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Egocentric versus allocentric perspective: From spatial to social and digital cognition

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Abstract

As mobile beings, it is important to maintain spatial information about our surroundings in everyday life. Neuroscience suggests the existence of two types of frames of reference in spatial memory: egocentric and allocentric representation. The former encodes the location of an object in relation to one's body, while the latter encodes the location in relation to the external environment. Spatial reference frames (RFs) play a critical role in spatial memory, allowing the storage of information to be organized into different coordinate systems. In general, in egocentric RFs, the locations of objects are encoded relative to the location-label of the main subject, while in allocentric RFs, they are encoded relative to each other or relative to landmarks in the environment. Egocentric representation is mainly innate, while allocentric representation derives mainly from acquired experience; thus, egocentric representation dominates in the early years of life, while allocentric representation gains ground during development. The underlying neural processes for egocentric and allocentric RFs appear to be at least partially overlapping. Taking together the findings, we may suggest that the dynamic connectivity of the spatially distributed network, rather than the activity of a single brain region, is critical for accurate recall spatial cognition. Also, the extent to which a spatially distributed memory network can rapidly exchange information is critical for the efficiency of its functional output. Interesting aspects of involvement of spatially tuned neurons in the understanding of domains of social cognition have been recently proposed. Furthermore, it is worth exploring the way in which 'the self' is experienced and navigated in new technological and AI environments. As we now live in a new digital era, the following questions arise: How do we perceive "presence" in human-AI interactions? Also, how can egocentric and allocentric representations produce social and cognitive maps in these technological environments?

Keywords

Egocentric perspective, allocentric perspective, spatial cognition, social cognition, hippocampal coding, digital era, AI environment

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Ego- and allo-centric representations

The concept of cognitive map, introduced by Tolman (1948), provides the basis of our understanding of mammalian spatial navigation. Representations of spatial relations are results of learning and are stored in long-term memory. Based on accumulating evidence, many researchers have argued that there are two types of reference in spatial memory: egocentric' and 'allocentric representation'. Egocentric representation encodes the location of an object in relation to one's body (object-self relation), such as "the toy is on my left". Allocentric representation encodes the location in relation to the external environment (object-object relation), such as "the toy is next to the desk". Simply put, the egocentric view is what we see now. The allocentric view arises from our ability to think about what we would see if we were somewhere else in space, while different authors have used the terms "allocentric," "object-centered," or "world-centered" to refer to representations of spatial relationships to other, external objects.

How we take in information, hold it in our minds for a long time, and turn it into an action plan is not well understood, but it likely involves the retrosplenial cortex. Spatial reference frames (RFs) shape our understanding of many cognitive processes involved in spatial cognition, such as perception, performing actions in space, and navigation. Spatial reference frames (RFs) play a critical role in spatial memory, allowing the storage of information to be organized into different coordinate systems. In general: (a) In egocentric RF, the positions of objects are encoded relative to the location-label of the main subject, (b) In allocentric RF, they are encoded relative to each other or to environmental landmarks-markers and do not depend on the position of the subject (Filimon, 2015, Zheng et al, 2021).

When moving to a new location, we must have the advantage of auto-motion cues to update the egocentric representation of locations. However, this updating process will become increasingly difficult as the distance of the journey and the number of remembered locations increase. Thus, more robust allocentric representations provide a better basis for flexible navigation. In terms of navigation, egocentric sensory information is integrated into our stored knowledge of allocentric space. For example, we know that sensory landmarks can shape where allocentric spatial receptive fields are set. In experiments where an animal runs in an environment, the visual cue/landmark is moved and the allocentric map moves accordingly. We also know that allocentric spatial maps are modified with experience in an environment as we integrate increasingly egocentrically processed contextual information. Thus, we know that a continuous integration between egocentric and allocentric coordinate systems occurs (Nardini et al, 2006).

Perspective taking in navigation

A basic way of describing 'perspective taking' comes from the study of spatial cognition. We encounter an important distinction of representations between: (a) The 'egocentric perspective', where spatial processing is done from the internal bodily perspective of the self, such as looking out through one's own eyes, (b) The 'allocentric perspective', where spatial processing operates for some external frame of reference, most commonly a Cartesian coordinate system. According to another approach, we distinguish the first-person (1P) perspective of the self from the third-person (3P) perspective of the other. According to this analysis, theory-of-mind (ToM) is the process of adopting a 3P perspective for someone. Combining these two approaches we can see that: (a) The 1P perspective is generally 'egocentric', (b) The 3P perspective is generally 'allocentric'. These types of relationships define what has been called the standard 'model of social cognition' (Brown, 2020).

Does the choice of spatial reference frame depend on (passive) perception vs. sensorimotor interactions with the environment, such as target-directed movements or navigation? Spatial decisions regarding where targets are relative to the object are translated into egocentric left/right decisions (ego-relative remapping). A wide variety of allocentric task effects are using egocentric spatial reference frames. Filimon (2015) argues that neither the way we encode space, nor the way we interact with space, need to make use of allocentric spatial reference frames independent of egocentric representations. According to Chafee and Crowe (2012), parietal cortex generates a hierarchy of spatial representations with three basic levels: (1) sensorimotor signals that are tightly coupled to stimuli or movements, (2) sensorimotor signals modified in strength or timing to mediate cognition (examples include attention, working memory, and decision-processing), (3) signals that encode frankly abstract spatial information (such as spatial relationships or categories) generalizing across a wide diversity of specific stimulus conditions.

'Potential space', that is, the space between the individual and experience, is at the heart of Winnicott's theory of 'transitional' space and objects. Arzy (2021) explores and introduces this concept into implementations of Winnicott's potential space, such as play, transitional phenomena, therapeutic space, culture, and creativity. Through such theoretical structures and clinical analyses, it is seen how representation and ownership, as well as their mutual relations, can help to better theoretical understanding, with potential benefits in clinical practice. Summarizing the 'theory of narrative self', 'agency' is defined as the sense that "I am the one who is in the navigation of environment, depicted on the map", while 'ownership' is the sense that "I am the one who navigated this path, using path integration, landmarks, and a recent cognitive map".

In the domain of time, 'agency' is defined as the sense that "I am the one who is simulating this future or remembering this past scenario". On the other hand, 'ownership' is the sense that "I am the one who has undergone (or will undergo) this experience, in conjunction with these events". Representation in the social cognitive map is defined as the sense that "I am the one who creates and evaluates interactions with people around me (or social network)". The ownership may have the sense that "I am the one involved in a social network". More generally, the narrative self (or experienced self) refers to the world through life stories. In this way, 'agency' can be defined as the sense that "I am the one telling the story", and the 'owner' (ownership) as the feeling that "I am the protagonist of the story" (Arzy, 2021).

Emergence of egocentric and allocentric representations

What makes one spatial frame of reference preferable over another? Ground-level viewpoints are more effective in egocentric navigation in terms of time and distance to the target than overhead viewpoints. Conversely, overhead viewpoints improve allocentric navigation performance relative to egocentric navigation (Török et al, 2014).

Most research focuses on separate developmental trajectories of different types of spatial representations, revealing that 'egocentric representation' develops and matures earlier than 'allocentric representation' (Hu et al, 2018). However, a theoretically interesting question remains to be explored: Once children have acquired the ability to use these two representations to encode locations, do they tend to rely more heavily on one of them? Since egocentric representation is earlier in development, emerging earlier and being used better, does it show priority in spatial memory processing when the abilities to use these representations reach maturity?

Despite the lack of direct empirical evidence on these issues, we can get some ideas from some theories. Wang & Spelke (2002) argued that (a) Human navigation and location coding depend primarily on the egocentric representation. (b) If both representations are available, the individual would prefer to rely on the egocentric one. In a study to test the formation of these two representations, they found that congenitally blind participants performed better using the egocentric frame of reference, while sighted participants showed preferential use of the allocentric frame of reference (Pasqualotto et al, 2013).

These findings suggest that the development of the allocentric representation requires visual input, while the egocentric representation may be innate. Other research suggests that children behave more egocentrically than adults, while adults can correct their egocentric interpretation more successfully (Epley et al, 2004). Therefore, we could again argue that egocentric representation dominates in the early years of life, while allocentric representation gains ground during development. In their study, Hu et al (2018) created two corresponding conditions, where only one type of spatial representation (either egocentric or allocentric) could be used to relocate the hiding location. The spatial relations used in these tests were similar, namely, left/right sense of self and left/right sense of a colored marker, which allowed for comparison of the two conditions. It was found that 5- and 6-year-olds searched less accurately than older age groups using allocentric representation, while their performance did not differ from older age groups on the egocentric representation task. Furthermore, all groups achieved higher accuracy on the egocentric task, compared to the allocentric one. These results suggest that, compared to the allocentric representation, egocentric representation reaches maturity earlier in development and becomes more exploitable, especially in the early years. This developmental trajectory is consistent with other research showing an advantage of using egocentric representations for encoding locations in early childhood (Ruggiero et al, 2016), while this has been suggested to be associated with delayed maturation of the hippocampus and surrounding regions (Newcombe & Huttenlocher, 2003).

Summarizing, when comparing the performance of children and adults in these studies, it is observed that a higher proportion of adults choose the allocentric representation in confrontation tasks. Egocentric and allocentric representations probably have different origins: (a) Egocentric representation is innate, (b) Allocentric representation comes from acquired experience. Based on this proposition, it is reasonable to assume that egocentric representation, as a more primitive form of spatial representation, plays a more important role in early development. But if so, what developmental mechanism leads to the shift to allocentric representation?

Neurobiological evidence

A growing body of neuroimaging studies pointed to a fronto-parietal network subserving egocentric representations, and to medio-temporal and parieto-temporal regions subserving allocentric ones (Zaehle et al, 2007). Specific areas in the dorsal striatum, such as the caudate, are responsible for egocentrically defined motor movements. The hippocampus and the parahippocampal areas are involved with allocentric navigation. The hippocampus, as a core component of the long-term episodic memory system, maintains and constructs world-centered perceptual information called the cognitive map and provides flexible navigation in space (Németh et al, 2025). The visuospatial translational processes between spatial representations are supposed to be supported by postero-medial brain regions, like retrosplenial and posterior cingulate cortices, by the Locus-Coeruleus Noradrenaline system with the prefrontal cortex, and by frontal brain regions, beside the Temporo-Parietal Junction (Orti et al, 2024, 2025). Examining neural representations of spatial reference frames (RFs) during human spatial navigation, Li et al (2021) found stronger activation for allocentric RFs in the middle frontal gyrus and cerebellar culmen, and common clusters of activation in the parahippocampal and lingual gyri. Another study found that activity related to allocentric and egocentric spatial RFs, across various experimental tasks, converges in the right parietal and right frontal cortex (Derbie et al, 2021).

The underlying neural processes for egocentric and allocentric spatial reference frames (RFs) appear to be at least partially overlapping. Both egocentric and allocentric tasks have been reported to activate overlapping parieto-frontal networks, with generally greater egocentric than allocentric activations in superior parietal and superior frontal cortex, especially in the right hemisphere (Chen et al., 2014; Saj et al., 2014). Additional foci of greater egocentric than allocentric activation have been reported in superior or middle temporal gyrus (Neggers et al., 2006). Allocentric tasks induce greater fMRI activations than egocentric tasks in temporal lobe structures and occipital regions, including the lingual gyrus (Chen et al., 2014); inferior temporal gyrus (Saj et al., 2014); and hippocampus (Zaehle et al., 2007). Other fMRI studies have reported increased functional connectivity between the hippocampus, the superior parietal cortex, and precuneus in allocentric tasks (Zhang and Ekstrom, 2013). Thus, despite the overlap between egocentric and allocentric task activations, allocentric tasks rely more on ventral occipito-temporal networks, whereas egocentric tasks activate parieto- frontal networks more strongly (Zaehle et al., 2007).

The fMRI studies have generally shown a pattern of overlapping activations in parieto-frontal regions for allocentric and egocentric tasks, which can presumably be explained by the common translation of both "egocentric" and "allocentric" targets into ego-relative coordinates. Additionally, regions specific to allocentric spatial judgment tasks overlap with ventral visual areas involved in object and object configuration processing. Allocentric tasks that involve mental navigation between different landmarks presumably involve additional mental transformations of the ego into different imagined orientations, hence activating hippocampal and related (e.g., retrosplenial) regions that encode or store multiple view- dependent scene representations during navigation. According to Filimon (2015), although the activation patterns for egocentric and allocentric tasks are partly distinct, they do not unequivocally support the existence of *allocentric spatial reference frames*, and could thus be reinterpreted using egocentric reference frames alone. The fMRI literature suggests that parietal activations (mainly posterior intraparietal sulcus and high-level visual areas) should generally be stronger for *seen*, rather than *imagined*, spatial relations, although the more difficult the (allo-to-ego) mental transformation required for an allocentric stimulus, the stronger the activation should be (Filimon, 2015).

Moreover, cognitive pupillometry can enrich the interpretation of behavioural data and offer additional insights into the cognitive processes involved in egocentric–allocentric transformations. Task-evoked changes in pupil size have been closely linked to the activity of the locus coeruleus–noradrenaline (LC-NA) system, a neuromodulatory network implicated in attention regulation. Recently, Orti et al (2025) found a larger pupil dilation in switching judgments from-allocentric-to-egocentric reference frames than from-egocentric-to-allocentric ones. Overall, the results showed that, for both non-switching and switching visuo-spatial processes, starting from an allocentric-based representation elicits a higher cognitive load than starting from an egocentric-based one.

Behaviorally, several studies have suggested an imbalance in the effort needed to switch between egocentric-and allocentric-based spatial strategies in healthy populations (Orti et al, 2024), as well as in psychiatric disorders. (Landgraf et al, 2010). Adopting an allocentric point of view and switching between egocentric and landmark-centered perspectives are impaired in psychotic patients, which might contribute to their altered personal and social world comprehension (Landgraf et al, 2010).

Extensions in the fields of social and digital cognition

Although we often talk about the "what" and "where" processing systems in the brain's topography, we don't know enough about the concept of a "who" system, that is, the neural processing of information about 'the self' versus 'the other', including the dimension of 'temporality' (Brown, 2020, Giotakos, 2025a). Overall, the 'who' system of the human brain mediates both the perceptual and behavioral aspects of social cognition and establishes the existential distinction between 'self' and 'other' in human cognition. According to Brown (2020), the main features of the "who" system are two complementary systems: (a) the 'other-as-self mechanism', whose main function is to perceive other people as proxies for the self, as occurs through the processes of mentalization and empathy, (b) the 'self-as-other mechanism', whose main function is to portray oneself as another, as if participating in some acting performance.

Also, James (1890) distinguished two understandings of the 'self': The self as "I" reflects the self as a subject of experience (self as subject) and the self as "Me" corresponds to the self as an object of experience (self as object). For Wittgenstein (1958), the "I", suggests the self-as-subject - for example, "*I* see me in the mirror" - and the "Me" the self as object - for example, "I see *Me* in the mirror". At this point, we could argue that the 'self as I' composes the egocentric, while the 'self as Me' composes the allocentric spatial perspective. Maybe, the distinction between 'self' and 'non-self' is often a matter of scale rather than a binary classification. We may discuss subcategories of the self by imposing additional constraints on the type of conscious content that is considered, as well as the nature of self-relatedness (e.g., whether it is ownership of, agency over, authorship, etc.) (Wozniak, 2018).

Following the award of the 2014 Nobel Prize in Physiology or Medicine (John O'Keefe, May-Britt Moser, Edvard I. Moser) for the discovery of the allocentric mapping of physical space by grid cells in the medial entorhinal cortex and hippocampal place cells, recent findings in cognitive neuroscience link cognitive maps to the hippocampal formation, including the entorhinal cortex, along with more diffuse areas in the brain. This emerging research trend has now extended to the social domain, where hippocampal coding of social variables is being investigated. An interesting form of involvement of spatially tuned neurons in social cognition has recently been proposed (Arzy & Kaplan, 2022), with the following basic propositions: (a) Place cells may indicate a specific individual in a given social situation, (b) Grid cells may indicate a hexagonal organization of a specific social network, according to a given 2D coordinate system, (c) Border cells may indicate a given social boundary (defined group, e.g. close family), (d) Head-direction cells may indicate a specific 'angle/slope' within the same social stratum (e.g. among all cousins, those my age).

Perhaps the most crucial part of the spatial transformation puzzle involves the 'head direction' neurons which orient us in allocentric space. Several lines of evidence suggest that angular velocity, encoded by the vestibular organs and an egocentric phenomenon, can be transformed into allocentric direction, generating the 'direction of things' in relation to the external world. This sense of 'allocentric direction' (a sense that reminds us of the 'directiveness' component of intentionality) is probably the foundation on which all allocentric spatial mappings are built. We know that we can close our eyes and visualize a panoramic view of our apartment. We can also zoom out even further and visualize a panoramic view of the apartment and the grocery store down the street, as well as where they are in relation to each other. This is our 'inner allocentric model' (Filimon, 2015, Zheng et al, 2021).

Extending the concept of 'directedness', we may think on an 'intentional system' as a higher order system, with a monitoring and regulatory role attributed to the brain and behavior. We suggested possible pathways of that intentional system in brain, following the conceptual and neurobiological traces of 'aboutness' and 'directedness' (Giotakos 2023b). The 'aboutness' intentionality sub-system seems to use an egocentric-like function, as opposed to the 'directedness' intentionality system, which uses an allo-centric-like function. Human intentionality is closely associated with consciousness and agency. In the case of psychosis, a failure of corollary discharges to suppress self-generated inputs, results in the absence of a "feeling of agency" in the ego-centric system, and in a compensatory enhancement of allo-centric priors, which might underlie delusions and hallucinations. (Giotakos 2023b, Leptourgos & Corlett, 2020). Also, we may consider mental disorders as the result of a radical disruption of intentionality, due to inappropriateness or lack of the intentional object or due to an inappropriate connection in some points of the suggested brain pathways of intentionality (Giotakos, 20023c). According to Searle (1983), intentionality is that characteristic of the mind with which mental states are directed *at* or *deal with* (about) or *refer to* or *are aimed at* states of the world. His theory also raises the problem of the intentionality of perception, by using the expression relating to the "experience of" and emphasizing that the preposition "of" in the "experience of" is precisely the "of" in the "intentionality of."

We are now called to live in new 'spaces' and 'environments' created by artificial intelligence, while AI-based psychotherapy applications have been evolving rapidly in recent years (Giotakos, 2025d). AI technologies seem to offer solutions to a complex world with enormous mental health needs and where both accurate diagnosis and effective treatment of mental disorders remain unfulfilled goals (Giotakos, 2025e). Empirical studies consistently show correlations between the sense of virtual embodiment and spatial presence. Manipulations designed primarily to strengthen or weaken virtual embodiment often have similar effects on spatial presence. According to Halbig and Latoschik (2025), 'spatial presence' and 'virtual embodiment' are shaped by a highly overlapping set of cues.

Virtual reality (VR) is based on the principles of embodied cognition, where learning and attention are enhanced through active participation of the body. The main characteristics of virtual reality therapy are: 'interaction', 'immersion', 'presence'. The term 'interaction' refers to the fact that the user is not just an external observer of the images on a computer screen but actively participates in the three-dimensional world of the computer, since he can navigate it, change it and manage its objects. The term 'immersion' indicates that the user has the perception that he is contained, surrounded and interacting with an environment that provides continuous stimuli and experiences. 'Presence' is defined as the psychological state or subjective perception in which, although part or all of a participant's experience in virtual reality is produced or filtered through technology, the participant's perception fails to accurately recognize the role of technology, resulting in the participant feeling that the technology is not participating in the experience at all. High levels of 'immersion' and 'presence' are associated with increased response to exposure therapy in virtual environments, as well as better therapeutic outcomes and prolonged therapeutic benefits (Mitrousia V & Giotakos O, 2016).

Bermudez-Contreras et al (2020) turn our attention to discuss how spatial navigation has been modeled using descriptive, mechanistic, and normative approaches and the use of AI in such models. They proposed that spatial navigation is an excellent area in which these disciplines can converge to help advance what we know about the brain. They also highlighted promising lines of research in which spatial navigation can be the point of intersection between neuroscience and AI. Alyassi et al (2025) examined recent progress in learning-based social navigation methods that deal with the complexities of human-robot coexistence. They found that many learning-based approaches outperform model-based methods in realistic coordination scenarios, stating that a key highlight is the end-to-end models, which achieve strong performance by directly planning from raw sensor input, enabling more efficient and adaptive navigation.

As we now live in a new digital era, the following questions arise: How do we perceive "presence" in human-AI interactions? How can egocentric and allocentric representations produce social and cognitive maps in these technological environments? Also, what role can 'intentionality' play in understanding this flow of perception? Reviewing the literature to determine how the brain perceives human and artificial intelligence "presence", in examples of social perception and decision-making, Harris (2024) wondered how much and in what way the brain's response to artificial intelligences would change, as people gain more experience with them and AI become more integrated into human life.

Taking together the findings of this brief review, we may suggest that the dynamic connectivity of the spatially distributed network, rather than the activity of a single region, is critical for accurate recall spatial cognition. The extent to which a spatially distributed memory network can rapidly exchange information is critical for the efficiency of its functional output. Furthermore, it is worth exploring the way in which "the self" is experienced and navigated in new technological and AI environments.

Main points of the egocentric and allocentric perspective in spatial and social cognition

Egocentric perspective	Allocentric perspective
The egocentric representation encodes the location of the object in relation to one's body (object-self relation), such as "the toy is on my left"	Allocentric representation -also named *object-centered*, or *world-centered* - encodes location in relation to the external environment (object-to-object relationship), such as "the toy is next to the desk"
The egocentric view is what we see now	The allocentric view arises from our ability to think about what we would see if we were somewhere else in space
Spatial processing is done from the internal bodily perspective of the self (such as looking out through one's own eyes)	Spatial processing operates for some external frame of reference, most commonly a Cartesian coordinate system
In egocentric spatial reference frames (RF), the positions of objects are encoded in relation to the location-label of the main subject	In allocentric spatial reference frames (RF), are encoded with respect to each other or to environmental landmarks and are independent of the subject's position
First-person (1P) perspective of the self	Third-person (3P) perspective of the other
The 1P perspective is generally 'egocentric'	The 3P perspective is generally 'allocentric'
'Ownership' is the sense that "I am the one who navigated this path, using path integration, landmarks, and a recent cognitive map"	'Agency' is defined as the sense that "I am the one navigating the environment, depicted on the map"
Ownership is the sense that "I am the one who has undergone (or will undergo) this experience, in conjunction with these events"	Representation is defined as the sense that "I am the one simulating this future or remembering this past scenario"
Ownership, the feeling that "I am the protagonist of the story"	Agency, the sense of "I am the one telling the story"
The 'other-as-self mechanism'	The 'self-as-other mechanism'
Ground-level viewpoints are more effective in egocentric navigation	Overhead viewpoints are more effective in allocentric navigation
Egocentric representation dominates in the first years of life	Allocentric representation gains ground during development
Egocentric representation is innate	Allocentric representation derives from acquired experience
The "I", suggests the self-as-subject, for example, "*I* see Me in the mirror"	The "Me" suggests the self-as-object, for example, "I see *Me* in the mirror"
Mainly fronto-parietal network	Mainly medio-temporal and right parieto-temporal regions
Dorsal striatum, such as the caudate	The hippocampus and the parahippocampal areas
Place cells	Head-direction cells
The 'aboutness' intentionality system	The 'directedness' intentionality system
Mental states '*refer to*' or *are 'aimed at'* states of the world.	Mental states are directed *at* states of the world

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