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The Tools of Enculturation

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Abstract

We propose an account of cognitive tools that takes into account the process of enculturation by which tools are integrated into our cognitive systems. Drawing on work in cultural evolution and developmental psychology, we argue that cognitive tools are complex entities consisting of physical objects, representational systems, and cognitive practices for the physical manipulation of the tool. We use an extensive case study of spatial navigation to demonstrate the core claims. The account we provide is contrasted with conceptions of cognitive tools that simplify cognition, in particular that they offload cognitive work, or that the tools themselves are temporary developmental scaffolds or props. Enculturation results in transformed cognitive systems, and we can now think and act in new ways with cognitive tools.

Keywords: Enculturation; Cognitive integration; Cognitive tools; Offloading; Scaffolding; Spatial cognition

1. Introduction

This article has two aims: First to present a case for the integration of cognitive tools into our cognitive systems as a process of enculturation. Second, to present an argument

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against the simplifying account of cognitive tools as “offloading” cognitive complexity or “outsourcing” cognitive processing to the tools themselves. The primary argument of this article is that human cognition is pervasively and profoundly enculturated and not just at the surface. Our brains are changed by social learning (Anderson, 2014; Menary, 2014) as well as the ways in which we interact with our physical, social, and cultural environments. Enculturation results in a deep integration between brain, body, and cognitive tools (Menary, 2007a). Humans are exceptional in just this sense. Much of the literature on cognitive tools has yet to fully embrace the importance of enculturation. One reason for this, we will argue, is an over-reliance on analysis of cognitive tools from the 1980s to the 1990s, which analyzes cognitive tools in terms of cognitive offloading and outsourcing.

This article will analyze the role of cognitive tools in enculturation by identifying what a cognitive tool is and how cognitive tools are integrated into our cognitive lives. We describe this integration as a process of enculturation. Enculturation does not simply result in a transformed cognitive system; it results in integrated cognitive systems that incorporate tools and cultural practices as proper parts of those systems and not just as developmental or causal scaffolds. The second section identifies what cognitive tools are. The third section outlines the core components of enculturation and how cognitive tools are integrated into cognitive systems. The fourth section presents a case study of enculturation and cognitive tools by analyzing the cognitive practices that transform our cognitive capacities for spatial navigation and wayfinding. In the fifth section, we argue against offloading and scaffolding approaches to cognitive tools.

2. Defining cognitive tools

Hominins have been making tools for a long time. The primary tools of early tool-making cultures, such as the Achulean, were stone tools crafted for cutting meat and scraping hides (Foley & Lahr, 2003). Many tools that behaviorally modern humans make are similarly practical in nature. They aid in performing a practical or physical task—cutting up meat, preparing it for consumption, or animal skins for clothing. However, some theorists have interpreted traces in the archaeological record as precursors to fully symbolic representational systems dating back as far as 800–300 kya (Colagè & D’Errico, 2020). Clear evidence of the systematic innovation and use of tools that aid us in performing cognitive tasks appears only very recently, perhaps in the last 5–10,000 years (Donald, 1991).

A cognitive tool is a tool that has been innovated and made for completing cognitive tasks. Cognitive tasks require us to be able to think through a series of steps in order to complete the task and, while humans and other animals are capable of reasoning, cognitive tools are designed to help us think through those steps and complete the task at hand (Gillett, 2021; Hutchins, 1995; Kirsh, 1995; Norman, 1991).

It seems that cognitive tools only appear systematically when there is a need for them, and there is a need for them only when humans begin a particular kind of life-way (or mode of living). This mode of living is characterized by (relatively) large, organized populations, which eventually became sedentary in urban landscapes and dwellings where very peculiar cognitive tasks emerged such as keeping track of economic exchanges, calculating the value of goods,

keeping records of laws, theological rules, calculating the amount of materials necessary for building dwellings, places of worship, palaces (Basu, Kirk, & Waymire, 2009; Graeber, 2011; Mullins, Whitehouse, & Atkinson, 2013; Schmandt-Besserat, 1996).

Behaviorally modern humans who do not live this way almost always engage in some form of symbolic activity, painting, creating narratives and origin stories that are verbally recited and generationally inherited as items of religious or cultural significance. The account of cognitive tools that we provide here covers general symbolic cognitive tools and specifically symbolic representational systems, such as writing systems and mathematical notations.

There are three broad classes of cognitive tools that we will propose (Menary, 2018b):

1. Symbolic tools: such as writing systems, number systems, computer languages, diagrams, or systematic frames of reference.
2. Sensory tools: Physical tools that are designed to extend our senses so that we can observe the microscopic, or the very distant, such as telescopes, magnetic compasses, and microscopes.
3. Tracking tools: Physical tools that are also symbolic and help us to keep track of features of our environment, such as rulers, protractors, sextants, radar systems, maps, and Global Positioning System (GPS) devices.

The primary examples of cognitive tools that we will focus on are the first and third types. There have been a number of analyses of cognitive tools. For example, those by: Clark (1997), Heersmink (2013), Humphreys (2004), Hutchins (1995), Norman (1991, 1993), and Menary (2007a, 2018b). Norman's influential analysis introduces the important concept of how cognitive tools change the nature of the task being performed and not just our ability to complete the task. Norman (1991) gives the example of using a checklist (e.g., a shopping list or safety procedure). In this analysis, a cognitive task that would involve the retrieval of items from memory is transformed into a series of physical manipulations of serially organized symbols and their correspondence to perceptual features in the environment.

The problem with Norman's analysis, and similar analyses, is that they are restricted to an account of cognitive tools as transforming the nature of cognitive tasks but not the nature of cognition itself. The enculturation analysis does not focus exclusively on task transformation, although this is indeed a crucial aspect of how humans use cognitive tools, but also on the transformation of our cognitive capacities themselves (Menary, 2007a, 2010, 2015, 2018a). Enculturation goes beyond task structuring and temporary scaffolds. Sometimes we organize our working environments to make cognitive tasks simpler or more ordered: This might be as simple as decluttering a desk or putting files into a logical order. But these examples are relatively trivial, and we do not think that the proper role of cognitive tools is to merely simplify cognition or to offload cognitive complexity onto the environment (e.g., see Kirsh, 1995, Sterelny, 2010). In Section 5, we will provide a clear set of objections to this way of thinking about cognitive tools.

Symbolic and tracking tools are complex entities because they must be, on the one hand, physical things that can be manipulated, but on the other hand, they must have some representational significance. The key here is the combination of the manipulation and the significance in a governing normative practice. A practice is a repeatable way of doing something that is

normative in the sense that there is a right and wrong way to do it (Menary, 2007a, 2018a). In the case of symbolic cognitive tools, it is not just the physical traces of the tools themselves that matter, it is also the normative practices for creating, ordering, and manipulating them. Consequently, one cannot consider the cognitive tool, the physical symbols, in separation from the practices, which govern their manipulation. Cognitive tools are to be thought of conjointly with cognitive practices (Menary, 2007a).

The critical feature of our account of cognitive tools is the nature of cognitive practices. Cognitive practices are a species of normative patterned practice (Menary & Gillett, 2017). Patterned practices are repeatable actions that can be spread out across a population, they are acquired through social or specific cultural learning. They are subject to alteration or amendment over time, and they are highly transmissible intergenerationally because they can be taught.

Their normativity is a consequence of their social nature and also because they are acquired through teaching and learning. In the process of teaching, the teacher indicates that there are right and wrong ways to perform a practice. The teaching process is normative in so far as it involves correction of mistakes; it, therefore, embodies the correct and incorrect way to act (Moore, 2017). Enculturation through cognitive practices results in those tools becoming integrated into our cognitive systems. We explain how this happens in Section 3. Our argument is that there are significant explanatory pay-offs to taking this approach to cognitive tools rather than an offloading or scaffolding approach (Menary, 2018a). In the next section, we outline the core features of enculturation.

3. Enculturation and cognitive integration

Enculturation gives us the resources to explain how we come to be a cognitive tool-using species and how humans acquire the capacities for deploying cognitive tools when completing cognitive tasks. It does this both in terms of the cultural evolution of tools and cognition (phylogeny) and in terms of the development of human cognition (ontogeny). The key to the phylogeny of human cognition is cumulative cultural evolution, and this appears to be primarily an achievement of humans. We would not be giving a detailed account of cognitive phylogeny and cumulative cultural evolution because it is not the focus of this article.¹ Let the following serve as a brief background before we move into a discussion of the key mechanisms of enculturation considered through the lens of cognitive development (ontogeny).

There is evidence of tool-using culture in animals, where the ability to use a tool (and in some cases its manufacture as well) is acquired through social learning (learning through social interaction with others; for summary, see Laland, 2017). Examples include tool making in chimpanzee societies (Gruber, Clay, & Zuberbühler, 2010), the dolphins of Shark Bay (Krützen et al., 2005), and New Caledonian crows (Taylor, Elliffe, Hunt, & Gray, 2010).

Importantly, the ability to make and use tools is not a natural instinct (Heyes, 2018); in other words, it is not strictly innate. Furthermore, the making and using of tools, at least in some animals are behaviorally transmitted or inherited. Therefore, it is not, strictly, a matter of genetic inheritance but is also of non-genetic inheritance. It is controversial whether or not social learning for tool use in animals constitutes cultural inheritance since it is unclear

that there is cumulative cultural evolution² in animal cultures (Heyes, 2018; Tomasello, 1999; Whiten, Hinde, Laland, & Stringer, 2011), even though there are clear instances of variation in behavior among animals (Whiten et al., 1999).

By contrast, the existence of cumulative culture in the human lineage is uncontroversial. Tomasello considers the most important feature of cultural inheritance systems to be what he calls “the ratchet effect” (Tomasello, Kruger, & Ratner, 1993): Innovations to cultural traits accumulate and are built upon over generations (cumulative cultural evolution). There are some disagreements about the exact nature of cumulative cultural inheritance (Boyd & Richerson, 2005; Tomasello, 1999), cultural learning (Tomasello et al., 1993), and the cultural intelligence hypothesis³ (Csibra & Gergely, 2009; Heyes, 2018; Tomasello, 1999). These debates need not detain us here. Suffice it to say, humans are tool users and makers par excellence. They are the only animals who are equipped for cultural learning⁴ that results in cumulative cultural inheritance, where novelty and innovation in technology are hallmarks of those cultures. In modern human societies, cultural inheritance and cultural learning are pervasive.

Models of cultural evolution include extended inheritance as a concept. This is simply the idea that there are multiple inheritance mechanisms, not a single one (Jablonka & Lamb, 2005). Cultural learning is the extended inheritance mechanism by which various cognitive traits are transmitted and acquired. It plays an important role in the development of cognitive traits and, therefore, in the enculturation of cognition.

Enculturation can be defined as the process by which cognitive capacities are altered and extended by cultural learning. The core features of enculturation are as follows:

1. Modern human minds are highly flexible/plastic and exhibit a high degree of cognitive potential.
2. Modern human minds are dependent upon cultural learning and high-fidelity transmission to acquire knowledge, skills, and develop and refine cognitive capacities.

These two conditions jointly allow for the transformation of cognitive abilities across the cognitive spectrum: problem-solving (Menary, 2007a), memory (Nelson & Fivush, 2020; Sutton, 2007), perception (Downey, 2016; Majid et al., 2018), executive functions (Braem & Hommel, 2019), attention, planning, group coordination (Gillett, 2021), social cognition (Heyes, 2019), emotions (Feldman Barrett, 2017), reading and writing (Fabry, 2018; Menary, 2007b, 2014), and mathematical cognition (Fabry & Pansar, 2021; Menary, 2015, Menary & Gillett, 2017). Enculturation is causally dependent upon the local cultural environment, and if there is variation in these environments, then we ought to see a variation in the cognitive routes to success. Each generation does not need to reinvent the wheel. Instead, gradual accumulations of incremental and small innovations and lucky advances can lead to composites that could not have been achieved by an individual within a single lifetime (Boyd, Richerson, & Henrich, 2011; Fabry, 2017; Henrich, 2016). Considering the challenges of spatial navigation, Hutchins (1995) points out that when agents tackle new challenges in their environment, they often do not start from scratch but rather build from the basis of the cultural knowledge and accumulated practices, strategies, and cognitive tools that they have. As such, humans can make use of cognitive tools that could not have been invented in a single lifetime. For

example, the invention and implementation of the mapping of the Earth using the Mercator projection took several centuries but forms the basis for many prototypical maps (Snyder, 1987).

Enculturation is pervasive across human cognition; modern human minds are highly flexible and attuned to cultural learning, social cooperation, and social communication. While cognitive development is strongly biased toward developing the capacities that allow for learning, cooperation, and communication, these capacities are still acquired and refined during development and in some cases across the lifespan (Heyes, 2018, 2019). In the following Sections (3.1 to 3.3), we focus on some of the ontogenetic mechanisms of enculturation.

3.1. Learning-driven plasticity and learning-driven bodily adaptability

Learning-driven plasticity is the capacity of the brain to make changes to neural and cognitive functions that are being driven by cultural learning (Menary, 2014). Learning-driven bodily adaptability, as proposed by Fabry (2018, 2020), “is associated with adaptive changes to the schemas of body parts by inducing changes to proprioceptive and sensori-motor processes” (2020, p. 3702). The key properties of learning-driven plasticity and learning-driven bodily adaptability characterize the changes of cognitive functions by virtue of cultural learning.

Cultural learning takes place in a highly structured learning environment: with communication between child and caregivers; practical tools, cognitive tools (such as symbolic representations); various norms and practices and institutions—including religious, legal, and educational. In some cases, learning may be unstructured, such as playing with peers, in others, it will be highly structured, such as planned lessons. The typical structuring of the learning environment is by the interactions between pupil and teacher and the communication and coordination strategies they use during the lesson. Cultural learning requires a wealth of structured stimulus rather than input impoverished of structure. Consequently, the familiar arguments from poverty of the stimulus do not have the same grip (Sterelny, 2003, 2012). The structure is built into the pedagogical techniques and the physical structure and layout of the learning environment. Cognitively, children must be flexible enough that they can adapt to these structured learning environments. For example, children begin their transformation into abstract mathematical reasoners by learning the serial order of numbers by counting on their fingers, repeating counting songs, and games. They also begin to visually recognize numerals, tracing and writing numerals in order, and so on (Bender & Beller, 2012; Moeller, Pixner, Zuber, Kaufmann, & Nuerk, 2011). In the Western navigational niche, children begin their transformation into spatial reasoners by acquiring linguistic terms for frames of reference, engaging with games, nature-based education, traversing spaces, and manipulations of graphics depicting spatial relations (Aladağ, Arıkan, & Özenoğlu, 2021; Ekiss, Trapido-Lurie, Phillips, & Hinde, 2007; Milkova & Pekarkova, 2021). Importantly, as we discuss in greater detail in Section 4, the capacity for abstract reasoning about space is related to children interacting with and learning to manipulate simple maps (Uttal, 2000).

3.2. *Cognitive potential*

What is cognitive potential? It is the potential of any cognitive system to acquire novel cognitive functions through a process of learning. Learning-driven plasticity and learning-driven bodily adaptability are key traits necessary for cognitive potential (Fabry, 2020; Menary, 2014). The key here is that the system should be flexible enough to accommodate the functional changes necessary for novel cognitive capacities. Cognitive potential can be understood in terms of the plasticity of neural circuitry, which allows it to be re-used for novel cognitive functions (Anderson, 2010, 2014; see also Colagè & D'Errico, 2020). There are a number of good examples of neural reuse,⁵ but we will not focus on these. Instead, we will focus on cognitive potential as a matter of acquiring cognitive capacities through learning. A classic treatment is Vygotsky's zone of proximal development (ZPD). The ZPD can be understood as the distance between an individual's current level of development and what they can potentially do. As such, teaching is a matter of guided participation in an existing practice (Vygotsky, 1978). Vygotsky's conception of psychological development is that cognitive, or psychological functions (or capacities), have cultural and social origins.

Vygotsky's conception of psychological development is an early example of enculturation: In learning, to manipulate cognitive tools, the cognitive capacities of the agent are transformed. They are now able to think and act in ways that were not available to them prior to developmental transformation (Cole & Gajdamaschko, 2007; Menary, 2007a). Vygotsky has been widely influential in contemporary developmental psychology and educational psychology; for example, Preiss and Sternberg define cognitive tools in a way that is inspired by Vygotsky and in line with the account that we present in this article:

[Cognitive tools] predominantly afford transformations on the symbolic aspects of cultural life and, eventually, transformations of the users of those technologies. In so doing, cognitive tools, as systems of representation, play a central role in both cultural evolution and cognitive development. (Preiss & Sternberg, 2006, p. 15)

We can also think of cognitive potential at a populational or species level in terms of the capacity for acquiring new or significantly transformed cognitive functions through cumulative cultural evolution and cultural learning. In enculturated cognitive systems, the cognitive potential is present not just in the plasticity of the human brain but also in the cultural accumulation of cognitive innovations, such as practices, artifacts, and representations. The cognitive potential then becomes a matter of cultural evolution: how adding new cultural components to enculturated cognitive systems increases the capacity of groups of agents and individuals to complete cognitive tasks.

One straightforward way of thinking of this is to look and see whether the introduction of new practices, symbols, or artifacts allows for the completion of cognitive tasks that were previously either not possible or intractable (Menary, 2018a), for example, mathematical cognition involving imaginary and complex numbers (Menary & Gillett, 2017), reliably traversing long distances safely through featureless, or changeable terrains (Aporta & Higgs, 2005; Hutchins, 1995).

3.3. *Dual-component transformations*

A standard conception of symbolic scaffolds as supports for cognition holds that once symbols are “internalized,” there is no longer any need to perform operations on them, except where this is a matter of offloading cognitive work. Enculturation, which leads to cognitive integration, entails something quite different: When children learn to recognize symbols, such as numerals and letters, they do so by manipulating them, drawing them, reciting them, manipulating blocks and figures, ordering them verbally and physically. The developmental process has dual components: mastering symbol systems, being able to recognize (public) symbols and their significance; and learning to create, manipulate, and order symbols in a physical medium. The mastery of symbol systems can be thought of as having two interacting developmental trajectories: the manipulation route and the meaning or significance route. The key outcome is that mastery does not entail that the capacity to manipulate symbols physically disappears.

A prediction of enculturation and cognitive integration is that the capacity to manipulate symbols is not a temporary developmental stage that is merely supportive of cognition, it is (partly) constitutive of the capacity to think symbolically. Symbolic cognition never dispenses with these dual routes. It is important to note that much of the educational literature still holds to the idea that cognitive tools are temporary developmental scaffolds and props that can be dispensed with once mastered. For example, Pakdaman-Savoji et al. state, when discussing the use of software for diagramming mapping of arguments: “As students use the DM [diagram map] to construct arguments over multiple occasions, they gradually reorganize their argumentation schema and eventually no longer need the software to construct arguments with warrants, rebuttals, and other advanced features” (Pakdaman-Savoji, Nesbit, & Gajdamaschko, 2019, p. 10). What they do not consider is how students might diagram arguments with pen and paper rather than in the app. If they still use diagrams to formulate arguments, then this is an example of dual-component transformations. Our case studies in Section 4 are good examples of dual-component transformations, and we shall allow that section to make the case for it.

In the rest of this section, we briefly outline the dimensions of integration that result from enculturation and dual-component transformations. These dimensions can be used as a way of determining how much integration there is in the case at hand. In the next section, we shall use those dimensions to evaluate the degree of integration in our case studies of cognitive tools for spatial navigation.

The key feature of cognitive tools is that they cannot be thought of independently of the cognitive practices, which we learn when we are taught how to manipulate those tools. The alternative to the enculturated way of thinking is to think of tools as props for thinking or as a way of outsourcing and offloading our thinking onto the tool (which will do the work for us). Call this the cognitive outsourcing approach: We outsource cognitive processing to cognitive tools, which do the cognitive work for us (Menary, 2012). In the next section, we outline the cognitive integration framework, which explains how cognitive tools are integrated into our cognitive systems.

3.4. *Integrated cognitive systems*

Cognitive integration is a framework for understanding cognition both as a consequence of cultural evolution and the prolonged development of an agent within cognitively structured environments (Menary, 2007a, 2018a). Integrated cognitive systems are a result of enculturation. By adopting the integrationist framework, it becomes clear that the ways in which we interact with cognitive tools, and physically manipulate them to successfully tackle cognitive tasks, cannot be reduced to the transfer of information or tightly coupled flows of information. This is because the successful use of a particular cognitive tool for the completion of a cognitive task involves more than the mere causal interaction of an agent and a tool.⁶ It also involves the acquisition and mastery of cognitive practices that govern the embodied manipulations of these tools toward the successful completion of cognitive tasks. In this manner, the capacities of the agent are transformed in a number of ways. First, the mastery of cognitive practices is associated with novel abilities for solving problems and acquiring knowledge. Second, it enables the agent to engage in forms of reasoning that would otherwise be impossible. Particularly important is the recognition that “[c]ognitive practices are genuine ‘components’ of our mental and cognitive capacities, they are dynamic, active, processes by means of which we think and successfully complete cognitive tasks” (Menary, 2013, p. 27).

The manipulation thesis has its roots in Rowlands’ definition: “[C]ognitive processes are not located exclusively in the skin of cognising organisms because such processes are, in part, made up of physical or bodily manipulation of structures in the environments of such organisms” (Rowlands, 1999, p. 23). Manipulations of cognitive tools are not just causal interactions but are also governed by cognitive norms, which are learned and mastered by agents during ontogeny. These norms direct the embodied manipulations of environmental features toward the successful completion of cognitive tasks. These cognitive processes are partially constituted by the manipulation of structures in the environment (Menary, 2007a; Rowlands, 1999).

Menary (2018a) introduced a dimensional framework for scoring integration. A case of genuine cognitive integration and not merely offloading would score highly along these core dimensions:

1. Coordinated interactions—interactions with the environment and others when completing cognitive tasks.
2. Cognitive practices that normatively regulate and coordinate those interactions.
3. Bodily manipulations of cognitive tools that identify the specifics of the interactions.
4. Cognitive transformations that result in the acquisition of a novel cognitive ability or the transformation of an existing ability. Cognitive transformations are a direct result of Enculturation.

The idea of coordinated interactions is quite general but that of cognitive practices is highly specific. Cognitive practices are regulative/normative ways of interacting with the environment or others when completing cognitive tasks. Sometimes these practices govern bodily manipulations of tools when completing cognitive tasks. Enculturation is the developmental

process by which cognitive abilities are acquired and transformed through cultural learning. Dual-component transformations are a good example of enculturation.

The integration of cognitive tools into our cognitive systems results in high degrees of coordinated interactions and transformations. Cases of cognitive tools that are mere supports for our cognitive systems or allow for us to offload cognitive work onto the tool itself, will fail to exhibit the same degree of coordination by cognitive practices and the transformation of our cognitive capacities.

We now turn to a case study of enculturation and integration.

4. A case study of the tools of enculturation: Spatial navigation

An important example of a cognitive trait, or more accurately a collection of traits, is spatial reasoning for the purposes of navigation and wayfinding—a fundamental task engaged in by many organisms traversing their environments. Knowing where one is, where to find various resources or conspecifics, and where to obtain safety are crucial to survival (Shettleworth, 2010; Waller & Nadel, 2012). Spatial navigation is a complex ability because it involves a wide variety of other cognitive capacities and the integration of multisensory information over space and time—memory, perception, and spatial updating between offline and online processing (Ekstrom et al., 2018; Wolbers & Hegarty, 2010).

Spatial cognition plays a central role in many other everyday cognitive tasks and behaviors in ways that often go unnoticed (Ishikawa, 2016; Montello & Raubal, 2012). In humans, skills in spatial navigation vary greatly across individuals (Ishikawa & Montello, 2006) and can be refined through training (Uttal et al., 2013). While humans share some basic phylogenetically widespread ways of engaging in spatial navigation and reasoning (Cheng, Shettleworth, Huttenlocher, & Rieser, 2007; Shettleworth, 2010), it is also important to recognize that there are wayfinding techniques and ways of reasoning about space that are peculiarly human, culturally learned, and involve the manipulation of cognitive tools.

Spatial cognition can broadly be distinguished into three scales, which present different challenges, each of which involves certain kinds of spatial skills (Newcombe & Shipley, 2015): small-scale (object manipulation), medium-scale (the immediate space surrounding an organism), and large-scale (environments that require significant locomotion in order to be perceived; Waller & Nadel, 2012). When tackling challenges in large-scale spatial reasoning, we can differentiate between navigation—the ability to follow a preset route through space—and wayfinding—the ability to take a novel route through space (Golledge, 1999). Navigation and wayfinding involve different forms of cognitive processing. Waller and Nadel (2012) differentiate between offline and online processing, involving multisensory information and memory, and the requirement for their integration—referred to as spatial updating. Navigation and wayfinding involve and produce different kinds of knowledge: object-place (e.g., landmarks); route (e.g., series of landmarks, path segments, and decision points); environment shape (e.g., carpentered spaces); and survey (the overall spatial layout of an environment; McNamara, 2012).

Human spatial navigation and wayfinding are replete with a wide array of differing kinds of “wayfinding technologies” (Mullen, Palac, & Bryant, 2016). These produce and facilitate

different kinds of knowledge (Gillett & Heersmink, 2019) and transform the way in which we think about space. We now discuss a range of examples based around the kinds of cognitive tools introduced in Section 3 with a focus on symbolic tools (Section 4.1); and tracking tools (Section 4.2). These examples have been chosen because they allow us to demonstrate the explanatory advantages of the enculturated approach.

4.1. *Symbolic tools*

Human groups have been engaged in collaboratively devising systematic approaches to navigation for millennia. This is an example of virtual collaboration in which cognitive potential is harnessed at a populational level. The basic problems have been tackled by a vast array of individuals across multiple generations, and this has reorganized the task space through the incremental creation and refinement of tools to help solve aspects of the task space (Hutchins, 1995; also see Boyd et al., 2011; Fabry, 2017; Gillett, 2018; Henrich, 2016; Sterelny, 2003; Tomasello, 1999). Hutchins identifies three main features of the cultural niche of navigation in the Western tradition: the increasing use of physical artifacts, digital measurement, and the importance of maps as the central cognitive tool (1995, pp. 95–112).

Below, we discuss maps; here, we focus on what is perhaps the most distinctive but overlooked aspects of wayfinding techniques in the Western cultural niche: the use of symbolic representational systems for measuring time and space in terms of discrete quantities. In his famous analysis, Hutchins (1995) emphasizes the base-60 structure of the various units of measurement—as opposed to the more common base-10 structure of Hindu–Arabic numerals.⁷ For example, time is measured in terms of minutes composed of 60 s and hours composed of 60 min; direction is measured in terms of 360° of the compass and degrees of angular measurement—latitude or longitude (each 180°). Distance is not measured using a base-60 structure, but the nautical mile is influenced by the base-60 structure. The last of these discrete units is the most complicated because the length of a nautical mile is proportional rather than absolute and is based on the system of angular measurement. One nautical mile is equivalent to 1 min of one arc of rotation on the surface of the Earth (i.e., there are 360×60 nautical miles around the circumference of the Earth, which is 21,600). As such, this unit of measurement has historically changed in absolute length depending on how measurements of the size of the Earth have been refined (Hutchins, 1995, p. 60).

This abstract representational cognitive tool has implications for how agents approach and compute spatial navigation tasks. An extensive range of empirical evidence suggests that learning a discrete numerical system has transformative effects for the neurocognitive profiles of agents: initiating both neuro-plastic changes to the structure and connections of cortical regions, especially the intraparietal sulcus, and also altering functional behavior toward tasks (Anderson, 2014; Ansari, 2008; Dehaene, 2007, 2011; Fabry, 2020; Menary, 2015; Menary & Gillett, 2017; Nieder & Dehaene, 2009).

The key feature of this systematic frame of reference for cognitive behavior is the discrete and digital measurement units that provide a way of quantifying space. Treating space as a discrete quantity seems like a perfectly ordinary and “normal” thing to do. But it is important to recognize that the “naturalness” of this way of thinking about space is a product of being

inculcated into this particular cultural niche. Space is an inherently continuous medium, so any spatial categories are constraints on the relational information (Holden & Newcombe, 2012).

In some cultures, abstract spatial categories do not treat space as a discreetly quantifiable medium. Instead, the cognitive practices and abstract representations categorize space for navigational tasks without quantifying it. For example, in traditional Micronesian nautical navigational practices, once beyond the sight of land, the expert navigator engages in two forms of abstract representations that involve “fictional motion” (Hutchins, 1995, 2005).⁸ First, they imagine their canoe remains stationary while the world moves around them. Agents learn to attend to the sensations of how their bodies feel while sailing in order to judge their speed, as well as the direction of their canoe. Additionally, an imaginary moving island called an “etak” is projected by the navigators to be beyond the horizon and traveling parallel to their course. This allows them to divide their journey into several non-discrete stages—e.g., a quarter of the way, halfway to the destination, and so forth—which are ratios that vary based on the environment conditions (e.g., prevailing winds, the strength of currents, seasonal changes, etc.).

The passage of the etak involves a second abstract representation: a sidereal compass of how stars rise and fall in the sky at different times of the day. These movements trace out “star paths” related to certain constellations. Hutchins notes that although seeing a star is a simple perceptual task, constellations do not exist independently of cultural knowledge traditions, which have arranged a set of stars into a perceptual group: “While an eye can register a pinpoint of light, seeing that pinpoint as a star is a cultural accomplishment” (2011, p. 441). He further elaborates that this is an embodied cognitive activity dependent on the agent’s “...brain, of course, but also on his body and his eyes, and on a set of traditional cultural practices that orchestrate the interactions among a complex collection of elements” (2008, p. 2012). This provides expert navigators who have learned how to see these patterns with a sidereal compass that defines 32 directions (Hutchins, 1995, p. 69, 2005).

Combined with the cognitive practices that govern their manipulation, these two abstract representational cognitive tools transform the capacities of the expert Micronesian navigators so that they are able to traverse vast regions of the sea without any landmarks. The Pacific region, such as the Caroline Islands, is notable for being approximately 0.2% land (Hutchins, 1995).

Hutchins (1995) remarks that the original attempts by anthropologists to understand this systematic frame of reference tried to impose the quantification metric of the Western cultural niche and thus were unable to understand how these cognitive practices actually operated. While this alternative system of navigation and thinking about space might seem baroque from a Western perspective, the point is to recognize that the quantifying metric also involves learning a complex set of cognitive practices for how to see the world a certain way—what Hutchins (2011) refers to as “seeing as,” and this too is a cultural accomplishment. It changes the way we think about space.

Porter (1992, 1995) notes that quantification trades in local nuance and richness for portability and usability: Systems of quantification transform local experiential skills and know-how into public knowledge through abstraction. Stripped of context, we now have a

standardized measure that treats all space and time as equivalent; that is, an objective measure. While this ignores local differences, it provides a systematic mapping strategy that can be transposed onto any place and time. Indeed, Nguyen (2020) emphasizes that quantified measures are more usable and portable precisely because they involve simplification. But using a quantified metric to tackle spatial navigation challenges is not just about simplifying the task space or offloading the workload. It is about learning and mastering a set of cognitive practices for a novel way of thinking about space that facilitates certain forms of abstraction that would otherwise be hard to obtain without this cognitive tool. Learning and mastering the cognitive practices from these differing cultural niches alters cognitive potential for wayfinding in different ways. In neither case, can we just conceive of this solely in terms of offloading or scaffolding.⁹

The discrete, symbolic representations for representing time and space inevitably score highly on the dimensions of integration (see Section 3.4): (a) clear instances of interactions with symbolic representations and measurements; (b) mastery of cognitive practices for interpreting and manipulating those symbols is very clearly necessary; (c) bodily manipulation of those symbols is important when interpreting charts, maps, and displays, or orienting oneself in regards to astronomical phenomena; (d) cognitive capacities for spatial navigation are profoundly transformed by the acquisition and mastery of these representational systems.

We now discuss maps as an example of tracking tools.

4.2. *Tracking tools*

What are maps when considered as cognitive tools? A standard response would be to think of maps as representations of space. However, the term “map” is hard to define and is used in lots of different kinds of ways (Montello & Raubal, 2012; Mullen et al., 2016; Uttal, 2000; Wood, 2010). Here, we are focusing on prototypical maps that portray a landscape from an overhead “God’s eye view”—for example, road maps, sea charts, atlases, and so forth. The common characterization as a “bird’s eye view” is a misnomer because maps do not portray the foreshortening that would naturally occur if one were simply up in the sky like a bird. Instead, maps are fictional depictions that use a standardized metric of discrete spatial points. Thus, maps enable a novel perspective that transcends one’s direct experience (Hutchins, 1995; Uttal, 2000).

Hutchins describes a prototypical map as the physical embodiment of the Western navigational tradition—a “crystallization of practice in a physical artifact” (1995, p. 107). A map blends several forms of conceptual space with physical space: the physical space of the map itself as an object upon which manipulations can be made; the conceptual iconic representation of the surrounding environment; and the conceptual spaces of the Mercator projection or whatever mapping framework is used. The latter includes several discrete measurement systems: compass directions; a longitudinal and latitudinal grid system imposed on the world (Hutchins, 1995, 2006, 2010). Hutchins (2005, 2010) adds that such a sophisticated cognitive achievement is made possible by the fact that the map acts as a “material anchor”—that is, the physical structures of the map make the conceptual representations more stable. One could argue that the map here is playing a role of offloading cognitive work from working memory

and simplifying perception because the external representations are “frozen” (Huebner, 2014, p. 179) allowing for, and simplifying, more prolonged engagements and refinements (also see Clark, 2008; Kirsh, 2010). But if we were to cease our enquiry at this juncture, we would overlook a range of important features.

The key point is that learning to use maps transforms our conception of space and alters cognitive potential. What is the impact of learning to use maps on an agent’s developing spatial cognition skills? In contrast to other organisms, because of cultural learning and cognitive tools, humans can learn about an environment in a variety of ways. A strategy that we share with many other species: by traversing a region we learn how to traverse it.¹⁰ Alternatively, we may use a species-specific strategy: to manipulate a prototypical map. The latter strategy provides a very different perspective on spatial information, compared to perspectives from the direct experience of navigating in the world.

Ingold (2000) makes a distinction between map users and wayfinding using local cultural knowledge. Imagine two scenarios. Scenario one: You are walking along with a map and a friend asks where you both are. At a point with a good view, you stop and pick out landmarks and then identify a place on the map as being where you are. Scenario two: You are walking around an area in which you are very familiar with someone who is a stranger to the land, who asks where you both are. At a point with a good view, you stop and pick out the landmarks and describe how this place relates to all the other places and associated narratives that go along with those places. You give an account of the local cultural history.

In this second scenario, Ingold is emphasizing that knowledge is picked up through lived experience—know-how. Ingold makes this distinction to point out that for many humans,¹¹ wayfinding is an intimate relationship with one’s local environment and one’s cultural niche. In contrast, he argues, map-making (cartography) can be quite abstract and divorced from our experience of living in the world and really understanding our relationship with the environment. Ingold defines wayfinding “...as a skilled performance in which the traveller, whose powers of perception and action have been fine-tuned through previous experience, ‘feels [their] way’ towards his goal, continually adjusting [their] movements in response to an ongoing perceptual monitoring of [their] surroundings”—the unfolding of a field of relations that are established through the agent becoming immersed in their environment (2000, p. 220).

However, what Ingold overlooks here is that although map-using is certainly a different strategy for wayfinding, *it is still wayfinding*. It just involves a different set of cognitive practices that involve a different way of engaging with the world and subsequently differing kinds of cognitive potential. And it is important to note that this is an active wayfinding technology. It is one that requires the coordination of the user, the world, and the external representation (Ishikawa, 2016; also see Gillett & Heersmink, 2019; Li, Zhu, Zhang, Wu, & Zhang, 2013). As such, it is not the case that the agent is divorced from the world. Instead, the cognitive tool mediates a transformed relationship, one that comes with novel capacities—and one that Ingold has identified: abstraction. If one conceives of a prototypical map only in terms of offloading, these details are overlooked.

Uttal (2000) has argued that when children learn to think and use maps to tackle spatial navigation challenges, this facilitates a mode of thinking about large-scale spaces in a way that cannot be obtained by direct experience. As Ingold’s two scenarios above highlight,

learning about a space with a map and through experience produce different kinds of knowledge. When traversing an environment, one has a dynamic egocentric interaction with salient information—for example, routes and landmarks. When using a map, all these features are portrayed statically in a single allocentric perspective (Uttal, 2000). An agent who can properly manipulate a map can gain visual access to a much larger range of spatial relations than would otherwise be possible and is therefore able to gain survey knowledge more easily. Maps allow agents to conceive of the world beyond their immediate experience. The primary way in which we know about the world beyond our immediate experience is through maps. We can consider spatial relations without actually having to traverse through that space. So in one sense, this is an augmentation of our senses—the capacity to visually perceive spaces that we would not otherwise directly experience and a novel form of perspective-taking. As Wood puts it: Maps give us “a reality that exceeds our vision [...] a reality that we can achieve in no other way” (2010, p. 15).

In terms of a new perspective, it is important to recognize that learning to use and think using maps helps children to acquire abstract concepts of space, and the ability to think systematically about spatial relations that they have not directly experienced.

An abstract conception of space is one in which space exists independently of objects within the space. Space itself becomes an object of inquiry and one that can be analyzed and measured by a discrete system. Young children tend not to think about space in this manner. Uttal argues that through interacting with maps—and their God’s eye top-down view—children develop in a highly structured cultural niche in which maps facilitate the development of survey-like representations. In turn, these enable novices to begin to make systematic insights and recognitions about relationships in the environment that transcends their direct experience and conceive of that which might not have otherwise been thought. Uttal concludes: “Exposure to maps affects how people think about spatial information. This effect is analogous to that of written text on people’s conception of language and mathematical symbols on their conception of number” (2000, p. 267).

The transformation of cognitive abilities is accompanied by neurocognitive changes. A neuroimaging study by Lobben, Lawrence, and Pickett (2014) focusing on mental rotation shows that enculturated agents engage with maps differently, compared to other geometrical arrays. The results showed that maps are categorized differently from other geometric objects and that they involve different neural correlates. This is consistent with previous research that emphasizes that map use involves taking different perspective-taking strategies. Mental rotations of maps involve the activation of the primary motor cortex, and the precentral gyrus, which is also correlated with egocentric and allocentric perspective-taking of an imagined movement. These results are indicative of learning-driven plasticity and the harnessing of cognitive potential for a culturally derived mode of thinking.

Modern maps have changed radically as computational power has made the production of geographic information exponentially easier (Bray, 2014). With the advent of large-scale mapping projects by information communication technology companies, such as Google, prototypical maps have changed from static arrays to dynamic graphic displays tailored to individual user’s needs. In many ways, GPS devices can be seen as the culmination of the Western tradition (see Aporta & Higgs, 2005). Arguably, no other cognitive tool has had

such a transformatory impact on human wayfinding behavior, practices, and neurocognitive profiles (Gillett & Heersmink, 2019; Hebblewhite & Gillett, 2020).

Prototypical maps score highly on all of the dimensions of integration that we introduced in Section 3.4, as the previous discussion shows, and this can be easily contrasted with a more passive form of map use, via GPS systems. In contrast to prototypical maps, which are an active wayfinding technology, GPS devices entail a passive role on behalf of the agent (Ishikawa, 2016; Li et al., 2013). The agent does not need to learn anything about the local environment in order to complete a wayfinding or navigation task, and so are in some sense dislocated from their environments (Aporta & Higgs, 2005). Numerous lines of experimental evidence suggest that the passive role of the agent leads to altered forms of cognitive processing in memory and perception (for summary, see Gillett & Heersmink, 2019). This raises the question of whether we can just consider these cognitive tools in terms of offloading and simplification. We now discuss this in more detail.

5. Against simplification

There are two alternative accounts of cognitive tools to the enculturated/cognitive integrationist position, which are instructive to consider: offloading and scaffolding. We argue that to think of cognitive tools in terms of offloading reduces their role to one of simplification of cognitive work for internal processing. To consider cognitive tools as scaffolding risk thinking of tools as temporary constructs that can be discarded when no longer needed or as external supports to cognition that are separable from it. How the scaffolding metaphor is interpreted matters when considering the nature and role of cognitive tools. Both the offloading and scaffolding approaches overlook the importance of the transformation of cognitive capacities through the acquisition of cognitive practices.

5.1. Offloading/outsourcing

Cognitive offloading is defined by Risko and Gilbert as "...the use of physical action to alter the information processing requirements of a task so as to reduce cognitive demand" (2016, p. 676). Offloading can reduce cognitive demand in a number of ways—what we can term "Kirsh's criteria": by simplifying perception, by simplifying load on working memory, and by reducing and simplifying computational workload (Kirsh, 1995; Kirsh & Maglio, 1994). Surveying a range of empirical experiments, Risko and Gilbert suggest that offloading is more likely to take place if certain conditions arise: First, increasing the cognitive load on working memory; second, disruptions in task performance; third, and perhaps most importantly, the agent's metacognitive evaluations about their own abilities and the relative demands of the task. They state that this evaluation can be conscious deliberation or an unconscious habit. For our purposes, the key point is that there is an assessment of whether one draws solely on internal cognitive resources or offloads onto an external resource.

Offloading takes little account of the developmental role of cognitive tools in enculturation. To take an offloading approach to cognitive tools is to minimize, or even ignore, the

importance of the role of cognitive tools in development. However, the importance of the acquisitions of symbol systems and the practices for manipulating them is crucial to the development of cognitive capacities such as reading and writing, mathematical cognition, and spatial navigation.

When the use of cognitive tools is framed in terms of offloading, it entails an internalist approach: All the actual cognitive work takes place inside of the head of the individual. The main goal of offloading is reducing internal cognitive load through altering features of the environment and the body. The agent alters features of the environment or the body to simplify the task space so that the burden on internal processing is reduced (e.g., tilting one's head or altering a physical array to aid a visual search task). So, according to this account, these alterations of the environment are not a proper part of the cognitive processing of the organism.

Cognitive tools then become specialized inputs and targets of action. Cognitive processing proper (e.g., memory, perception, etc.) is in-between and takes place solely inside the head. Indeed, it appears that offloading should only happen when the working load or cognitive demands are high. Offloading outside of these conditions is referred to as "erroneous"—based on a poor metacognitive evaluation of whether the agent actually needed to offload (Risko & Gilbert, 2016). However, cognitive integration, which follows after dual-component transformation, implies the exact opposite; manipulating cognitive tools is a normal cognitive activity past the developmental stage, precisely because our cognitive abilities have been transformed by these dual developmental routes.

Let us return to the discussion of GPS systems. Should we think of them just in terms of cognitive offloading? They radically simplify the cognitive task and simplify perception and memory by largely outsourcing a majority of the cognitive processing involved here—thus meeting all of Kirsh's criteria for what is entailed in cognitive offloading (Kirsh, 1995; Kirsh & Maglio, 1994). Many theorists do indeed describe these kinds of wayfinding technologies as "replacing" spatial thinking (e.g., Montello & Raubal, 2012), and others are concerned about issues of "cognitive decline" (e.g., Carr, 2014; Risko & Gilbert, 2016).

But one of the factors that is overlooked by focusing on internal information processing is the cognitive practices that agents must acquire and master in utilizing GPS devices. The point is that this is not just about the offloading of information processing onto cognitive tools but rather the ways in which different normative patterned practices entail different ways in which agents engage in spatial reasoning. It is not just a simplification of the problem space. It is an entirely novel way of comprehending wayfinding as a fundamental everyday task that must be tackled (for further discussion, see Gillett & Heersmink, 2019).

In summary, if we conceive of cognitive tools in terms of offloading, then this radically curtails the role and depth of what humans actually do with cognitive tools. It renders them as mere crutches for impairment or deficit or as developmental aids. While the limitations on internal resources and how cognitive tools can simplify cognitive load are surely part of the story, it is inaccurate to think that this is the primary way in which cognitive tools are used. What the offloading picture overlooks is the importance of cognitive practices involved in manipulating cognitive tools and the transformatory impacts these can have.

Table 1
This table summarizes the key differences between the offloading, scaffolding, and enculturation/integration views

	Offloading	Scaffolding	Enculturation/Integration
Main claim	Cognitive tools reduce cognitive load by simplifying perception, computations, and working memory	Cognitive tools are temporary structures that facilitate learning. They can be discarded once an agent achieves a certain level of proficiency	The manipulations of cognitive tools are governed by cognitive practices. Cognitive agents must learn and master the cognitive practices
Transformation	An agent is able to overcome limitations of onboard resources (e.g., working memory)	An agent is able to achieve a task that they otherwise are difficult without environmental support	Cognitive potential and the acquisition of novel cognitive capacities
Part of integrated cognitive system	No. Cognitive processing takes place solely inside the head. Cognitive tools are specialized inputs into the system	No. Cognitive tools, which are scaffolds, are only temporary aids	Yes. Learning and mastering cognitive practices transform an agent's neurocognitive profile. Manipulating a cognitive tool is partially constitutive of cognitive processing

5.2. Scaffolding

Another way of conceiving cognitive tools is in terms of scaffolding. Scaffolding is a complex term to define because there is a conceptual ambiguity in how it is used by different theorists and in different areas of research (for similar points, see Larvor, 2020; Saarinen, 2020; Sutton, 2016). Scaffolding has been used to refer to cognitive tools in both broad and narrow ways.¹²

On a narrow definition, scaffolds are developmental structures—the way in which other agents or features of the environment can act in a manner to assist novices in achieving a cognitive task that they otherwise could not do (for summary, see Larvor, 2020; Sutton, 2016); for example, an expert directing a novice's attention and steering their decision-making to stay successfully on track toward the completion of a task. The idea here behind the metaphor of scaffolding, as Sutton makes clear, is that it is only a developmental stage that is removed after it is needed toward the completion of a structure: "Scaffolding is, in general, not itself part of the building. Rather, it is when operating successfully, merely temporary, to be dispensed with at the appropriate stage of development. Use of the metaphor thus forces us to be clear about our unit of analysis" (Sutton, 2016, emphasis added). As we articulated in Sections 3.2 and 3.3, the enculturated approach accounts for developmental scaffolding in terms of guided learning and cognitive potential. But, cultural learning of this kind results in dual-component transformations, the capacity to recognize public symbols as having significance and the capacity to create and manipulate them in order to complete cognitive tasks. Consequently, the metaphor of scaffolding as temporary and external does not get a grip on enculturated cognitive systems.

If one considers cognitive tools as a scaffold in this narrow sense, then one is committed to them being useful only during a developmental or learning, stage. As such, they are an aid only to be used while an agent masters how to complete a cognitive task. This is an inappropriate way of understanding cognitive tools because they are not merely a developmental stage to be discarded once an agent gains sufficient expertise. Instead, acquiring and mastering the cognitive practices that govern how cognitive tools are manipulated, entails transformative developmental changes in an agent's cognitive abilities. These changes alter how an agent comprehends and engages in reasoning in an ongoing manner. And this is because cognitive tools are integrated into our cognitive system.

Alternatively, on a broad definition, a cognitive scaffold is the way in which any features of the environment support, aid, and enhance cognitive processes (Clark, 1997; Larvor, 2020; Sterelny, 2010; Sutton, 2016; Varga, 2019). The broader usage has several issues. First, by attempting to encompass such a wide range of different phenomena, it is conceptually unclear and overlooks important distinctions.

For instance, there are important differences between neural plastic changes associated with learning-driven plasticity in ontogeny and the phylogenetic changes; between one-off interactions with a material object and on-ongoing interactions; and between social relationships and solitary cognitive work.¹³ Referring to all of this under the umbrella of scaffolding does not seem helpful since it elides useful distinctions. Even if we can avoid these ambiguities, a second concern is that the scaffolding metaphor implies a temporary structure separate

from the agent. In some instances, this may be appropriate, but in many other contexts—such as the use of cognitive tools in navigation and wayfinding practices—this will be misleading. Third, many theorists use scaffolding in a similar manner to offloading—insofar as scaffolds environmentally support cognition by simplifying internal processing. Focusing on reducing processing complexity forces us to overlook an important consequence of enculturation: That using cognitive tools involves learning and mastering cognitive practices that govern their usage and that this process leads to a transformation of the capacities of the agent. We summarize the differences between the enculturation/integration and offloading and scaffolding in Table 1.

6. Conclusion

The primary argument of this paper has been to show how we can think about the incorporation of cognitive tools into our cognitive systems via a process of enculturation. We have also argued that there is more to cognitive tools than temporary scaffolding and offloading. We have done that by giving an account of cognitive tools that highlight the importance of cognitive practices and the transformational impact of learning how to interpret and manipulate the tools themselves. Once we begin to examine cognitive tools in terms of their teachability, the practices that govern their deployment, and the developmental effects on our cognitive systems, we will be less likely to consider them to be simply temporary scaffolds or a means of offloading cognitive work.

Cognitive tools are a core part of how humans think and reason in the world. Agents acquire and master the cognitive practices that govern the normative manipulations of cognitive tools toward the successful completion of cognitive tasks. Learning how to manipulate cognitive tools transforms not only the task space but also the neurocognitive profile of the agent. They facilitate novel abilities through shaping cognitive potential. Using the example of spatial navigation and wayfinding, we have shown that the enculturation and the cognitive integration framework provide a deeper and richer explanatory account for considering how humans manipulate and think with cognitive tools in the wild.

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Notes

- 1 See Sterelny (2003, 2012) for a detailed discussion.

- 2 That there are cumulative improvements preserved and transmitted to the next generation.
- 3 Also called the Vygotskian Intelligence Hypothesis (Tomasello 1999).
- 4 Learning that is specifically for the inheritance of culture.
- 5 See Anderson (2014) for an extensive treatment.
- 6 It is for this reason that integrated cognitive is different to and rejects standard formulations of extended cognition in terms of the parity principle (see Menary, 2006, 2007a for more details).
- 7 An important point of note: This does not involve 60 different symbols but instead uses Hindu–Arabic numerals in sets arranged around 60 rather than 100.
- 8 There is a fictional component to the Western navigational niche as well, albeit one of a very different kind. We discuss this below in Section 4.2.
- 9 We discuss this in more detail below in Section 5.
- 10 Some would argue by developing an internal cognitive map, we do not take stance on that here. It may be that we only map important features of the environment that we then use as navigational guides (e.g., landmark and route knowledge rather than survey knowledge).
- 11 Arguably, until the invention of GPS devices and their successful deployment in smartphone technologies, this was the primary way in which almost all humans acquired knowledge for navigational and wayfinding tasks—through one’s own lived experience and the experiences of others in one’s cultural niche.
- 12 Saarinen (2020) makes similar points about how the concept of scaffolds are used in discussions of situated or extended affectivity, but he draws different conclusions than we do here.
- 13 See Varga (2019) for an explicit and systematic account of scaffolds that attempts to encompass all of these different phenomena.

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