RIVISTA INTERNAZIONALE DI FILOSOFIA E PSICOLOGIA
DOI: 10.4453/rifp.2021.0023
ISSN 2039-4667; E-ISSN 2239-2629
Vol. 12 (2021), n. 3, pp. 242-253

FORUM

# I am mind, therefore I am map. Mapping as an extended spatio-temporal process

Sonia Malvica[α] & Alessandro Capodici[α]

Ricevuto: 10 novembre 2020; accettato: 14 maggio 2021

**Abstract** The multifaceted nature of the map animates a wide range of debates that reveal its interdisciplinary nature. Our goal is to overcome classical cognitivism harmonizing the fields of neuroscience, geography, and enactivism to promote a holistic view not only of the map, but also of human beings and, more specifically, of the dynamic subject-world relationship. We have retraced the spatiality of the body and described the spatial dimension of implicit and explicit bodily skills and properties involved in the exploration of – and engagement with – the world. We believe that maps, which present space in isolation, cannot grasp the global quality of subjective experience: space and time are not separable concepts for a cognitive agent engaged in the world. Finally, going beyond the theory of the extended mind to extended consciousness, we argue that ecological mapping, mental mapping, and practical mapping are closely interrelated.
KEYWORDS: Mapping; Enactivism; Image; Perception; Extended Consciousness

**Riassunto** *Sono una mente, quindi sono una mappa. La costruzione di mappe come processo spazio-temporale esteso* – La natura poliedrica della mappa anima una vasta gamma di dibattiti che rivelano la sua natura interdisciplinare. Nostro scopo è quello di superare il cognitivismo classico, armonizzando campi quali la neuroscienza, la geografia e l'enattivimo, per promuovere una visione olistica non solo della mappa, ma anche dell'essere umano e, più specificamente, del rapporto dinamico tra soggetto e mondo. Intendiamo ripercorrere la spazialità del corpo e descrivere la dimensione spaziale delle abilità e delle proprietà corporee implicite ed esplicite implicate nell'esplorazione del – e nel coinvolgimento con – il mondo. Crediamo che le mappe, che presentano lo spazio in maniera isolata, non possono cogliere la qualità globale dell'esperienza soggettiva: lo spazio e il tempo non sono concetti separabili per un agente cognitivo coinvolto nel mondo. Infine, passando dalla teoria della mente estesa a quella della coscienza estesa, intendiamo sostenere che la creazione di mappe ecologiche, mentali e pratiche sia un'attività profondamente interconnessa.
PAROLE CHIAVE: Mappatura; Enattivismo; Immagine; Percezione; Coscienza estesa

[α]Dipartimento di Scienze Cognitive, Psicologiche, Pedagogiche e degli Studi Culturali, Università degli Studi di Messina, via Concezione, 6 - 98122 Messina (I)

E-mail: sonia.malvica@unime.it(✉); alessandro.capodici@unime.it

## 1 Introduction

THE "MAP" ALWAYS NEEDS TO be contextualized, as it animates a wide range of debates and theoretical applications that reveal its complex interdisciplinary nature. In the contemporary imagery, this term coincides with the map understood as a human artifact, a socio-political construction, or visual object that mediates the mundane experience, extending the subject's possibilities. In addition, as a result of technological and scientific progress, it is not uncommon to find this word in different contexts, as when referring to the brain and more specifically to cortical regions, topographic maps, and complex interconnections of (biological and artificial) neural networks. For example, Nicosia[1] recently described the brain as a "multi-layered map", proposing a careful analysis of the methodological continuity between geography and neuroscience.

Moreover, in her account of plasticity, Malabou[2] adopted a cartographic metaphor to discuss the functional relationship between the neuronal domain and the subjective experience of the mind. Thus, the author states that the Self, is «a synthesis of all the plastic processes at work in the brain; this permits us to hold together and unify the cartography of networks».[3]

In an attempt to describe spatial cognition as an integrated system, the ecological direction of our work starts by introducing subjects as plastic agents, underlying the emergence of dynamic processes that arise between the Self and the world. We will retrace the spatiality of the body – considered by phenomenologists as the zero-point of experience[4] – to emphasize how being a body represents the primary condition of worldliness.[5] Hence, we will describe the spatial dimension of implicit and explicit bodily skills and properties involved in the exploration of – and engagement *with* – the world. To do this, we will focus on the evolutionary process of our species, on the bodily structures that shape spatial abilities and, necessarily, on the pressure for movement that characterizes living beings.

Beyond recognizing, predicting and avoiding risks, survival coincides with the ability to move for short or long periods of time to achieve resources (food, water, shelter) and go back to the starting point.[6] The performative navigation of each species is rooted in the structural properties of the body, which determine the functional possibilities in relation to the perceptual world inhabited by the species.[7] For example, ants' spatial orientation skills are based on a sophisticated navigation system that relies, among others, on a step counter,[8] olfactory landmarks,[9] wind direction,[10] visual, magnetic and vibrational cues.[11]

This basic evolutionary drive to move clearly involves human animals too; for our ancestors, to some extent, «moving was thinking».[12] The oldest findings about the migrations of human ancestors suggest that, even before the modern expansion of brain size and cognitive abilities, *Homo Erectus* had already faced the first intercontinental journey.[13] Migratory phenomena are fundamental for the survival of many species; however, within the realm of living creatures, the human species appears as an "ecological anomaly".[14] Human societies have been able – through technology and language evolution – to go beyond the limits of environmental adaptability, spreading all over the world.[15]

Human spatial navigation is not exclusively based on the dialectic between bodily possibilities and environmental circumstances but is mediated by technological systems of spatial orientation[16] and – as will be described more fully in the next section – by material, visual, and digital maps.

The purpose of this paper is to describe spatial cognition as a multi-layered system[17] scaffolded in temporality. We argue that, in human beings, ecological mapping, mental mapping and practical mapping are closely interrelated and together they give rise to the "re-presentation" of the environment and, as we will see at the end, the extension of consciousness.

## 2 Exploration, extension and "affordance"

The classical notion of "cognitive map"[18] concerns mental representations of paths, distances, directions or, in other words, internal models of spatial processing.[19] Although it has been strongly criticized,[20] this idea has widely influenced the scientific effort related to spatial behavior in the fields of cognitive neuroscience[21] and ethology.[22]

Since the hippocampus is significantly involved in the perception of space and the position of the body placed in it, many studies focused on the involvement of this area in spatial navigation and spatial memory.[23] However, as we will try to discuss, it would be a mistake to consider human spatial mental abilities as disconnected from the body and the surrounding world: the interaction with the environment is first of all grounded and shaped by action and can be defined as "indexical",[24] i.e. based on a particular viewpoint.[25]

The expression of "navigation of *here and now* affordances" adopted by Brincker[26] in the context of her "sensorimotor maturation theory" is particularly interesting for the understanding of human experience, especially if discussed and compared with a navigation mode that she defines as «an imagined, remembered or otherwise currently counterfactual bodily space»[27].

Moreover, as far as space skills are concerned, we share with other animal species primitive neuroanatomical structures. However, «humans possess a tool which can greatly facilitate spatial navigation: the physical map».[28] In this sense, the theory of the extended mind proposed by Clark and

Chalmers[29] – and currently widespread in the academic debate[30] – appears fundamental, as will be described in the last paragraph.

Some authors consider "map-making" as a species-specific human activity[31] that, from a phylogenetic point of view, seems to date back to the Upper Palaeolithic.[32] The gradual and peculiar evolution has allowed Homo sapiens to access – through a functional "exaptation" of readapted peripheral structures – language, symbolic thought, collective meanings, institutions, and arts.[33] In line with a naturalistic and embodied conception of the mind, Pennisi[34] recently recalled the work of Leroi-Gouhran[35] to describe how human evolution began in the feet, to emphasize the assumption that the structural revolution preceded the cognitive one.

As already mentioned, technology has been crucial in the process of human becoming since, according to the principle of "metaplasticity" proposed within the Material Engagement Theory (MET),[36] «we make things which in turn make us».[37] Indeed, in the context of Paleolithic images, Malafouris[38] has described how sensorimotor engagement has given rise to «a new special kind of perception of the world not previously available». Similarly, Parisi[39] argues that artifacts are not to be understood as the product of representative capacity, but rather as the material pole that contributes to its development, therefore:

> [Our ancestor] began to see in a representational way when – as a result of the sensorimotor engagement put in place – he created the conditions for which the basic properties of vision manifest, transforming his pre-dominantly performative-phenomenological mind into a reflective and representational mind[40]

Here, it is necessary to specify that our approach does not overlap with the enactivist perspective proposed by Hutto and Myin, which radically excludes representations from cognition. [41] Indeed, as Clark already pointed out at the end of the last century, some tasks are always searching for representations.[42]

Defining enactivism as sensorimotor engagement through the world does not necessarily mean embracing a radical approach: in line with Clark's definition of "action-centered representations", perception and action are coupled into a mechanism where «perception is itself tangled up with specific possibilities of action»,[43] so «action-oriented representations [...] simultaneously describe aspects of the world and prescribe possible actions».[44] The action-centered representations are «a hybrid view in which perception sensory-motor loops is a kind of action/representation mix» as «sensory-motor loops that develop in certain sorts of situations over time as a result of experience».[45]

Clark cited Ruth Millikan's "pushmi-pullyu representations" (PPR)[46] as proof of "translation" of an environment change into a behavioral one, characterizing something more primitive than directive and descriptive representations. Moreover, Millikan recognized in Gibson's perceptual representations a case of PPR:[47]

> Think of perceptual representations simply as states of the organism that vary directly according to certain variations in the distal environment. The perceived layout of one's distal environment is, first, a representation of how things our there are arranged- a descriptive representation. It is also a representation of possible ways of moving within that environment [...] The representation of a possibility for action is a directive representation. [...] There is no reason to represent what can be done unless this sometimes effect its being done [...] PPRs are more primitive than either purely directive or purely descriptive representations.[48]

The representations proposed by Clark just pointed out that cognitive processes require the cognitive agent's sensorimotor contingency, then «cognition does not build upon universal, context-invariant models of the world, but is subject to constraints of the local spatiotemporal environment»:[49] in the following sections we will see how this statement define the map. In conclusion, "engagement" is the keyword to understand the role of the action, and it allows to avoid falling into the abstraction so feared by the enactivism.[50]

In the geographical field, some authors defined maps as "spatial practices"[51] "in a state of becoming",[52] with the aim of emphasizing the subjective and dynamic qualities of mapping, which is rooted in an embodied and temporalized experience of space that unfolds mainly in action:

> Maps are of-the-moment, brought into being through practices (embodied, social, technical), always remade every time they are engaged with; mapping is a process of constant reterritorialization. As such, maps are transitory and fleeting, being contingent, relational and context dependent. Maps are practices - they are always mappings; spatial practices enacted to solve relational problems (eg: how best to create a spatial representation, how to understand a spatial distribution, how to get between A and B, and so on).[53]

From an ontogenetic point of view, maps assist spatial planning and sensorimotor navigation by opening fields of possibilities that are, nevertheless, conditioned by subjective history, affects, and skills.[54] In the scientific literature, however, there are some accurate observations regarding this approach that cannot be overlooked.[55]

With regard to this, it is not our intention to get into the cartographic debate; rather, we want to make some remarks about the organism-environment co-constitution. At this level of analysis, the concept of "affordance" introduced by Gibson,[56] represents a basic example, since it does not refer to any isolated subjective quality nor spatial properties, describing instead a relational possibility that arises through interactions between the organism and his environment.

The corollary of spatial properties includes position, size, distance, direction, shape, and movement trajectory.[57] During the exploration of the environment, we never come across images such as those lying on a canvas, but instead, we access the information directly; information that will be conveyed only partially by the picture through the invariant escorts at a precise moment, within a specific environment, under the gaze of a given observer.[58]

Today there is a broad consensus on the assumption that "map practice" can be considered a cultural universal that emerges very early in children, along with the corollary of doodles, geometric lines, drawings.[59] It is interesting here to return to Gibson's studies, which focused on the ability of children to engrave traces on surfaces through what he calls "fundamental graphic act".[60] The children, once they have learned how to handle the instruments, immediately engage in this activity. Their doodles present a series of visual invariants including, for example, the quality of the straight, the curved, the zig-zag, the intersection, and the parallelism:[61]

> The traces he leaves on the paper are not just lines, or the outlines of forms, but the distinguishing features of the environment. While drawing, he may be looking at something real, or thinking about something real, or thinking about something wholly imaginary; in any case, the invariants of his visual system are resonating.[62]

We believe that Gibson's last quote makes clear the close intertwining of multiple spatial modalities, actively experienced by subjects through corporeality.[63]

## 3 Embodied subjects engaged in spatiality

Classical cognitivism had the merit of going beyond the behaviorist conception that considered the mind as a sort of inaccessible black box.[64] However, it has given rise to a disembodied view of the mind (comparable to a "mental sandwich") that prioritizes the internal seasoning attributable to cognitive processes and neglects the motor and sensory ones.[65]

Embodied cognitive science, on the other hand, starts from the biological and physiological dimension of cognition, placing corporeity and sensorimotor possibilities at the center of the analysis. Thus, it is possible to speak of an embodied subject, space-time located, which actively explores the environment through "a rich landscape of affordances",[66] goal, and saliences. In this vision, neural activity does not explain all the possibilities and facets of the lived experience; therefore, this approach contravenes the idea of a disembodied subject placed within a passive environment. The emphasis is placed on the flexibility of organisms and the implicit drive for change inherent in the environment. The experience is constituted in the action of a subject who moves in a directly perceived environment.[67] In this sense, the body represents the "vehicle of being in the world".[68] Body properties shape perception and possibilities of action, so it is useful to consider the human body as structured, first of all, on three axes: head/foot, forehead/back, right/left. Moreover, the human being is equipped with four limbs that move and act preferably forward.[69]

The exploration of the world requires the deployment of specific capabilities, such as the recognition of objects and events ("what"), their location ("where"), and the avoidance of obstacles ("how").[70] For this reason, the visual system has been considered primary in spatial cognition.

In the neuroscientific field, it is quick to think about the classic distinction made by Ungerleider and Mishkin[71] between the dorsal stream ("where pathway", delegated to objects location) and the ventral stream ("what pathway", involved in their recognition). A few years later, Goodale and Milner[72] reworked this division, associating the dorsal stream – now "how pathway" – to the action-oriented visual process, and the ventral stream – always "what pathway" – to the visual process related to perception. However, as pointed out by Gallese,[73] this marked separation between perception and action seems to be problematic and weakly supported by empirical evidence. Vision cannot be considered an activity confined in the brain; the enactive theory of perception, indeed, describes it as a dynamic exploration of the world made possible by bodily movements – of eyes, head, limbs – which progressively triggers changes in the sensory stimulus in virtue of the interests and actions of the subject.[74] Earlier, Gibson[75] had already spoken of "optic array" referring to the changing arrangement of the environment determined by the movements of the observer. In this approach, therefore, perception and action are strictly interconnected.[76]

Here, it is possible to think about the well-known experiment conducted by Held and Hein[77] on two groups of newborn kittens. In this setting, a carousel connects the environmental exploration of two cats, one of which is free to move with its limbs and the other – placed inside a basket – is dragged by the movement of the first. After a few weeks, groups of cats benefiting from autonomous motility showed full visual-motor capacity, unlike those restricted to mere passive vision. From an enactive point of view, this experiment is emblematic because it shows that «interacting with the environment induces the brain to develop the structures necessary for its adequate perception».[78]

Among the scientific literature, there is a distinction between "personal space" (inhabited by the body), "peripersonal space" (immediately adjacent to the body) and "extrapersonal space" (beyond the possibilities of the limbs). According to Gallese,[79] the existence of peripersonal space shows that space is mapped in motor terms, since the peripersonal range is typically inhabited by hands and mouth movements. Today, there is agreement on the assumption that peripersonal space is flexible and can extend to incorporate tools.[80] Moreover, Gallagher[81] recently described how the social experience, shared with other subjects and artifacts, can modify the perception of peripersonal and extrapersonal space. Moreover, these latter two seem to be associated with distinct neural correlates.[82]

In the philosophical, neuroscientific, and geographical fields, the notion of "spatial reference frame" refers to the coordinates that structure the spatial perspective. It is possible to speak of an "egocentric frame" (which refers to the position of something based on self-location) and an "allocentric frame" (which denotes, regardless of one' own position, the spatial relationships between objects). Gallagher and Zahavi[83] defined egocentric space as «the perspectival space of perception and action that is defined relative to the perceiving or acting body». The allocentric space, instead, «is purely objective space that can be defined in terms of latitude and longitude».[84] Although the properties of space are the same all over the world, the way people relate to them can vary from culture to culture. For example, while some languages use an egocentric system of spatial reference (i.e., "turn right"), other languages use an allocentric system, related to the position of objects or geographical coordinates.[85] So,

> despite the correlated nature of the two strategies, they have distinguishable characteristics that can influence cognitive map formation and real-world performance differently.[86]

More generally, during the natural flow of experience, there are contingent and flexible shifts between these spatial frameworks. For example, while learning a map implies the adoption of an allocentric perspective, learning a path through one's own sensorimotor experience takes place in an egocentric perspective.[87] Moreover, sense of place,[88] the time spent in it, the individual personality, and the presence of other individuals can lead to the adaptable alternation of frames.

However, Gallagher and Zahavi[89] emphasized how the lived experience cannot be caught only through these spatial frames; rather, they highlighted the perceptual "self-referencing" level, considering the "proprioceptive frame of reference" as the zero-point, the "here" from which the experiential horizon departs. Gallagher and Zahavi adopt the distinction made by Merleau-Ponty[90] between "spatiality of position" and "spatiality of situation", focusing on the articulation of pragmatic actions whose point of origin is represented by the body, so that «I am not conscious of my body as an intentional object. I do not perceive it; *I am it*».[91] Nonetheless, what has been described so far is limited exclusively to a polyhedral meaning of space which, if taken in isolation, does not return the global apprehension of the experience in the world. Space, indeed, is connatural to time, as will be discussed in more detail in the next section.

## 4 I am "spacetime", therefore I map

Bodily subjects are "perspective" on the world, and then they can conceive a *situation* as "situated action".[92] Additionally, Heidegger's notion of *Dasein*[93] goes beyond the "objectified space", since phenomenology is compatible with the *Umwelt*[94] as ontological status that sees the world as lived from the individuals, according to the *Being-in-the-world* that conceives the subject only starting from the experience that makes a context of action possible. *Dasein* needs to start from a space that is also the time that characterizes the Being itself.[95] We thus face a precise notion of space, which requires the gaze of the individual collocated in both space and time.

Following this reflection, Gell[96] recognizes two conceptions of time in philosophy, starting from a definition of "A-series" or "B-series" events according to McTaggart's reflection. If the A-series events show a dependence on the other event on the "past-present-future" line, the B-series ones follow a causal chain based on the "before-after", thus entering the awareness of needing the chronotope as well as the four-dimensional space conceived through the theory of relativity. It is not necessary to go into the details of the mathematical analysis required to know that dealing with spacetime requires a four-dimension vector as the only tool that allows us to study events. Spacetime needs a reference system that includes a spatial but also temporal axis.

Two B-series events are linked by a precise relationship dependent on the interval that separates them, meaning by interval an invariant which, depending on the assumed value – positive, negative or null – makes possible the conception of the future, past, and present starting from a precise observer.

Considering this, time also shares the centrality of the subject. Gell, in his reflection on time from an anthropological point of view, recalls Hägerstrand and his *time-map* as the basis of chronogeography, to conceive the environment of an individual (which outlines his field of action and existence) and, with it, his maps, starting from spatial elements that are compatible with his temporal possibilities. A map is, therefore, an expression of how the subject recognizes the geographical context that belongs to him and which, consequently, he recognizes himself in. We speak of "daily prism" to designate that part of spacetime accessible to the individual, who has the possibility of constituting his social Being only through movement, that is both space and time.[97] Hägerstrand's model aims to insert social individuals within the analysis through a spacetime system, defining social systems «as bundles of space/time "paths" pursued by particular individuals ("life-lines")» and the population «as a network of individual "paths" in time and space».[98] This approach is a physicalist path, but Gell identifies in the chronogeography proximity to sociological investigations, as well as:

> a language in which it is possible to construct permutable structural models which represents both the spatio-temporal relationships in the environment which are the geographers' primary concern, and also the implicit dimension of social ideas which are embodied in these relationships.[99]

The importance of the fourth dimension is traced by Gell[100] in Duchamp's work, precisely in *Network of stoppages* (1914), in which he recognizes a spacetime map. *Network of Stoppages* is both a preparatory-map for another work, *Large glass*, and a sketch of *Young man and girl in spring*. All of this is on a single same canvas, so the artist was staging the author-agent:

> The *Network* looks like a "map" because it is part of a "map" of *time*. But this is can only be a four-dimensional map. Like Bergson, Duchamp downplays the "merely" visible, or its illusionistic representation. Like Bergson, he distrusts our perception "which is merely analytic and synthetic", and seeks instead the "current of creative energy" (i.e. *durée*, or Heideggerian "being") which "gushes forth through matter". This is the fourth dimension.[101]

Let us return, therefore, to the general map problem. It seems that the map needs to overcome the spacetime dichotomy, since space can hardly be conceived without time. The subject indeed fixes itself through spatial coordinates. However, the role of the fourth coordinate is equally relevant, and emblematic of a new reference system which, rather than being interested in objects, focuses on events, concerning which we take a precise position and which presuppose an individual in a continuous relationship with the environment.

When we observe a map, we also observe the subjects who made it possible, both in space and in time. The map is the result of an enactive presence[102] of the subject that conditions the map's shape. A map is then a concretization of the choices already made in the past by the individual.[103]

Seeking further proof from the world of art (which is, in effect, the expression of how individuals place themselves in the world), the optical art of the latter half of the twentieth century concretizes the importance of spacetime by considering the artwork as the relationship between the active subject and the object: the kinematic elements inserted in the artworks allow the construction of the art itself starting from the observer, who, placing himself in spacetime, becomes a co-author of the artwork. Yayoi Busama's *The Passing Winter*, Julio Le Parc's *Continual Mobile, Continual Light* and Jim Lambie's *Zobop*[104] are just three examples of the definitive union between perception and action. Art becomes a spokesperson for enactivism, proposing works made by the exploration of the observer, who builds his, own personal map. These artworks need the subject's exploration to be artistically complete, as requested by the optical art.

## 5 I map, therefore I am extended

Following what has been discussed, to observe a map also means to observe the subjects who made it possible. The map is the result of an enactive presence[105] of the subject that conditions the map's shape. A map is then a concretization of the choices already made in the past by the individual,[106] that need to be in the world as part of the system.

As final cognitive considerations, in order to conceive the human being-map system, we support Parisi's proposal[107] to accept the theory of extended consciousness. If we introduce the notion of consciousness as an «ecological relationship that the organism establishes with its environment»,[108] we recover the body-agent-in the world and an enactive theory of perception that places the maps in the ontological status of the human species. Still following Parisi, it is not the mind that extends, but rather the ontological dimension of the subject. Such a conclusion shows compatibility with Heidegger's notion of *Dasein*, the spacetime ontological status of the individual, and the map-nature of the cognitive agent, which propose in the world his active role, searching (and "anticipating",[109] as requested by an autopoietic system) continuously through the feedback typical of the dynamical systems.

Maps are definitely a cognitive process and then, part of the cognitive agent. Just think of *Geographical Information System* (GIS) and how such technology carries on the shape of the individuals. According to the definition of GIS as a particular database system (e.g. *Google Maps*) that allows to collect and display both spatial[110] and non-spatial[111] geographical information from a problem-solving environment,[112] Capodici and Russo[113] defined GIS as "upgraded participatory mapping", since they allow a tracking process which with the map is modulated by the individual as agent. The subject's actions continuously process the map, so the same destination will not produce the same map for different users.[114] According to this, technologies allow what Parisi called "medial feedback", based on the role of devices in the subject-environment relationship. If the technology is "strong" enough, it will be able to change the way the subject experiences the world, according to a prosthetic relationship that implements a biological reconfiguration of the nervous system.

An example of a prosthetic relationship comes from the neuroscientific paradigm of the rubber hand illusion, where the subject develops a sense of ownership towards a rubber hand appropriately placed through a specific set up. More precisely, in the moving rubber hand illusion,[115] the subject can observe the fake limb moving synchronously with the movement he makes through his covered hand. What follows is the development of a greater sense of ownership and sense of agency than with no movement, particularly if the prosthetic limb is obviously placed in a way that is compatible with the body schema.[116]

Active movements, then, "help" the sense of the presence of the subject that "is" according to the peri-personal and extra-personal spaces he perceives. A cognitive agent is not then a fixed entity, since he is continuously searching for feedback from the environment, and according to such feedback, shows his plasticity, that is the result of the feedback process itself.

Some MRI researches showed how spatial memory's improvement is the result of the enactive cognitive agent: for example, a study on taxi drivers' orientation abilities confirmed more hippocampal grey matter in subjects who passed exams for taxi driver than in ones who didn't pass it[117] or, even more so, in subjects with no taxi driver experience.[118] Also, Maguire and colleagues[119] emphasized the grey matter's difference between taxi drivers and bus drivers as a consequence of the latter's not attentive task (bus drivers always drive the same routes, automatically), which don't perform the specific role with an active status.

This plasticity justifies what Parisi calls "enactive images" and which, in a certain sense, lead back to the counterfactual navigation of Brincker:[120] they present what is absent and replace the mental representations of classical cognitivism, producing extended imagery that acts as cognitive baggage for the "predictive" processes that allow us to be in the world, according to the affordance notion.

Following several studies that observed the link between the activation of mirror neurons and the notion of affordance, Brincker[121] proposed the transition from the classic mirror system to a sensorimotor system that places mirror neurons within what she defines as a social affordance space. She then recognized the contextual nature of mirror neurons and their predictive role; also, these neurons play a fundamental role in predictive and decision-making terms and highlight the autopoietic nature of the individual-environment system. More precisely:

Many neuroscientists [...] continue to use a

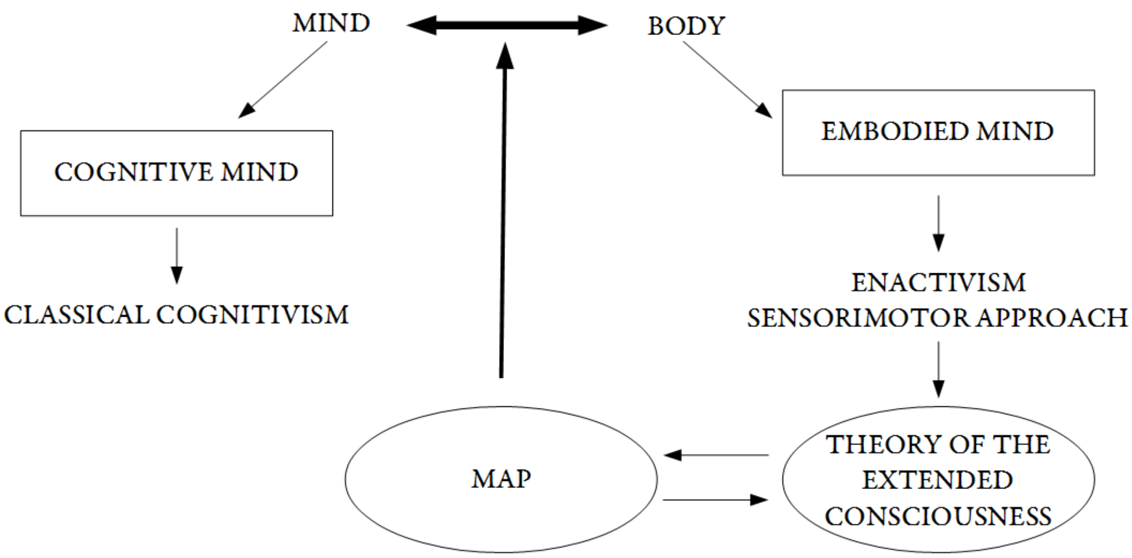


**Figure 1.** Scheme on the theory of extended consciousness and the map's cognitive role

terminology of "translation" or "mapping", indicating separate sensory and motor formats. They thus fail to appreciate the possibility that such sensorimotor processes might change the very organization of the perception [...]. In summary, mirror neurons have repeatedly been theorized as some sort of translational interface between action and perception (as well as between self and other). The question however is whether we have two functionally independent kinds of cortical representations or systems – sensory and motor – to translate between I propose that fronto-parietal circuits might instead support an inherently sensorimotor functional organization that is anticipatory and feedback-based in nature.[122]

In accordance with what has just been exposed, it can be useful to remember the activation of the default mode network (DMN) on the occasion of social cognitive processes. Such activation is defined by Brincker[123] as an energy consumption that however allows the individual to respond to stimuli even when he is far from attention states. It is then a state of "mind-wandering", which concerns actions not directed towards a goal but can bring advantages such as social cohesion.[124]

In conclusion, our work aimed to show that the multifaceted nature of the map can represent a fruitful crossroads of interdisciplinary research. We believe that the adoption of an enactivist perspective prevents the reduction of the map to a static artifact and, contextually, the consciousness to a monad-brain.

## Acknowledgments

The Authors contributed equally to this work.

## Notes

[1] Cf. E. NICOSIA, *Geography and neuroscience*.
[2] Cf. C. MALABOU, *What should we do with our brain?*.
[3] *Ibid.*, p. 58.
[4] Cf. S. GALLAGHER, D. ZAHAVI, *The phenomenological mind*.
[5] Contemporary phenomenological studies discuss how our bodily engagement is not solely confined to the physical body; human corporeality also extends to virtual worlds, as in eSports (Cf. D. EKDAHL, S. RAVN, *Embodied involvement in virtual worlds*; D. EKDAHL, S. RAVN, *Social bodies in virtual worlds*.
[6] Cf. B. TVERSKY, *Spatial cognition*.
[7] Cf. A. FALZONE, *Species-specificity, language, representation*; A. FALZONE, *Performatività ed evoluzione*; A. PENNISI, A. FALZONE, *Linguaggio, evoluzione e scienze cognitive: una introduzione*.
[8] Cf. M., WITTLINGER, R. WEHNER, H. WOLF, *The ant odometer*.
[9] Cf. K. STECK, B. S., HANSSON, M. KNADEN, *Smells like home*.
[10] Cf. R. WEHNER, *Desert navigator*.
[11] Cf. C.A., FREAS, P.N. FLEISCHMANN, K. CHENG, *Experimental ethology of learning in desert ants*.
[12] L. MALAFOURIS, *On thinghing*, p. 16.
[13] Cf. C. FINLAYSON, *Biogeography and evolution of the genus homo*; V. CALZOLAIO, T. PIEVANI, *Libertà di migrare*.
[14] A. PENNISI, A. FALZONE, *Il prezzo del linguaggio*, p. 261.
[15] Cf. A. PENNISI, *L'errore di Platone*.
[16] For example, satellites, signal lights, road signs, vehicles.
[17] Investigating human spatial cognition also means taking into account symbolic, semantic and cultural aspects; in this regard, it is possible to think about language (Cf. B. WHORF, J. B. CARROLL, *Language, thought, and reality*; S.C. LEVINSON, *Space in language and cognition*; A. FULGA, *Language and the perception of space, motion and time*). On the other hand, Barsalou (Cf. L. W. BARSALOU, *Grounded cognition*) has proposed the principle according to which even abstract concepts are grounded on embodiment and sensory-motor experience (cf. also Cfr. G. LAKOFF, M. JOHNSON, *Metaphors we live by*), although it will not be possible to address this issue during this work.
[18] Cf. E.C. TOLMAN, *Cognitive maps in rats and men*.
[19] D.R. MONTELLO, *Spatial cognition*, pp. 112-113.
[20] Cf. T. INGOLD, *The perception of the environment*.
[21] Cf. J. O'KEEFE, L. NADEL, *The hippocampus as a cognitive map*; D.P. CAIN, D. SAUCIER, *The neuroscience of spatial navigation*.
[22] Cf. V.P. BINGMAN, *Spatial navigation in birds*; F.C. DYER, *Spatial cognition and navigation in insects*.
[23] Cf. T.I. BROWN, A.S. WHITEMAN, I. ASELCIOGLU, C.E. STERN, *Structural differences in hippocampal and prefrontal gray matter volume support flexible context-dependent navigation ability*; G. IARIA, L.J. LANYON, C.J. FOX, D. GIASCHI, J.J. BARTON, *Navigational skills correlate with hippocampal fractional anisotropy in humans*; S.J. SHETTLEWORTH, *Memory and hippocampal specialization in food-storing birds*; B.R., SONNENBERG, C.L. BRANCH, A.M. PITERA, E. BRIDGE, V.V. PRAVOSUDOV, *Natural selection and spatial cognition in wild food-caching mountain chickadees*.
[24] T. INGOLD, *The perception of the environment*, p. 223.
[25] S. CAQUARD, *Cartography III: A post-representational perspective on cognitive cartography*.
[26] Cf. M. BRINCKER, *Navigating beyond "here & now" affordances*.
[27] *Ivi*, p. 2.
[28] M. J. PROULX, O. S. TODOROV, A. TAYLOR AIKEN, A. A. DE SOUSA, *Where am I? Who am I? The relation between spatial cognition, social cognition and individual differences in the built environment*.
[29] Cf. A. CLARK, D.J. CHALMERS, *The extended mind*.
[30] M. COLOMBO, E. IRVINE, M. STAPLETON, *Andy Clark and his critics*.
[31] Cf. P. G. BAHN, J. VERTUT, *Journey Through the Ice Age*; A. CAPODICI, G. RUSSO, *Map making as bodily engagement*.
[32] Cf. P. UTRILLA, C. MAZO, M. C. SOPENA, M. MARTÍNEZ-BEA, R. DOMINGO, *A palaeolithic map from 13,660 Calbp*; J. SVOBODA, *On landscapes, maps and ppper paleolithic lifestyles in the central european corridor*.
[33] Cf. A. PENNISI, A. FALZONE, *Il prezzo del linguaggio*; A. PENNISI, A. FALZONE, *Linguaggio, evoluzione e scienze cognitive*.

[34] Cf. A. Pennisi, *Prospettive evoluzioniste nell'embodied cognition. Il cervello "inquilino del corpo"*.
[35] Cf. A. Leroi-Gourhan, *Le geste et la parole*.
[36] Cf. L. Malafouris, *How things shape the mind*.
[37] D. Ihde, L. Malafouris, *Homo faber revisited*, p. 196.
[38] L. Malafouris, *Before and beyond representation*, p. 295.
[39] F. Parisi, *La tecnologia che siamo*.
[40] *Ivi*, p. 121.
[41] Cf D. D. Hutto, E. Myin, *Radicalizing enactivism*; D. D. Hutto, E. Myin, *Evolving enactivism*.
[42] A. Clark, *Being there*.
[43] *Ivi*, p. 51.
[44] *Ivi*, p. 49.
[45] N. Salay, *Representations*, p. 297.
[46] Cf. R. Millikan, *Pushmi-Pullyu representations*.
[47] More recently, Gallagher outlined how the term "representation" can be always problematic when it comes talking about action; indeed, he also seemed to reject the definition of Gibson's perceptual representation proposed by Millikan and recognized in PPR a perceiving-percept dichotomy (S. Gallagher, *Enactivist interventions*, p. 98). Although we follow a phenomenological approach, our work aims to show how the map, usually defined as a "representation of the world", could also work in the enactivism's field if it is defined as the result of the cognitive agent's engagement.
[48] *Ibid.*, pp. 191-192.
[49] A.K. Engel, A. Maye, M. Kurthen, P. König, *Where's the action?*, p. 202.
[50] Cf. A Clark, *Predicting peace*.
[51] R. Kitchin, M. Dodge, *Rethinking maps*, p. 335.
[52] R. Kitchin, C. Perkins, M. Dodge, *Thinking about maps*, p. 17.
[53] R. Kitchin, M. Dodge, *Rethinking maps*, p. 335.
[54] Cf. M. Dodge, R. Kitchin, C. Perkins, *The map reader*.
[55] For example, Lo Presti described the concerns of several cultural and political geographers about the risk that this type of arguments might have the result of leaving out «the communicative dimension of the map, its evocative and emotional depth, – the *energheia* – or the political discourse and the apparatus within which it is created» (L. LoPresti, *(Un)exhausted cartographies*, p. 149).
[56] Cf. J.J. Gibson, *The ecological approach to visual perception*.
[57] Cf. D.R. Montello, *Spatial cognition*.
[58] Cf. J.J. Gibson, *The ecological approach to visual perception*.
[59] Cf. J. Blaut, *Natural mapping*.
[60] J.J. Gibson, *The ecological approach to visual perception*, p. 263.
[61] *Ibid.*, pp. 263-264.
[62] *Ibid*, p. 266.
[63] This seems to be even more true in contemporary societies, where screen devices guarantee at any moment not only the possibility of accessing a map that is progressively updated during movement but also of sharing one's dynamic position with others in real-time (cf. J. Pánek, *From mental maps to geoparticipation*; P. Haciguzeller, *Archaeological (digital) maps as performances*).
[64] J.B. Watson, *Psychology as the behaviorist views it*, p. 158.
[65] Cf. S. Hurley, *Consciousness in action*.
[66] Cf. E. Rietveld, J. Kiverstein, *A rich landscape of affordances*.
[67] Cf. S. Gallagher, D. Zahavi, *The phenomenological mind*.
[68] Cf. M. Merleau-Ponty, *Phenomenology of peception*.
[69] B. Tversky, *Spatial cognition*, p. 201.
[70] M.J. Proulx, O.S. Todorov, A. Taylor Aiken, A.A. De Sousa, *Where am I? Who am I?*, p. 2.
[71] Cf. L.G. Ungerleider, M. Mishkin, *Two cortical visual systems*.
[72] Cf. M.A. Goodale, A.D. Milner, *Separate visual pathways for perception and action*.
[73] V. Gallese, *The "conscious" dorsal stream*, p. 2.
[74] Cf. A. Noë, *Out of our heads*.
[75] Cf. J.J. Gibson, *The ecological approach to visual perception*, p. 136.
[76] *Ibidem*.
[77] Cf. R. Held, A. Hein, *Movement-produced stimulation in the development of visually guided behavior*.
[78] T. Fuchs, *The brain-A mediating organ*, p. 204.
[79] V. Gallese, *The "conscious" dorsal stream*, p. 7.
[80] Cf. A. Maravita, A. Iriki, *Tools for the body (schema)*.
[81] Cf. S. Gallagher, *Situating interaction in peripersonal and extrapersonal space*.
[82] Cf. V. Caggiano, L. Fogassi, G. Rizzolatti, P. Thier, A. Casile, *Mirror neurons differentially encode the peripersonal and extrapersonal space of monkeys*; C. Teneggi, E. Canzoneri, G. Pellegrino, A. Serino, *Social modulation of peripersonal space boundaries*.
[83] S. Gallagher, D. Zahavi, *The phenomenological mind*, p. 141.
[84] *Ibidem*.
[85] Cf. A. Fulga, *Language and the perception of space, motion and time*, cit.
[86] L.J. McCunn, R. Gifford, *Spatial navigation and place image ability in sense of place*, p. 210.
[87] M.J. Proulx, O. S. Todorov, A. Taylor Aiken, A. A. De Sousa, *Where am I? Who am I?*, p. 14.
[88] Cf. L.J. McCunn, R. Gifford, *Spatial navigation and place image ability in sense of place*, cit.
[89] S. Gallagher, D. Zahavi, *The phenomenological mind*, p. 142.
[90] M. Merleau-Ponty, *Phenomenology of perception*, p. 100.
[91] S. Gallagher, D. Zahavi, *The phenomenological mind*, p. 143.
[92] Cf. J. Sartre (1943), *L'être et le néant*.
[93] Cf. M. Heidegger (1927), *Sein und Zeit*.
[94] Cf. J. von Uexküll, *A stroll through the worlds of animals and men*.
[95] Cf. A. Vallega, *Heidegger and the issue of space*.
[96] Cf. A. Gell, *The Anthropology of time*.
[97] Cf. T. Hägerstrand, *What about people in regional science?*.
[98] A. Gell, *The anthropology of time*, p. 193.
[99] *Ibid.*, p. 197.
[100] Cf. A. Gell, *Art and agency*.
[101] *Ibid.*, p. 249.
[102] Cf. A. Noë, *Out of our heads*.
[103] Cf. A. Greenfield, *Radical technologies*.
[104] Cf. Tate website (http://tate.org.uk) for artworks' photos.
[105] Cf. A. Noë, *Out of our heads*.
[106] Cf. A. Greenfield, *Radical technologies*.
[107] Cf. F. Parisi, *Tecnologie enattive*.

[108] *Ibid*, p. 134.
[109] Cf. E.A. Di Paolo, *Autopoiesis, adaptivity, teleology, agency*.
[110] Cf. P.A. Burrough, *Principles of geographic information systems for land resources assessment*.
[111] Cf. H.D. Parker, *The unique qualities of a geographic information system*.
[112] Cf. D.J. Cowen, *GIS versus CAD versus DBMS: What are the differences?*.
[113] Cf. A. Capodici, G. Russo, *Map making as bodily engagement*.
[114] Cf. A. Greenfield, *Radical technologies*.
[115] Cf. A. Kalckert, H.H. Ehrsson, *Moving a rubber hand that feels like your own*.
[116] Cf. S. Malvica, A. Re, *La coscienza che si estende*.
[117] Cf. K. Woollett, E.A. Maguire, *Acquiring "the knowledge" of London's layout drives structural brain changes*.
[118] Cf. E.A. Maguire, D.G. Gadian, I. S. Johnsrude, C.D. Good, J. Ashburner, R.S.J. Frackowlak, C.G. Frith, *Navigation-related structural change in the hippocampi of taxi drivers*.
[119] Cf. E.A. Maguire, K. Woollett, H.J. Spiers, *London taxi drivers and bus drivers*.
[120] Cf. M. Brincker, *Navigating beyond "here & now" affordances*.
[121] Cf. M. Brincker, *Beyond sensorimotor segregation*.
[122] *Ivi*, p. 6, and 9.
[123] Cf. M. Brincker, *Navigating beyond "here & now" affordances*.
[124] Cf. C.J. Cela-Conde, F.J. Ayala, *Art and brain coevolution*.

## Literature


Bahn, P.G., Vertut, J. (1997). *Journey through the ice age*, University of California Press, Berkeley (CA).

Barsalou, L.W. (2008). *Grounded cognition*. In: «Annual Review of Psychology», vol. LIX, n. 1, pp. 617-645.

Bingman, V.P. (1990). *Spatial navigation in birds*. In: «Neurobiology of Comparative Cognition», pp. 423-447.

Blaut, J. (1991). *Natural mapping*. In: M. Dodge, R. Kitchin, C. Perkins (eds.), The *map reader: Theories of mapping practice and cartographic representation,* John Wiley & Sons, Oxford, pp. 318-326.

Brincker, M. (2014). *Navigating beyond "here & now" affordances. On sensorimotor maturation and "false belief" performance*. In: «Frontiers in Psychology», vol. V, 2014, Art. Nr. 1433 – doi: 10.3389/fpsyg.2014.01433.

Brincker, M. (2015). *Beyond sensorimotor segregation. On mirror neurons and social affordance tracking*. In: «Cognitive Systems Research», vol. XXXIV, pp. 18-34.

Brown, T.I., A.S. Whiteman, I. Aselcioglu, C.E. Stern, *Structural differences in hippocampal and prefrontal gray matter volume support flexible context-dependent navigation ability*. In: «Journal of Neuroscience», vol. XXXIV, n. 6, 2014, pp. 2314-2320.

Burrough, P.A. (1986). *Principles of Geographic Information Systems for Land Resources Assessment*, Clarendon Press, Oxford.

Caggiano, V., Fogassi, L., Rizzolatti, G., Thier, P., Casile, A. (2009). *Mirror neurons differentially encode the peripersonal and extrapersonal space of monkeys*. In: «Science», vol. CCCXIV, n. 5925, pp. 403-406.

Cain, D.P., Saucier, D. (1996). *The neuroscience of spatial navigation: Focus on behavior yields advances*. In: «Reviews in the Neurosciences», vol. VII, n. 3, pp. 215-231.

Calzolaio, V., Pievani, T. (2016). *Libertà di migrare: perché ci spostiamo da sempre ed è bene così*, Einaudi, Torino.

Capodici, A., Russo, G. (2019). *Map making as bodily engagement.* In: «Reti Saperi Linguaggi», vol. VI, n. 2, pp. 223-237.

Caquard, S. (2015). *Cartography III: A post-representational perspective on cognitive cartography*. In: «Progress in Human Geography», vol. XXXIX, n. 2, p. 225-235.

Cela-Conde, C.J., Ayala, F.J. (2018). *Art and brain coevolution*. In: «Progress in Brain Research», vol. CCXXXVII, pp. 41-60.

Clark, A. (1997). *Being there: Putting brain, body and world together again*, The MIT Press, Cambridge (MA).

Clark, A. (2015). *Predicting peace: The end of the representation wars. A reply to Michael Mandary*. In: T. Metzinger, J.M. Windt (eds.), *Open MIND,* vol. VII, MIND Group, Frankfurt a.M.

Clark, A., Chalmers, D.J. (1998). *The extended mind*. In: «Analysis», vol. LVIII, n. 1, pp. 7-19.

Colombo, M., Irvine, E., Stapleton, M. (2019). *Andy Clark and his critics*, Oxford University Press, Oxford/New York.

Cowen, D.J. (1988). *GIS versus CAD versus DBMS: what are the differences?*. In: «Photogrammetric Engineering and Remote Sensing», vol. LIV, n. 11, pp. 1551-1555.

Di Paolo, E.A. (2005). *Autopoiesis, adaptivity, teleology, agency*. In: «Phenomenology and the Cognitive Sciences», vol. IV, n. 4, pp. 429-452.

Dodge, M., Kitchin, R., Perkins, C. (2011) *The map reader: theories of mapping practice and cartographic representation*, John Wiley & Sons, Oxford.

Dyer, F.C. (1994). *Spatial cognition and navigation in insects*. In: L.A. Real (ed.), *Behavioral mechanisms in evolutionary ecology*, Chicago University Press, Chicago, pp. 66-98.

Ekdahl, D., Ravn, S. (2019). *Embodied involvement in virtual worlds: The case of eSports practitioners*. In: «Sport, Ethics and Philosophy», vol. XIII, n. 2, pp. 132-144.

Ekdahl, D., Ravn, S. (forthcoming). *Social bodies in virtual worlds: Intercorporeality in Esports*. In: «Phenomenology and the Cognitive Sciences», first online 27 april 2021 – doi: 10.1007/s11097-021-09734-1

Engel, A.K., A. Maye, M. Kurthen, P. König (2013). *Where's the action? The pragmatic turn in cognitive science*. In: «Trends in Cognitive Sciences», vol. XVII, n. 5, pp. 202-209.

Falzone, A. (2012). *Species-specificity, language, representation: The auditory-vocal technology in the sapiens*. In: «Reti Saperi Linguaggi», vol. I, n. 1, pp. 44-47.

Falzone, A. (2018). *Performatività ed evoluzione*. In: «Reti Saperi Linguaggi», vol. V, n. 1, pp. 149-160.

Finlayson, C. (2005). *Biogeography and evolution of the genus homo*. In: «Trends in Ecology and Evolution», vol. XX, n. 8, 2005, pp. 457-463.

FREAS, C.A., FLEISCHMANN, P.N., CHENG, K. (2019). *Experimental ethology of learning in desert ants: Becoming expert navigators*. In: «Behavioural Processes», vol. CLVIII, pp. 181-191.

FUCHS, T. (2001). *The brain-A mediating organ*. In: «Journal of Consciousness Studies», vol. XVIII, n. 7-8, 2001, pp. 196-221.

FULGA, A. (2012). *Language and the perception of space, motion and time*. In: «Concordia. Working Papers in Applied Linguistics», vol. III, pp. 26-37.

GALLAGHER, S. (2017). *Enactivist interventions: Rethinking the mind*, Oxford University Press, Oxford.

GALLAGHER, S. (2018). *Situating interaction in peripersonal and extrapersonal space: Empirical and theoretical perspectives*. In: T. HÜNEFELDT, A. SCHLITTE (eds.), *Situatedness and place: Multidisciplinary perspectives on the spatio-temporal contingency of human life*, Springer, Berlin, pp. 67-79.

GALLAGHER, S., ZAHAVI, D. (2008). *The phenomenological mind: An introduction to philosophy of mind and cognitive science*, Routledge, London/New York.

GALLESE, V. (2007). *The "conscious" dorsal stream: Embodied simulation and its role in space and action conscious awareness*. In: «Psyche», vol. XIII, n. 1, pp. 1-20.

GELL, A. (1996). *The anthropology of time: Cultural constructions of temporal maps and images*, Berg, Oxford 1996.

GELL, A. (1998). *Art and agency. An anthropological theory*, Oxford University Press, New York.

GIBSON, J.J. (2015), *The ecological approach to visual perception* (1979), Psychology Press & Routledge Classic Editions, London/New York.

GOODALE, M.A., MILNER, A.D. (1992). *Separate visual pathways for perception and action*. In: «Trends in Neurosciences», vol. XV, n. 1, pp. 20-25.

GREENFIELD, A. (2017). *Radical technologies. The project of everyday life*, Verso, London/New York.

HACIGÜZELLER, (2017). *Archaeological (digital) maps as performances: Towards alternative mappings*. In: «Norwegian Archaeological Review», vol. LII, n. 2, 2017, pp.149- 171.

HÄGERSTRAND, T. (1970). *What about people in regional science?*. In: «Papers of the Regional Science Association», vol. XXIV, n. 1, pp. 7-24.

HEIDEGGER, M. (1927). *Sein und Zeit*, M. Niemeyer, Tübingen.

HELD, R., HEIN, A. (1963). *Movement-produced stimulation in the development of visually guided behavior*. In: «Journal of Comparative and Physiological Psychology», vol. LVI, n. 5, pp. 872-876.

HURLEY, S. (2002). *Consciousness in action*, Harvard University Press, Cambridge (MA).

HUTTO, D.D., MYIN, E. (2012). *Radicalizing enactivism: Basic minds without content*, MIT Press, Cambridge (MA).

HUTTO, D.D., MYIN, E. (2017). *Evolving enactivism: Basic minds meet content*, MIT Press, Cambridge (MA).

IARIA, G., LANYON, L.J., FOX, C.J., GIASCHI, D., BARTON, J.J. (2008). *Navigational skills correlate with hippocampal fractional anisotropy in humans*. In: «Hippocampus», vol. XVIII, n. 4, 2008, 335-339.

IHDE, D., MALAFOURIS, L. (2019). *Homo faber revisited: Postphenomenology and material engagement theory*. In: «Philosophy & Technology», vol. XXXII, n. 2, pp. 195-214.

INGOLD, T. (2020). *The perception of the environment: Essays on livelihood, dwelling and skill*, Routledge, London/New York.

KALCKERT, A., EHRSSON, H.H. (2012). *Moving a rubber hand that feels like your own: A dissociation of ownership and agency*. In: «Frontiers in Human Neurosciensce», vol. VI, Art.Nr. 40 – doi: 10.3389/fnhum.2012.00040.

KITCHIN, R., DODGE, M. (2007). *Rethinking maps*. In: «Progress in Human Geography», vol. XXXI, n. 3, pp. 331-344.

KITCHIN, R., PERKINS, C., DODGE, M. (2009). *Thinking about maps*. In: M. DODGE, R. KITCHIN, C. PERKINS (eds.), *Rethinking maps: New frontiers in cartographic theory*, Routledge, London, pp. 1-26.

LAKOFF, G., JOHNSON, M. (1980). *Metaphors we live by*, University of Chicago Press, Chicago.

LEROI-GOURHAN, A. (1964). *Le geste et la parole*, 2 voll., Albin Michel, Paris.

LEVINSON, S.C. (2003). *Space in language and cognition: Explorations in cognitive diversity*, Cambridge University Press, Cambridge.

LO PRESTI, L. (2017), *(Un) exhausted cartographies. Re-living the visuality, aesthetics and politics in contemporary mapping theories and practices*, Ph.D. Thesis, University of Palermo – http://hdl.handle.net/10447/220860.

MAGUIRE, E.A., GADIAN, D.G., JOHNSRUDE, I.S., GOOD, C.D., ASHBURNER, J., FRACKOWLAK, R.S.J., FRITH, C.G. (2000). *Navigation-related structural change in the hippocampi of taxi drivers*. In: «Proceedings of the National Academy of Sciences of the United States», vol. XCVII, n. 8, pp. 4398-4403.

MAGUIRE, E.A., WOOLLETT, K., SPIERS, H.J. (2006). *London taxi drivers and bus drivers: A structural MRI and neuropsychological analysis*. In: «Hyppocampus», vol. XVI, n. 12, pp. 1091-1101.

MALABOU, C. (2009). *What should we do with our brain?*, Fordham University Press, New York.

MALAFOURIS, L. (2007). *Before and beyond representation: Towards an enactive conception of the Palaeolithic image*. In: C. RENFREW, I. MORLEY (eds.), *Image and imagination*, McDonald Institute, Cambridge, pp. 289-302.

MALAFOURIS, L. (2013). *How things shape the mind. A theory of material engagement*, MIT Press, Cambridge (MA).

MALAFOURIS, L. (2014). *On thinking*. In: N. JONES, S. SKINNER (eds.), *Torque#1. Mind, language and technology*, Link Editions, London, pp. 9-20.

MALVICA, S., RE, A. (2019). *La coscienza che si estende. L'azione oltre la dicotomia soggetto-mondo*. In: «Reti Saperi Linguaggi», vol. VI, n. 1, pp. 151-170.

MARAVITA, A., IRIKI, A. (2004). *Tools for the body (schema)*. In: «Trends in Cognitive Sciences», vol. VIII, n. 2, pp. 79-86.

MCCUNN, L.J., GIFFORD, R. (2018). *Spatial navigation and place image ability in sense of place*. In: «Cities», vol. LXXIV, pp. 208-219.

MERLEAU-PONTY, M. (1962). *Phenomenology of perception* (1945), Routledge and Kegan Paul, London.

MILLIKAN, R. (1995). *Pushmi-Pullyu representations*. In: «Philosophical Perspective», vol. IX, pp. 185-200.

MONTELLO, D.R. (2015). *Spatial cognition*. In: N.J. SMELSER, P.B. BALTES (eds.), *International encyclopedia of the social and behavioral sciences*, Elsevier,

Amsterdam/New York, II ed., pp. 14771-14775.
NICOSIA, E. (2019). *Geography and neuroscience. A new representation of cerebral territories*. In: «Reti Saperi Linguaggi», vol. VI, n. 1, pp. 3-24.
NOË, A. (2009). *Out of our heads: Why you are not your brain, and other lessons from the biology of consciousness*, Hill and Wang, New York.
O'KEEFE, J., NADEL, L. (1978). *The hippocampus as a cognitive map*, Oxford University Press, Oxford.
PANEK, J. (2016). *From mental maps to geoparticipation*. In: «The Cartographic Journal», vol. LIII, n. 4, pp. 300-307.
PARISI, F. (2015). *Tecnologie enattive. La mediazione da una prospettiva cognitivista*. In: «Reti Saperi Linguaggi», vol. IV, n. 7, pp. 125-148.
PARISI, F. (2019). *La tecnologia che siamo*, Codice, Torino.
PARKER, H.D. (1988). *The unique qualities of a geographic information system: A commentary*. In «Photogrammetric Engineering and Remote Sensing», vol. LIV, n. 11, pp. 1547-1549.
PENNISI, A. (2014). *L'errore di Platone,* Il Mulino, Bologna.
PENNISI, A. (2016). *Prospettive evoluzioniste dell'embodied cognition. Il cervello "inquilino del corpo"*. In: «Reti, Saperi Linguaggi», vol. III, n. 1, 2016, pp. 179-201.
PENNISI, A., FALZONE, A. (2010). *Il prezzo del linguaggio. Evoluzione ed estinzione nelle scienze cognitive*, Il Mulino, Bologna.
PENNISI, A., FALZONE, A. (2017). *Linguaggio, evoluzione e scienze cognitive: una introduzione*, Corisco, Roma/Messina.
PROULX, M.J., TODOROV, O.S., TAYLOR AIKEN, A., DE SOUSA, A.A. (2016). *Where am I? Who am I? The relation between spatial cognition, social cognition and individual differences in the built environment*. In: «Frontiers in Psychology», vol. VII, Art. Nr. 64 – doi: 10.3389/fpsyg.2016.00064.
RIETVELD, E., KIVERSTEIN, J. (2014). *A rich landscape of affordances*. In: «Ecological Psychology», vol. XXVI, n. 4, pp. 325-352.
SALAY, N. (2016). *Representations: Problems and solution*. In: A. PAPAFRAGOU, D. GRODNER, D. MIRMAN, J. TRUESWELL (eds.), *Proceedings of the 38th annual meeting of the Cognitive Science Society*, Cognitive Science Society, Philadelphia, pp. 295-300.
SARTRE, J.P. (1943). *L'être et le néant. Essai d'ontologie phénoménologique*, Gallimard, Paris.
SHETTLEWORTH, S.J. (2003). *Memory and hippocampal specialization in food-storing birds: Challenges for research on comparative cognition*. In: «Brain, Behavior and Evolution», vol. LXII, n. 2, pp. 108-116.
SONNENBERG, B.R., BRANCH, C.L., PITERA, A.M., BRIDGE, E., PRAVOSUDOV, V. (2019). *Natural selection and spatial cognition in wild food-caching mountain chickadees.* In: «Current Biology», vol. XXIX, n. 4, pp. 670-676.
STECK, K., HANSSON, B.S., KNADEN, M. (2009). *Smells like home: Desert ants, cataglyphis fortis, use olfactory landmarks to pinpoint the nest*. In: «Frontiers in Zoology» vol. VI, Art. Nr. 5 – doi: 10.1186/1742-9994-6-5.
SVOBODA, J. (2017). *On landscapes, maps and upper paleolithic lifestyles in the central european corridor: The images of Pavlov and Pedmostí.* In: «Veleia», vol. XXXIV, pp. 67-74.
TENEGGI, C., CANZONERI, E., PELLEGRINO, G., SERINO, A. (2013). *Social modulation of peripersonal space boundaries*. In: «Current Biology», vol. XXIII, n. 5, pp. 406-411.
TOLMAN, E.C. (1948). *Cognitive maps in rats and men*. In: «Psychological Review», vol. LV, n. 4, pp. 189-208.
TVERSKY, B. (2008). *Spatial cognition. Embodied and situated.* In: P. ROBBINS, M. AYDEDE (eds.), *The Cambridge handbook of situated cognition,* Cambridge University Press, Cambridge, pp. 201-216.
UNGERLEIDER, L.G., MISHKIN, M. (1982). *Two cortical visual systems*. In: D.J. INGLE, M.A. GOODALE, R.J.W. MANSFIELD (eds.), *Analysis of visual behaviour*, MIT Press, Cambridge (MA), pp. 549-586.
UTRILLA, P., MAZO, C., SOPENA, M.C., MARTÍNEZ-BEA, M., DOMINGO, R. (2009). *A palaeolithic map from 13,660 Calbp: Engraved stone blocks from the late magdalenian in Abauntz cave (Navarra, Spain)*. In: «Journal of Human Evolution», vol. LVII, n. 2, pp. 99-111.
VALLEGA, A. (2003). *Heidegger and the issue of space. Thinking of exilic grounds*, The Pennsylvania State University Press, University Park.
VON UEXKÜLL, J. (1934). *A stroll through the worlds of animals and men*. In: C. SCHILLER (ed.), *Instinctive behavior*, International Universities Press, New York 1934.
WATSON, J.B. (1913). *Psychology as the behaviorist views it.* In: «Psychological Review», vol. XX, n. 2, pp. 158-177.
WEHNER, R. (2020). *Desert navigator. The journey of the ant*, Harvard University Press, Cambridge (MA).
WHORF, B., CARROLL, J.B. (1956). *Language, thought, and reality: Selected writings of Benjamin Lee Whorf*, MIT Press, Cambridge (MA).
WITTLINGER, M., WEHNER, R., WOLF, H. (2006). *The ant odometer: Stepping on stilts and stumps*. In: «Science», vol. CCCXII, n. 5782, pp. 1965-1967.
WOOLLETT, K., MAGUIRE, E.A. (2011). *Acquiring "the knowledge" of London's layout drives structural brain changes*. In: «Current Biology», vol. XXI, n. 24, pp. 2109-2114.