinion. For example, words like *really* or *very* intensify messages like "It's *really* cold outside" or "you're *very* well-spoken." Sentiment neurons are pretty much the same thing, just named for the speaker intensifying their view on something, such as "I *really* don't want to go." Similarly, negation neurons respond to the function a particular word has on the message's meaning. A common and easily-extractable negation is "not." Jespersen (1965) gives an example of a functional notion of lexical meaning regarding negation. He initially defines "not" as the space "between the term quantified and nothing." In other words, "not" is not negative in itself, but actively alters the meaning of the attached concept. Jespersen (1965) evidences this with how negations can also function to increase quantity. For example, *bad* and *not* are both negations, but the way they convey meaning is not based on what they signify, but how they function. For example, if someone says *you are not a bad person*, the *not* reduces the value of the entire following predicate, whereas *bad* simply serves to describe *person*. This too is an important note—*bad* is an adjective, so when *bad* is immediately precedes *person* it indicates additional meaning to *person* rather than taking away from *person*.[5] This is not an effect of precedence, because in contrast to *bad*, if *not* were to immediately precede *person* (to make the sentence *you are not [a] person*) it changes the previously conceived notion of person. Also, switching the placement of *bad* and *not* makes this sentence: *you are bad a not person*. The resulting confusion further evidences their meaning is

[5] A psychology analogy: if modifiers could condition lexical meaning, negative adjectives would be sort-of like positive punishments, and negative adverbs would be like negative punishments.

not a direct effect of precedence. Perhaps this difference is why saying *you are not a bad person* is not the same thing as saying *you are a person.* If *bad* and *not* simply both meant "negation," it seems they would simply cancel each other out. However, Jespersen (1965) identifies a difference in linguistic and mathematic double negatives—the negatives in language do not simply cancel out and negate into neutrality (even if they are the same word, i.e. *not not*), perhaps because the sole presence of negatives in a sentence predestines their inability to be ignored, especially considering the presence of negation neurons specifically encoded to notice them. While negation neurons respond to negations themselves as opposed to where they occur in a sentence, the meaning of the sentence is dependent on where the negation is placed within it (Jespersen, 1965).

Semantic Tiling

In a computational semantic model, Sajjad et al. (2022) found a neural correlation to open and closed class concepts (they group together both morphological and semantic aspects in which a word is open or closed—the latter mainly refers to the ordering of what the meaning of words associate with, ie. "Monday" is closed because there is an order to days of the week but a general term like "day" or "color" does not belong to a set sequential taxonomy). They found closed class concepts are more localized in the brain and fewer neurons react to them compared to open class concepts, which are more distributed and cause more neurons to respond. (Sajjad et al. (2022) use the word neuron to refer to an output; they use it interchangeably with "features" and "units.") Sajjad et al. (2022) report on the extent in which open and closed class concepts are localized and interestingly include semantic concepts, hypothesizing that the brain processes semantic meaning either locally or distributed based on its open or closed class. In contrast, Huth et al. (2016) aimed to determine the localization of semantic processing by categorizing certain words that are processed in a specific part of the brain based on a common association. Sajjad et al.’s (2022) reframe that open-class concepts are more distributed and closed class concepts are more localized is a satisfyingly reflective semantic map mimetic to its morphology. Huth et al. (2016) looked for *where* semantic concepts were localized (emotional association of the word), whereas Sajjad et al. (2022) looked for the *extent* semantic concepts were localized (systems of word association). Huth et al.’s (2016) study aims to discover a semantic map of the brain, where a certain part of the brain stores a certain semantic category. Although Huth et al. (2016) assume the localization that Sajjad et al. (2022) question, their studies might not necessarily contradict because they concentrate on the different aspect of a word: Sajjad et al. (2022) looks for the signifier, Huth et al. (2016) look for the signified. However, even if Sajjad et al.’s (2022) study does not contradict Huth et al.’s (2019), it would further prove the anti-localization of processing because both studies support that a word is not associated with meaning without being oriented in context (Sajjad et al., 2022).

Huth et al. (2016) name twelve categorical clusters of words that correspond with a localized area in the brain in which they are processed and stored based on their semantic association (they correlate mainly with the lateral and medial parietal cortex and superior and inferior prefrontal cortex). These clusters are: visual, tactile, locational, mental, abstract, numeric, emotional, temporal, social, communal, professional, and violent. Barsalou (2017) questions the reliability of these clusters due to the nature of concept. For example, Huth et al.’s (2016) model suggests that the word “painful” belongs to the semantic cluster “violent”, associating with words like “die” and “poison.” However, Barsalou (2017) argues for the frame in which semantic features associate with context-dependent relevance and their significance in, for lack of a better word, surviving a situation. In this idea, a word like “painful” would not automatically signal to the brain to be processed in the category “violent” but would trigger an embodied feeling of the word relevant to the elements of the present frame. For example, if you are getting a flu shot and the nurse tells you “this won’t be painful,” the word “painful” might associate with words semantically similar to “needle, sharp, sting, pinch” rather than a static cluster of words in a predetermined category of “violent” such as “crash, break, die, poison.” Semantic processing is variable with context, words associate with words relevant to performing a task, including past relevant information and information used for prediction and decision making. To extend this example, “painful” would associate differently in a person who’s had a dull ongoing hurt in their leg for years from someone who just snapped their tibia falling off a ladder from someone with a migraine from someone hurt by their past. This embodiment used to conceptualize meaning reflects in the brain: Esopenko et al. (2012) explain that when stimulating subjects’ arm-areas (from the brain), they were able to recognize arm-related words faster than other body parts, and same with the legs—when stimulated, subjects recognized leg-related words the fastest.

The different associations of a word’s meaning process in different parts of the brain—a reason why semantic processing consistently activates several different areas within the parietal lobes, frontal lobes and temporal lobes (Binder et al. (2009) as cited in Barsalou, 2017). Barsalou (2017) gives the example of a tool: to break down the concept of the tool is to examine its aspects, which uncoincidentally match parts of the brain underlying their perception. A certain part of the brain extracts its shape, another its action, another its applied potential, another its resulting movement (Barsalou, 2017). Multiple parts of the brain are necessary to process words and fully understand their meaning, and this varies depending on the sphere and the components within it, or rather the features it is responding to. The word “tool” in itself is an abstract generalization requiring a conceptual categorization—it is difficult to visualize a tool without thinking of a specific kind of tool—similar to Lakoff’s (2004) example, that to visualize “furniture” without thinking of a chair or table or any single type of furniture is an impossible task. The compositional modality of neural response exemplified with a tool evinces the interconnectedness behind conception, somewhat mimetic of the linguistic composition behind the word.

CONCLUSION

To determine meaning is an act of association, conceptual in nature, and therefore is a necessarily interdisciplinary pursuit. This is exemplified in the field of conceptual semantics, which emphasizes the compositional nature of language: the idea that meaning is composed of a hierarchy of underlying structures (Anderson & Lightfoot, 2002). Conceptual semantics views a word as a memory, that when realized, reveals information of multiple linguistic units composed of functions and features integrated under an overarching schema (Jackendoff, 2019). Conceptual semantics operates off the idea that the meaning of words exists within the brain, as Jackendoff (2019) writes, “there is no place other than speaker’s heads to localize meaning.” Rather than understanding universal constraints of language and thought to come from the environment or language itself, constraints come from mental structures of meaning that adapt to interpret the world (Jackendoff, 2019). In contrast to the aim of formal semantics to describe how humans express the world through language, conceptual semantics aims to describe how humans express their perception of the world. It emphasizes the intermediary between the world and linguistic expression: the brain.

Meaning, as a sole movement to the “indicated” or “signified,” is dependent on pattern recognition, learned associations, and long-term retrieval. However, the “signified” notion does not preserve through stagnation in the interconnected, multi-sensory, categorically processing brain. We determine meaning not by knowing, but by responding through shifting structural, conceptual, and contextual constraints. Our ability to find word-meaning is our ability to recognize a language representation, but ultimately see through it and respond to the concept indicated beyond our sensory perception of it. Already, this generates multiple responses from brain regions, such as visual and auditory recognition in occipital and temporal areas, hippocampal long-term memory and retrieval, parietal integrative concept processing, and frontal coordination. This reiterates that semantic comprehension is a neural function but is not exclusively localized to a particular neural structure. The mechanism behind our semantic ability may seem primarily neurological, yet the brain that had a single, consistent method of semantic retrieval went extinct once it developed the linguistic and philosophical thought processes that imposed conceptual constraints, effectively enabling an inversion of perceptive operations. The auditory system does not sense sound without precedence, and in turn receives information with a predetermined meaning, which also arises from externalized structure. Further, conceptual frames simplify tasks of determining meaning while the context elicits relevant associations.

Yet perhaps precedence, concept-schema, and context are not so much determinants of meaning as they are more determinants of significance, in turn highlighting the meanings we become conscious of. Maybe, to advocate for their temporoparietal basis, they are orientational: precedence indicates when, concept indicates what, context indicates where—these external determinants of meaning serve to inform our search for increasingly abstract indications, and in turn underlie a facet of our cognition and consciousness that enable us to construct meaning ourselves, at least perceivably.

The study of semantics is uncoincidentally relevant across multiple disciplinary domains. In particular, the semantics that originated from the linguistic frame becomes increasingly functional in context of its neurological localizations, and reflectively, mechanisms of the brain’s conceptual network gain new footing through a linguistic framework. Semantics should be an interdisciplinary study that integrates foundational logic from both neuroscientific and linguistic domains. Searching for the mechanisms behind meaning through a single discipline inevitably results in gaps of understanding, yet are mitigated by the presence of another approach serving as a connective reference. Neuroanatomical and linguistic understandings of meaning share several similar applicable structures, and examining them concurrently enhances interconnective progressions of each. Utilizing the overlap in their shared pursuit contributes to a fuller understanding of semantics and layers into a deeper complexity to reveal new questions and possible explanations for the simultaneously vast and intricate patterns behind meaning.

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