Hypothesis

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Proprioception and Multimodality: Integrating Continuity and Discreteness in Language and Gesture

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Abstract: Introduction: Numerous studies on the ontogenetic development of human language have highlighted the importance of multimodal interactions in learning and communication. This study approaches the topic from a novel perspective, grounded in a fundamental theoretical premise: the multimodality of languages is essential for learning and semiosis, emerging in cognition through proprioceptive awareness. Methodology: The semiotic and communicative activity of different languages is analyzed across two dimensions: continuity and discreteness. These dimensions are shaped by the specialized processes of each cerebral hemisphere and their integration. This study explores these dynamics through an extensive interdisciplinary review of literature from cognitive sciences, semiotics, developmental psychology, and linguistics. Multimodal interactions between mother and infant are analyzed as primary examples, where continuous flows, such as prosody and facial expressions, integrate with discrete elements, such as first words and tactile or visual stimuli. Results: The integrated processing emerging from the right hemisphere (semantic continuity) and the left hemisphere (syntactic discreteness) transcends the mere sum of their specialized information. Instead, this integration operates at a metalevel enabled by multimodal metaphors. This creative process is facilitated by the proprioceptive-kinesthetic system, which also involves the cerebellum and limbic areas. This system, aware of the body's action space and its parts, organizes external stimuli (perceptual, exteroceptive) and internal stimuli (emotional, interoceptive) into configurations built upon natural axial coordinates. These coordinates are rooted in brain-body lateralization and the vertical axis associated with upright posture and balance. Moment by moment, in readiness for action, the sensory, emotional, and other properties of elements within proprioceptive awareness form "configurations of meaning" that simultaneously embody semantic and syntactic programming features. Conclusion: The findings of this study aim to deepen our understanding of multimodal communication and offer insights for further research into language and communication disorders in children. Proprioception is proposed as fundamental to a comprehensive understanding of semiotic and cognitive systems. The multimodal integration paradigm of continuity-discreteness aspires to transcend the traditional conception of modal languages as autonomous in their expressive and functional domains.

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1. Introduction

Human language, from the earliest stages of life, develops through a complex interaction of bodily perceptions, emotions, and external stimuli. Every multimodal communication, such as that between a mother and her infant, operates along two essential dimensions: continuity and discreteness. The processing of continuous information is traditionally associated with the right hemisphere, which specializes in the global management of emotional and spatial contexts. In contrast, the left hemisphere segments information into discrete and organized elements, such as syntactic chains (Chomsky, 1957; 1995) or articulated gestures (Gotts et al., 2013; Van der Haegen&

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Cai, 2018). This hemispheric lateralization, which is already rudimentarily present before birth, raises a fundamental challenge: how can two such distinct modes of processing be effectively integrated? Established models, such as those proposed by Gazzaniga and Le Doux (1978), emphasize the role of the left hemisphere as an "interpreter." It constructs syntactic pathways to justify actions, emotions, or perceptions as coherent and logical narratives based on conscious situations processed by both hemispheres. From another perspective, Tononi et al. (2016) argue that as the specialization of information in each hemisphere increases, the integration must become more complex, transcending the sum of partial information to enable the emergence of self-awareness. The theory proposed in this article identifies the proprioceptive system (Hillier, Immink, & Thewlis, 2015) as an essential mediator of this integration. Proprioception is the mind-body's ability to perceive and recognize the position, movement, and orientation of its parts in space without relying on vision or touch. This function is facilitated by sensory receptors known as proprioceptors, located in muscles, tendons, and joints, which relay information to the central nervous system. Proprioception is critical for motor control, balance, and coordination. In conscious states, proprioceptive information converges with emotional and perceptual (multimodal) inputs within the holistic continuum processed by the right hemisphere. This spatial processing enables the right hemisphere to maintain a map where the entire body and its parts are represented in a topological arrangement of interdependencies. This configuration organizes and manages other stimuli to be processed. Sensory stimuli—such as sounds, shapes, or colors of external objects, and even scents—are not perceived as merely belonging to the external environment. Instead, they are internalized within the body's embodied domains: right or left, up or down, front or back. These are axial coordinates intrinsic to the body. From this perspective, sensory stimuli, before reaching the cognitive processing level, immediately activate somatic components controlled by proprioception, rendering them proactive. In humans, and only in humans, proprioception is conscious, allowing for the voluntary alertness of muscles, tendons, and joints to address specific tasks. Consider an athlete focusing on their body while awaiting the starting signal. External (perceptive, exteroceptive) and internal (emotional, interoceptive, proprioceptive) stimuli flow within the continuum of hemispheric processing, arranging themselves along proportional topologies that serve as computational tools of the right hemisphere. Emotional stimuli that trigger action are often qualities of an object of interest (e.g., the scent of a person). If such stimuli are strong enough to bring the mind-body into a state of readiness for action (e.g., approaching the person to engage), the body parts involved in programming the action will be proprioceptively controlled. On the body's axial map, properties such as proximity/distance and accessibility are measured for the relevant perceptive stimuli regarding the intended action. If the continuum processing flow is interrupted by a frame that infinitesimally precedes the readiness-for-action decision, we arrive at the "proprioceptive configuration of meaning." This is used by the left hemisphere as a programmatic script to sequence the gestures required for the action. The left hemisphere relies on pre-established programs based on the "automatic" memory of syntactic chains of previously executed actions whose effectiveness has been validated through experience and learning. The proprioceptive configuration of meaning, central to this paper's reflections on multimodal languages (especially in infants), is a timeless state—existing only in that immeasurable moment—where various figures (i.e., the salient qualities of bodily and multimodal stimuli) coalesce at the moment of decision-making. This configuration pertains to action in the same way as it does to locutionary acts, where the proprioceptive schema of the speech apparatus is involved. Humans can consciously utilize this schema when speaking "knowingly," conveying emotions, or singing.

2. Discussion

2.1. Proprioception as Mediation Between Continuity and Discreteness in Semiosis

French structuralist semiotics has demonstrated the efficacy of spatial representations in describing binary semantic relationships. The most well-known visual schema, Greimas' semiotic square, uses orthogonal coordinates to logically organize categorical terms according to relations of

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opposition (e.g., male-female), contradiction (male vs. non-male), and complementarity (non-male: female). This approach was employed to describe well-established semantic systems within specific cultures, where even ambiguous terms from cultural imaginaries—such as "hermaphrodite" or "angel" in the context of sexuality—found their place within the diagram. However, as structuralism faced deconstructivist critiques, Western culture increasingly rejected rigid categorizations. For instance, in the domain of sexuality, contemporary discourses on non-binarity and gender fluidity reflect this shift. Nonetheless, Greimas and his followers, including J. Fontanille and Zilberberg, had already sought to introduce new criteria for fluidity in analysis, such as a semiotics of passions and a plastic/figurative semiotics of perception. Both approaches sought to position terms of a category at the poles of a "tensive axis," introducing gradual dynamics. For example, between joy and sadness, a culture might recognize intermediary terms like melancholy or serenity. The difference between binary categorizations and this approach lies in their respective logics: passions or emotions emerge from a phenomenologically experienced continuum of the body, characterized by its intensities and subjective qualities, while conceptual categorizations rely on discrete, rational logic. Similarly, when semiotics delves into the perceptual and experiential dimensions of meaning—belonging to the domain of continuity—spatial coordinates, such as those of the semiotic square, give way to topological coordinates, particularly in the analysis of visual or sculptural texts through plastic and figurative semiotics. When contemplating a painting, interpreting a sculpture, or reading a novel, we as spectators or readers cannot access the real mind or intentions of the author. What we can do is immerse ourselves in the coherent world of the text itself, adopting the perspective of a figure who, in articulating "I-other than me," reveals elements of the scene through the projection of their own axial coordinates. These coordinates organize the relationships between figure and background, among elements like colors, lines, and forms. The topological axes that traverse the situated body of this "instance of enunciation" determine and reveal what is above or below, right or left, central or marginal, near or far. How do these elements, through their relationships, signify? For instance, a figure placed at the center of a composition is perceived as dominant, whereas one at the margins seems secondary or peripheral. Similarly, verticality might emphasize an upward tension (e.g., spiritual elevation) or a downward one (e.g., fall, degradation). A ship positioned along the top-left to bottom-right diagonal, according to our conventions, is seen as docking; the opposite diagonal suggests it is departing. These reflections are critical for two reasons. First, they enable us to semiotically explore the fundamental difference between continuous and discrete processing methods, which cognitive neuroscience attributes respectively to the right and left hemispheres. Second, at the heart of this work lies the sensorimotor system of proprioception and kinesthesia, proposed as the system mediating reciprocal translation between the languages of the two hemispheres. Moreover, the "tensive" conception through which semiotics has approached perceptual and emotional meaning can only be fully understood via proprioception. Proprioception regulates bodily balance, spatial orientation, and, most notably, the uniquely conscious tension of muscles. Observing a Caravaggio painting immediately reveals extreme muscular tensions, often voluntarily controlled, as in the famous Narcissus, who bends toward the water and reflects his tension in his own image. Perhaps Caravaggio's most significant innovation was the introduction of proprioception into his works. Frequently, the subjects he painted are "Caravaggio-within-the-work," proprioceptive even in their enunciation (what the French might call "enunciated enunciation"). In the model we propose, the topological coordinates embedded within manifested language become proprioceptive, directly rooted in the body rather than external Cartesian axes. Meaning, as we will demonstrate, arises and forms moment by moment through the proprioceptive system, integrating perceptions, emotions, and movements into dynamic schemas. In this regard, Greimas' narrative paradigm will prove especially valuable, as we will see.

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2.2. *Multimodality and Conscious Proprioception*

2.2.1. Multimodality

Every modality of language used in mother-infant communication is structured along two essential dimensions: continuity and discreteness. It is well established that hemispheric anatomy and function begin to lateralize even before birth (Tzourio-Mazoyer, 2016). Gazzaniga and Le Doux's (1978) dual theory provides a solid foundation for understanding the interaction between these dimensions. According to these authors, the right hemisphere is specialized in spatial, emotional, and holistic processing, managing the continuous dynamics of communication, such as prosody and the sensory-emotional context. In contrast, the left hemisphere focuses on analytical segmentation, such as forming logical-syntactic chains and articulating words or other modal elements like gestures (Witterman et al., 2011). The role of the left hemisphere as an "interpreter," as described by Gazzaniga, explains how linguistic narratives emerge from the need to create coherence among multimodal signals processed by the brain. For the infant, the world emerges within the vast sensory and emotional continuity governed by the dominant right hemisphere. This perceived continuity is expressed through gradual and constant flows, such as the prosody of the caregiver's voice, rhythmic rocking, the taste of flowing milk, maternal scents, and the changing expressions of the caregiver's face. Discreteness, on the other hand, arises in distinct and punctual elements: isolated sounds, initial vocalizations or words, visual cues, fleeting touches, facial details, and sharper olfactory or gustatory stimuli. The discovery of new stimuli, their repetition, and their multimodal overlap are crucial for learning (Davis et al., 2017). Functional specialization allows each hemisphere to manage information using highly specific processing methods. According to Tononi, Massimini, and Koch (2016), anatomical and functional lateralization creates a paradox: the more one hemisphere specializes and processes information independently, the greater the need for an integrative mechanism to coordinate these elaborations with the other hemisphere. In Integrated Information Theory (IIT), the entire brain system achieves a state of consciousness only when a total information quantity (Φ, or phi) is reached. Φ measures the synergy of an integrated system, producing something greater than the mere sum of its parts. Long before IIT, Russian semiotician Lotman (1990) addressed this issue within the framework of information theory. He envisioned a "third system" facilitating reciprocal metaphorical translation between the two hemispheric languages. Lotman argued that bi-hemispheric integration generates global information that is not merely quantitative but qualitatively new, producing human creativity. The theory developed in this work builds on Lotman's cognitive model to address the problem of interhemispheric integration in semiosis and human communication. A key principle of Russian cultural semiotics is that no language—not even verbal language—can generate semiosis or intersubjective communication without the support of another language. We thus adopt the general hypothesis that semiosis and communication are inherently multimodal. The innovative theoretical framework proposed here seeks to explain the integration of hemispheric processing modes (continuous and discrete) alongside multimodal or cross-modal communication. This involves revisiting established theories of embodied simulation while introducing a new paradigm that integrates the proprioceptive-kinesthetic system with emotional, perceptual, and cognitive systems. In the context of bi-hemispheric interaction, proprioception acts as a sensorimotor interface. It gathers emotionally and sensorially continuous (modal) information into an internal body representation and organizes it into a configuration suitable for interpretation by the programmatic and discrete activity of the left hemisphere. The mental effect of this mediated interaction is what we term a "configuration of meaning."

2.2.2. Proprioception as the Basis of Multimodal Configurations of Meaning

A primary example of this dynamic is observed in multimodal interactions between mother and infant. For instance, pointing represents a triadic form of communication, including the self, the other, and the object. This gesture, appearing within the first months of life, is equivalent to a complete sentence: ("take-that-and-give-it-to-me"). At the moment of pointing, the infant's mental world

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contains not just the object and caregiver alternately but also memories of prior gestures—crawling toward the object, extending the arm, and grasping it. The object is mentally represented with its associated smell, taste, tactile experience, and gravitational properties. Among these elements, certain ones contribute to constructing the configuration of meaning, emerging as a snapshot of the self-perceptual, emotional, and sensory flow:

A) The object evokes an emotion tied to another modality, such as touch, scent, or the pleasure of playing with it again.

B) The infant's left hemisphere formulates a programmatic sequence of gestures required to reach the object, but the program remains incomplete if, for example, the object is out of reach.

C) Through embodied simulation learned from interactions, the infant realizes that their own gestures can be substituted by those of the caregiver to achieve the goal.

The configuration of meaning during pointing is therefore shaped by proprioceptive awareness of the actions needed to grasp the object, visual (imagined) representations of the caregiver's substitutive gestures, and the object itself—not as an ontological reality but as a cluster of sensory and emotional qualities that make it the focus of a goal-oriented program. We generically term these various elements "figures" and refer to their atemporal arrangement—a snapshot within the flow of the continuum—as the configuration of meaning. This configuration is a mental topology, containing elements already selected from the continuum for syntactic concatenation by the left hemisphere. These conditions are crucial for the child, through repeated exposure, to learn the name and function of an object in action programs. These functions correspond to action verbs the child progressively acquires: to go, to take, to give, etc. The configuration of meaning, as a mental effect of joint hemispheric processing, aligns with moment-to-moment consciousness, even when still. Proprioception, as the fastest somatosensory response system, organizes bodily readiness for action. In critical situations, such as confronting a threatening dog, this rapid response ensures muscular readiness. Humans, unlike animals with genetically predisposed responses, can devise creative solutions, like picking up a stick for defense. This innovation reshapes the configuration of meaning, generating a new state of consciousness. Lotman emphasized that such creative choice can lead to "explosions of meaning" (Lotman, 1992). These mechanisms also explain linguistic readiness, where proprioception guides the performative act of speaking through topological configurations. This model integrates proprioception and multimodal dynamics into the creative processes of human communication and semiosis.

2.3. Continuity and Discreteness in the Language of the Maternal Face

2.3.1. The Primordial Configuration of Meaning in Emotional Dialogue: The Maternal Face

The vital affectivity of the newborn demands the continuous presence of the mother, initially for nourishment and protection. From the earliest weeks of life, infants exhibit a natural preference for human faces, which, through their changing expressions, combine muscular tensions and relaxations in the areas of the eyes, nose, and mouth. Even in their first days, infants demonstrate the ability to imitate at least some facial expressions associated with basic emotions, such as anger, sadness, and disgust (Prunty, Keemink & Kelly, 2021). The well-established theory of embodied simulation posits that this mirroring is facilitated by certain areas of the brain containing multimodal neurons known as "mirror neurons." These neurons respond both to the motor system's own actions and to the observation of those actions performed by others. However, the neonatal simulation of another's face does not resemble goal-oriented actions with sequential gestural articulation over time, as seen in the classic example of grasping, where the goal is directed toward a tangible object. In this case, the "masks" of basic emotions, as self-contained signifiers, are presented as a single configuration of elements. The conformations of the eyes, nose, and mouth, for example, are not interpreted through the sequence of their transformations but in their immediate appearance. This has led to the hypothesis that innate neural bases exist for the recognition of basic or universal emotions: joy, sadness, anger, fear, surprise, and disgust. Indeed, these same expressions and simulations, with their corresponding emotional contents, appear to be consistent across human cultures (Cohen & Cashon,

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2001; Weinberg & Tronick, 1994). In reality, the transition from one basic emotional expression to another does not occur abruptly. Instead, transitional configurations emerge from the continuum of expressive dynamics and convey social meanings, such as "doubt," "irony," or "severity." These configurations, however, are more "adult" and influenced by the cultural communication norms of the individual's environment. A notable phenomenon is the neutral face: devoid of euphoric or dysphoric muscular contractions, it represents the background continuum against which learned expressions transition from one to another. From the perspective of Greimas's (1971) generative semiotics, the neutral face might correspond to a pole of the fundamental semantic axis: life/death, in opposition to the smiling face, which represents maximum muscular tension.

For this reason, the "neutral" mask is not devoid of meaning. On the contrary, if exposed for prolonged periods, it can deeply disturb the infant, who searches in vain for shared vital responses within it (Stern, 2005). This disturbance could affect the child's personality in cases of depressed mothers or emotionally detached caregivers (Stein et al., 2010; Behrendt, Konrad, Perdue & Firk, 2020).

2.3.2. Proprioceptive Awareness Enables the Actor to Pretend

As discussed, facial expressions convey meaning as snapshots of the emotional continuum. Their social significance emerges within an atemporal configuration of content: a specific arrangement of muscular tensions and relaxations, distinct from other configurations, unequivocally expresses "joy," "anger," or alternatively "doubt," "irony," etc. These oppositions are typically binary (or/or), and the differences between masks rely on a fixed typology in which the same elements—forehead, eyes, nose, mouth, cheeks -are combined. The topology of these elements is organized along axial coordinates: left-right (e.g., eyebrows, eyes, nasal dilation, asymmetric mouth movements) and top-bottom, which lateralizes the face and its associated body. However, in advanced communication, facial expressions adapt seamlessly to the emotional modulations of discourse and/or action. Here, the transformation of expressions reintegrates into the continuum, as attentional mechanisms no longer dwell on their primordial meaning. This subtlety is demonstrated by a professional actor's facial expressions, where the proprioceptive system governs every transition. From a semiotic perspective, the neutral mask represents the implicit condition for transitioning between emotional states and thus serves as the sensory continuum underlying the range of possible multimodal emotional configurations. In moments of heightened emotional tension, individuals often look into another's eyes to discern and predict their intentions. The eyes, however, are twofold: the right eye is connected to the left hemisphere, which seeks even the slightest facial detail that might transition into an expression (or body posture) signaling another's intention. An intention, after all, is the anticipation of an entire motor program that might be hostile to the observer. The program, executable only in an and/and arrangement of elements, involves figurative chains of another's gestures based on the observer's own movement experiences oriented toward a goal. Anticipating oneself as the object of another's program arises from the virtues of embodied simulation—a phenomenon hypothesized here to depend on the proprioceptive-kinesthetic system. As noted, the proprioceptive system prepares the body for action based on the disposition and origin of perceptual and emotional stimuli surrounding it. The kinesthetic system, part of the same overarching sensorimotor macro-system as proprioception, is involved in motor programming and the automatic control of actions (posture, balance during movement). It ensures the most precise behavior based on previous experiences analogous to the current condition and its objective. In the proprioceptive phase of readiness for action, the left eye (connected to the right hemisphere) explores the other's face as the center of expansion of a multisensory background. This background subsumes the entire context into the present moment, creating an atemporal state where, in anticipation of the other's first move, every potential gesture and environmental object is virtually involved in future action, whatever it may be. Consider a stereotypical adventure narrative: the duel. The protagonist awaits the adversary's first move. While gazing into the opponent's eyes, they must anticipate the slightest indication of movement. However, in their readiness for action, mastery of proprioception is crucial—knowing the position and potential of each muscle in wielding the sword is more important than speculating on the adversary's offensive move. As mentioned, the highly myelinated proprioceptive nerve fibers transmit signals faster than any other reactive fibers. In perception, the visual system is the fastest signal transmission system. Therefore, the combination of vision (of the stimulus) and proprioception is the most critical attentional and re-attentional function in human evolutionary adaptation. Mammals such as apes, cats, and dogs possess a more or less developed proprioceptive system, but it is unconscious and entirely subordinate to kinesthesia, whether for attack or defense. The most decisive biogenetic change in hominids may have been the development of proprioceptive awareness, the unique condition enabling humans not only to anticipate an opponent's moves but also to invent new, unpredictable moves—such as using a bone jaw to deliver a fatal blow (Lotman, 1992). In linguistic communication, this mechanism remains consistent. The process begins with the intention to develop a goal-oriented action program, such as delivering a clear and effective message. However, this goal is often unmet, requiring conscious proprioception to construct and project a new configuration of meaning onto a frame of the continuum. The old message is dismantled, and a new one is assembled with novel emotional, tonal, and prosodic caricatures. Even in this case, we can speak of multimodal creative correction.

2.3.3. The Metaphorization of Emotions

The infant's "reading" of the maternal face is embodied, with proprioception remaining unconscious, as we will see, until the development of pointing. This process is invariably influenced by additional signals from the caregiver's presence, where visual, auditory, tactile, and olfactory stimuli form a holistic background for interpreting emotional cues. For example, body warmth, the sound of the caregiver's voice, and maternal odors reinforce the visual categorization of the face, illustrating how sensory stimuli are processed synesthetically (Leleu et al., 2019; Rekow et al., 2021). At this stage, the infant does not perceive itself as a separate entity but as part of a sentient unit encompassing the mother and their environment, where the caregiver's actions and emotions are experienced as an extension of the infant's internal state. This "holistic maternal-infant self" forms the real and symbolic space within which the infant begins segmenting its experiences. Over time, this holistic self will undergo a process of differentiation and cultural learning, gradually shaping the intersubjective self and eventually the individual self (Trevarthen & Aitken, 2001). Within this continuum of the holistic self, we can hypothesize that the infant organizes early self-world knowledge through initial categorizations. Here, proprioception acts as a fundamental mediator in structuring the infant's intimate experience, categorizing information from various sensory domains: tactile, visual, olfactory, and auditory. This integration requires a convergence hub to organize sensory stimuli based on their spatial presence around the body while maintaining coherence within the experiential continuum. The overlap of multimodal stimuli from the same direction reinforces and makes certain signals semiotically interchangeable—for example, a caress on the cheek that combines touch and warmth, or a voice that prepares the mind for discernment of meaning. A voice may become "warm" when associated with touch or "cold" when distant, while a caress or gaze becomes "sweet" when linked to feeding. The collaboration between the exteroceptive system (skin) and proprioceptive system is cumulative and synergistic, enabling increasingly refined awareness of different body parts. Furthermore, proprioception, as a multimodal hub integrating visual stimuli related to the maternal face with tactile, thermal, and kinesthetic signals, enables the infant to anchor these perceptions to its own body, associating them with internal bodily and emotional states. As clarified in current research, this occurs through embodied simulation, whereby the infant not only recognizes the mother's emotions but "lives" them internally. Interpersonal empathy arises because, in neonatal stages, no separation exists between self and other. If embodied simulation leads to empathy and mind-reading, it is plausible that this requires the infant—and later the child—to have internally and perhaps intensely experienced the emotions of others it interprets through its theory of mind. Emotions such as joy, fear, or anger are associated with physiological variations, including heart rate, respiration, or neurotransmitter release (Panksepp, 1998). These emotions are also

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unconsciously registered in the facial contractions characterizing them and, according to our hypothesis, within the unconscious domain of proprioception. According to Meltzoff and Moore (1989, 2018), early imitation ability is mediated by an innate representational code that connects the perception of a gesture to its production. However, even the earliest simulations, such as tongue protrusion, can be considered acquired through the infant's embodied memory. During sucking, the infant has already perceived the movements and multimodal perceptual qualities of its own tongue. Thus, before embodied simulation, there is embodied cognition of movements (Sadoski, 2018). Through embodied simulation, the infant, seeing in the mother a holistic self, confirms the integrity of various emotional sources through proprioception, even though this function remains unconscious. We have posited that the combinations of differential semantic traits distinguishing basic emotions within a semantically closed system derive their ability to convey meaningful information from the fact that muscular conformations vary while maintaining relative positions. In other words, the face has its own topology, clearly expressed by axial coordinates across dimensional planes: The vertical axis (from the center of the forehead to the chin). The horizontal axis (across the eyes, nostrils, and mouth). The front-back axis (profile and body orientation). These axes structure the topology of facial emotions while also organizing the directional origin of all sensory stimuli from another's body. For instance: Anger is manifested by wide-open eyes, eyebrows curved downward, and a forward-oriented body posture. Disgust is expressed through a wrinkled nose, raised lips, and a posture retreating from the object. Importantly, these axes and planes are perceived by the infant from an interior, proprioceptive perspective tied to the body's lateralities and asymmetries, rather than external Cartesian planes imposed on the environment. From this perspective, universal facial expressions should be understood as the primordial forms of configurations of meaning in motor acts aimed at communicating emotions.

2.4. The Pragmatics of the Communicative Act

We have seen how, in the infant, pointing transforms communicative acts into intentional actions. Every intentional act presupposes the achievement of a goal, as in purposeful actions. Similarly, in natural language, a message must achieve its objective, which is to modify the cognitive or emotional state of the recipient (Violi 2001). Imagine the content of the message as the tip of an arrow aimed to "hit the mark" in the recipient—for instance, to seduce them—and the speaker as an archer. The archer's right hand activates, taking the arrow from the quiver, examining its structure with the right eye aligned with the drawing hand, nocking the arrow, aiming, pulling the string, and releasing it. This procedure consists of a sequence of actions that must be executed in strict temporal order. The left hemisphere's task is to execute the gestural sequence as precisely as possible, relying on embodied experiential memory. However, the alignment of the bow—ensuring the perfect coordination of hand-eye-tip-target is, guided by the left hand and arm, which hold the bow and control the axial coordinates (up-down, left-right) for accurate aiming. In the movements of this hand, temporal sequence is irrelevant to the effectiveness of the shot; the gestures occur in a topological, atemporal articulation. This reflects the processing style of the right hemisphere. Now suppose that hitting the target holds immense emotional value for the archer, as in an Olympic competition. The target seems to reflect all possible outcomes of the shot—successes and failures—with corresponding satisfactions or disappointments. Each execution error could be decisive. In natural language, the process is no different. Now imagine that the message, previously metaphorized as the arrow, is a declaration of love intended to "strike the heart" of its recipient. At the critical moment of articulation, the program for the opening sentence will be governed by a particular tension in the vocal muscles, poised to deliver the message. Simultaneously, the voice will prepare for prosodic modulation (rhythm, intonation, pauses) and adopt a specific tone (e.g., warm, reassuring, or confident). The body's posture will be adjusted for approach, the face prepared for a smile—expressions of the continuous dimension dominated by the right hemisphere. Meanwhile, the left hemisphere selects the most effective words, articulates them precisely, and ensures their suitability for achieving the communicative goal. The configuration of meaning established in the moment before execution is therefore crucial and is entirely governed by the proprioceptive system. This system determines the relative, topological positions of the elements to be employed. Once the motor act begins, however, proprioceptive awareness gives way to the kinesthetic precision of vocal performance. If this performance fails to achieve the desired effect and the recipient's response indicates doubt or misunderstanding, a creative correction—based on a new configuration of meaning—emerges within the dialogue. Thus, when discussing the performativity of language, it is insufficient to state that language is action; instead, we must recognize that natural language and gestural semiotics are metaphors for one another. Human semiotics and communication are inherently multimodal, as Lotman had already clarified. He explored the dynamics of continuity and discreteness on numerous occasions, asserting that there are two interdependent semiotic modeling systems: one is language, and the other is the organization of space (Lotman, 1990). Similarly, Greimas distinguished between a macrosemiotics of natural language and one of the natural world (Greimas, 1983). Both authors, however, acknowledged the lack of adequate tools to investigate spatial dimensions. Nonetheless, Greimas & Fontanille (1984) provided an intriguing model of "plastic and figurative semiotics," from which we have adopted the concept of the relational topological arrangement of semantic elements within the elaborative model of the right hemisphere.

2.5. Asymmetry and Dialogue Between Hemispheres

The model of interhemispheric interaction based on the distinction between continuity and discreteness raises the question of how dialogue between cortical structures occurs, given the functional diversification of the hemispheres and their information processing systems. The superior temporal sulcus (STS) functions as a multimodal crossroads, integrating emotional, social, and sensory signals to provide coherence to information derived from independent modules. This function is enabled by the STS's ability to process continuous aspects (prosody, dynamics) and discrete aspects (concatenated words, gestural sequences) bilaterally, allowing integrative synthesis (Beauchamp et al., 2008; Calvert, Campbell & Brammer, 2000; Krumhansl & Castellano, 1983; Kreifelts et al., 2009). The dialogue between the two hemispheres is mediated by commissures such as the corpus callosum and the anterior commissure, which not only transmit information but also modulate it actively. The inferior parietal lobules (IPLs) reflect hemispheric specializations: the left IPL processes discrete and syntactic tasks, while the right IPL integrates spatial and global information (Caspers et al., 2011). Similarly, the hippocampal commissure connects the sequential and verbal memory of the left hippocampus with the contextual and spatial memory of the right hippocampus, highlighting the brain's adaptive plasticity in bilateral integration (Rosenzweig et al., 2011; Gloor et al., 1993). These mechanisms, while elucidating many aspects of interhemispheric interaction, do not entirely resolve the issue of increased integrative activity surpassing the sum of separately processed hemispheric information, as suggested by Tononi or Lotman. However, studies on the STS demonstrate increased activity in interhemispheric synchrony during integrative tasks, underscoring the critical role of bilateral cooperation (Stevenson & James, 2009; Stein et al., 2012). Extending this observation beyond the central nervous system (CNS), it is crucial to consider the role of the somatosensory proprioceptive and kinesthetic systems in mediating the exchange of asymmetric information. Recent literature has emphasized the importance of cerebellar asymmetry in sensory and motor integration processes (Weeks, Terrien & Bastian, 2017; Prochazka, 2021). The cerebellum regulates muscle tone, harmonizes movements, and segments gestures into discrete sequences while maintaining overall fluidity (Boisgontier & Swinnen, 2014; Fuentes & Bastian, 2010). In the cerebellum, which operates ipsilaterally with respect to each side of the body, proprioceptive and kinesthetic functions activate alternately depending on the task. The right cerebellum collaborates with the left hemisphere, providing pre-learned and memorized motor concatenations that the left hemisphere integrates into logical, goal-directed sequences. Conversely, the left cerebellum retains more fragmented micro-gestures, which are made available to the right hemisphere for correcting ineffective movements, ensuring a creative and adaptive response (Schlerf et al., 2015; Timmann et al., 2010). This synergy is mediated by the cerebellar vermis, which receives

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stimuli from vision and exteroceptive receptors, integrating them with proprioceptive information to manage the alternation between continuity and discreteness (Wang et al., 2016; Hayashi, Kato & Nozaki, 2019; Bernard-Espina, Beraneck, Maier & Tagliabue, 2021). In routine activities such as walking or driving, the mind relies on the default network. In this state, the left hemisphere suspends direct control of the body and plans future actions through syntactic concatenations of thoughts, images, or bodily schemas. The right hemisphere, meanwhile, integrates sensory perceptions into a global framework, monitoring environmental or bodily changes (Park et al., 2009; Panouillères et al., 2012). In critical situations, such as a sudden attack, this dynamic shifts: the right hemisphere detects urgency and mobilizes both cerebellums. The right cerebellum organizes ipsilateral movements into precise sequences to stabilize balance and action, while the left cerebellum provides corrective micro-gestures to the right hemisphere, which harmonizes them into a global response (Timmann et al., 2010; Peterburs & Desmond, 2016). A similar mechanism is observed in language. During routine conversations, the default network allows the left hemisphere to concatenate words without conscious control, while the right hemisphere modulates rhythm and intonation. In emotionally intense situations, language becomes more nuanced: the cerebellum coordinates phonatory micro-gestures, the right hemisphere adjusts timbre to reflect emotional states, and the left hemisphere constructs logical and coherent responses. In conclusion, the model demonstrates how mind and body operate in synergy, integrating continuous and discrete dimensions. This dynamic, observed in both movement and language, highlights the crucial role of the cerebellum and its interactions with the hemispheres in adaptive and creative information management (Peterburs & Desmond, 2016).

2.6. Multimodal Semiotics

In the pre-linguistic environment of hominids, the acquisition of conscious proprioception constituted a fundamental semantic bridge, connecting perceptions and actions through cognitive (mental) configurations that could be socially shared. For example, a gesture like pointing was not merely a movement signaling danger but a metaphor for social intention—an indexical signal directing another's attention toward an object or purpose. Similarly, facial expressions became embodied metaphors of lived emotions, understood empathically through embodied simulation. To be sure, even a dog can grasp the intentions of its peers through signals such as facial contractions (growling) or displays of submission or sexual readiness. However, the uniquely human ability to consciously feign an expression that conveys emotions represents a singular phenomenon in the animal kingdom and perhaps the earliest form of creativity. This ability depends on a proprioceptive system that knows the location and state of each muscle required to form an expression. This awareness, in turn, enables shared communication through embodied simulation, forming the background upon which collective actions are orchestrated. For instance, a grimace of disgust is no longer merely a reaction to an olfactory or gustatory stimulus but can intentionally communicate concepts like "avoid this food." The evolutionary leap that led to the emergence of verbal language occurred when certain sounds, initially part of a continuous vocal flow, were selected and conventionally associated with gestures, objects, or purposes. This transformation was made possible by the proprioceptive system's capacity to create metaphorical connections across different modalities, such as sound and movement, vision and touch, emotion and vocalization. For example, a guttural sound initially produced as a spontaneous vocalization might have been associated with a gesture of offering, serving as the precursor to a word like give. Over time, the object being offered assumed the name of a sound that metaphorized it. If the object changed but the gesture of giving remained, the movement itself acquired meaning because of its dual linguistic and motor interpretation. In the pragmatics of giving, the gesture inhabits the interface of a configuration of meaning, entering as a topologically organized figure in relation to the object-sign, as well as to the emotional and sensory figures of the context. This process unfolds against the backdrop of a shared experiential continuum, where meaning emerges in "readiness for action," as articulated in the maxim of C.S. Peirce (1992–1998). An essential aspect of this process is the multimodal and metaphorical nature of pre-linguistic communication. Even before articulated language, elements of

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one modality could function as metaphors for others: A grimace could represent the experience of pain. A hand gesture could evoke the warmth or shape of an object. A facial expression could serve as the visual metaphor of an emotion. This metaphorical capacity was already a product of embodied simulation and proprioceptive awareness, enabling the encoding and decoding of configurations of meaning through shared bodily experience. However, for sounds to become words, a common semantic background was necessary: a shared ground of meanings built through social interaction and conscious proprioception. It is here that humans developed the unique capacity to attribute symbolic meaning to discrete elements such as sounds. These sounds derive significance not only from their logical, syntactic concatenations but also from their emergence within a multimodal and emotional continuum, where they are configured to make sense of locutionary action and its object. From Rhythmic Movement to Linguistic Syntax Regarding linguistic syntax, it can be hypothesized that it represents a symbolic extension of rhythmic bodily schemas organizing intentional action (Heard & Lee, 2020). Syllabic alignment with the rhythms of speech may mirror the fundamental rhythms of human movement (Gordon, Jacobs, Schuele & McAuley, 2015), such as walking or running, or the "politeness" of social movements (Phillips-Silver & Trainor, 2007). In stuttering, for example, there is, on the one hand, the programming of an utterance with a clear communicative intention, and on the other, the inability to maintain syllabic rhythms that depend not only on linguistic control but also on proprioceptive regulation (Max & Yudman, 2003). These rhythms could represent a proto-syntactic kinesthetic structure capable of organizing coherent action sequences. Bodily rhythms may provide a cognitive substrate for acquiring linguistic forms, as they temporally and axially organize movement: language, too, is "directed" at someone, or it can be "spoken to the wind" (Tilsen, 2009). This hypothesis aligns with the evolutionary exaptation of language areas, regions of the brain originally dedicated to motor programming adapted for new functions. These areas' "other tasks" likely involved rhythmically and syntactically organizing purposeful actions, suggesting a functional continuity between movement and languages (Gallese & Lakoff, 2005; Kotz & Schwartze, 2010).

3. Conclusions

This study has explored the fundamental role of the proprioceptive-kinesthetic system in integrating continuous and discrete languages, highlighting how this dynamic contributes to the construction of meaning and human communication. Far from being a mere bodily function, proprioception emerges as a crucial element linking perception, emotion, and cognition, opening new perspectives for understanding the interaction between embodied experience and symbolic thought. Through the analysis of concrete examples such as pointing, facial expressions, and voice modulation, the article suggests that human language and communication can be interpreted as inherently multimodal processes. The ability to combine continuous and discrete dimensions, simultaneously managing perceptual flows and segmented elements, forms the foundation of a potential multimodal semiotics in which body and mind collaborate to generate complex and shared meanings. This perspective aims to contribute to debates on the origins of language and communication, as well as on the bodily foundations of creativity and unlimited semiosis. The study also seeks to provide insights for research on language disorders and therapeutic applications that consider proprioceptive regulation and multimodal integration as tools to enhance communication and symbolic thinking. Far from offering definitive answers, this work aspires to stimulate interdisciplinary dialogue, encouraging the view of language and communication not as isolated processes but as the dynamic interplay of body, mind, and experience. The proposal of a multimodal semiotics represents, in this sense, a step toward a more integrated understanding of signification processes and their grounding in the human condition.

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