DISSERTATIONES SEMIOTICAE UNIVERSITATIS TARTUENSIS

48

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OSCAR SALVADOR MIYAMOTO GÓMEZ

The Forms of Memory: Biosemiotic Modelling of Alloanimal Episodic Semiosis

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Department of Semiotics, Institute of Philosophy and Semiotics, University of Tartu, Estonia

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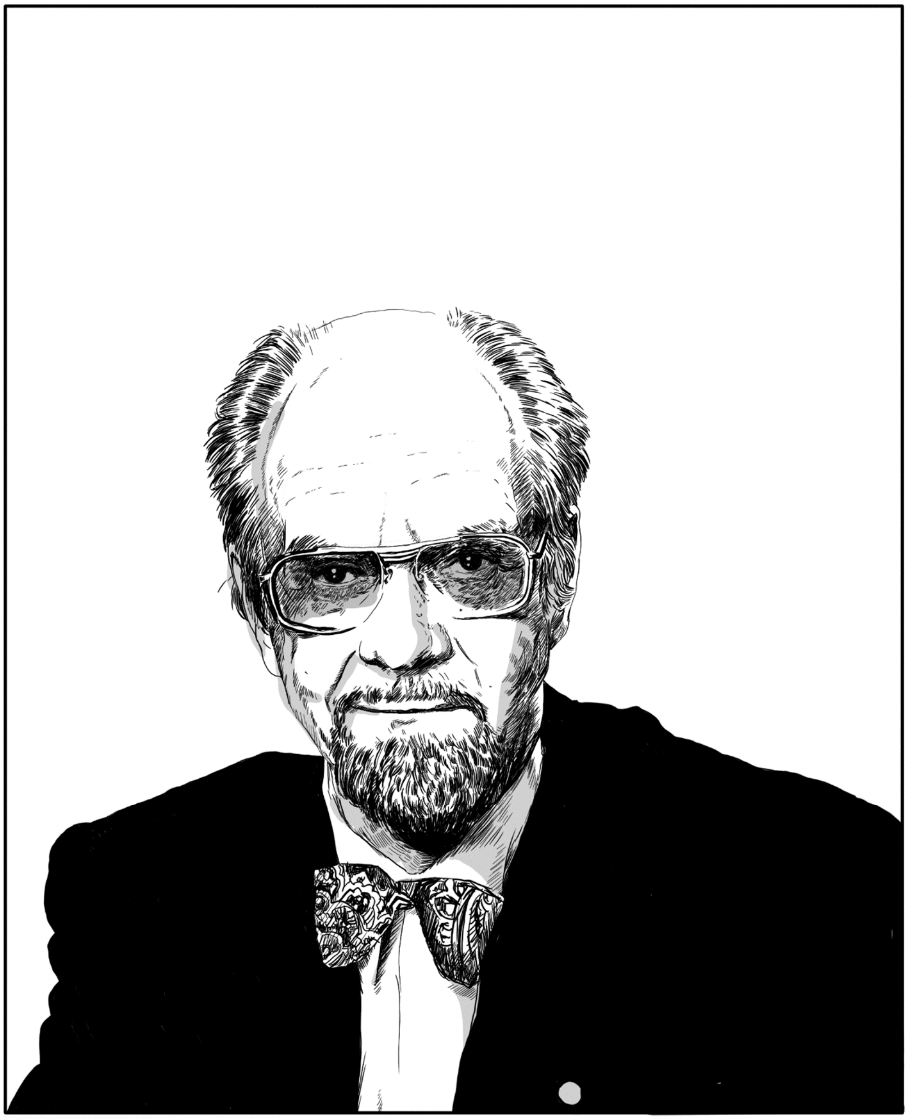

Endel Tulving

TABLE OF CONTENTS

BECAUSE OF A MILLION LOVES

> We are their heir, dust on their palm
> We are because of a million loves
> We're the perfume of the timeless
> Last sighs of a million loves.
>
> -Tuomas L. J. Holopainen (2024)

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LIST OF PUBLICATIONS INCLUDED IN THE DISSERTATION

I. Miyamoto, Oscar 2021. Four Epistemological Gaps in Alloanimal Episodic Memory Studies. *Biosemiotics* 14(3): 839–857.

II. Miyamoto, Oscar 2024a. From Mind to Memory: Bridging Charles Peirce and Endel Tulving Through Phenomenology of Time. In: Tragel, Elli Marie (ed.), *Explorations in Dynamic Semiosis*. Switzerland: Springer Nature, 169–188.

III. Miyamoto, Oscar 2024b. The virtual habits underlying the behavioural hallmarks of alloanimal episodic memory: a Peircean model. *Cognitive Semiotics* 17(2).

IV. Miyamoto, Oscar 2023. Questions concerning certain faculties claimed for semiotic selves. In: Kõvamees, Erik; Miyamoto, Oscar; Randviir, Anti (eds.), *Concepts for Semiotics II*. Tartu Semiotics Library 24. Tartu: University of Tartu Press, 81–98.

LIST OF ABBREVIATIONS

Abbreviation	Definition
AEM	Alloanimal Episodic Memory
ELM	Episodic-like Memory
EM	Episodic Memory
GUTP	Gradualism, Unitarism, Transformativism, Pluralism
Id	Dynamic Interpretant
If	Final Interpretant
Ii	Immediate interpretant
MDC	Medium Downward Causation
MeC	Memory Content
MeF	Memory Flexibility
MeS	Memory Structure
MTT	Mental Time Travel
Od	Dynamic Object
Oi	Immediate Object
S	Sign, Representamen, or Sign-vehicle
SM	Semantic Memory
SPI	Serial, Parallel, Independent
W-W-W/W	What-Where-When/Which

INTRODUCTION

Which are the *commonalities* between human and (other) animal forms or Episodic Memory (EM)? In other words, how to account for the fact that a variety of species skillfully display an equivalent form of long-term memory for what-where-when subjective experiences? This question has motivated my research, first and foremost, due to its bioethical significance.

Our current evolutionary understanding of human memory would not be possible without decades of comparative research on alloanimals or all "animals besides the human animals" (Deely 2015: 19). This is especially the case of EM or 'autobiographical' memory, which depends on a finely tuned orchestration of neurobiological basis (e.g. neural substrates), cognitive-behavioral contexts (e.g., goal-oriented tasks), and phenomenological dimensions (e.g., first-person experiences).

EM was formerly believed to be uniquely human, but nowadays it is considered as a quintessential hallmark for studying the parallel evolution of consciousness in a variety of animal families, like rodents, primates, and birds. For example, episodic cognition has been discussed in The Cambridge Declaration on Consciousness of 2012 (Low *et al*. 2012), and more recently in The New York Declaration on Animal Consciousness of 2024, which considers the welfare and ethical interests of alloanimals as sentient individuals. These examples of evidence-based advocacy allude to alloanimal forms of self-awareness, dreaming, planning, emotional regulation, causal reasoning, and the attribution of mental states to conspecifics, which are phenomena relevant for the zoosemiotic understanding of EM in alloanimals.

Moreover, answering the above question is crucial amidst the anthropogenic disruption of animal societies. Cultural habits, shared knowledge, and arbitrary codes are zoosemiotic features that depend on complex forms of memory that are not genetically inherited but episodically learned during an individual's lifetime. Against this background, it will be concluded, the scientific community now bears the moral responsibility of recognizing in some alloanimal families the status of *subjects of a life* or individuals that possess "beliefs and desires; perception, memory, and a sense of the future, including their own future; an emotional life together with feelings of pleasure and pain; preference- and welfare-interests" (Regan 2004: 243).

The present work is not a stand-alone dissertation, but a companion to contextualize two journal articles and two book chapters. These publications, appended in the printed version of this text, revolve around the interdependent notions of *memory*, *time*, and *self*. In a manner of speaking, those texts are a continuation of "A Biosemiotic Phenomenology of Time in Episodic Memory" (Miyamoto 2020), an MA thesis connecting the semiotics of Charles S. Peirce (1839–1914) and the experimental work of Endel Tulving (1927–2023), father of EM theory.

The unifying title of this dissertation could be explained as follows. First, it suggests that semiosis or meaning-making is the common process that underlies the pragmatic and intentional essence of EM and its analogue manifestations in different species. Second, it implies that such goal-oriented sign process can be explained by means of a pluralistic model that recognizes species-specific features but is still general enough so as to be applicable to a variety of alloanimal families. Such a model was introduced in Miyamoto (2024b).

All in all, the title of the dissertation hints at the idea that EM is itself a natural kind or primary modelling system dependent on semiosis, famously defined as "the capacity of a species to produce and comprehend the specific types of models it requires for processing and codifying perceptual input in its own way" (Sebeok, Danesi 2000: 5). Section four puts forward a novel definition of such cross-species form of meaning-making in terms of "episodic semiosis".

ALL THESE SCANNERS WHIRRING AWAY 'sets the stage' by defining human EM, its known phenomenology, its neural substrates, and its cognitive-behavioral overlapping with equally important memory systems. In a second move, EM is explained within the wider multispecies context of the Memory System Framework, one of the leading interdisciplinary paradigms in memory studies. This introductory section also serves as a supplement to Miyamoto (2024a), where I delved into the philosophical compatibilities between Tulving's ideas about consciousness and Peirce's mediations about time.

SO ALL LIFE IS A GREAT CHAIN is a short essay that compares EM with the process-like nature of a delta river. The metaphor of the "Mississippi Delta of Memory" rephrases and connects ideas from the otherwise alien jargon of experimental memory studies. Despite its metaphoric credentials, this segment aims to convey the idea that human EM cannot be scientifically studied in isolation but considering a multi-species or pluralistic approach.

HE WHO UNDERSTANDS BABOON is a walkthrough 'behind the scenes' of the dissertation. It reconstructs the inquiry process, including its research problem, methods, and the novelty of its results. It provides a rationale for the appended publications, partaking in the wider context of posthumanism, convergent evolution, and pluralistic narratives in zoosemiotics. The adoption of the term "alloanimals" is also justified. This section aims to be a postscript to Miyamoto (2021), where I reviewed the literature in the field of alloanimal episodic memory (AEM), and identified the 'Nagelian', 'de Waalian', 'Chomskyan', and 'semiotic' gaps.

FAIR AVERAGE MEN introduces the term "episodic semiosis", a concept that encapsulates the cross-species essence of AEM. This pragmatic term does not aim to substitute or override the traditional psychological and neurocognitive definitions of human EM, but it focuses on the *common* semiotic elements underlying EM in a variety of species, including humans. The purpose of this section is to sketch possible ethological applications of Peircean semiotics to concrete AEM cases. More specifically, I use the paradigmatic Cache-Recovery Model of AEM to tell the anecdotical story of 'Nevi', a hooded crow retrieving hidden snacks based on their mental expiration dates.

THE BEAUTY OF THE ROSE is meant to be an appendix to Miyamoto (2024b), arguably the most relevant publication included in this dissertation. It addresses some of the most frequently asked questions concerning the AEM model therein proposed. For instance, it spells out (1) what forms of temporality and causality are being depicted, (2) how its formal design is supposed to be read, and (3) what kind of phenomena are considered within its categories. All in all, this addendum discusses some terminological nuances that have been the cause of misperception.

AN IRRATIONAL FANCY provides the overall concluding remarks and take-away message of the dissertation. This final section examines the extent of the answers provided to four research questions. Are there episodic phenomena beyond human EM? What is the relation between semiosis and phenomena in AEM? Should a biosemiotic phenomenology be practiced as pure theory, or as applicable for experimental AEM studies? And how can biosemiotics contribute to understanding phenomenology in AEM? Future directions of bioethical research and advocacy beyond semiotics are envisioned.

1. ALL THESE SCANNERS WHIRRING AWAY

> The single most critical piece of equipment is still the researcher's own brain. All the equipment in the world will not help us if we do not know how to use it properly, which requires more than just knowing how to operate it. Aristotle would not necessarily have been more profound had he owned a laptop and known how to program. What is badly needed now, with all these scanners whirring away, is an understanding of exactly what we are observing, and seeing, and measuring, and wondering about.
>
> -Endel Tulving (in Culham 2006: 53)

Where were you and what were you doing three sunsets ago?

When were you last at the grocery store, and what items did you buy there?

When and where did you last meet your best friend?

When and where, most likely, will you do each of the above again?

If you can answer these questions without the help of 'external' information, it could be said that you possess Episodic Memory (EM). EM is a long-term neurocognitive system that relies on the conscious elicitation of non-present personal experiences, either already lived or yet-to-be lived. The most characteristic process associated with EM is dubbed "Mental Time Travel" (MTT) (Perrin, Michaelian 2017: 228), which involves a phenomenological or first-person projection of sensations, intentions, and actions in non-present spatiotemporal scenarios (Miyamoto 2020: 2).

The term EM was coined by Endel Tulving (1972: 382–402), a Canadian-Estonian experimental psychologist considered the father of EM theory. The pioneering work of Tulving and his colleagues accounts for the clinical fact that there are two forms of long-term declarative memory systems with an interrelated but *distinguishable* neurophenomenology (Renoult, Rugg 2020). The first one is Semantic Memory (SM), being responsible for *knowing* factual and conceptual information (regardless of their truth or false values). The second one is EM, being responsible for *remembering* or reconstructing lived experiences and the spatiotemporal context of their in-situ acquisition (regardless of being veridical or falsidical memories).

Namely, knowing the date and place of your birth is possible thanks to SM, even if your EM naturally lacks a subjective recollection of that autobiographical event. In turn, vividly recalling the first time you made a friend at high school is possible thanks to your EM, even if your SM does not necessarily know the exact date and place of that episode.

Episodic MTT allegedly was realized when you visualized the ‘scenes’ of (1) the activity you were performing a few days ago, including the procedural steps, proprioceptive sensations, and locations involved; (2) your purpose for visiting the shop and the precise items you were looking for; (3) the close bodily presence of your friend and its characteristic voice and gestures; and more interestingly, (4) your estimation of *future* instantiations of those habitual yet unique what-where-when episodes, regardless of them never coming into being as premediated.

If you cannot accurately remember the ‘when’ of questions two and three, nor predict the ‘when’ in question four, most likely you are able to contextually differentiate among *which one* of the many occasions those episodes have occurred or will ostensibly occur. In this sense, EM is alternatively defined as a what-where-when/which (W-W-W/W) form of memory (Easton, Eacott 2008) (Eacott, Easton 2010). Section three builds on this alternative definition of EM to coin the more general term “episodic semiosis”, which comprises the so-called “episodic-like memory” (ELM) in animal species other than humans (herein referred to as AEM).

Phenomenology wise, EM is said to be a “representation-hungry” domain (Kiverstein, Rietveld 2018) insofar as it requires the transient manipulation and visualization of mental imagery (Gjorgieva *et al.* 2023). As suggested by studies on Alzheimer’s disease (Hussey *et al.* 2012) and aphantasia (the partial or total absence of a ‘mind’s eye’), “imagery may be a normative representational tool for wider cognitive processes” such as EM (Dawes *et al.* 2020: 10022). In semiotic terms, this suggests that episodic cognition is closely related to the vivid re-experiencing or subjective elicitation of multisensorial sign-vehicles or *representamens* of different kinds[1].

Ontogeny wise, SM is developed first in early childhood, and it is a prerequisite for the later development of EM, which continues to mature between 6 and 12 years of age (Guo *et al.* 2024). Neuroanatomically speaking, human EM highly depends on the hippocampus in ways that other memory systems do not (Yonelinas *et al.* 2024). Namely, the loss of EM due to specific brain injuries (Dickerson, Eichenbaum 2010) does not cause the ‘retroactive’ loss of SM (Clayton, Wilkins 2017: 4), but the loss of the latter would compromise EM in almost every aspect, since SM is necessary for grasping the meaning of worldly objects and navigating space.

---

[1] In Peircean semiotics, a “representamen” is a logical correlate and the central link in the process of semiosis, to the extent that thought itself cannot be performed without signs (CP 2.302). The paradigmatic example of this are natural symbols and their capacity to convey general concepts or information with varying degrees of breath and depth (cf. Bellucci 2021). Sign-vehicles or representamens, in this sense, work as a sensible medium or iconic ‘model’ (e.g., image, diagram, metaphor) potentially standing for something other than thought itself (e.g., a cognizable object, an intelligible phenomenon, or a concept) to an interpreter or meaning-maker (cf. Miyamoto 2024a: 172).

The difference between SM (aka 'relational' memory) and EM (aka 'remembering' memory) was first discovered in 1958 by the Danish-American neurologist Johannes Maagaard Nielsen (1890–1969), when he distinguished "categorical amnesia" from "temporal amnesia" in a patient (Tulving 2002: 11). In the words of Nielsen (1958: 25):

> A study of pathways of memory formation has revealed a basic fact not suspected when this study began—there are two separate pathways for two kinds of memories. The one is memories of life experiences centering around the person himself and basically involving the element of time. The other is memories of intellectually acquired knowledge not experienced but learned by study and not personal.

The former kind of autobiographical memory is the one affected by temporal amnesia or hippocampal amnesia, which causes the phenomenological inability to recall personal experiences and imagine future scenarios (Klein *et al.* 2002). People with that condition, namely, would still be able to recognize their wife and recall her name. They would even be able to find their way through their neighborhood, and play the piano as usual (Wearing 2005). Alternatively put, despite their hippocampal (episodic) impairment, their categorical (semantic) conceptualization, spatial navigation, and procedural skills would remain almost intact.

Nonetheless, hippocampal amnesiacs, similarly to people with neurodegenerative dementias (Irish *et al.* 2016), would not be able to intentionally recall the what-where-when anecdote of how they met their spouse, remember how they first moved into their current house, nor conceive themselves playing the piano in a non-present spatiotemporal scenario. As put by Michaelian (2016: 6), healthy EM "provides the subject both with first-order knowledge of what happened in the past and with meta-level knowledge of how he knows that it happened".

EM relies on a distributed neural "core network" (Beaty *et al.* 2018) capable of reinstating or triggering patterns of cortical activity that were present during previous lived scenarios (Sabo, Schneider 2022). This "hippocampal replay" of events (Chen, Wilson 2023: 553) consolidates the memory of awake or 'online' experiences. However, this does not mean that the phenomenological or experiential aspects *underlying* episodic MTT are 'stored' in the brain as physical or crystallized information that can be 'retrieved'. The rememberer's first-person or subjective experience taps into a cognitive phenomenon qualitatively different than digital computational information processing: our abductive or creative capacity to logically *infer* the practical bearings of virtual W-W-W/W personal scenarios (West 2022: 98)[2].

The 'virtuality' of EM lies in the diagrammatic possibilities iconically present(ed) in the vividness of our recollections and prospections, provided they are verisimilar (analogue or life-like) representations *of* something other than themselves (a non-present scenario). The idea of a virtual or "mental representation"

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[2] See Miyamoto (2024b) for an account of EM in terms of "virtual habits" or the "pre-enactment of specifically framed episodes in the inner world" (West 2017: 61).

is central to understanding the cognitive advantages of EM in the face of missing or occluded ‘external’ information during our everyday lives. This is, episodic subjects *visualize* and *perform* virtual episodes that would not be cognizable without the model-like capacities of (re)constructive multisensorial mental imagery (van Woerkum 2021).

In summary, EM provides both a sensible structure and a cognizable content to the vividness of our recollected experiences, and it flexibly informs our prospective guesses about the future. Notably, the phenomenology of MTT and the neurobiological basis of EM are organically inseparable but should not be conflated. Episodic elicitations, “mental imagery” or “mental images” (Blaisdell 2019) in the ‘mind’s eye’ are not quantitatively ‘measurable’ but, nonetheless, they *co-occur* with the reactivation of quantifiable neural patterns in the brain, oftentimes referred to as “neural representations” (Xue 2018).

Section four resumes the above causal nuance between analogue mental imagery (in terms of formal causation) and neural patterns (in terms of efficient causation). The current point being that EM cannot be holistically understood without considering neurobiological, phenomenological, and cognitive-behavioral aspects, as shown by figure 1.

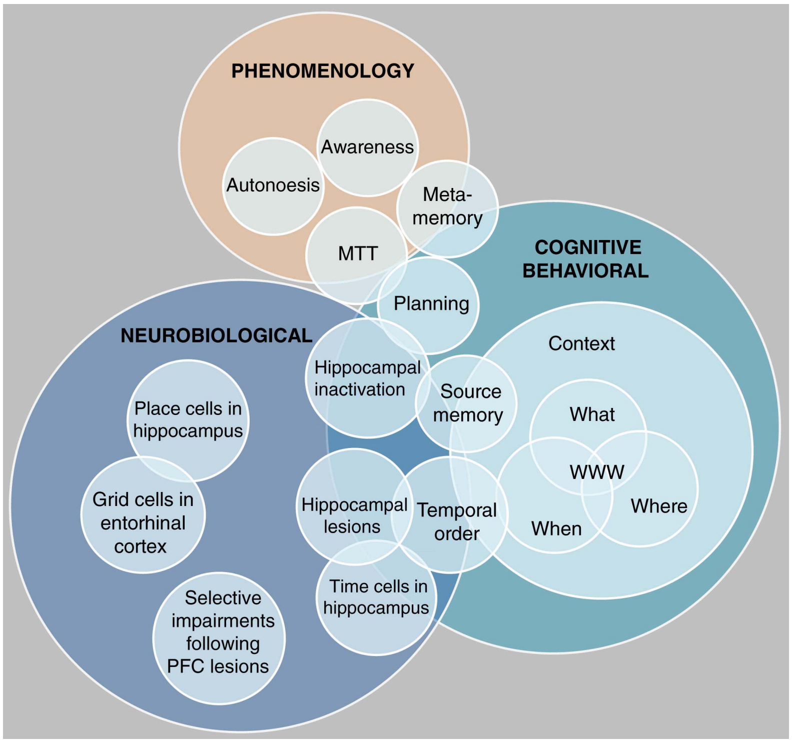

Figure 1: “Constellation of mnemonic features of episodic memory”. Reproduced with explicit permission from the authors (Templer, Hampton 2013: 802) and from ©2013 Elsevier Ltd. Published by Elsevier Inc. License number 5822470574821.

Adding up to the complexity depicted in figure 1, understanding EM also requires considering the multimodal capacities of other forms of memory that are equally vital during our lifetime. Namely, EM's "event-construction" (Madore *et al.* 2019) invokes the evanescent afterimages of Sensory Memory (Cowan 2008: 26); the automatic or unconscious expression of Procedural Memory (West 2019: 65); the executive focus of Working Memory (Plancher *et al.* 2018: 6); and, as we have seen, the conceptual and indexical knowledge of SM (Renoult, Rugg 2020: 2).

Put differently, EM is enriched by the lingering impressions from our senses; it is expressed through the fluid movements in the actions we perform; it is constrained by the number of items on which we can focus at a time; it brings to consciousness the concepts and worldly facts we have learned; and it is even present in the creative hallucinations of our dreams (Payne, Nadel 2004). In the words of Tulving (2005: 10):

> Like all other systems, episodic memory consists of a number of interacting neural and cognitive components which together are capable of operating in a manner that the same components in isolation, or in different combinations, cannot. Like all other neurocognitive systems, it is complex and not easily summarized in a few words.

In short, far from being a unitary entity, EM's re-imaginative capacities seem to depend on a multimodal orchestration of different memory subsystems. This dissertation is especially concerned with the biosemiotic relationship between the phenomenological and neuro-cognitive spheres featured in figure 1.

EM has also been explained in relation to a "continuum of stages" or thresholds of consciousness (Vandekerckhove *et al.* 2014). These have been called "anoesis" (or 'unknowing' awareness), "noesis" (or 'knowing' awareness), and "autonoesis" (or 'self-knowing' awareness) (Vandekerckhove, Panksepp 2009). In Miyamoto (2024a: 179), on the basis of Tulving (1985a, 1985b), I proposed a Peircean characterization of these forms of consciousness under the metaphor of the "looking glass" of memory or the act of recognizing oneself in a mirror.

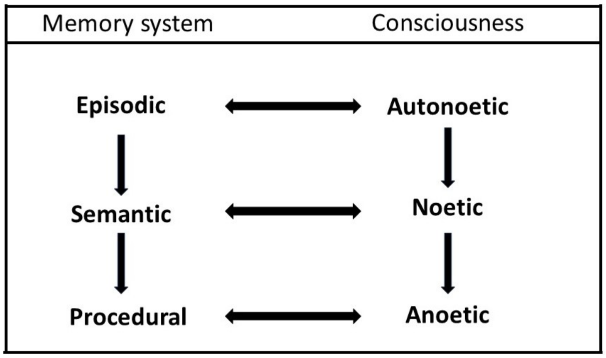

Figure 2: "A schematic diagram depicting the relations between memory systems and varieties of consciousness". The figure reproduces the original version by Tulving (1985a: 3) with permission from ©Canadian Psychological Association.

These three underlying forms of consciousness are said to *control*, respectively, Procedural Memory, SM, and EM, as originally put forward by Tulving's famous "class-inclusion hierarchy" (Tulving 1983). This additionally implies that figure 2 depicts an ontogenetic hierarchy: Procedural Memory works as a neurocognitive prerequisite for SM; and SM works as a neurocognitive basis for EM, but not the other way around. Therefore, it has been clinically observed that loss of EM's autonoetic 'upper' control (e.g., due to hippocampal amnesia) does not necessarily have a 'downwards' impact on SM's noetic control, but the loss of the latter would indeed cause the *upward* disappearance of the former.

This is known as the "SPI (serial, parallel, independent) model that postulates process-specific relations among the memory systems" (Tulving 1995: 839). It clinically explains why (1) some people are able to possess a normal SM despite having lost EM due to hippocampal lesions; and why (2) hippocampal amnesia not only implies the loss EM, but also the loss of autonoesis or the adjacent type of subjective awareness that used to *control* episodic MTT.

The crucial point being that, without these three memory-based forms of consciousness, EM would have to start 'from scratch' at every instant, devoid of the main habits that make us 'ourselves'. This is, we would experience every first-person episode as if it was the very first one of its kind, and we would conclude every action as if it was the very last one.

We are, in this sense, finely tuned time travelers. We are continuously informed by the multisensorial qualia coming from Sensory Memory (lasting milliseconds). We unconsciously express the dispositional skills of Procedural Memory (on a demand basis). We are directed by the task-oriented attention of Working Memory (lasting a few seconds). Our beliefs are grounded on the conceptual knowledge of SM (lasting years). And our subjective permanence across time is replicated by autonoesis or the autobiographical awareness of EM (lasting a lifetime). This multisystemic orchestration is known more generally as the Memory System Framework[3]:

> The memory system framework is fundamental to the contemporary study of learning and memory. Within this framework, the various memory systems have distinct purposes and distinct anatomy, and different species can solve the same task using different systems. […] The notion of multiple memory systems is now widely accepted and establishes an important organizing principle across species for investigations of the biology of memory. (Squire, Dede 2015: 11)

I have elsewhere explained the role of EM withing the Memory System Framework as being an 'editor' syntactically manipulating the imagistic language of a film in the making. I dubbed this as the "movie studios" metaphor (Miyamoto 2020: 15). This dissertation deserves a new analogy as an attempt to convey the introductory idea that EM is not reducible to an 'intracranial' mechanism, but it demands to be explained as a long-term distributed sign process bigger than the

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[3] See Roediger et al (2017: 7–20) for a thorough typology of memory terms within such a framework.

remembering self or subject. In a manner of speaking, our purposeful mind, our sensitive soul, and our biological body are inseparable in the flow of memory, persisting and symbiotically evolving over a continuous lifetime. Despite its metaphoric credentials, the analogy presented in the next section is meant to exhibit the challenges of conceptualizing human EM and later defining its commonalities with respect to AEM.

2. SO ALL LIFE IS A GREAT CHAIN

> "From a drop of water," said the writer, "a logician could infer the possibility of an Atlantic or a Niagara without having seen or heard of one or the other. So all life is a great chain, the nature of which is known whenever we are shown a single link of it".
>
> -Arthur Conan Doyle (1898: 24)

Episodic MTT could be thought of as an ancient fluvial system in communication with the ocean, like the Mississippi River Delta. On the one hand, continental waters flow southwards through distributary channels, which diverge and converge in flexible ways. On the other hand, sea waves and tides push back, reshaping the coastline and its sedimentary composition. Like the Mississippi and the Gulf of Mexico, human EM relates with the world through an irreducible influx of processual complexity.

The 'Mississippi Delta of Memory', as it were, is always busy with voyaging ships ('episodes') that come and go. Beneath the swirling surface, the currents ('neural pattern reinstatement') are depositing sediments and transporting nutrients vital for soil fertility. Likewise, the steady watery flow has shaped the riverbed with long-lasting ripple marks, craving the soil with indelible structures ('neural pathways' or 'default networks').

Figure 3: "Earth from Space: Mississippi River Delta", picture taken on 25/05/2012 by the European Space Agency's Landsat satellite system. Credit: ©ESA and United States Geological Survey.

In this metaphor, the river's crystalline watercourse (hippocampal 'stream' or 'replay' of experience) can be traversed in both directions by mental time travellers. They may sail southwards ('future-oriented thinking') but also northwards ('past-oriented thinking'). To accomplish this, our imaginary sailors not only need procedural skills and long-term knowledge of the world, but also a navigational compass of the highest sensitivity known as 'chronesthesia' or consciousness of a subjective time (Nyberg *et al.* 2010).

Adding to this expeditionary intricacy, the Mississippi's headwater and distributaries influence each other over time. Namely, the varying volume carried by the river's tributaries ('memory content') will affect the speed and depth of its ramifications ('memory structure'). The latter might even change direction and disconnect due to geological factors, like erosion (e.g., aging), natural disasters (e.g., brain lesions and neurodegenerative diseases), and even by human intervention (e.g., pharmacological suppression of the hippocampus).

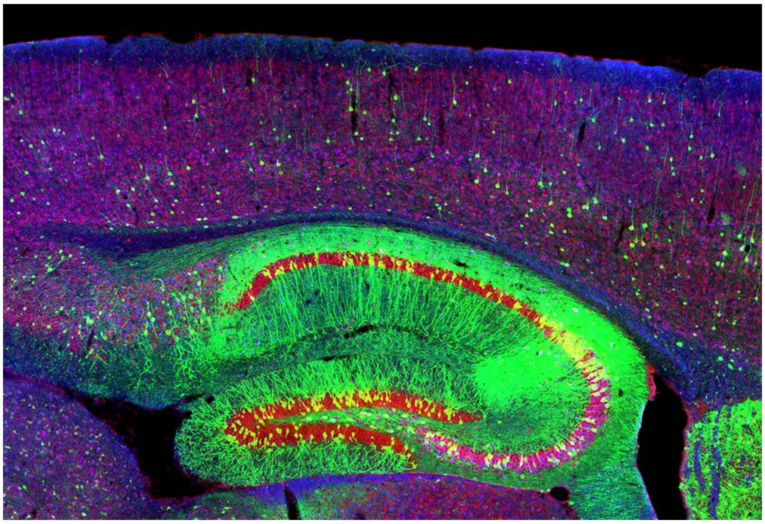

Figure 4: "Hippocampus and neurons of mouse with the neurodegenerative disease". Credit: Eunice Kennedy Shriver National Institute of Child Health and Human Development (NICHD).

Without the Mississippi's tributaries in Illinois, Missouri, and Ohio there would be no delta. Under the same token, the virtual verisimilitude of EM would be ungrounded without the input of Sensory Memory (the vividness of sentience), Procedural Memory (automatic bodily 'know-hows'), and SM (conceptual and spatial correlations).

The Mississippi Delta of Memory behaves both like an embodied structure *and* a distributed process where perception, intentions, and actions become almost indistinguishable from each other. If this is true, we cannot sail the same river twice because it does not carry the same water, and we are not the same person we used to be, or so goes the reasoning attributed to Heraclitus. In like manner, we cannot relive a past situation in the exact same manner twice, for we do not 'carry' the same memories, and we are not the exact same subject that navigated that scenario per se.

What is it, then, that makes it possible for episodic subjects to aptly remember (and anticipate) experiences in a relatively consistent fashion? Or, in our fluvial terms, what makes it possible for mental time travellers to successfully traverse back and forth a constantly changing river system? We may not be able to sail the same Mississippi twice, nonetheless we aptly sail it again, and again, *as if* it was virtually the same system that we once physically traversed.

A good captain constantly keeps in mind both, the outbound and the inbound trips. Similarly, the episodic ships of memory do not randomly appear at the Gulf of Mexico, and they do not automatically make their way back to Louisiana. Episodic memories, like voyagers, purposefully go back and forth all the time between two diachronic but coupled domains. This is the case despite the Mississippi's tendency to flow southwards under normal conditions.

Virtual (pre-lived and re-lived) episodes are a 'floating' medium that fluidly communicate the fresh water of *simulation* (aka imagination) and the seawater of *action* (aka behaviour). Without the imagistic possibilities displayed by episodic prospection, we would always stick to whichever route is already at hand, unable to preview the Mississippi's combinatorial options. And without our body and its ecological embeddedness, our memory would never update its worldly affordances, being otherwise unable to follow through an actual journey.

Still, the Mississippi Delta is not unique. There is a myriad of similar lotic ecosystems on Earth, and regardless of their size or latitude, they possess equivalent qualitative virtues, such as the Nile Delta in Lower Egypt, and the Ganges Delta in Eastern South Asia. In the bigger picture, these ancient marvels of nature resemble one another, even if their structures, contents, and flexibility vary in some fashion[4].

The individual attunement of these deltas to the more general regularities on Earth is, in this way, pragmatically analogous: they all 'behave' like rivers. In like manner, human EM is but one example of the more general phenomenon of EM in the animal kingdom, also known as "episodic-like memory" or, as I prefer to call it, AEM (alloanimal episodic memory). Under this logic, human EM *and* AEM could be said to be forms of *episodic semiosis*: a habitual sign process by which the formal qualities of a memory (as *representamen*) simultaneously stand for both (1) the ostensible existents of an already enacted or experienced past, and the virtual possibilities of a yet-to-be enacted or pre-lived future (as *object*), by means of recognition and goal-oriented choice-making (as *interpretant*).

---

[4] In the experimental jargon of AEM studies, the behavioral hallmarks of AEM consist of a combination of *structure* (the formation of mental imagery), *content* (some intelligible what-where-when/which features of non-present scenarios), and *flexibility* (the purposeful capacity of generalizing and updating memories).

3. HE WHO UNDERSTANDS BABOON

> Origin of man now proved. —Metaphysic must flourish. —He who understands baboon would do more towards metaphysics than Locke.
>
> -Charles Robert Darwin (in Barrett 1987 [1838])

From a biosemiotic perspective, a major advantage and a major **research problem** present when studying EM in alloanimals or "animals besides the human animals" (Deely 2015: 19). On the one hand, an increasing offer of experimental evidence shows that a plurality of species evolved "episodic-like memory" (ELM) (Zacks *et al.* 2022), or a memory system that is pragmatically analogous to human Episodic Memory (EM).

This includes scrub-jays (Cheke, Clayton 2012), crows (Boeckle *et al.* 2020), magpies (Zinkivskay *et al.* 2009), pigeons (Zentall *et al.* 2008), chickadees (Feeney *et al.* 2009), hummingbirds (Jelbert *et al.* 2014), rats (Crystal, Smith 2014), mice (Fellini, Morellini 2013), monkeys (Hoffman *et al.* 2009), gorillas (Schwartz *et al.* 2005), chimpanzees and orangutans (Martin-Ordas 2016), dogs (Fugazza *et al.* 2020), elephants (Chusyd *et al.* 2021), dolphins (Davies *et al.* 2022), octopi (Poncet *et al.* 2022), and cuttlefish (Jozet-Alves *et al.* 2013).

On the other hand, those studies challenge (1) Tulving's initial hypothesis that the metacognitive basis of episodic phenomenology are uniquely human, and (2) the more recent widespread assumption that even if other species possess such phenomenology (e.g., a conscious spatiotemporal projection of the self), we would never be able to confirm it because we cannot "access" their lived experiences or "measure" their consciousness (Martin-Ordas *et al.* 2013: 1438), or so goes the famous "other minds problem" (Harnad 2016). As put by Cheke and Clayton (2010: 916), "behavioral evidence of episodic-like memory can never be taken as evidence for episodic memory as it is experienced by humans".

This seeming divide between "external" behavior and "internal" mental experiences has led laboratory-based approaches to typically remain agnostic or rather skeptical about the lived experiences in their experimental subjects so as not to "anthropomorphize" them. In contrast, semiotics of memory articulates very refined claims about phenomenology, but it tends to give for granted the neurobiological and evolutionary basis of memory (Bouissac 2007: 71).

In Miyamoto (2021) I reviewed the above impasse between experimental evidence and anthropodenial in terms of four epistemological gaps: the "Nagelian, de Waalian, Chomskyan, and semiotic gaps" in alloanimal episodic memory (AEM). For the purposes of the present section, these gaps could be further synthesized on the basis of Rattasepp's (2018) multispecies semiotics, as four interrelated scientific discourses that block the way of inquiry:

1. The ‘nature’ or essence of EM can be determined by studying humans alone. This idea leads to preclusion and non-falsifiability when it comes to testing AEM.
2. The most ‘important’ characteristic of AEM is that it ‘lacks’ something human (e.g., autonoesis and verbal intersubjectivity). This leads to the belief that human EM is ‘higher’ in degree or ‘superior’ in kind.
3. When human EM is compared with AEM, the former is described as ‘unique’; and when AEM is compared between alloanimals, the latter are described as merely differing from one another. This idea arbitrarily divides the phylogenetic continuity of EM and AEM.
4. The distinction between human EM and AEM is something ‘mental’, or reducible to the mental (e.g., Mental Time Travel); and understanding EM’s ‘true nature’ is only reached when we expel or remove the animal from it (e.g., instincts and circadian rhythms). This idea reinforces the ontological divide between psychological accounts of human EM and ethological accounts of AEM.

The above advantage-challenge contrast, four epistemological gaps, and four scientific discourses mostly stem from a misunderstanding between human-based definitions of EM and cross-species definitions of EM. Tulving’s original definition of EM stated that it “stores and retrieves information about temporarily-dated episodes or events, and temporal–spatial relations among events” (Tulving 1972: 385). If such criteria were used to interpret current evidence in AEM studies, it would be necessary to say that episodic remembering and episodic anticipation are indeed present in a variety of species.

Tulving (2005: 47) himself admitted this when he stated that “Clayton’s scrub-jays would have been certified as full-fledged episodic creatures back in 1972”. Since then, there has been an emergence of constantly changing definitions of EM, some of which recognize future-oriented MTT in alloanimals (Zentall 2013), with Eurasian jays (*Garrulus glandarius*) perhaps being the most paradigmatic example (Cheke, Clayton 2012: 174). The extrapolation of such evidence to other species has slowly paved the way for newer definitions of EM that include both humans and alloanimals:

> Episodic memory is the remembrance of one’s own previous experiences and can be done by both human and non-human animals. Episodic memory is supported by a distributed network of cortical and sub cortical brain regions, but requires the involvement of the hippocampus unlike other memory systems. Mental time travel, the re-experiencing or imagining of a sequence of events, is dependent on episodic memory […] Additionally, this new definition does not require conscious recollection and there is no distinction between episodic and episodic-like memory. When possible, self-report distinctions between memory processes should be avoided (e.g., remember/know procedures) and should be instead tested using source-memory or item-strength (such as confidence ratings) procedures. (Madan 2020: 189)

Most of our understanding of EM's phenomenology had traditionally come from studies on English-speaking human subjects. It is a matter of course that a series of human-specific traits were eventually added to the original definition of EM, such as "autobiographical consciousness" (Martin-Ordas 2016: 46) or an "experiential sense of 'mineness' of relived and pre-lived episodes" (Perrin 2016: 46). According to Tulving's latest definition of the concept, EM "makes possible mental time travel through subjective time—past, present, and future. […] The essence of episodic memory lies in the conjunction of three concepts—self, autonoetic awareness, and subjective time" (2005: 9). In this regard, Allen and Fortin (2013: 10379) observe a problem referring to a similar definition by Tulving (2002):

> Although this definition may capture the phenomenological aspects associated with episodic memory in humans, it relies entirely on verbal reports of subjective mental experiences. Because this definition of episodic memory precludes its investigation in animals, the hypothesis that this capacity is unique to humans lacks falsifiability.

Human EM seems to be a primary modelling system that ontogenetically precedes the full acquisition of language (Tulving 2005:12), yet it is enhanced by the latter and its symbolic scaffoldings. Still, the ability to *verbally* report MTT in terms of an autobiographical "past, present, and future" should not be conflated with the goal-oriented *behavioral* expression of episodic forms of recollection and prospection, otherwise "episodic memory can be defined in a way that essentially guarantees that it is unique to humans" (Muñoz, Morris 2009: 1181).

Indeed, using tense-based parameters for assessing temporal awareness hinders research not only in alloanimals, but also in neuropsychiatric patients with impaired language (Dere *et al.* 2006: 1216), and young children with less-developed verbal abilities (Clayton, Russell 2009: 2330). Not coincidentally, AEM studies frequently refer to their "non-human" experimental subjects as "non-verbal creatures" (Clayton, Wilkins 2017). These expressions define alloanimals for what they 'lack', or by 'not being like us', reinforcing the consequent misconception that humans are not animals per se (Anderson 2019: 177). From a biosemiotic perspective, thus, this divide between human and "non-humans" in AEM could be classified as one of the "fractures in knowledge arising from the division of scientific labor" (cf. Sebeok 1986: 24).

Against this interdisciplinary background, the **main goal** of my research has been to develop a cross-species biosemiotic model of AEM, one that serves as a common ground for understanding the *phenomenology* supporting episodic mental representations, and the *teleology* motivating episodic goal-oriented behavior in alloanimals. In Chávez-Barreto *et al.* (2022) I sketched the conceptual basis of such a model, which was designed to specifically address the "semiotic gap" in AEM (Miyamoto 2021: 845). In Miyamoto (2024b) I put forward a full-fledged version of the model. Roughly speaking, the latter is a pragmatic diagram that accommodates to the experimental evidence that episodic alloanimals do the things they do (in the short, mid, and long terms) because they arbitrary choose to (as Habitualiter), (2) because it is sensibly possible to do so (as Virtualiter), and because they can afford to do it (as Actualiter).

During the earliest stages of my research (e.g., when it was merely a research project proposal), I framed the above goal as a form of applied "biotranslation" (Kull, Torop 2011: 16) (cf. Marais, Kull 2016). The rationale behind this was that AEM experiments essentially translate innenwelt formation in terms of semiosis or how (1) a hypothetical form of episodic imagery or memory *structure* (subjectively experienced by a 'rememberer'), represents or binds (2) some what-where-when/which memory *content* that objectively informs (3) the intentional behavior or teleological expression of memory *flexibility* (Crystal 2010). Although I did not continue using the concept of biotranslation as such, it could be said that modelling of AEM in Miyamoto (2024b) adjacently falls under this method, also referred to as "non-linguistic, process semiotics" (Marais 2018: 48).

The **novelty** of this form of biosemiotic modelling is justifiable if we consider that the phenomenological implications of AEM tend to be neglected in behavioral studies (Xue 2018: 558). Understandably enough, the need for models that translate observable behavior in terms of their underlying phenomenology has repeatedly been acknowledged in the literature (Dere *et al.* 2005) (Martin-Ordas 2016: 306) (Cyrstal 2009, 2021). Admittedly, there are already some interdisciplinary models that conform to the comparative evidence that AEM is a case of convergent neo-Darwinian evolution (Aggleton, Pearce 2001) (Emery, Clayton 2004) (Seed *et al.* 2009) (Crystal 2021).

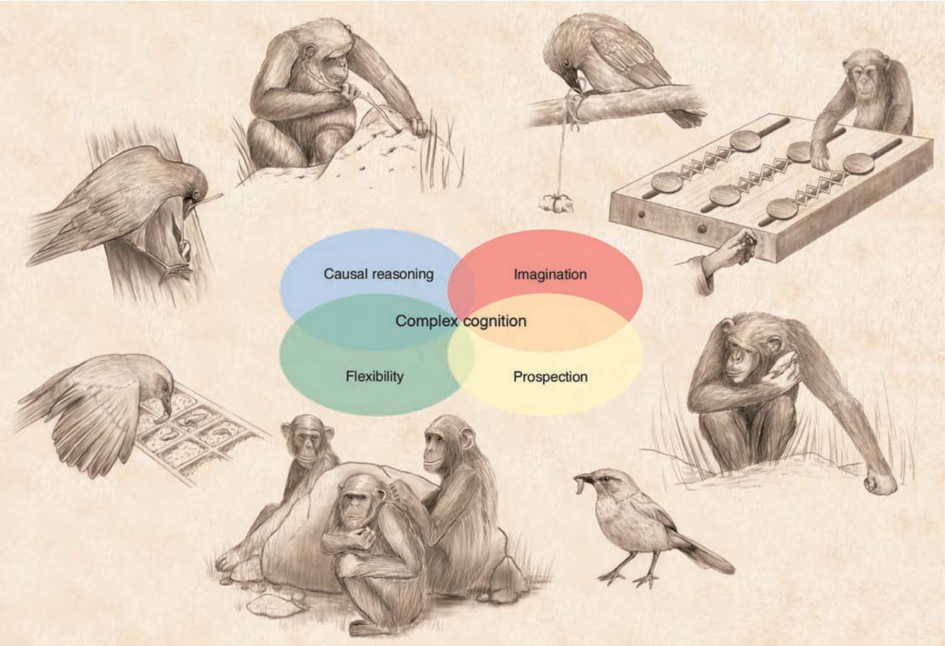

Figure 5: "Illustration of the four nonverbal cognitive tools displayed by corvids and apes, which are proposed as the basis for complex cognition". Reproduced from Emery and Clayton (2004: 1906), including drawings by C. Cain, and reprinted with permission from the American Association for the Advancement of Science (AAAS).

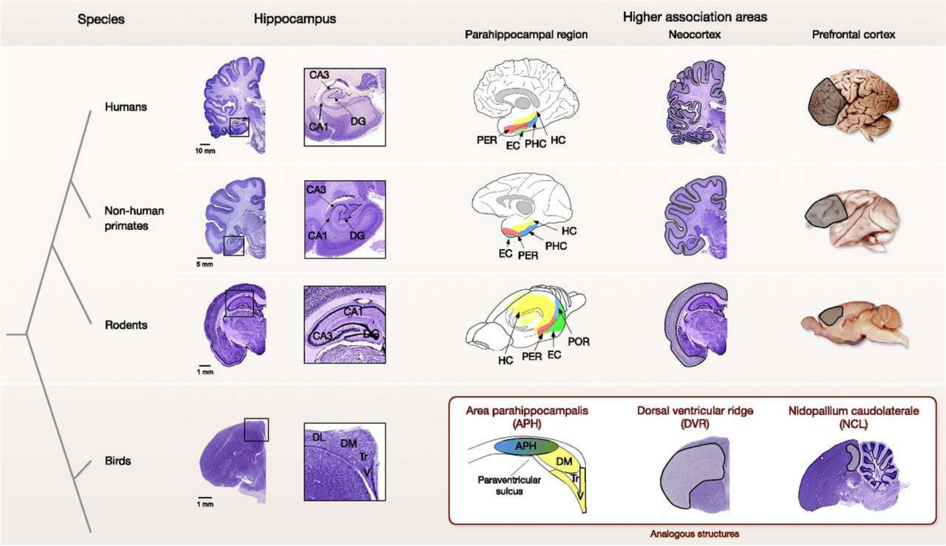

Figure 6: "Brain regions important for episodic memory". Reproduced with permission from Allen and Fortin (2013: 10381) and © 2024 National Academy of Sciences.

Models like figures 5 and 6 address why, despite neuroanatomical differences, distinct species are able to display analogue W-W-W/W forms of AEM (Rattenborg, Martinez-Gonzalez 2013). As put by Clayton and Emery (2009: 111), "the ability to remember the what, where and when of unique past episodes is the hallmark of episodic memory that can be tested in animals".

In other words, in this cross-species context, the famous thesis of multiple realizability (Bickle 2020) becomes relevant to account for how equivalent cognitive processes and mental states can be achieved through different neural substrates in different species, such as the conscious attention of Working Memory (Chudasama 2010), and the imaginative capacities of Mental Time Travel (MTT) (Dere *et al.* 2019).

Compared to the above evolutionary and neuroanatomical models, there is a smaller number of cross-species *phenomenological* models of AEM; not to mention the absence of a biosemiotic model that specifically insists on the underlying role of semiosis in forming the what-where-when structure of episodic representations or 'mental imagery'. A representative example is displayed in figure 7 below.

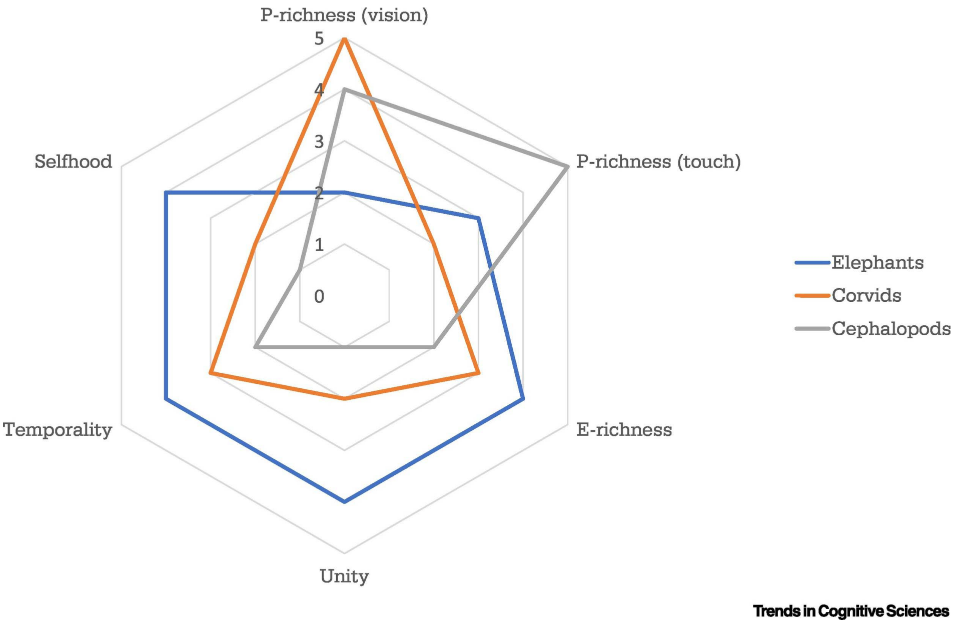

Figure 7: "Hypothetical Consciousness Profiles for Elephants, Corvids, and Cephalopods". Reproduced from Birch et al (2020: 789), with permission from © 2020 Elsevier Ltd. Creative Commons CC-BY license.

Against this background, my research initially revolved around four general **research questions** already posed by Tønnessen *et al*. (2018: 323). Although these questions were formulated to translate alloanimal Umwelten in general, I progressively adapted them to the particular context of AEM studies as follows: (1) Are there episodic phenomena beyond human EM? (2) What is the relation between semiosis and phenomena in AEM? (3) Should a biosemiotic phenomenology be practiced as pure theory, or as applicable for experimental AEM studies? And (4) How can biosemiotics contribute to understanding phenomenology in AEM?

The **research methods** used to approach these questions mostly consisted of documentary research, the body of which is composed of historiographical meta-studies, comparative neuroanatomical studies, and experimental ethological studies. First and foremost, I followed already existing research that made a case for the need to further characterize the *common* phenomenological features underlying and supporting AEM.

The latter could be summarized in the form of **four** claims or theses: (1) the '**objective**' claim, (2) the '**mental representation**' claim, (3) the '**evolutionary background'** claim, and (4) the '**imaginative consciousness**' claim (which integrates the previous claims for the most part):

1) Key phenomenological traits of AEM can be objectively tested through non-verbal behavior:

> Episodic memory has a distinctive phenomenology: it involves “mentally reliving” a past event. It has been suggested that characterising episodic memory in terms of this phenomenology makes it impossible to test for in animals, because “purely phenomenological features” cannot be detected in animal behaviour. Against this, I argue that episodic memory's phenomenological features are impure, having both subjective and objective aspects, and so can be behaviourally detected. Insisting on a phenomenological characterisation of episodic memory consequently does nothing to damage the prospects for detecting it in nonhuman animals. (Boyle 2020: 641)

2) Mental representations play a role in understanding overlapping features of AEM.

> defining memory types on the basis of the brain structures involved rather than on identified cognitive mechanisms risks missing crucial functional aspects of episodic memory, which are ultimately behavioral. The most productive way forward is likely a combination of neurobiology and sophisticated cognitive testing that identifies the mental representations present in episodic memory. Investigators that have refined their approach from asking the naïve question ‘‘do nonhuman animals have episodic memory’’ to instead asking ‘‘what aspects of episodic memory are shared by humans and nonhumans’’ are making progress. (Templer, Hampton 2013: 802)

3) Some key features of EM are evolutionarily shared by humans and alloanimals:

> Episodic memory, the ability to episodically recall unique past experience and to have mental representation of events in time was once thought to be limited to humans. However, extensive work, mostly by Clayton and co-workers, has demonstrated that some animals can certainly have episodic-like memory. […] Similarly, examining episodic memory and metacognition, once considered unique to humans, helped identify their core mechanisms and possible evolutionary background in animals: the need to separate episodic and semantic memories quite early in behavioural evolution and the availability of associative models for metacognition suggest that some forms of episodic memory and metacognition may be common in animals. (Arbilly, Lotem 2017: 4,6)

4) There are “partially overlapping cognitive capacities that require, generate, or serve as building blocks of imaginative consciousness”, as quoted from Zacks’ *et al.* list (2022: 39-40):

> a) Episodic/event memory, showing a sense of time and place, and the unification of elements to form a discriminable scene.
>
> b) Flexible offline updating, recombination, and reconstruction of stored memories (apparent, for example, during dreaming).

c) Causal, goal-directed learning, which involves recognition that actions cause outcomes and learning that outcomes satisfy needs […].

d) Enhanced control of emotions, so that online and offline events do not elicit the same action programs.

e) Enhancement of both asocial and social attentional skills.

f) Planning or prospective memory requiring integration over time, causal reasoning and monitoring of one's actions.

g) In a social context — attribution of intentions to others ('theory of mind'), pointing to social-causal reasoning.

h) Pretend play (mainly in great apes and children).

Methodology wise, the dissertation consisted in applying Peircean biosemiotics to the umwelt analysis and translation of AEM as a cross-species primary modelling system. Additionally, during the earliest formulations of my research, I framed such methodology within Jaroš and Maran's (2019: 385) GUTP (Gradualism, Unitarism, Transformativism, and Pluralism) typology under the narrative of *pluralism*.

The latter assumes that (1) umwelten are species-specific but also display intersubjective and convergent features; (2) humans do not have 'superior' mnemonic and/or mental faculties; and (3) semiosis is a universal or natural kind of sign-process vital for the species-specific phenomenology of sentient lifeforms. This pluralistic narrative was developed and justified in more detail in Miyamoto (2023) within the broader biosemiotic context of Semiotic Self Theory.

The **main findings** or results of my research are not found in this introductory chapter per se, but in the conclusions of the four appended publications. In this sense, I commend the reader to check section seven in advance. Nonetheless, in the bigger picture, this dissertation acquires retroactive consciousness of a more general finding that was already suggested as part of the research problem. This is, even if they are not homologous, human EM and AEM have more pragmatic commonalities between them than previously suspected. For instance, both could be explained in the phenomenological terms of *virtual habits* (Miyamoto 2024b), making a case for the need to research EM and AEM hand in hand as analogue forms of episodic semiosis. This resonates with Anderson's argument for a semiotic human-alloanimal ethnology:

> In the 21st century, we are discovering that many of the distinctions assumed between life forms—for instance, between humans and alloanimals, and between animals generally and plants, and between any of the above and other forms of life —have been gradually lessened or even eliminated. This is the result of better semiotic understanding of life and living, and of increased detection of communication within and between units of analysis, whether that be individual organism, a group of conspecifics, or unrelated species in proximity or even at distances from each other. (Anderson 2016: 6)

As comparative approaches have shown for decades, the commonalities between EM and AEM allow the study of one form to shed light on the study of the other. This resembles how it was eventually acknowledged that a variety of species possess Semantic Memory (SM), the memory system responsible for consciously and voluntarily recalling and communicating information with others (Griffin 2001: 4833). An iconic example is how Hampton (2005, 2001) showed that rhesus macaque monkeys are able to purposely report the presence or absence of particular visual memories depending on their declarative or metacognitive confidence before a test (cf. Griffin, Speck 2004: 5).

Because EM is a subtype of declarative memory that *depends on* SM (another form of declarative or conscious memory system), it follows that alloanimals with AEM have been known to already possess the 'minimal' neurocognitive prerequisites that are necessary to speak about a fully-fledged EM, alongside Procedural Memory, Sensory Memory, and Working Memory. This idea is shown in more detail in figure 8 below.

Semantic/Episodic Memory Common Features	**Episodic Memory Unique Features**
1. Key function: Knowing—Registering, storing, and using sharable knowledge of the world. 2. Multimodal input. 3. Transmodal storage. 4. Fast encoding operations—single-trial learning possible. 5. Large, complex, highly structured storage. 6. Stored information is representational—isomorphic with what is, or could be, in the world. 7. Stored information is propositionalizable. 8. Stored information can be used as a basis of inferences. 9. Information processing is highly sensitive to context. 10. Stored information can be accessed flexibly. 11. Stored information is expressed symbolically. 12. System is cognitive—contents can be thought about. 13. Behavioral expression is optional and not obligatory. 14. Operations do not require awareness of time.	1. Key function: Remembering—Conscious awareness of happenings in subjective time (chronesthesia). 2. Makes possible mental time travel in both temporal directions, past and future. 3. Operations accompanied by autonoetic conscious awareness. 4. Operations depend on a remembering self. 5. More recently evolved than other memory systems. 6. Ontogenetic development lags behind other memory systems. 7. More vulnerable to disease, injury and aging. 8. Operations require the establishment and maintenance of a special neurocognitive set—episodic retrieval mode. 9. Operations depend on semantic memory. 10. Episodic remembering implies semantic knowing, but semantic knowing does not imply remembering. 11. Dependent on prefrontal cortex and other neocortical regions in a way that other systems are not.

Semantic/Episodic Memory Common Features	**Episodic Memory Unique Features**
15. Operations accompanied by noetic conscious awareness. 16. System interacts closely with other neuro-cognitive systems, such as those involved in in language, affect, and reasoning. 17. Dependent on widely distributed cortical and subcortical neural networks, including temporal lobe and diencephalic structures. 18. Present in a wide range of animals; highly evolved in mammals and birds	12. Probably unique to humans

Figure 8: "Features of Episodic Memory", table reproduced from Tulving (2005: 11), with permission from © 2024 Oxford University Press. License number 95944.

SM was also believed to be uniquely human, but nowadays it is uncontroversial to recognize it in a myriad of species. This is the case because experimental evidence on SM essentially underwent a philosophical reinterpretation, parting ways with the label "intelligent but unthinking behavior" (also referred to as the "animals do not know that they know" argument), which has been criticized by posthumanism (Wolfe 2010: 40).

In short, SM is now considered a neurocognitive system that is *analogous* or equivalent between a plurality of species. There is even more reason to believe the same will eventually happen to EM if redefined zoosemiotically. Hopefully, the convergence of biosemiotics and AEM studies will contribute to reconsider the 'suspicion' that alloanimals are some sort of illiterate hippocampal amnesiacs "stuck in the present", as thoroughly criticized by Zentall (2005; 2006; 2013).

As I have tried to show, increasing empirical evidence directly contradicts the famous Bischof-Köhler hypothesis (cf. Cheke, Clayton 2010: 916), which states that alloanimals are permanently and unconsciously improvising, not being able to dissociate themselves from their current motivational state. In response, the phenomenological apparatus of (Peircean) biosemiotics has the responsibility to raise to the challenges (and advantages) posed by this evidence, potentially contributing to the more general idea of semiotics as a "science of memory" (Bouissac 2007).

4. FAIR AVERAGE MEN

> Take off the wings, and put him in breeches, and crows make fair average men. Give men wings, and reduce their smartness a little, and many of them would be almost good enough to be crows.
>
> -Henry Ward Beecher (1871: 2)

'Nevi' hides a snack in the nooks of an old house's pitched roof. It is probably an invertebrate or a piece of edible garbage, like a veggie or a breadcrumb. Before flying away, this hooded crow (*Corvus cornix*) makes sure that potential pilferers are not peeking. Two days later, before sunset, Nevi will discreetly come back to retrieve the cache from his secret pantry, one of many distributed across the neighborhood.

This is but a 'snapshot' of Nevi's lifetime, which may span as long as 16 years. What is more, Nevi's theftproof food-storing behavior is but an infinitesimal link in the coevolution of caching and pilfering in corvid societies (Grodzinski, Clayton 2010), an ancient game of deception and theory of mind.

Far from being the product of mere chance, or the result of an automatic reflex, Nevi's deeds are the expression of ***episodic semiosis***: a habitual sign process by which the formal qualities of a memory simultaneously stand for both (1) the ostensible existents of an already enacted and experienced past, and (2) the virtual possibilities of a yet-to-be enacted and lived future. Let's break down this idea into the most semiotically 'standard' (Peircean) terms possible.

There is a consolidated fact or ***dynamic object***: Nevi hid the snack (what) on the roof (where) two sunsets ago (when). Although this spatiotemporal event is gone, it may later be (re)presented or (re)instantiated in Nevi's mind in the form of an equivalent what-where-when elicitation or ***representamen***. Without the subjective ability to freely recall the caching episode on a demand basis, Nevi would most likely forget about his precious snack. This declarative what-where-when memory is 'internal' in the sense that Nevi would be able to still remember the hidden cache even if some socioenvironmental cues were occluded or absent (e.g., physical landmarks, the presence of conspecifics, and even if the snack was not there anymore).

This (re)*presentation* of a lived event or 'replay of an experience' is not 'stored' in Nevi's brain per se, even though it cooccurs with the reinstatement of a distributed neural pattern. Rather, this what-where-when memory exists as a *virtual* disposition in Nevi's 'mind's eye', possessing the capacity or virtue to sensibly inform him about the consequences of that specific caching episode. The latent presence and potential replicability of this memory is crucial for Nevi's "ability to produce rich, flexible representations of various past events, and to prepare for specific events in the future in a number of different ways" (Jelbert, Clayton 2017: 99).

Nevi chose to fly from across town in order to retrieve this specific cache, perhaps because he knew it was about to expire, or because there were not enough fresh items to forage elsewhere today. This consequential (past-oriented) action could be said to be a ***dynamic interpretant***. Such observable behavior arguably demonstrates Nevi's phenomenological capacity of recalling the what-where-when episode by means of species-specific sensations, thoughts, and actions.

Naturally, Nevi's imagistic memory is not an ontological copy of the physical past, an ostensible spatiotemporal entity that is far more general and somehow inaccessible. The finite and synchronic qualities of Nevi's memory, instead, present what is known as the ***immediate object*** (EP2: 495), which is just *some* intelligible characters of the dynamic object, as formally imputed by the representamen's phenomenological features.

In other words, Nevi's memory substitutes or analogically stands for something other than itself in *some* relevant or pertinent (what-where-when) capacities. The properties of such ***immediate object*** could objectively be inferred from the systematic observation of Nevi's behavior, provided Nevi's memory "(A) stores detailed information about visuo-spatial features of an event; (B) represents the event's temporal structure; (C) represents a past event as past; [and] (D) stores some self-specifying information about the subject at the time of the event" (Boyle 2020: 18).

Even more remarkable, Nevi hides dozens of similar items in several spots every week, but he can sensibly distinguish between seemingly identical caching episodes. This is, Nevi needs to conceptually discern between replicas of different types of what-where-when/*which* episodes. Nevi not only knows the semantic difference between 'peanut in pitched brown roof' and 'cricket next to big round gravestone' caching episodes, but also the unique *timing* and/or *context* of episodes of the same kind (Eacott, Easton 2010).

Indeed, before performing the bodily actions (or dynamic interpretant) of consuming any item on his omnivorous secret menu, Nevi is to make choice-making: the recognition of one among several simultaneously available courses of action. This first grasped meaning or identification of a memory is said to be the ***immediate interpretant***. But once our feathered meaning-maker actually consumed the hidden item of his choice, there is every likelihood that a ***final interpretant*** will be formed: a virtual habit or more general disposition determining the reinstantiation of future courses of action in the face of similar circumstances (MS 939:22).

Namely, Nevi will develop the purposeful (and likely self-conscious) habit of retrieving items with shorter shelf lives before other items *if* given the opportunity. This habit is as consistent as it is flexible. Nevi will adjust his food-storing strategies during freezing winters since the shelf lives of caches are considerably longer.

The 'virtuous' or eloquent reality of what-where-when/which (W-W-W/W) episodes in Nevi's lifetime is *both* the synchronic result of his 'imaginary' or imagistic mental representations *and* the causal or diachronic result of his 'real' embodied actions. In this sense, episodic semiosis goes beyond the merely phenomenological. It is an inferential process that proportionally connects and updates the *ontological* universes of "Possibles" (e.g. mental simulations) and "Existents" (e.g. items and factual events) by means of the universe of "Necessitants" (e.g. habits and goals) (EP2: 478-479).

All in all, the subjectivity of Nevi's 'internal' lifetime and the objectivity of his 'external' ecological time experientially coincide as consequential or pragmatic corelates in episodic semiosis, a long-term sign-process by which an experienceable medium or *representamen* (e.g., a vivid memory) virtually stands for an absent *object* (e.g., an already lived episode) by means of an *interpretant* (e.g., an inferential or choice-making act with future practical bearings).

Representamens, immediate objects, and final interpretants have different names in experimental corvid studies: respectively, Memory Structure (MeS), Memory Content (MeC), and Memory Flexibility (MeF). But, in the standard terms of Peirce's hexadic semiosis, the above caching episode could be summarized as a an ever-evolving influx implying at least six distinct semiotic correlates that coincide and unfold over time:

1. **Dynamic object** (Od) belonging to the ontological universe of *Existents*:
   The embodied event of Nevi purposefully hiding the snack on the roof two sunsets ago.
2. **Immediate object** (Oi) or MeC:
   Some W-W-W/W cognizable qualitative aspects of the actual caching episode.
3. **Representamen** (S) or MeS, belonging to the universe of *Possibles*:
   Nevi's memory possessing the analogous W-W-W/W virtues of something other than itself.
4. **Immediate interpretant** (Ii):
   A first recognition or choice-making made among two or more simultaneous possibilities.
5. **Dynamic interpretant** (Id) or action:
   The actual bodily behaviour of retrieving the cache.
6. **Final interpretant** (If) or MeF, belonging to the ontological universe of *Necessitants*:
   The development of an adaptable habit influencing future caching/retrieving episodes.

Peirce's 1908 model of hexadic semiosis (Od→Oi→S→Ii→Id→If) is said to be an irreversible causal chain (Jappy 2020: 166), triggered by the dynamic object, and unidirectionally determining the subsequent elements. Episodic semiosis, in contrast, requires accounting for how the final interpretant will evolve and influence subsequent instantiations of dynamic objects or caching/retrieving episodes. More interestingly, this long-term phenomenon demands an explanation of how other final (teleological or anticipatory) interpretants may have *preceded* Nevi's resolution to strategically hide the snack in the first place.

Let's break down the above idea into the least standard semiotic terms possible. If "time is what keeps everything from happening at once" (Cummings 1922: 46), memory is what keeps us from *feeling*, *wanting*, and *doing* everything at the same time. Indeed, in Nevi's episodic semiosis, timing and contradiction are of the essence. As put by Peirce (CP 1.493):

> for an event there is requisite: first, a contradiction; second, existential embodiments of these contradictory states; [third,] an immediate existential junction of these two contradictory existential embodiments or facts, so that the subjects are existentially identical; and fourth, in this existential junction a definite one of the two facts must be existentially first in the order of evolution and existentially second in the order of involution. We say the former is earlier, the latter later in time. That is, the past can in some measure work upon and influence (or flow into) the future, but the future cannot in the least work upon the past. On the other hand, the future can remember and know the past, but the past can only know the future so far as it can imagine the process by which the future is to be influenced.

Nevi's anticipatory feat required what appears to be at least two conflicting events, states, or dynamic objects: snack being cached (a consolidated fact), and snack being retrieved (a potential action). From the perspective of an external observer, both events may look like unidirectional and discrete actions. However, from Nevi's long-term subjective perspective, both episodes are connected through a temporal phenomenology that is bidirectional and continuous, where W-W-W/W correlates are habitually recombined and differentiated during semiosis. As put by Kemple (2019: 154):

> The triadicity of semiosis, therefore, consists not merely in a chain of linear events, but each element—object, vehicle, and interpretant—receiving its determination through the specifically semiosic relation itself: the nature of the interpretant determines its bearing to the sign-vehicle and to the object, which object in turn determines the appearance of the sign-vehicle and thus the effect upon the interpretant, while the nature of the sign-vehicle determines both its receptivity to the causality of the object as well as its transference to the interpretant. While the nature of the interpretant serves simultaneously with the nature of the sign and the nature of the object in determining the nature of the semiosic relation, the causality of the sign is objective or specifying causality. […] What makes an act semiosic, therefore, is not (as some may think) the actuality of interpretation, but rather the impression of the object on the interpretant by means of the sign.

Under the same token, episodic semiosis does not consist of a unidirectional hexadic chain per se, but of an influx where at least two conflicting hexadic chains are mutually determined and negotiated through a mediator: **If1**→Od1→Oi→S→Ii→Id↔**If3**↔Id←Ii←S←Oi←Od2←**If2**. In Miyamoto (2024b) I presented a full account of this way of modelling episodic memory, in terms of three interrelated forms of virtual habits.

If1 was dubbed “Virtualiter”, a mode of cognition inspiring a MeS (Od1→Oi→S→Ii) and displaying present-oriented “resolutions” in the form of “episodic simulations” (Id↔). If2 was dubbed “Actualiter”, a mode of cognition informing a Memory Content (Ii←S←Oi←Od2) and enacting past-oriented “implementations” in the form of “episodic actions” (↔Id). And If3 was dubbed “Habitualiter”, a general mode of cognition controlling a Memory Flexibility (Id↔If3↔Id) and differentiating future-oriented “determinations” of simulations and actions.

Extrapolated to Nevi’s food-storing hexadic snapshot, we could further account for his episodic semiosis in terms of the above 13 correlates, which could be provisionally dubbed as a “devil’s dozen” or the more famous “baker’s dozen’ metaphor”.

First, Nevi remembers and visualizes the W-W-W/W caching episode (a present-oriented elicitation). This could be modelled as If1→Od1→Oi→S→Ii→Id. It means that a habit of experience or Virtualiter (If1) visualizes a Memory Structure (Od1→Oi→S→Ii) in the form of a neurophenomenological simulation (→Id). Second, Nevi retrieves the snack in an actual W-W-W/W scenario (a past-oriented action). This could be modelled as Id←Ii←S←Oi←Od2←If2. It means that a habit of conduct or Actualiter (If2) proceeds with a MeC (Ii←S←Oi←Od2) in the form of a bodily action (←Id). So far, we could say that the qualitative possibilities present in Nevi’s memory, as a representamen or sign, *turned into* the quantitative actualities of Nevi’s past as an eventual object, in *some* capacities.

The virtual retrieving episode (Od1) and the actual retrieving episode (Od2) however, were connected across time and space by a general habit of thought or Habitualiter (If3), otherwise known as MeF, which pertinently determines the optional transformation between mnemonic simulations into procedural actions and vice versa (Id↔If3↔Id). Episodic semiosis is a subjective-objective confluence where If3 possesses the virtues of the ontological universe of Necessitants or *would be*’*s*; If1 displays the virtues of the ontological universe of *Possibles* or *could be*’*s*; and If2 affords the ontological universe of *Existents* or the reality of what *actually was* the case.

In the more metaphorical terms of the Mississippi Delta of Memory, at the general tributaries or ‘beginning’ of Nevi’s delta there is a phenomenal dimension I call ‘Virtualiter’ (a final interpretant of the emotional kind) where ‘crews’ are barely *visualizing* their potential routes and sensing their future needs. The Virtualiter serves as a panoramic ‘lookout’ for voyagers to make improvised *resolutions* about where they want to go, to figure out what ship they need to board, and to map their uncharted route.

At the many distributaries or ‘ends’ of Nevi’s delta there is an embodied dimension I call the ‘Actualiter’ (a final interpretant of the energetic kind), where crewed ships engage with the landscape. The Actualiter is a situated navigation, the moments when ships *implement* their preconceived (or improvised) route, and temporarily culminate their quest at the sea.

Nevi’s ‘crew and captain’ (aka ‘body-mind’) are accustomed to improvising on the spot, but their long-term success lies in their determination to bidirectionally move between their origin and their destination. Nevi's episodic behaviour is certainly not caused by the absolute chance of an unpredictable process (e.g., dreaming), nor by the absolute force of a mechanical structure (e.g., reflex pathways). There seems to be a more powerful and compelling causal force influencing our traveller's *flexible* and *optional* trajectories. Such teleological dimension is the 'Habitualiter' (a final interpretant of the logical kind), which could be thought of as the long-term agendas, goals, and preferences influencing the arbitrary *choices* of alloanimals like Nevi.

Nevi's verisimilar recollections largely overlap with free imagination, but they have a distinct phenomenology grounded on actual *experience* (Rivadulla-Duró 2022: 12). In the Peircean terms of phaneroscopy (his equivalent term for phenomenology), the unbound hallucinations of human imagination depend on Firstness and emotional interpretants, while AEM (similarly to healthy human EM) mostly relies on Secondness and logical interpretants (West 2017: 64). This is, Nevi's WWW/W creative "episode-building" (West 2018: 92) aims to pertinently represent the *actual potentialities* of the envisioner's world, insofar as to achieve a plausible end-state or goal.

The "baker's dozen" (**If1**→Od1→Oi→S→Ii→Id↔**If3**↔Id←Ii←S←Oi←Od2←**If2**) is a minimalist way of modelling episodic semiosis, provisionally accounting for how Nevi is able to reconcile two otherwise contradictory dynamic objects: (1) the potential or yet-to-be enacted episode of him retrieving the snack on the roof during a future time (Od1), and (2) the embodied or already-enacted episode of him retrieving the snack on the roof in a past time (Od2).

Indeed, (episodic) memory is not so much about objectively witnessing the mechanical unfolding of physical events (e.g., the unidirectional sequence past→present→future), as it is about the pragmatic ordering or enacting of lived episodes (e.g., the anticipatory becoming present↔future↔past). If future becomes present, and present becomes past, the past holds the potential to become future, in the sense that it may be 'revisited' in the present, to some extent and in some capacities. It is the Habitualiter's anticipatory virtues as a mediator (↔future↔) that precede *and* succeed (Id↔**If3**↔Id) the individuation of both episodic elicitations and actions.

Naturally, this does not mean that every aspect of Nevi's behaviour is the cause of episodic semiosis. Arguably, a large part of Nevi's conduct could be explained in terms of him learning semantic rules via SM, which allows Nevi to map the location of his nest and foraging spots, and to update concepts (e.g. semantic categorization) regarding which conspecifics are familiar or alien, and even which allospecific species are friend or foe. Indeed, Nevi owes a large portion of his knowledge to the factual relations expressed by the natural dicisigns in his SM: "the very memorizing of storage caches, often close to small landmarks, constitute so many Dicisigns: 'This place contains food'" (Stjernfelt 2014: 155).

There are other aspects of Nevi's conduct that could be simply explained through non-episodic mechanisms, such as relative familiarity, trace of memory decay, classical conditioning, involuntary retrieval, associative cuing, and even circadian rhythms. Nonetheless, once the latter have been ruled out as the causal source of long-term MeF, a tentative hypothesis to account for his anticipatory actions is to link them with the phenomenology of episodic semiosis. This long-term sign-process allows the phenomenological binding of a unique W-W-W/W episode in ways of which other memory systems in isolation are incapable.

Nevi is taking a 'casual' walk on a busy street. He is actually inspecting a patch of grass on the sidewalk. He finds something fresh to snack on, but he does not eat it right away, almost as if containing his excitement. He knows fellow crows are watching. He flawlessly conceals the food inside his beak, and then *pretends* to bury it next to a utility pole. Nevi very well knows it takes a thief to catch a thief (Kelley, Clayton 2017), since he has been a chronic victim of pilfering.

'Loki', a younger hooded crow, comes to inspect the caching scene right after Nevi flew away, only to realize that there was nothing left behind. I feel sorry for Loki. I place a bunch of peanuts in front of my porch, but Loki will eat them only when he makes absolutely sure I am not watching from my window. I imagine Loki thinking "this is too good to be truth". He does not believe that I am 'gifting' food to him, but that he is 'stealing' from me. After enough pranking episodes involving Nevi and me, Loki will develop a more suspicious attitude towards those that seem to hide snacks in plain sight and right next to the caching spot: "the question 'why?' emerges from the organisms need for a memory-based future prediction with the aim of dissecting causality" (Lotman 2021: 77).

5. THE BEAUTY OF THE ROSE

> Logicians imagine that an idea has to be connected with a brain or has to inhere in a 'soul'. This is preposterous: the idea does not belong to the soul; it is the soul that belongs to the idea. The soul does for the idea just what the cellulose does for the beauty of the rose; that is to say, it affords it opportunity.
>
> -Charles Santiago Peirce (1902: CP1.216)

This section serves as an appendix to Miyamoto (2024b). It addresses some frequently asked questions concerning the below AEM model, which I proposed as the central piece of my research. The number one question I get asked the most is what type of **temporality** and/or **causality** is the model depicting? The short answer is that it shows an anticipatory temporality by means of final causality. However, there are further clarifications to be made in this regard.

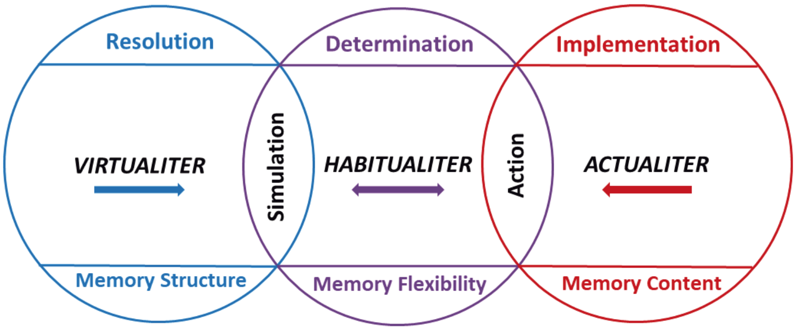

Figure 8: "A multispecies cognitive model explaining episodic behaviour as the result of an irreducible meaning-making process between three modalities of virtual habits", reproduced from Miyamoto (2024b).

The Aristotelian distinction between efficient causation and final causation is an essential part of Peircean semiotics. The former causality pertains the physical realization of a reaction or work, while the latter causality pertains the *intentions* or purposes motivating an optional action. Indeed, Peirce clearly recognized how selfless mechanical causation differs from a subjective temporal causation (CP 1:211, 1.325, 2.86, 7:366; W 8:128).

It is said that in efficient causation there is no ontological distinction between the past and future states of a physical system, since they are virtually reversible or equivalent in terms of energy conservation (e.g. like an hourglass or an engine). In contrast, in final causation there is an irreversible or teleological logic of becoming from future to present, and from present to past (e.g., the scene construction in episodic MTT).

Contemporary Peircean semiotics still recognizes semiosis as the phenomenological interplay between past-oriented (efficient) and future-oriented (final) ‘arrows of time’ (cf. De Tienne 2016). In like manner, my Peircean modelling of AEM is interested in distinguishing final causation and, at the same time, understanding its continuity with respect to efficient causation, without which optional purposes could not have any actual efficiency in the world (e.g., via the embodiment of formal and material causes).

The interplay between efficient and final forms of causation has also been recognized in biosemiotics and other fields. For instance, Deacon (2012: 270) explains the emergent organization of living systems as the passage from morphodynamics (e.g., work) to teleodynamics (e.g., intentionality). Also, in Uexküllian paradigms there is a distinction between a physical “eotemporality” and a phenomenological “biotemporality” (Fraser 2017: 46). And, even in Wittgensteinian paradigms, there is a difference between an objective “information time” and a subjective “memory time” (Rizzo, 2016: 137).

The above distinctions could be grouped, respectively, under the “B-series” and “A-series” of time (Nomura *et al.* 2019). In this context, my modellistic account of AEM belongs to the later series (entailing final causation, teleodynamics, biotemporality, and memory-time), where a first-person timekeeping is done via agency, memory, and anticipation. More specifically, according to Nomura *et al.* (2019: 270) the A-series time is concerned with:

> personally sensed subjective time under the influence of individual experiences, such as jet-lag or time slowing down, moving fast or being frozen […] one’s sense of the past, present and future, i.e., tense, where boundary making depends on the individual’s pace and tempo.

The second question I get asked the most about my model is what is the reason for its peculiar **geometry** or design? The short answer is purely practical, insofar as it serves the purposes of visually explaining a hypothesis in its minimal terms. However, my views on episodic phenomenology have undergone several changes over the past six years, and so has the model.

My early account of human EM (Miyamoto 2020), following De Tienne (2016), placed (what today I call) the Virtualiter’s Firstness at the center of the phenomenology of time. I dubbed this the “III↔I↔II extrapolation”. Roughly speaking, the latter made emphasis on a present-oriented or ‘presentist’ understanding of memory. In Aristotelian terms, I placed formal causation at the center, as the flexible gateway communicating final causation (on the left) with efficient causation (on the right), while material causation was being subsumed and implied by the other forms of causation.

Similarly, the first prototype of my AEM model preserved the primacy of the Virtualiter as the timeless gateway between the Habitualiter’s Thirdness and the Actualiter’s Secondness. I believe this ‘old’ configuration (cf. Chávez-Barreto *et al.* 2022) is still adequate in explaining some aspects of AEM when it comes to the immediacy and internality of the phenomenal present as Umwelt (cf. Kull 2015a, 2015b, 2018).

In contrast, the current version of figure 8 displays a pragmatic or future-oriented understanding of memory. Following West (2013, 2016, 2017, 2018, 2019, 2022), the model resumes the argument that (virtual) *habit* is the defining long-term causal force of AEM, being the flexible (self-controlling and arbitrary) mediator between Virtualiter and Actualiter.

This displacement of the Virtualiter improved the way the model depicts the intertwined roles of formal causality (what I call 'resolution') and efficient or bodily behaviour (what I call 'implementation') by means of final causality (what I call 'determination'). Such configuration of the model, thus, attributes a double consciousness to the Habitualiter, in the sense that resolutions cannot bypass determinations to communicate with implementations. And, likewise, Memory Structure (MeS) cannot be imputed a Memory Content (MeC) without the reinterpretative capacities of Memory Flexibility (MeF).

Another way of explaining this crossroad-like conflict was termed the "baker's dozen" (in section four), where the final-logical interpretant "If3" was said to play the role of an intermediator or Habitualiter: If1→Od1→Oi→S→Ii→Id↔**If3**↔ Id←Ii←S←Oi←Od2←If2. Extrapolated to figure 8, this form of episodic semiosis maps as follows:

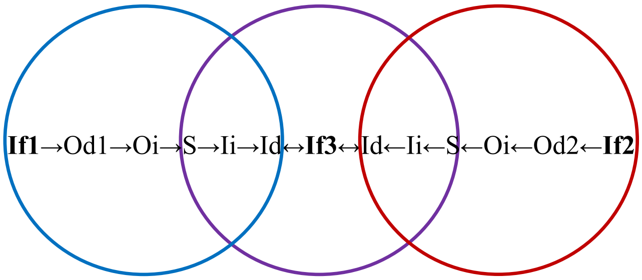

Figure 9: "The baker's dozen of episodic semiosis" models the interdependent relationships between 13 semiotic correlates in AEM. The blue circle refers to the Virtualiter's memory structure, the purple circle refers to the Habitualiter's memory flexibility, and the red circle refers to the Actualiter's memory content. The overlapping between blue and purple represents the stage of simulation, and the overlapping between red and purple represents the stage of action.

The 'horizontal' or 'linear' design of figures 8 and 9 has been objected for several reasons. For instance, it has been argued that the model does not 'make justice' to the irreducibility of semiosis; or that it does not 'simultaneously' show all the possible interactions between Habitualiter, Virtualiter, and Actualiter. Along those lines, the most common suggestion the model has received is that it should depict the three forms of virtual habit as a perfect symmetrical triad, as the following figure shows:

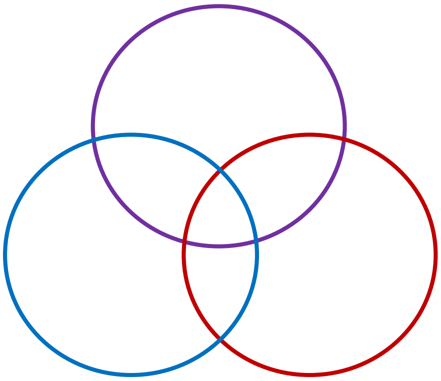

Figure 10: a ruled-out configuration of the AEM model in Miyamoto (2024b), which has been suggested independently by several colleagues, either for aesthetic or diagrammatic reasons.

In this sense, it is worth clarifying that figures 8 and 9 are not intended to be a Venn diagram representing all the possible combinatorial options of its categories. The configuration of figure 10 has never been adopted because it does not conform to the process-like nature of episodic semiosis and the (synchronic and diachronic) individuation of its correlates.

Instead, the aim of figures 8 and 9 is to be a tool for explaining an episodic (long-term) processuality, which is bidirectional and gets constantly updated (short-term). In this sense, the spirit of figure 8 is arguably closer to the dynamicity of Uexküll's (1992) [1934] functional cycle, or even to Eco's (1976: 142) hermeneutical model of the reader: semiotic diagrams that consider the temporal logic of becoming in different but coexisting modes of experience.

Said in Peircean jargon, figure 8 aims to depicts the causal relations between three general types of temporal expressions of stage or "general determinations of time" (CP 5.458), which are *simultaneity*, *precedence*, and *succession* (W1: 530). This is why I made the case that the Habitualiter's determinations always precede both, the simultaneity of the Virtualiter's resolutions, and the succession of the Actualiter's implementations.

The current intention of figure 8 would be lost if we represented AEM as the sudden and perfectly symmetrical overlapping in figure 10 (everything interacting everywhere at once). The phenomenology of AEM is, though, far from being perfectly distributed and instantaneous. As we have seen, AEM is more comparable to a delta river that is materially never the same but preserves its formal virtues over time thanks to its structure, flexibility, and contents.

The third question I get asked the most about figure 8 is what kind of **phenomena** it is supposed to be depicting? I am afraid there is no short answer for this, other than saying that it virtually depicts the undetermined and inexhaustible plurality of possible forms of sensations, thoughts, and actions involved in AEM.

For example, this model is general enough so as to be applicable to the cache-recovery model (mostly in birds), the cued-triggered associative retrieval (mostly in primates), the hippocampal replay of stream of events (mostly in rodents), and possibly other experimental models that test AEM on the common basis of observable behaviour, which assume alloanimal sentience and creativity at the very least.

On top of Miyamoto (2024b), I would like to address the third question in the alternative terms of Medium Downward Causation (MDC), where "an entity on a higher level comes into being through a realization of one amongst several possible states on the lower level —with the previous states of the higher level as the factor of selection" (Emmeche *et al*. 2000: 24).

In the case of figure 8, the Virtualiter's sphere is said to contain the 'higher level' entities, while the Actualiter's sphere contains the 'lower level' states[5]. More particularly, the Virtualiter's resolutions (vividness, intentions, and solutions) are higher *recognizable* formal entities coming into being, first, through the simulation stage (aka 'hippocampal replay'). In turn, the Actualiter's implementations (procedural affordances and semantic-indexical knowledge) work as the lower *correlational* entities coming into being through the accomplishment of one among the actual what-where-when configurations through the action stage (aka 'behaviour').

More crucially, the Habitualiter's determinations (self-control, agency, and regularity) act as medium or *governing* entities that come into being through the teleological realization of one among optional what-where-when/which goals in the level of MeF, which consider both simulation and action. The Habitualiter's sphere, then, is to be read as the multidirectional crossroad communicating (1) the inferential continuum between Virtualiter and Actualiter; and (2) the teleological hierarchy from phenomenology to behaviour. The Habitualiter acts as a causal conduit that cannot be bypassed, but also as a plastic or proportional 'translator' that enables a *multicausal* auto-communication in AEM. In the words of Emmeche *et al*. (2000: 24):

> In contrast to strong DC, medium DC does not involve the idea of a strict "efficient" temporal causality from an independent higher level to a lower one, rather, the entities at various levels may enter part-whole relations (e.g., mental phenomena control their component neural and biophysical sub-elements), in which the control of the part by the whole can be seen as a kind of functional (teleological) causation, which is based on efficient, material as well as formal causation in a multinested system of constraints.

Indeed, even if the Virtualiter suggests a lively variety of courses of action (S→Ii→Id: a virtual chain of simulation starting with a representamen), the Habitualiter still needs to choose in such a way that the Actualiter is able to realize them (Id←Ii←S: an efficient chain of action culminating in a dynamic interpretant). AEM does not have such a strong causal power to simply enact

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[5] For the purposes of the "downward" metaphor, it should suffice to imagine that figure 8 is turned 90° clockwise, so that the Virtualiter is seen on top and the Actualiter is seen at the bottom.

everything the Virtualiter simulates, nor such a weak causal power to enact only those actions previously enabled by the Actualiter. Instead, AEM has a 'medium', but flexible, causal power that allows novelty, recursive self-control, and consistency over time. Hence, the Habitualiter could be said to display the main features of habits observed by Peirce: "a tendency or disposition, regularity or continuity, physical/cognitive readiness, coordinating mind and matter, and habituescence" (West 2013: 118).

Neurocognitive or body-mind approaches usually try to understand the *causal* links between simulation (e.g., measuring a neural pattern reinstatement) and action (e.g., measuring observable behaviour). Concerning this causal continuity, figure 8 implies that the absence of a higher formal entity (resolution) will suspend the optional realization of its corresponding behavioural 'lower' counterpart (implementation), but the physical perturbation of the latter does not necessarily guarantee the retro-causal disappearance of the former.

Namely, if an episodic subject (e.g., a rat) is unable to recognize or elicit any mental representation in the form of MeS (e.g., due to induced hippocampal amnesia), it will not be able to afford any what-where-when/which MeC; and therefore, it would be unable to flexibly act on the basis of a specific non-present spatiotemporal scenario. This is the hierarchy I was referring to when I said that the Virtualiter's phenomenology is necessary to explain its teleological influence on the Actualiter's implementations. In the more minimalistic terms of semiosis, this amounts to say that without the representamen, the object cannot make its semiosic way to the interpretant, and the latter cannot influence and establish a cognizable relation with its object.

However, if the rat does not display any evident episodic behaviour in the meantime (perhaps because it is simply in a resting state), it does not mean that the rat is unable to virtually attribute a what-where-when/which content to an ongoing conscious memory simulation. This is to say, in episodic semiosis, even energetic interpretants (in the form of actions) are not automatic but *optional*. As Zacks' *et al.* (2022: 39–40) have argued, AEM implies an "enhanced control of emotions, so that online and offline events do not elicit the same action programs".

In contrast, forcefully immobilizing a cat's body (constraining the Actualiter's actions) will not eliminate the cat's persistent disposition (the Habitualiter's determinations) to fight back every time. Perhaps, on the contrary, this externally imposed loss of bodily freedom would have such a repercussion in the cat's memory, rallying the Virtualiter's resolutions, to the extent that the poor pet will force its way out of the veterinary's hands or, even better, it will eventually conceive a resolute escape plan to prevent this periodic situation from happening again. This may occur over and over until, of course, one day our cat's habituescence *opts to* mindfully give up, temporarily suspending the physical struggle. As put by West (2013: 124):

> When habit insinuates itself into the realm of the creative unconventional, it requires more than a volitional character – it entails "taking up" a habit. Taking a habit goes beyond physical laws in Secondness and self-governed impulsivity in

> Firstness. Rather, Habit is elevated to higher expressions of Thirdness—those which uncover novel patterns of being, acting, or conceptualizing. Habit in this heightened expression constitutes "habituescence" (c.1913: MS 930: 31–32). "Habituescence" transcends regularity of action in Secondness, and patterns of feelings in Firstness and even conventional regularity and continuity in Thirdness. […] At this level Habit gives rise to conscious self-control.

The current point is that, even in the absence of observable or 'external' bodily actions (efficient causes or bodily 'conduct'), MDC in AEM implies recognizing the *different* roles performed by the interpreter's goals (final causes) with respect with their own body and neural correlates (material causes). For example, during human MTT the experimental subject is not premeditating on purpose the orderly activation of specific areas in their own brain (a 'default network' as visualized in real-time through brain scans). Instead, the trained human subject is *controlling* and formally previewing their own *virtual* (externally 'unobservable') behaviour yet to be enacted (cf. Nyberg et al. 2010).

In like manner, the characteristic activation of AEM cellular substrates (in the material plane of a 'hippocampal replay' or a neural pattern reinstatement) is most likely *caused by* the vivid elicitation of the Virtualiter's resolutions in relation to the Habitualiter's determinations, and even perhaps to the Actualiter's (past or future) implementations, and not the other way around. This is, the material substrates of memory do not individually act out of their own 'volition' all at once, then "triggering" the remembere's experience. It is the rememberer's controlled MTT that collaterally activates those patters of neurobiological activity.

In other words, figure 8 is closer to depicting episodic "thoughts constraining neurophysiological states" [where] "the higher level is characterised by organizational principles —lawlike regularities— that have an effect ("downward", as it were) on the distribution of lower level events and substances" (Emmeche *et al.* 2000: 25).

AEM studies possess remarkable neurobiological knowledge of how "hippocampal representations" arise motivationally (Ólafsdóttir *et al.* 2018). Nonetheless, a biosemiotic understanding of AEM is to go beyond describing the reactivation of neural dispositions and electromagnetic patterns. As I have tried to highlight, characterizing the phenomenology of controlled and vivid mental representations may be helpful in understanding the forms in which AEM is later behaviourally expressed.

In this way, the processuality of AEM cannot be reduced to purely material causes (e.g., reactions between 'external' environmental features and 'inner' neural substrates), nor purely efficient causes (e.g., available cellular energy and metabolic consumption). Instead, episodic subjects enact a future-oriented logic with which AEM enters inferential whole-part relationships. In summary, AEM is not a mereological composite of independent physical parts in spacetime, but a multicausal process being realized through semiotic relata during a *lifetime*, as exemplified by the baker's dozen of episodic semiosis.

Addressing the three questions considered so far, it could be said that figures 8 and 9 depict a semiosis-based form of biotranslation, one in which the Virtualiter's resolutions are translated into the Actualiter's implementations by means of the Habitualiter's determinations. In terms of temporality, both figures depict a semiotic process where the Virtualiter's vividness is grounded on emotional interpretants (which are present-oriented), the Habitualiter's choice-making is grounded on logical interpretants (which are future-oriented), and the Actualiter's affordances are grounded on energetic interpretants (which are past-oriented). To conclude, I once more recur to West (2013: 117):

> Peirce's sense of habit encompasses both temporal and spatial continuity, given that regularity is expressed as physical and functional resemblance across instantiations. Habit as regularity likewise requires coherence of cooccurring entities, states of being, or events. As such, habit (as a system of continuous existents) is the essence of Thirdness—it governs how the instantiation of one phenomena implies the presence or relevance of another (reagents). In fact, habit embodies the very core of logic-based meaning relations intrinsic to Peirce's Interpretant, housed in the Logical Interpretant.

6. AN IRRATIONAL FANCY

> It is by no means an irrational fancy that, in a future existence, we shall look upon what we think our present existence, as a dream.
>
> -Edgar Allan Poe (1849: 231)

> Not unfrequently a dream is so vivid that the memory of it is mistaken for the memory of an actual occurrence.
>
> -Charles Santiago Peirce (1868: CP 5.217)

Let us conclude, first, by remembering the initial question asked in the earliest stages of the dissertation. What are the commonalities between human and (other) animal forms or Episodic Memory (EM)? Decades of comparative research already showed that human EM and Alloanimal Episodic Memory (AEM) display neurobiological and cognitive-behavioural similarities. However, these do not necessary imply that different species possess a homologous underlying experience of what-where-when/which (W-W-W/W) scenarios.

While recognizing such a nuance, I initially formulated the hypothesis that the species-specific phenomenological aspects of episodic experience can, nevertheless, be modelled or translated in terms of a cross-species sign-process, which I later named "episodic semiosis". To make such a case, my research had to deal with four ubiquitous epistemological gaps in the scientific literature. I nicknamed them the 'Nagelian', 'de Waalian', 'Chomskyan', and 'semiotic' knowledge gaps (Miyamoto 2021). My doctoral research focused on filling the latter gap.

The methodological strategy I used to bridge the semiotic gap was focusing on the three known behavioural hallmarks of AEM. The latter are Memory Structure (MeS), Memory Content (MeC), and Memory Flexibility (MeF). MeS is said to display a formal binding for mental representations of non-present scenarios, MeC is said to convey some actual or objectual W-W-W/W aspects about non-present scenarios, and MeF is said to control adaptive choice-making by recombining MeS with MeC.

The more I learned about how these episodic hallmarks are known to be skillfully expressed by different species, the more I realized that the semiotic or meaning-making aspects bringing them together are crucial. So much so, that they deserved to be studied beyond a quantitative analysis of a behavioral 'output', as it is usually the case in laboratory contexts.

From the perspective of Peircean biosemiotics, I argued that these common hallmarks can indeed be causally explained in terms of an irreducible relationship between the representamen-like virtues of MeS, the object-like virtues of MeC, and the interpretant-like virtues of MeF. If this fallible meaning-making relationship is indeed of a semiosis-like nature, then it is possible to account for the fact that a variety of species display an analogue long-term form of memory for W-W-W/W experiences.

Against this background, the main goal of my research was to put forward an evidence-based model that conforms to such semiotic irreducibility. This is why the model proposed in Miyamoto (2024b) not only acknowledges the experiential (phenomenological) aspects of AEM, but also the inseparable relationship of the latter with respect to its motivational (teleological) and enactive (behavioral) counterparts.

Developing such an ambitious model, notwithstanding, demanded outclassing the otherwise 'atomistic' terms of semiosis as traditionally understood. The Peircean concept of *virtual habit* was vital to devise such general model, to the extent that I later identified three distinct episodic modalities of virtual habit in AEM (Virtualiter, Actualiter and Habitualiter), which could be said to communicate and individuate into a 13-correlate semiotic chain.

These categories were already sketched by Peirce himself in the context of virtual forms of cognition, and within his broader realist perspective on universals. Building upon this, section four explored how Peirce's ontological universes (Possibles, Necessitants, and Existents) are communicated by episodic semiosis itself. The novelty of my model, however, lies in applying the idea of virtual habit to the multispecies context of AEM studies. Revising the semiotic work of West (2013, 2016, 2017, 2018, 2019, 2022) was crucial in this regard since it already provides a cognitive account of human EM in terms of virtual habit and logical interpretants.

Second, I would like to conclude by revisiting the secondary questions that guided my research, to determine the extent of their provisional answers. These four questions, listed in section three, have challenged my semiotic ideas for the past years, and have co-evolved in unanticipated ways. They are, by no means, exhausted by the findings provided by my research.

(1) **Are there episodic phenomena beyond human EM**? Our best guess to account for the ubiquity of MeS in AEM is to assume that there are, indeed, episodic experiences or elicitations in other species. Just like in human EM, the inferential support of multisensorial mental imagery seems to be crucial for the simultaneous consolidation and reactivation of episodic memories. It is in this sense that AEM is considered to be a primary modelling system.

Whether this imagery is mostly visual, tactile or of another kind, depends on the particular species being studied. For example, corvids seem to heavily rely on visual elicitations, while rodents seem to mostly rely on olfactory ones. This is the main reason why the Virtualiter, as some sort of multimodal 'mind's eye', was said to structure or give form to an inexhaustible and indeterminate plurality of qualitative impressions (qualisigns), which are virtually endowed with practical bearings on the interpreter's future conduct, independently of its species.

Another way to answer this question is by reconsidering the aforementioned “Nagelian gap”, or the famous “what is it like to be a bat?” problem. According to this position, we cannot simply ‘interview’ alloanimals to characterize their innenwelt in our own terms. However, this seeming limitation incentivizes to aprioristically negate the empathetic possibility of aptly imagining sensorial phenomena that are ‘not measurable’ from a materialistic perspective.

In contrast, the ‘subjective-objective’ claim supports the argument that key phenomenological traits of MeS can be indirectly tested *through* non-verbal behavior, without the need to recur to tense-based self-reports. As put by Boyle (2020: 18), there are empirical ways to demonstrate that AEM “(A) stores detailed information about visuo-spatial features of an event; (B) represents the event’s temporal structure; (C) represents a past event as past; [and] (D) stores some self-specifying information about the subject at the time of the event”.

(2) **What is the relation between signs and phenomena in AEM**? The understanding of semiosis as an experiential process demands making a phenomenological correlation between representamens, objects, and interpretants. Understood in this way, semiosis and EM theory were said to be theoretically compatible (Miyamoto 2024a), leading to the conclusion that episodic cognition could be approached as an *inferential* sign-process rather than as a computational one. Namely, Tulving’s threshold of memory-based forms of consciousness (Anoesis, Noesis, and Autonoesis), sheds light on Peirce’s cenopythagorean categories (Firstness, Secondness, and Thirdness), and vice versa. We now have comparative elements to argue that such compatibility is also operative in AEM in equivalent forms.

Therefore, the logical notion of representamen (as a sign vehicle) was crucial to answer this second question, in the sense that it accounts for the mediating role of mental imagery as a sensible medium that virtually stands for something other than itself in some capacities to a ‘rememberer’. According to the ‘mental representation’ claim (Templer, Hampton 2013: 802), this kind of mental imagery or MeS plays a critical role in understanding the overlapping cognitive features of EM and AEM rather than the purely neurobiological ones.

As I have outlined, episodic semiosis is a crossroad where MeS, MeC, and MeF habitually converge and recombine. Far from reducing AEM to a single phenomenon, this understanding of episodic semiosis allows for a plurality of representamen-based sensations, interpretant-based intentions, and object-oriented actions that are not necessarily homologous but *analogical*. This is, they experientially culminate in equivalent consequences from a pragmatic perspective, rather than from an anthropomorphic psychologist perspective.

(3) **Should a biosemiotic phenomenology be practiced as pure theory, or as applicable for experimental AEM studies**? As far as the dissertation goes, I only managed to develop the evidence-based concepts necessary to biosemiotically account for the cross-species commonalities of AEM. However, I do believe that biosemiotics has the potential to be applied in experimental AEM contexts. After all, Peircean semiotics was devised as a “cenoscopic” science, meaning that its fallibilistic stance is concerned with the a posteriori discovery of everyday

phenomena, or experience common to all living beings. Hence, I also emphasized the applicability of the cenopythagorean categories to AEM and Tulving's neurocognitive theory.

One unexpected result while devising such a multi-species Peircean model was its consequent indeterminacy regarding which alloanimals it is suitable for, and what kind of species-specific phenomena it is able to account for. I attempted to clarify some of these concerns in section five. Also, in section four, I advocated for the need to apply the model to an episodic subject in a more personalized and contextual fashion.

I have not contemplated, though, whether my biosemiotic model could be relevant for the comparative understanding of human EM. If that turned out to be the case, it would be as natural as it would be ironic. For now, it should suffice to estimate that my model could be perhaps applicable in researching EM in neuropsychiatric patients with impaired language, and young children with less-developed verbal abilities. This is the case because MeS, MeC, and MeF have already been proposed as non-linguistic ethological criteria to also account for human EM (Clayton, Russell 2009).

It remains to be seen to what extent my model could be applicable to either non-invasive, semi-invasive, or invasive ethological experimental designs. For example, I elsewhere have envisioned the possibility of adapting the model as a pragmatic complement to regular ethograms. Unfortunately, the finalization of such a paper was not possible within the timeframe of this dissertation. A sketch of such applicability was featured in Miyamoto (2021: 851).

The next step to accomplish it would be to make operational versions of the categories in figure 8 that have no clear conceptual counterparts in the behavioral jargon of AEM studies. More specifically, this would be the case of the Virtualiter's resolutions (vividness, intentions, and solutions); the Actualiter's implementations (procedural affordances and semantic-indexical knowledge); and the Habitualiter's determinations (self-control, agency, and regularity). This seems a possibility if we consider that AEM studies already possess very refined experimental methods to research the equally crucial (overlapping) categories of "simulation" and "action".

(4) **How can biosemiotics contribute to understanding phenomenology in AEM**? The scope of this dissertation is not limited to species that have already been behaviorally tested, but also to those that might eventually be proven to possess the hallmarks of AEM. In this sense, my contribution is to have created a pluralistic narrative that provides an optimistic response to the 'de Waalian' gap or the 'are we smart enough to know how smart animals are?' problem.

The latter is not so much about questioning the episodic phenomenology of tested species anymore, as it is about our philosophical attitudes allowing us to agree on its objective similarities (and differences) with respect to human EM. Those intersubjective similarities mostly mean the flexible expression of analogous goal-oriented behavior based on non-present W-W-W/W scenarios. Hence, AEM was not understood through a behavioristic framework, but through a pragmatic one (EP1: 132). This is to say, purposeful actions in themselves are seen as sensible effects of meaning or choice-making, rather than the uncontrollable output of an inaccessible psyche or mental ‘black box’. In short, AEM not only was researched as a subjective phenomenon but ultimately as an intersubjective (and therefore intelligible) one.

With such a spirit, phenomenological studies on AEM can, in turn, contribute to a better biosemiotic understanding of alloanimal umwelten in general. For example, a possible contribution to the pluralistic narrative of zoosemiotics is the ‘evolutionary background’ claim, according to which some key features of EM are evolutionarily shared by humans and alloanimals (Arbilly, Lotem 2017: 4,6).

The biosemiotic attitude adopted by the dissertation provided reasons to dismiss the ‘Chomskyan gap’ or the ‘Why only us?’ problem, which endorses the view that EM is afforded by language-based cognition. In Miyamoto (2024b) I made the case that AEM, instead, diagrammatically operates via natural propositions (cf. Stjernfelt 2014:155) or dicisigns: “signs in which index and icon together assert and imply arguments” (West 2017: 81).

The above being said, the takeaway message of this conclusion could be divided in the form of four ideas or propositions. (1) The multimodal nature of EM cannot be determined by studying humans alone, especially if we consider the multi-species context of the Memory System Framework, as explained in section one. (2) The most important characteristic of AEM is not that it ‘lacks’ something human (e.g., linguistic and cultural scaffoldings), but the fact that it is necessary for understanding the true semiotic essence of EM, which is arguably shared by an unsuspected plurality of species. Under this logic, human EM is neither ‘higher’ in degree nor ‘superior’ in kind.

(3) The ontogenesis of human EM is unique in its own ways, and so are the species-specific features of AEM. This means that both merely differ from one another in some respects or capacities. (4) The ontological distinction between human EM and AEM should not allude to something ‘mental’ (e.g., Mental Time Travel or autonoesis), since the ‘other minds problem’ could also be applicable to other human beings (e.g., people with which we cannot communicate by means of language). Put otherwise, it is not that EM’s ‘true nature’ is understood only when we ‘expel’ or remove the ‘animal’ from it (e.g., instincts and circadian rhythms), but when we recognize the intrinsic animality of humans. It is in this way that we can outclass psychologistic accounts of human EM (which usually risk being anthropocentric) and behavioristic accounts of AEM (which usually risk being mechanistic).

Two final remarks are in order. First, there are further bioethical implications of recognizing the semiotic commonalities between AEM and human EM. One of them being the argument that both are a natural kind of memory (Cheng, Werning 2016). Although these bioethical implications were not meant to be actively advocated for as part of the dissertation, they point to future research directions beyond semiotics (e.g., evidence-based policy making).

Zoosemiotics holds the Sebeokian premise that the value of the entire animal kingdom is coextensive with the complexity of meaning-making or semiosis: the passage from sensorial awareness to actions by means of choice-making (cf.

Miyamoto 2023). Life is the only known phenomenon that causally brings together sentience, agency, and intentionality in such a way. As I have argued, episodic semiosis is a very special form of such general phenomenon.

It is up to us, as the human species, to acknowledge and preserve the continuity of AEM, which is a process naturally grounded on socioenvironmental demands. Ironically enough, it seems that ethologists have understood the zoosemiotic nature AEM for decades, even if they do not explicitly define it as a meaning-making phenomenon. In this sense, biosemiotics could nowadays be a valuable tool against the anthropogenic disruption of AEM in animal societies. This responsibility cannot be overstated, even more so if we see Earth as an ecosemiosphere (cf. Maran 2021).

Several conference papers on this type of advocacy have been presented as a collateral result of the dissertation, and they suggest unexplored research paths. For example, they formulate ways on how to advocate for experimental subjects in clinical studies through a biosemiotic framework, one that takes into consideration their long-term and continuous capacity to choose, experience, and act with respect to their own *lifetime*. This becomes more clear when we consider evidence for the astonishing capacities of episodic anticipation and future planning, most notably in corvids (Boeckle *et al.* 2020), non-human primates (Beran *et al.* 2015), and rodents (Crystal 2013).

Second, AEM studies and biosemiotics have the potential to outclass the contemporary analytical criteria for consciousness tests in alloanimals, the very same ones that are applied to "intelligent machines" (Pennartz et al. 2019). In other words, instead of assuming that alloanimals are non-self-conscious subjects until proven otherwise (Shea, Heyes 2010), we should start from the inverse fallibilistic position: episodic alloanimals should be considered as self-conscious, until proven otherwise.

Arguably, this dissertation provided elements for reconsidering the historical 'suspicion' that alloanimals are some sort of illiterate hippocampal amnesiacs with aphantasia, "stuck" in time (Roberts 2002). This is to say, the aprioristic belief that they lack the vividness of a mind's eye, improvising with no long-term sense of their own contextual, meaningful, experiences.

Modelling the temporal phenomenology of AEM is, consequently, central to make an epistemological turn, which may lead to a consequent bioethical change that makes experimental research follow similar moral guidelines than human EM research. Besides the famous principle of equal consideration (DeGrazia 1993), thus, the idea of "subject-of-a-life" resonates with the concept of AEM as a *lifetime* memory. Subjects of a life are individuals that:

> have beliefs and desires; perception, memory, and a sense of the future, including their own future; an emotional life together with feelings of pleasure and pain; preference- and welfare-interests; the ability to initiate action in pursuit of their desires and goals; a psychophysical identity over time; and an individual welfare in the sense that their experiential life fares well or ill for them, logically independently of their utility for others and logically independently of their being the

> object of anyone else’s interests. Those who satisfy the subject-of-a-life criterion themselves have a distinctive kind of value—inherent value—and are not to be viewed or treated as mere receptacles. (Regan 2004: 243).

Alloanimals do not simply survive, they have lives and ‘agendas’, utterly interesting and lively ones. I exhort the reader to continue thinking whether episodic species (listed in section two) should be treated as subjects of a life(time) or, what is the same, as fully fledged episodic interpreters, like humans are. Hopefully, this invitation will re-spark fruitful debates on the equality or inequality of the moral status of some alloanimals and humans.

7. OVERVIEW OF PUBLICATIONS INCLUDED IN THIS DISSERTATION

I) Miyamoto, Oscar 2021. Four Epistemological Gaps in Alloanimal Episodic Memory Studies. *Biosemiotics* 14(3): 839–857.

This review paper identified several knowledge gaps that were crucial to decide the goals of my research from its initial stages. The most relevant was the "semiotic gap". It refers to what I argue is an unacknowledged semiotic relation between the known cross-species behavioural hallmarks of "episodic-like" memory: Memory Structure, Memory Content, and Memory Flexibility.

I make a case that these could be understood in terms of semiosis or a sign-process involving, respectively, representamens (e.g., 'mental imagery'), objects (e.g., intelligible features of non-present spatiotemporal scenarios), and interpretants (e.g., goal-oriented choice-making). To the extent of my knowledge, this is the first paper in the literature making an explicit terminological connection between episodic-like memory in animals and Peircean biosemiotics. The paper features the following sections:

1. The Background of Alloanimal Episodic Memory Studies
2. The 'Nagelian', 'de Waalian', 'Chomskyan' and Semiotic Gaps
3. Cache-Recovery Model: *What-Where-When* Memory
4. Cued-Triggered Associative Retrieval
5. Hippocampal Replay of Stream of Events
6. The Concept of *Semiosis* as a Crossroad between Evidence and Theory

II) Miyamoto, Oscar 2024a. From Mind to Memory: Bridging Charles Peirce and Endel Tulving Through Phenomenology of Time. In Tragel, Elli Marie (ed.), *Explorations in Dynamic Semiosis*. Switzerland: Springer Nature, 169–188.

This book section compared the philosophical commonalities between Tulving's ideas on episodic phenomenology, and Peirce's meditations on the logical relationship between mind and time. Although this work does not explicitly connect with AEM studies, it served the dissertation as a philosophical subtext to later make a comparative connection with the pluralistic narrative of zoosemiotics and the multispecies concept of subject of a life. The chapter pays homage to Prof. Endel Tulving (1927-2023), being titled after Tulving's famous paper "Episodic memory: from mind to brain" (Tulving 2002). The chapter features the following sections:

1. The Peirce-Tulving continuum
2. Semiosis as the crossroads of time
3. The looking glass of memory

III) Miyamoto, Oscar 2024b. The virtual habits underlying the behavioural hallmarks of alloanimal episodic memory: a Peircean model. *Cognitive Semiotics* 17(2).

This research paper is a direct ‘sequel’ to Miyamoto (2021), being perhaps the most important work within the dissertation. It addresses the so-called “semiotic gap” by further applying the minimalistic concept of semiosis to the behavioural hallmarks of episodic-like memory or what-where-when memory.

However, this paper took a step further by proposing a cross-species cognitive model that explains episodic behaviour in terms of three underlying *virtual habits*. These were called Virtualiter, Habitualiter, and Actualiter. The main argument of this work is that (1) during the stage of episodic simulation (either past-oriented or future-oriented), the Virtualiter iconically stands for the Actualiter (as a ‘pre-tested hypothesis’) to the Habitualiter; and (2) during the stage of action, the Actualiter indexically stands for the Virtualiter (as a hypothesis being tested in real time) to the Habitualiter. In short, these virtual habits of sentience, thought, and action, were said to account for the bidirectional and flexible phenomenology of time in episodic-like memory. The paper features the following sections:

1. The semiotic gap in alloanimal episodic memory studies
2. Episodic memory as virtual habit
3. The Virtualiter and Memory Structure
4. The Actualiter and Memory Content
5. The Habitualiter and Memory Flexibility
6. Synchronicity and diachronicity: two readings of the model
7. Further directions and applications of the model

IV) Miyamoto, Oscar 2023. Questions concerning certain faculties claimed for semiotic selves. In Kõvamees, Erik; Miyamoto, Oscar; Randviir, Anti (eds.), *Concepts for Semiotics II*. Tartu Semiotics Library 24. Tartu: University of Tartu Press, 81–98.

This book section delved into the broader concept of *self*, which is crucial for our comparative understanding of other animal species as episodic subjects. Its title, a remembrance of Peirce’s famous paper “Questions Concerning Certain Faculties Claimed for Man”, hints at the idea that semiotics deals with the experiential study of (open-ended) *interpreters* rather than the private reality of individual subjects. Although this text does not explicitly address alloanimal episodic memory, it taps on foundational discussions on sentience that are the subtext for many of the phenomenological premises of this dissertation. The chapter features the following sections:

1. Biosemiotic basis of Semiotic Self Theory
2. Beyond the internalist-externalist dichotomy
3. Interpretative faculties of semiotic beings
4. Conclusion: Applications and future opportunities for SST

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SUMMARY

Where were you and what were you doing three sunsets ago? When were you last at the grocery store, and what items did you buy there? When and where did you last meet your best friend? When and where, most likely, will you do each of the above again?

If you can answer these questions without the help of external information, it could be said that you possess Episodic Memory (EM). This peculiar long-term neurocognitive system relies on your capacity to consciously relive past personal experiences, and pre-live probable future scenarios. Some animals have EM too, such as crows, magpies, pigeons, rats, mice, gorillas, monkeys, chimpanzees, orangutans, dogs, elephants, dolphins, octopi, and many others.

This doctoral dissertation explains how these animal species, similarly to humans, are capable of answering what-where-when questions in their own particular ways. The main finding of this research is that animal EM depends on a meaning-making process I call “episodic semiosis”. This process connects mental images and non-present spatiotemporal scenarios by means of interpretation. In other words, animal EM displays a Memory Structure, Memory Content, and Memory Flexibility.

The term EM was coined by Endel Tulving (1927–2023), a Canadian-Estonian experimental psychologist considered the father of EM theory. The pioneering work of Tulving and his colleagues explains why there are two different forms of long-term memory systems. The first one is Semantic Memory (SM), responsible for knowing factual and conceptual information. The second one is EM, responsible for remembering or reconstructing lived experiences and their spatiotemporal context.

For example, knowing the date and place of your birth is possible thanks to SM, even if your EM lacks a subjective recollection of that autobiographical event. In turn, vividly recalling the first time you made a friend at high school is possible thanks to your EM, even if your SM does not necessarily know the exact date and place of that event. Animals with EM also possess SM. Although the semantic knowledge of animals is not expressed verbally, it can be expressed through behaviour. The dissertation also explained the interdependence of EM with respect to SM, and other forms of memory present in the animal kingdom.

The dissertation studied EM from a biosemiotic perspective. It explained how animals with EM sense and modify their ecosystem as a meaningful world. Using ethological evidence, I created biosemiotic ‘maps’ or ‘models’ of their senses, habits, and actions. These models were designed to answer four main questions. (1) Are there episodic phenomena beyond human EM? (2) What is the relation between semiosis and phenomena in animal EM? (3) Should a biosemiotic phenomenology be practiced as pure theory, or as applicable for experimental studies in animal EM? (4) How can biosemiotics contribute to understanding phenomenology in animal EM?

The conclusions of the dissertation can be divided into four ideas. (1) The nature of EM cannot be determined by studying humans alone, especially if we consider the multi-species context of EM. (2) The most important characteristic of animal EM is not that it 'lacks' something human (e.g., language), but the fact that it is necessary for understanding and comparing the true semiotic essence of human EM. Human EM is neither 'higher' in degree nor 'superior' in kind.

(3) The development of human EM is unique in its own ways, and so are the species-specific features of animal EM. This means that both merely differ from one another in some respects or capacities. (4) The ontological distinction between human EM and animal EM should not be reduced to something 'mental' (e.g., Mental Time Travel). The 'true nature' of EM is not understood when we 'expel' or 'remove' the animal from it (e.g., instincts), but when we recognize the intrinsic animality of humans. It is in this way that we can go beyond psychological accounts of human EM and behavioral accounts of AEM.

A biosemiotic understanding of EM is crucial amidst the anthropogenic disruption of animal societies. Cultural habits, shared knowledge, and arbitrary codes are features that depend on complex forms of memory that are not genetically inherited but learned during a lifetime. Under these terms, it is concluded, biosemiotics has the responsibility to recognize episodic experimental subjects as rather being subjects of a lifetime.

KOKKUVÕTE

Mälu vormid: loomade episoodilise semioosi biosemiootiline modelleerimine

Kus sa olid ja mida tegid kolm päikeseloojangut tagasi? Millal sa viimati toidupoes käisid ja milliseid asju sa sealt ostsid? Millal ja kus sa viimati oma parima sõbraga kohtusid? Millal ja kus sa kõige tõenäolisemalt kõike ülalnimetatut uuesti teed?

Kui suudad neile küsimustele vastata ilma kõrvalise abita, võib öelda, et sul on episoodiline mälu. See omapärane pikaajaline neurokognitiivne süsteem tugineb sinu võimele teadlikult uuesti läbi elada varasemaid isiklikke kogemusi ja ette näha võimalikke tulevikustsenaariume. Episoodiline mälu esineb ka loomadel, näiteks varestel, harakatel, tuvidel, rottidel, hiirtel, gorilladel, šimpansidel, orangutanidel, koertel, elevantidel, delfiinidel, kaheksajalgadel ja paljudel teistel.

Käesolev doktoritöö selgitab, kuidas need loomaliigid, sarnaselt inimestele, on võimelised vastama mis-kus-millal küsimustele neile omasel viisil. Selle uurimistöö peamine järeldus on, et loomade episoodiline mälu sõltub tähendusloome protsessist, mida ma nimetan “episoodiliseks semioosiks”. Läbi tõlgenduse ühendab see protsess vaimsed kujundid ja aegruumilised stsenaariumid. Teisisõnu, loomade episoodiline mälu annab tunnistust mälu struktuurist, mälu sisust ja mälu paindlikkusest.

Termini episoodiline mälu võttis kasutusele episoodilise mälu teooria isaks peetud Kanada-Eesti eksperimentaalpsühholoog Endel Tulving (1927–2023). Tulvingu ja tema kolleegide teedrajav töö selgitab, miks on olemas kaks erinevat pikaajalise mälusüsteemi vormi. Esimene neist on semantiline mälu, mis vastutab faktilise ja kontseptuaalse teabe talletamise eest. Teine on episoodiline mälu, mis vastutab elatud kogemuste ja nende aegruumilise konteksti mäletamise või rekonstrueerimise eest.

Näiteks on sinu sünnikuupäeva ja -koha teadmine võimalik tänu semantilisele mälule, isegi kui sinu episoodilisel mälul puudub sellest autobiograafilisest sündmusest subjektiivne mälestus. Tänu oma episoodilisele mälule on sul omakorda võimalik eredalt meenutada esimest korda, kui sa keskkoolis uue sõbraga kohtusid, isegi kui sinu semantiline mälu selle sündmuse täpset kuupäeva ja kohta ei tea. Episoodilise mäluga loomadel on ka semantiline mälu. Kuigi loomade semantiline teadmine ei väljendu verbaalselt, saab seda väljendada läbi käitumise. Doktoritöö selgitas ka episoodilise mälu vastastikust sõltuvust semantilisest mälust ja teistest loomariigis esinevatest mäluvormidest.

Doktoritöö uuris episoodilist mälu biosemiootilisest vaatenurgast, selgitades, kuidas episoodilise mäluga loomad tajuvad ja muudavad oma ökosüsteemi tähendusrikkaks maailmaks. Kasutades etoloogilisi tõendeid, koostasin ma nende meeltest, harjumustest ja tegevustest biosemiootilised “kaardid” või “mudelid”. Nende mudelite eesmärk oli vastata neljale põhiküsimusele. (1) Kas väljaspool inimese episoodilist mälu on episoodilisi nähtusi? (2) Milline seos on semioosi ja elatud kogemuste vahel loomade episoodilises mälus? (3) Kas biosemiootilist fenomenoloogiat tuleks praktiseerida puhta teooriana või on see rakendatav ka loomade episoodilise mälu eksperimentaalsete uuringute puhul? (4) Kuidas saab biosemiootika aidata kaasa fenomenoloogia mõistmisele loomade episoodilises mälus?

Dissertatsiooni järeldused võib jagada neljaks ideeks. (1) Episoodilise mälu olemust ei saa kindlaks teha uurides ainult inimesi, eriti kui arvestada episoodilise mälu mitmeliigilist konteksti (2) Loomade episoodilise mälu kõige olulisem omadus ei ole see, et tal "puudub" midagi inimlikku (nt keel), vaid asjaolu, et loomade episoodilise mälu kaudu on võimalik inimese episoodilise mälu tõelise semiootilise olemuse mõistmine ja võrdlemine. Inimese episoodiline mälu ei ole ei astmelt ega olemuselt "kõrgem".

(3) Inimese episoodilise mälu areng on ainulaadne, nagu on seda ka loomade episoodilise mälu liigispetsiifilised omadused. See tähendab, et need erinevad teineteisest ainult mõne aspekti või võimekuse poolest. (4) Inimese episoodilise mälu ja loomade episoodilise mälu ontoloogilist eristamist ei tohiks taandada millekski "vaimseks" (nt mentaalne ajarännak). Episoodilise mälu "tõelist olemust" ei mõisteta mitte siis, kui me looma sellest "välja ajame" või "eemaldame" (nt instinktid), vaid siis, kui tunneme ära inimeste loomupärase loomalikkuse. Just sel viisil saame minna kaugemale inimeste episoodilise mälu psühholoogilistest ja looma episoodilise mälu käitumuslikest selgitustest.

Biosemiootiline arusaam episoodilisest mälust on loomaühiskondade antropogeensete mõjude keskel ülioluline. Kultuurilised harjumused, jagatud teadmised ja arbitraarsed koodid on omadused, mis sõltuvad keerukatest mäluvormidest, mis ei ole geneetiliselt päritud, vaid elu jooksul õpitud. Sellest tulenevalt on biosemiootika kohustus näha loomi mitte kui ellu jäävaid organisme, vaid mõistusega olendeid, kes omavad elusid.

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REVIEW ARTICLE

Four Epistemological Gaps in Alloanimal Episodic Memory Studies

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Abstract

Experimental studies show that some corvids, apes, and rodents possess a common long-term memory system that allows them to take goal-directed actions on the basis of absent spatiotemporal contexts. In other words, evidence supports the hypothesis that Episodic Memory —far from being uniquely human— has evolved as a cross-species meaning making system. However, within this zoosemiotic breakthrough, neurocognitive studies now struggle characterizing the *relations* between teleological factors (e.g. interpretant-based choice-making) and phenomenological factors (e.g. representamen-centered experiences) that would account for the episodic behavior displayed by these living beings (e.g. object-oriented actions). Within such field, this paper identifies four epistemological gaps —the 'Nagelian', 'de Waalian', 'Chomsky-an', and 'semiotic' gaps—, making a case for the need of a future biosemiotic model of Alloanimal Episodic Memory (AEM) to come into the equation. As a whole, I conclude that experimental developments in AEM research, and philosophical advancements in biosemiotics could converge through the concept of *semiosis*. Introducing the latter would account for animal episodic agency as a causal influence and continuity between the above relations, outclassing the reductionist and Cartesian separation between 'external' bodily behavior and 'internal' computational operations.

Keywords Animal Episodic Memory · Phenomenology · Biosemiotics · Zoosemiotics · Cognitive Semiotics · Agentive Semiotics.

Introduction

By *alloanimals* I refer to "animals besides the human animals" (Deely, 2015: 19), which are usually referred in studies of Episodic Memory (EM) as "non-human" (Templer & Hampton, 2013) or "non-verbal creatures" (Clayton & Wilkins, 2017). I

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use the term alloanimals instead of the classic "non-human animals" because the latter, as explained by Anderson (2020: 177–178), semantically reinforces the idea that humans are not animals *per se*. Also, on the basis of Rattasepp's multispecies semiotics (2018), it could be argued that the expression "non-human" is grounded on anthropocentric discourses through which living beings are defined by what they 'lack', or by 'not being like us'. The term *alloanimals*, as such, was coined by Count (1973) but has been incorporated into biosemiotics by Anderson (2016: 8) and Kemple (2019: 168).

By *alloanimal episodic memory* (AEM), more specifically, I currently refer to a small subset of alloanimals where consistent evidence of episodic cognition has been found (mainly corvids, apes and rodents). On the other hand, yet, by AEM I also refer to species that *eventually* may be proven to possess the neurocognitive essence of EM as well, most likely a wide range of untested mammals, birds, and reptiles, as suggested by Allen and Fortin (2013).

The general goals of this paper are to draw attention to relevant findings in AEM, and highlight the potential of reinterpreting that evidence biosemiotically. Such 'semiotic turn', I will argue, would be able to address an unacknowledged semiotic continuity between *metaphysical* categories (e.g. intentions and goals), *phenomenological* categories (e.g. mental images or representational vehicles), and behavioral categories (e.g. actions upon spatiotemporal scenarios). With such aims in mind, I structure the paper as follows.

Firstly, I review the background and breakthroughs in AEM studies, as well as some of its foundational concepts, such as Episodic Memory (EM), Mental Time Travel (MTT) and the Core Network. This opening section could be seen as an introduction of such interdisciplinary field to Biosemiotics, highlighting some of its cognitive and phenomenological implications.

Secondly, I identify four epistemological gaps: the 'Nagelian', 'de Waalian', 'Chomskyan', and 'semiotic' gaps, as I nickname them. These gaps, I explain, have prevented AEM studies from openly attributing MTT to some highly-tested species. And, instead, the gaps make AEM studies 'suspect' that consistent episodic agency is not necessarily caused by conscious episodic recollection (a key declarative aspect of EM in humans), but by a series of alternative non-episodic mechanisms (e.g. Semantic Memory and classical conditioning).

Thirdly, I summarize some of the leading models and experimental paradigms of AEM: 'Cache-recovery' (in corvids), 'Cued-triggered associative retrieval' (in apes), and 'Hippocampal replay of stream of events' (in rodents). With this section, I aim to provide an overview of how the above gaps have influenced evidence-based accounts of AEM, which make emphasis on evaluating behavioral outcomes, but postpone discussion on the already mentioned teleological and phenomenological aspects of alloanimal MTT.

And finally, I propose a semiotic characterization of AEM, using biosemiotic concepts such as agent, teleodynamics, biotranslation, and semiotic causality. With this final section, I sketch out pragmatic alternatives for the future development and application of a cross-species biosemiotic model of AEM. The latter, I conclude, may address the four gaps by explaining the continuity or influence between intentions (inasmuch Thirdness), experiences (inasmuch Firstness), and actions (inasmuch Secondness) afforded by AEM.

The Background of Alloanimal Episodic Memory Studies

EM is classically defined as our "autobiographical memory for events that occupy a particular spatial and temporal context" (Squire et al.1993: 459). EM was discovered by the Estonian-Canadian neuroscientist and experimental psychologist Endel Tulving (1972: 382–402), when he identified a neurocognitive system that would account for the clinical fact that reliving (and pre-living) a spatiotemporal scenario is phenomenologically and neurologically *distinct* from simply knowing a fact via Semantic Memory (SM).

For example, EM is at stake when we recollect the occasion in which we learned how to ride a bike, including the relational *context* of our intentions, sensations and actions. In contrast, SM allows us to define what a bike is, regardless of us being able (or not) of reliving the experiential flow in which we learned how to ride it. Put differently, SM memorizes 'pieces' of factual and timeless information that are *propositional* in their logical essence (Tulving, 2005: 12), such as the idea 'bikes have two wheels'. Within this example, SM could be metaphorically thought of as an 'encyclopedic' or 'conceptual' modelling system; while EM could be thought of as an 'autobiographical' modelling system that involves some sort of 'mind's eye' or 'first-person perspective' that can be mentally projected into non-present contexts.

Both EM and SM are subtypes of Declarative Memory within Long Term Memory (LTM), meaning that both are expressed through conscious or explicit *recollection*[1]. In contrast, Non-declarative Memory is mainly associated with skill-based information that is expressed through *performance* or bodily actions that are, to some extent, unconscious (Squire & Dede, 2015: 2). Namely, Procedural Memory, a subtype of Non-declarative Memory, would be the main neurocognitive system responsible for allowing us to actually ride a bike 'automatically', without needing to retrieve or recollect conceptual or temporal knowledge.

EM started being explored by studying patients with hippocampal amnesia, which is caused by the loss of key hippocampal structures. People with this condition are unable to contextually recall past *experiences* (e.g. remembering their wedding), or to imagine future scenarios (Klein et al., 2002), but they still preserve their categorical knowledge of the world (e.g. being aware of to whom they are married). In other words, they lose EM, but do not lose SM[2].

Tulving's original concept of EM (1972: 385) was born amidst informational and computational theories of human memory, such as the influential multi-store model, proposed by Atkinson and Shiffrin (1968). In this context, EM was framed within the structural organization of already known memory subsystems, such as Sensory Memory, Working Memory, Procedural Memory and, of course, SM. Nowadays, EM is lively researched as a central component of such framework, which eventually became a multispecies model of memory, learning, and consciousness[3]. In the words of Squire and Dede:

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[1] See Tulving (2005: 11) to know about the overlapping and unique features of EM with respect to SM from a human-alloanimal comparative perspective.

[2] See Wearing (2005) to have a closer look at the implications of hippocampal amnesia and EM loss.

[3] Thorough definitions of these memory subsystems can be found in Roediger, Zaromb and Wenbo's typology of memory terms (2017: 7–20).

> Within this framework, the various memory systems have distinct purposes and distinct anatomy, and different species can solve the same task using different systems. […] The notion of multiple memory systems is now widely accepted and establishes an important organizing principle across species for investigations of the biology of memory. (2015: 11)

EM studies have progressively refined their neurocognitive or body-mind systemic approach by identifying and testing embodied structures and phenomenological processes that go hand in hand (Schacter & Tulving, 1994). In this regard, Mental Time Travel (MTT) is known as the main *process* involved in EM (Miles et al., 2010). In consonance with studies on hippocampal amnesia, evidence suggests that MTT not only is responsible for our retrospective capacities (past-oriented cognition), but also for our prospective abilities (future-oriented cognition). In this sense, there has been a pragmatic 'change of direction' in EM studies (Klein, 2013), where the (re)imaginative capacities of EM are considered to have evolved for the adaptive purposes of *anticipation*, rather than for retrospection alone (Schacter et al., 2007; Szpunar et al., 2013). Thus, MTT has been typified as a multidimensional ability that may take the interdependent forms of *simulation*, *prediction*, *intention*, and *planning* (Szpunar et al., 2014: 18415).

In turn, the main neurological *structure* recruited by EM during MTT is known as the Core Network or 'default network'. Its neural substrates have been mapped in detail, due to remarkable technological advancements in measuring and visualizing the neurophysiological activity of EM in relation to other memory systems (Moscovitch et al., 2016). As Benoit and Schacter report, such structure specifically engages "parts of the medial surface, the hippocampus and parahippocampal cortex within the medial temporal lobes, and the temporal and inferior posterior parietal cortices on the lateral surface" (2015: 450). Even the neurobiological basis of EM has been genetically profiled in human subjects (Luksysa et al., 2015).

Decades of interdisciplinary EM studies, however, have shed light on metaphysical and phenomenological questions that go beyond the classic computational terms of information processing, and signal operations in neural networks (e.g. 'encoding', 'storing', and 'retrieving'). To mention just a few examples, EM raises the problems of "true memory" versus "false memory" recognition (Slotnick & Schacter, 2004); our sensitivity to "actual" and "inactual" objects (Perrin, 2016: 47); a measurable form of consciousness known as "chronesthesia" (Nyberg et al., 2010: 22357); the entanglement between imagination and recollection (Schacter & Madore, 2016); how Alzheimer's disease disrupts the 'mind's eye' (Hussey et al., 2012); how a condition known as "aphantasia" causes the lack of mental imagery (Brons, 2019: 11); and different interpretations of the neurophenomenology of time (e.g. see Perrin & Michaelian, 2017), including Moderate Continuism, Strong Continuism, Metaphysical Discontinuism, etcetera.

Human EM is by no means a new topic to semiotics, specifically on the cognitive side. Most notably, West (2017, 2018a, 2018b, 2019) has conducted in-depth theoretical and empirical research on the basis of Peircean semiotics. For example, she has accounted for neurocognitive evidence in terms of logical interpretants, dicisigns, and *virtual habits* or "pre-enactment of specifically framed episodes in the inner world" (2017: 61). I elsewhere resumed some of her findings to offer a biosemiotic account of human EM, namely, in terms of "biotemporal forms of argumentation" (Miyamoto, 2020: 45). Human EM has also received other semiotic treatments in a more speculative and incidental fashion (e.g. Puura, 2013: 150; Sonesson, 2015: 30; Kull, 2018: 144). To the extent of my knowledge, nonetheless, AEM has not undergone in-depth biosemiotic or zoosemiotic analysis yet.

The 'Nagelian', 'de Waalian', 'Chomskyan' and Semiotic Gaps

Because EM was clinically characterized in humans first, AEM studies inherited a *comparative* perspective when discussing their results. This is to say, they proceeded by testing hypothesis on alloanimal phenomenology, but reflecting on the basis of how English-speaking human adults verbally report their MTT experience, such as involving *autonoesis* or an "autobiographical consciousness" or an "experiential sense of 'mineness' of relived and pre-lived episodes" (Michaelian et al., 2016: 46). Similar implications, reasonably enough, have been the source of four *epistemological* gaps that have shaped the field until this day, insofar as they constrain our possibilities of scientific knowledge. Even though these gaps are beyond the scope of this paper, it is essential to briefly explain them, since they suggest how a biosemiotic (and zoosemiotic) interpretation of experimental evidence may complement the AEM models reported in the upcoming section.

The **first gap** concerns the empirical challenge of evaluating AEM on the basis of observable behavior alone. Evoking Thomas Nagel's ubiquitous work (1974), I tag this as the 'Nagelian' gap, or the 'What is it like to be a bat?' problem, in the sense that researchers cannot simply 'interview' alloanimals —either in labs or in natural habitats— to further characterize their Innenwelt in our own terms. Even if scientists have a deep neuroanatomical understanding of EM (e.g. Bird & Burgess, 2008), it is the experimental control of environmental settings and behavioral *outcomes* that is usually considered the only reliable data from which we may speculate on AEM as 'external' observers.

In essence, this gap consists of aprioristically negating the empathetic possibility of characterizing subjective and sensorial phenomena that are 'not measurable' from an empirical perspective (e.g. Martin-Ordas et al., 2013: 1438). Similarly, the Nagelian gap has already been criticized by perspectives that postulate intersubjective ways of mapping the Umwelt of other animals (e.g. see Akins, 1996).

Overlapped with such ethological problem, the **second gap** concerns the Cartesian divide through which scientists claim that even if behavioral observations satisfy the pragmatic and contextual criteria of EM (e.g. goal-oriented choice-making on the basis of absent contexts), there is no epistemic possibility of inferring the precise kind of spatiotemporal relations that alloanimals are *aware* of, regardless of being analogue or even homologue to human MTT (e.g. Suddendorf & Busby, 2003). Put differently, episodic behavior is considered as a fact, but is not considered enough to 'attribute' episodic phenomenology to alloanimals; as if their actions were not the agentive culmination or enactment of their intentions in relation to their perception. In contrast, human episodic behavior is often, by default, explained in direct *connection* to the ability to subjectively envision (and differentiate) non-present scenarios.

I nickname this second situation as the 'de Waalian' gap, or the 'Are we smart enough to know how smart animals are?' problem (de Waal, 2016). The latter, thus, is not so much about doubting the episodic agency of tested alloanimals, as it is about *our* philosophical capacities to find ways of inferring its teleological causality, and creating satisfactory pragmatic models that allow us to agree on its phenomenological similarities (and differences) with respect to human EM on the basis of analogous behavior.

Still concerning this second gap, I perceive, some researchers would rather deny AEM, than (1) empirically disprove studies showing that EM works as a cross-species memory system; or than (2) test human EM only through behavior. The latter option would be especially useful to minimize linguistic bias; increase ethological validity; and research MTT as a cross-cultural phenomenon, as has been suggested by Martin-Ordas (2016: 307).

When it comes to the **third gap** in AEM studies, as explained by Muñoz and Morris (2009: 1173), there is the invalid but underlying argument that EM should be considered human-specific because MTT seems to be falsifiable only through tense-dependent instructions and reports. For example, Nyberg et al. (2010) obtained the first fMRI-assisted evidence of human chronesthesia (a type of temporal awareness associated with EM) while *verbally* asking their trained subjects to visualize themselves as taking a walk in a familiar location during an imaginary past ("yesterday"), the present ("right now"), an imaginary future ("tomorrow"), and a real past ("remember").

This constitutes a gap in the sense that similar approaches cannot account for existing AEM evidence, since the latter is obtained through non-verbal behavioral markers that suggest pre-linguistic forms of MTT (e.g. simulation, prediction, intention, and planning). I nickname such glottocentric methodology, then, as the 'Chomskyan' gap, or the anthropocentric 'Why only us?' situation (e.g. see Berwick & Chomsky, 2017). Although this type of experimental design is explicitly tailored for testing healthy human EM, verbally-assisted MTT may be just *one* possible form in which the phenomenology of EM may be tested.

In short, this Chomskyan gap reinforces the contentious view that EM is afforded by language-related cognition, an argument that has already been criticized by Corballis (2013b) from an evolutionary standpoint. In contrast, MTT studies report evidence supporting West's view that EM diagrammatically operates via *natural propositions* (e.g. see Stjernfelt, 2015:1024) or *dicisigns*: "signs in which index and icon together assert and imply arguments" (West, 2017: 81). As I will later argue, such semiotic perspective already suggests the possibility of an epistemological shift in AEM studies.

The above three gaps, thus, give the overall impression that EM can be understood by studying a minority of humans through their language-dependent reports. However, similarly to SM, EM has undergone a post-linguistic turn —as it were— when researchers eventually found that EM is a modelling system that ontogenetically precedes the acquisition of language and, yet, is enhanced by the latter and its cultural scaffoldings. In Tulving's words:

> It is important to note that neither semantic nor episodic memory as defined here depends on language or any other symbol system for its operations, although both systems in humans can greatly benefit from language. […] Language may have played an important role in the evolution (or co-evolution) of human semantic memory, and probably even more so in the evolution of episodic memory, and it

> can greatly facilitate the operations of memory and learning systems, but it is not necessary for such operations. (2005: 12–13)

Finally, the **fourth gap** concerns the unacknowledged *semiosic* nature of EM's phenomenology. Except for West (2017, 2018a, 2018b, 2019), EM researchers have not explained neurocognitive evidence in terms of semiosis per se[4]. Nevertheless, experimental and theoretical studies constantly refer to some sort of "representational vehicles", "intentional contents", and "awareness" (Michaelian et al., 2016: 13). Similarly, authors like Perrin (2016: 47) point to a relation between a "mode", a "content" and an "object"; while Allen and Fortin (2013: 10379) refer to "structure, content, and flexibility".

Despite the terminological overlapping, these and other EM accounts have different understandings of the way such categories relate to each other. In this regard, I observe that those EM studies aim to characterize an underlying logical influence that is very well known to semiotics, involving no other than *interpretants*, *representamens*, and *objects*.

The semiotic gap lies, then, in the fact that AEM studies have failed to agree on the relation *between* the seemingly triadic phenomena they constantly observe. In comparison, what we consistently call *representamen* (in Peircean semiotics) is compatible with Michaelian, Klein and Szpuna's idea of "representational vehicles", with Perrin's idea of "content", and with Allen and Fortin's idea of "structure".

Instead of a semiotic phenomenology, those categories are usually explained in a computational fashion or, as put by Xue, through a "mechanistic understanding of the representations and processes underlying episodic memory" (2018: 558). More concretely, memory-making is often explained mainly in terms of the Core Network (e.g. neural substrates) and its corresponding 'operations' (e.g. neural pattern reinstatement), respectively, as *material* and *efficient* forms of causation[5].

As a consequence, I observe, this gap postpones the agentive characterization of two biosemiotic elements without which episodic behavior cannot be satisfactorily explained: final causation (e.g. intentions and goals), and the phenomenal or experiential aspect of episodic awareness. The latter, as matter of fact, is a foundational problem of EM studies, ever since Tulving proposed his triadic "class-inclusion hierarchy" (1985: 3) in order to explain why different neurocognitive systems (including EM) seem to be *controlled* by different types of awareness. I will continue addressing this gap in the subsection "The Concept of *Semiosis* as a Crossroad between Evidence and Theory".

So far, this section sketched four problems or *impasses* that I observe in AEM studies, making a case that these gaps are mainly derived from anthropocentric and Cartesian hypothesis on cognition. Naturally, these might not be the only epistemological gaps existing in the field, and it might be the case that other researchers see them as a single gap, or as a multi-layered deep philosophical disagreement that has not a unitary resolution. What I wished to highlight with this section, though, is the fact that AEM is still undergoing a lively and fruitful debate regarding relational phenomena

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[4] Herein I refer to the main definition of semiosis proposed by Peirce as "an action, or influence, which is, or involves, a cooperation of three subjects, such as a sign, its object, and its interpretant" (CP 5.484).

[5] See Gershman and Daw (2017: 110) for computational models of learning via EM in humans and alloanimals.

that, to the extent of my knowledge, have not yet been described biosemiotically or zoosemiotically.

Equally relevant for this paper, though, is the ethological, evolutionary and experimental evidence of AEM, which shows that human EM may be much more similar to AEM than previously thought. In the below section I summarize some representative studies, which may have already paved the way for a future biosemiotic model of AEM to come into the equation, and help bridging the four gaps.

Cache-Recovery Model: *What-Where-When* Memory

Clayton and Dickinson (1998) reported feeding behavior of Californian scrub jays (*Aphelocoma coerulescens*) that cannot be accounted for via non-episodic features alone (e.g. circadian rhythms, environmental hints, relative familiarity, classical conditioning, semantic encoding, involuntary retrieval, associative cuing, among other factors). Their evidence suggests that these corvids rely on a declarative or conscious form of Long Term Memory (LTM) that allows them to catch, hide and retrieve perishable and non-perishable food through the recollection of unique lived experiences.

To avoid what, I assume, would have been considered as anthropomorphization, Clayton and Dickinson framed the above findings as 'Episodic-*like* memory', rather than simply EM. Their experiments are famous for being the first demonstrating that an alloanimal species behaviorally satisfies Tulving's initial definition of EM in a number of ways. Such definition claims that EM "stores and retrieves information about temporarily-dated episodes or events, and temporal–spatial relations among events" (1972: 385). Tulving acknowledged this breakthrough when he stated that "Clayton's scrub-jays would have been certified as full-fledged episodic creatures back in 1972" (2005: 47).

Although Clayton and Dickinson's hypothesis has not been disproved, their comparative results caused a polemic that made some neurocognitive scientists redefine EM in such a way that its *uniquely human* status was still maintained. This was done through categories that defined MTT as a tense-dependent representation, or as an autobiographical construct. More concretely, I refer to the concept of *chronesthesia* or "a form of consciousness that allows individuals to think about the subjective time in which they live" (Nyberg et al., 2010: 22357); and to the similar concept of *autonoesis*, or a 'self-knowing' consciousness about our own memories being 'owned' by us as persons (Clayton & Wilkins, 2017: 2).

Such findings on scrub jays have been further supported by revisions on ethological questions (e.g. naturally occurring ecological demands); and meticulous experimental controls (e.g. including hand raised jays in lab environments) (e.g. see Clayton and Emery, 2009:110). Newer experiments suggest that corvid EM is even more 'human-like' than previously believed, inasmuch it satisfies the *combination* of 'content', 'structure', 'flexibility', 'single-trial' and 'contextual detachment', which have been used as some hallmarks for ruling out non-episodic mechanisms as the cause of episodic behavior (Martin-Ordas, 2016: 310–312).

Namely, it has been found that corvid EM (1) retains the spatiotemporal unfolding of trial-unique cache sites (Clayton et al., 2001); (2) contextually drives some social behaviors that require adopting an allocentric perspective, like hiding caches to outsmart attentive pilferers (Emery & Clayton, 2001); (3) accounts for the display of strategic planning abilities (Raby et al., 2007); and (4) necessarily demands a declarative or conscious experiencing. As summarized by de Kort, Dickinson and Clayton:

> The jays remember the what-when-where components of a caching episode (content), these components are integrated (structure), and can be updated and generalized over situations (flexibility). The interpretation of the temporal aspect of the jays' episodic memory remains contentious however. For the memory to be episodic-like, the when component needs to result from time being encoded explicitly in memory as opposed to being a by-product of a decaying memory trace. We present new data in favor of explicit encoding of temporal information in the memory of scrub-jays. (2005: 159)

In summary, this progression of studies could be nicknamed as the 'cache-recovery paradigm', which modelled AEM in terms of a 'what-where-when' memory on the basis of Tulving (1972)[6]. Subsequent accounts have capitalized on the insights from this corvid paradigm in order to design ways of studying EM in neuropsychiatric patients with impaired language (Dere et al., 2006: 1216), and in young children with less-developed verbal capacities (Clayton & Russell, 2009: 2330). This is especially relevant if we take into account the first three gaps mentioned in the previous section.

Cued-Triggered Associative Retrieval

Episodic memories are usually recollected explicitly in our mind through goal-directed thinking, but they can also unfold involuntarily through associative cueing (cued recall). Martin-Ordas et al. (2013) tested the latter expression of EM in some of our closest relatives. They reported problem-solving behavior in captive chimpanzees (*Pan Troglodytes*) and orangutans (*Pongo abelii*) that satisfies the hallmarks of autobiographical cued recall in humans. Roughly speaking, they demonstrated that after being presented with an unexpected cue, the experimental subjects were able to remember and discriminate the what-where-when of unique events that happened either 2 weeks ago, or 3 years earlier; and act accordingly in a similar problem-solving scenario.

Their experimental control capitalized on a strategy known as 'unexpected questions', so that subjects could not anticipate from semantic encoding of repeated trials (e.g. memorizing the set of rules for completing similar tasks and obtaining rewards)[7].

The precedent for this behavioral model comes from similar AEM studies on apes (e.g. Hampton, 2001; Martin-Ordas et al., 2010), and from EM studies on tool-use in young children (e.g. Martin-Ordas et al., 2014). Next to this model of AEM, we can also take into consideration the 'Contextual tool-planning paradigm', which makes

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[6] See Muñoz and Morris (2009: 1173) for further discussion on neurophysiology, and neuroanatomy of this model (e.g. the analogue core network possessed by corvids and other species).

[7] See Martin-Ordas (2016) for thorough discussion on this paradigm from a human-alloanimal comparative perspective.

more emphasis on the *declarative* and voluntary expression of EM in wild apes (e.g. Janmaata et al., 2014). In short, this parallel paradigm operates with the hypothesis that apes are able to dissociate themselves from their current motivational states and, according to the context, episodically plan for probable tool-dependent tasks (e.g. selecting and saving specific tools for future situations).

Hippocampal Replay of Stream of Events

Panoz-Brown et al. (2018) developed a behavioral technique based on a list of trial-unique odors to test EM in laboratory rats. Unlike the 'corvid' and 'ape' models —which are non-invasive—, this experiment capitalized on the possibility of biochemically impairing the rats' core network[8], in order to demonstrate that rats performed differently when (1) their hippocampus was selectively suppressed; and (2) after the impairment was reversed.

From the above, it is reported that rodent subjects satisfy five criteria of EM: (1) are able to remember multiple events in a sequential order; (2) do not rely on non-episodic mechanisms for completing the tasks; (3) their retention was part of long term memory; (4) their recollection was resistant to interference from other memories; (4) and their recollection was dependent on a hippocampal core network. As summarized by Panoz-Brown and colleagues:

> Our approach provides an animal model of episodic memory replay, a process by which the rat searches its representations in episodic memory in sequential order to find information. Our findings using rats suggest that the ability to replay a stream of episodic memories is quite old in the evolutionary timescale. (2018: 1628)

As I tried to outline so far, the 'hippocampal replay' model has overcome notable challenges for controlling and interpreting conduct through 'observable' behavioral markers. However, similar laboratory-based experimental studies avoid further discussion on the equally important category of 'replay' and the different degrees of *awareness* it would necessarily imply as part of MTT. For instance, the above replay model suggests that rodent EM brings into play a type of thinking that, similarly to human EM, would diagrammatically represent actual spatiotemporal structures, rather than linguistic metaphors or grammatical tenses (Stocker 2012: 386). Such possibility would be in consonance with the claim that MTT's 'first-person' perspective or 'replay' is primarily grounded on sensory-motor systems (Miles et al., 2010: e10825).

Similarly, Martin-Ordas and colleagues explicitly avoided discussing conscious interpretations in chimps because "this feature cannot be measured in nonhuman animals" (2013: 1438). This omission might prevent 'anthropomorphization' bias, but also acts as some sort of Cartesian comfort zone, one that guarantees the impossibility to address the already presented 'Nagelian', 'de Waalian', and 'Chomskyan' gaps, let alone the 'semiotic' gap.

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[8] See Lu et al. (2012) for evidence on the rodent Core Network and its relation with EM.

Before moving to the next section, I would like to make a final historiographical annotation. The above evidence-based AEM models are, by no means, the only ones. However, I observe, this review should serve the current purposes of drawing semiotic attention to this field, and provoke further questions in the reader. In this regard, there are comprehensive reviews of AEM models by Crystal (2018), and Dere et al. (2006).

The Concept of *Semiosis* as a Crossroad between Evidence and Theory

Resuming the fourth epistemological problem (the 'semiotic' gap), I argue that semiosis is the causal continuity that is observed in AEM models. By 'causal' I refer to Hoffmeyer's concept of "semiotic causality" (2008: 64). According to this standpoint, biosemiotic phenomena relate final causes (e.g. intentionality in MTT) with efficient causes (e.g. hippocampal activity) in such a way that the former cannot be reduced to the latter. This is arguably at stake in EM because its object-oriented *actions* (the ethological behavior acting as Secondness) are *caused* by interpretant-based *intentions* (the teleological processes acting as Thirdness). Representamen-centered *sensations* (phenomenological experiences acting as Firstness) would be the medium or crossroad allowing the *continuity* of such causal influence or sequence. Altogether, this type of causality is irreducible, and resembles the known triadic relation of Interpretant⇔Representamen⇔Object[9].

Such 'semiotic shift' allows me to draw the following characterization. EM (inasmuch interpretant) is the *mediator* connecting episodic images (inasmuch representamen) with spatiotemporal scenarios (inasmuch object) in some capacities (inasmuch ground) to an *agent* (inasmuch interpreter) during MTT performance (inasmuch time)[10].

By 'agent' I mean the Morrisean pragmatic concept of interpret*er*, or the organism for which the sign vehicle functions as a sign. I include this fourth aspect in the otherwise triadic concept of semiosis, because it reflects the fact that not only signs have effects *on* living interpreters (e.g. a rat, a scrub jay, or a chimpanzee), but the latter are also sign *users*, having consequent effects on the signs they episodically recollect or visualize. Such idea of an episodic agent presupposes, indeed, the notion of interpretant, but also encompasses it, getting closer to the teleodynamic idea of an interpreter who directs its own behavior (e.g. see Deacon 2012: 265). More specifically, I think of the episodic agent as a special *type* of Pattee's general definition of interpreter as:

> A semiotically localized (bounded) system that survives or self-reproduces in an open environment by virtue of its memory-stored controls and constructions. That distinguishes interpreters from inanimate physical systems that evolve

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[9] In the context of EM, I elsewhere applied Hoffmeyer's idea of semiotic causality to Peirce's "Temporal Expressions of Stage", consisting of *precedence*, *contemporaneity*, and *succedence* (W1: 530). I called this the "Thirdness⇔Firstness⇔Secondness extrapolation" or "III⇔I⇔II" (Miyamoto, 2020: 31–36).

[10] I base this account on Peirce's further explanation of a sign as "something which stands to somebody for something in some respect or capacity […] The sign stands for something, its object. It stands for that object, not in all respects, but in reference to a sort of idea, which I have sometimes called the ground of the representamen." (CP 2.228).

> dynamically simply because they follow the memoryless state-determined laws of nature. (2010: 536).

Viewed in this way, AEM allows an *episodic agent* to mentally recollect multisensorial images to intentionally or willfully remember the *what*, the *where*, and the *when* of a lived experience, and *act* accordingly. I use "intentionally" and "willfully" as synonyms, and by them I mean that EM's behavioral expression is *optional* (Tulving, 2005: 11). In other words, episodic recollections —like semantic recollections— may culminate in goal-oriented or purposeful actions only by choice, and also involving the attention of Working Memory.

When it comes to the expression "lived experience", I use it as a synonym of the more popular expression "spatiotemporal event". However, it has been called to my attention that this might be confusing. Thus, by "lived experience" I make emphasis on the fact that a spatiotemporal event, phenomenologically speaking, has been perceived or lived to some degree by an episodic agent (e.g. as a flow or replay of multisensorial images and feelings related through precedence, simultaneity, and succession). By "spatiotemporal event", then, I make emphasis on the fact that an *external* observer (e.g. lab scientists keeping track of time in a clock or a calendar) is required to speak about 'events' as a construction depending on the relativistic notion of physical time, rather than phenomenological time as experienced by others[11].

Taking into account Clayton and Emery (2009:110), I would also add a '*who*' component to the *what*, *where*, and *when* of a lived experience, inasmuch episodic agents are also socially aware of conspecifics' long-term knowledge, probably via allocentric mind-wandering. As we know from West (2018: 92), episode-building implies not only a proprioceptive awareness (egocentric view), but also takes into account the *intersubjective* perspective of others (allocentric view). In the case of AEM, this could be thought of as some kind of empathetic or emonic simulation that increases the predictive power of MTT in social contexts (e.g. crows hiding caches to outsmart attentive pilferers). The below table sketches and summarizes this semiosis-based account by listing examples of its concepts in the context of the corvid AEM model (Table 1):

The above table aims to show that semiosis —the connection between representamens and objects through the mediation or effect of interpretants— works as an epistemological basis for understanding episodic phenomena. The reason for this, I argue, is that semiosis can conceptually incorporate the categories of *structure*, *content* and *flexibility*, which are already stablished criteria in cross-species AEM behavioral tests (e.g. see de Kort et al., 2005: 159; and Allen & Fortin (2013: 10379).

The first column ('Multisensorial images') would correspond to the criterion of **structure**, insofar as "the information about the event and its context is integrated in a single representation" (Allen & Fortin, 2013: 10379). The second column ('Re/Pre-

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[11] However, it is to be discussed elsewhere to what extent the contextual detachment in alloanimal EM allows agents to recollect their lived or pre-live experiences as seen from an 'external' and more general perspective (e.g. as a particular event within a general lifetime). The latter problem would equal to discuss if alloanimal EM demands *chronesthesia*, as it does in humans (Nyberg et al., 2010: 22357). These nuances are especially relevant if we consider that EM is *declarative* or "self-referencing" (Crystal, 2018: 105), in the sense that it demands a *conscious* recollection where the episodic agent *knows* that it *knows* something.

Table 1 Conceptual summary of a semiosis-based account of AEM, using the example of Californian scrub jays studied by Kort et al. (2005: 159)

Episodic Agent (e.g. a Californian scrub jay)		
Multisensorial images (representamens afforded by Sensory Memory)	**Re/Pre-lived experiences** (interpretants afforded by Episodic Memory)	**Actions** (object-oriented actions afforded by Procedural Memory and Working Memory)
Perceived colors, scents, flavors, temperatures, sounds, textures, proprioceptive sensations, etcetera.	**What**: e.g. cues, food caches, rewards, environmental items.	Recognize *what* caches are more perishable than others (e.g. worms or nuts).
Mental maps or spatial models of a given environment or habitat (e.g. a forest, or an experimental setting in a lab).	**Where**: e.g. location, position, configuration, orientation or vection of items.	Locate *where* a non-visible specific food item was hidden (e.g. peanuts from a grid of holes in the soil); or find hideouts where perishable items remain edible for longer periods (e.g. shaded areas).
Mental replay of a re-lived or pre-lived experience (teleodynamic or goal-directed episode-building).	**When**: e.g. sequential order of relations between what, where, and who (precedence, simultaneity and succession).	Anticipate *when* a food item will no longer be edible (e.g. eat fresh worms first, and nuts later; and stop minding 'expired' worms, or 'pillaged' caches).
Mental 'pictures' of conspecifics and their distinctive features (perceptual models).	**Who**: e.g. allocentric awareness of which surrounding conspecifics know (or do not know) the where and when of a food cache.	Hide food items in such a way that attentive pilferers cannot steal them (e.g. hide caches only when no one is looking); or, conversely, steal food caches.
Mental Time Travel: e.g. *simulation*, *prediction*, *intention*, and *planning* with regards to a contextual practice (e.g. in a natural environment), or a trial-unique event (e.g. 'unexpected question' in a lab).		

lived experiences') would correspond to the criterion of **content**, inasmuch "the individual remembers information about the event ("what") and its context of occurrence (e.g., "where" or "when" it happened)" (Allen & Fortin, 2013: 10379). And the third column ('Actions') would correspond to the criterion of **flexibility**, because "the memory can be expressed to support adaptive behavior in novel situations" (Allen & Fortin, 2013: 10379).

In my view, this extrapolation already suggests the basis for constructing a biosemiotic model of AEM in the future. As I tried to highlight, available evidence demonstrates the semiotic causality of EM, inasmuch the simultaneity of a perceived representamen (Firstness), connects the precedence of an interpretant (Thirdness) with the succession of an object-oriented action (Secondness). Certainly, the pragmatic logic between these phenomenological categories should be elsewhere developed more thoroughly, incorporating the already suggested notion of *episodic agent*.

Possibly, this could be done through the notions of chronosyntactics, chronosemantics and chronopragmatics (Miyamoto, 2020: 37–56). This means the possibility of researching (1) memory **structure** as the *sequential* relations among episodic images; (2) memory **content** as the *ground* between episodic images and absent spatiotemporal scenarios; and (3) memory **flexibility** as the *use* of episodic images during MTT by means of virtual habits. Such model could be also useful from a zoosemiotic perspective, if we acknowledge that AEM studies —despite the four gaps— essentially aim to understand Umwelt[12] in terms of how different degrees of awareness (e.g. see Tulving, 1985: 3) are in constant translation with the effective behavior displayed by an *actor* or agent, and with the phenomena lived by a conscious *experiencer*.

In this triadic but Uexküllian sense, the above table could be preliminarily understood as a model of biotranslation (Marais, 2019), explaining how Sensory Memory (lasting < 1 s) is transformed into Long Term Memory (lasting a life-time) —and vice versa— by the attentive means of Working Memory (lasting < 1mn) and the bodily means of Procedural Memory. More concretely, I am suggesting that AEM could be modelled as a meaning-making system necessarily involving a *continuity* between intentions afforded by Working Memory (D'Esposito & Postle, 2015: 116); multisensorial feelings afforded by Sensory Memory (Tripathy & Ögmen, 2018: 2); and actions afforded by Procedural Memory and other forms of non-declarative memory (Squire & Dede, 2015: 2).

In summary, what I am arguing is that, from a biosemiotic perspective, we already possess the theoretical foundations to account for the observed influence between *intentions*, *sensations*, and *actions* at stake in AEM. Such continuity is semiosis, and underlies the cross-species nature of AEM.

Nonetheless, modelling AEM in terms of semiosis as argued above, poses the risk of underestimating certain species-specific features of EM. Also, it may oversimplify the diverse features of EM within the complementarity of the whole memory system framework (e.g. the dependence of EM on SM). As eloquently put by Temple and Hampton:

> we should expect memory to have evolved differently in different species so as to match their cognitive capacities to species-specific ecological demands, making a single conception of episodic memory overly restrictive. Focus on a single specific set of criteria can make it difficult to identify interesting and informative species-specific specializations in memory. (2013: 803)

Even so, biosemiotics could address this potential issue by recurring to the *pluralistic* stance proposed by Jaroš and Maran (2019: 385). By the latter I refer to assuming that (1) humans do not have aprioristically 'superior' mnemonic faculties; and (2) recognizing that umwelten are species-specific but also display intersubjective and convergent features. Accordingly, further interdisciplinary research could be organized around the idea of a biosemiotic phenomenology applied to human-alloanimal Umwelt continuities (e.g. Tønnessen et al. 2018; Jaroš & Pudil, 2020).

Inspired by these pluralistic approaches, my understanding of semiosis affords an epistemological shift if we also define it as "the capacity of a species to produce and comprehend the specific types of models it requires for processing and codifying perceptual input in its own way" (Sebeok and Danesi, 2000: 5). In turn, this would bring AEM theory closer to the ideas of *timing* and *anticipation* as modelling systems present across living beings (e.g. Magnus, 2011; Kurismaa, 2016; Nomura et al., 2019).

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[12] Umwelt understood as the "phenomenal world or the self-world of the animal" (Uexküll, 1992: 319), or the "psycho-biological uniformity" shared by the members of a species (Fraser, 2007: 37).

Semiotic models of AEM, ultimately, would help us to outclass the famous impasse of the 'problem of other minds'. For example, the evidence-based hypothesis that corvids possess EM (which explains why they flexibly express episodic behavior) implies overcoming Cartesian views that focus on nominalistic mental entities that, allegedly, 'cannot' be inferred or understood by any means (e.g. as discussed by Akins, 1996). In other words, semiosis-based hypothesis, joint with behavioral evidence, are susceptible of being disproved, unlike the hypothesis that EM is uniquely human because language is uniquely human. As put by Allen and Fortin, regarding the Chomskyan gap and the concept of chronesthesia:

> Although this definition may capture the phenomenological aspects associated with episodic memory in humans, it relies entirely on verbal reports of subjective mental experiences. Because this definition of episodic memory precludes its investigation in animals, the hypothesis that this capacity is unique to humans lacks falsifiability. (2013: 10379)

We do not need to ontologically *be* a bat or a crow in order to develop an analogical mapping of their phenomenology. Instead, a semiosis-based description of AEM, as proposed here, aims to reveal the sign relations through which the world becomes meaningful to a particular living being and its species. The ultimate point being that interpretants and intentions might be somehow 'private' (in the metaphysical sense), but representamens (in the pragmatic sense) have a common veracious potential in direct relation to object-oriented actions, which are accessible to pragmatic scientific inquiry (e.g. see Beuchot, 2019: 13).

Conclusions

Developing a biosemiotic account of AEM poses a double challenge. Firstly, it requires applying an already existing semiotic theory *to* a very well established transdisciplinary field with no semiotic epistemology. And, secondly, it implies the extrapolation of experimental evidence *from* such field in order to empirically ground semiotic hypotheses that predate or do not necessarily considered EM studies.

In this regard, it is exciting to imagine if Peirce (in review) and Uexküll (1992 [1934]) had the neurocognitive evidence of the memory system framework at their disposal when developing, respectively, Phaneroscopy and Umwelt theory. In like manner, it is worth imagining how EM theory would look like nowadays if Endel Tulving was a biosemiotician in addition to already being a neuroscientist and experimental psychologist.

This paper aimed at combining the deductive power of semiotics, and the inductive power of experimental research. The crossroad for doing that, I argued, is the concept of semiosis, presenting a double *opportunity* rather than a double challenge. A semiosis-based model of AEM has the potential to communicate the understanding of metaphysical phenomena (e.g. the teleological implications of intentionality in living beings) with the understanding of neurophysiological phenomena (e.g. the hippocampal networks without which EM cannot operate). I observe that such non-reductionist and non-Cartesian model is still needed.

The ‘crossover’ between philosophical advancements in biosemiotics and the falsifiable knowledge of experimental research, could be thought of as both: a ‘biosemiotic turn of AEM-studies’, or also as a ‘mnemonic turn of zoosemiotics’ (e.g. Bouissac, 2007: 71). The long-term goal would not merely be to provide AEM-studies with a cross-species model, but also to incorporate their evidence into biosemiotics as a way to update perspectives related with alloanimal phenomenology. In this regard, AEM researchers may benefit from making a converse historiographical move: to introduce semiotic literature to their field. Hopefully, the list of references of this paper may serve as a handy starting point in that regard.

In the end, the lack of (bio/zoo)semiotic tools in AEM leaves us without cross-species models that satisfactorily explain why rodents, corvids and apes *act* as fully fledged episodic interpreters, despite being different species[13]. Otherwise, we will continue being comfortable with the anthropocentric and Cartesian ‘suspicion’ that these agents are, however, some sort of mute hippocampal amnesiacs, stuck in the phenomenal present, and acting mindlessly without a long-term sense of their own contextual, meaningful, experiences. It is only fitting that “a wise man, therefore, proportions his belief to the evidence”, as Hume would put it (1999 [1748]: 56). We, nonetheless, should not let the inductive limitations of current evidence to be an obstacle for developing better deductive theories in the future.

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[13] See Allen and Fortin (2013: 10379) for discussion on how EM could have evolved in a diversity of species either by coevolution or by convergent evolution. Also, see Suddendorf and Corballis (2010) for the initial rejection of those claims; and Corballis (2013a; 2013b) for their latter acceptance.

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II

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From Mind to Memory: Bridging Charles Peirce and Endel Tulving Through Phenomenology of Time

Oscar Miyamoto

1 The Peirce–Tulving Continuum

Charles S. Peirce (1839–1914) is considered the first American experimental psychologist (Cadwallader, 1974, 1975). He did not live to see the advent of neurosciences as we know them today. Peirce could only have dreamed of psychological experiments assisted by neuroimaging technologies and biomolecular and computational methods (cf. Noggle & Davis, 2021). However, his research already suggested that memory processes are central to understanding the dynamic relation between mind and time since the latter two require the logic of a recursive *continuity*.

Peirce conducted pioneering studies on color perception (W3, p. 211) and tactile perception (Peirce & Jastrow, 1884). Today, this type of research could be experimentally evaluated in terms of "sensory memory" and its 100-millisecond threshold, which is the preconceptual anteroom of long-term forms of memory (Tripathy & Ögmen, 2018, p. 2).

Peirce's "psychophysical" experiments tested his hypothesis that all cognition is inferential (Cristalli, 2017). He provided evidence for arguing that even the experiential sensations (e.g., "percepts"), from which we initially draw our long-term knowledge (e.g., "beliefs"), are not instantaneous replicas of physical quantities (e.g., "measurements"), but neurocognitive phenomena mediated by an interpretative process (e.g., "semiosis") that continuously evolves *over time* (CP 1.167).

In memory and homage to Prof. Endel Tulving (1927–2023), whose pioneering research has inspired me to combine semiotics with cognitive neuroscience.

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Besides the evanescence of sensorial experience (CP 1.379), Peirce was also interested in the permanence of our long-term temporal experience. He speculated about a *general* type of awareness or sensitivity that continuously keeps track of time intervals that would otherwise be causally separated. Namely, concerning child development, Peirce asks in "Questions Concerning Certain Faculties Claimed for Man" whether we have an "intuitive self-consciousness" related to time (CP 5.225–229). In like manner, he elsewhere pondered on something that resembles the precise long-term function of what today we know as Episodic Memory (EM):

> There may be a consciousness of the events that happened in a whole day or a whole lifetime. According to this, two parts of a process separated in time —though they are absolutely separate, in so far as there is a consciousness of the one, from which the other is entirely excluded— are yet so far not separate, that there is a more general consciousness of the two together. (W3, pp. 73–74)

Similarly, in 'The Conception of Time Essential in Logic', he posits that "it may perhaps be though that one consciousness extends over more than a limited interval of time" (W3, p. 105). Nowadays, this type of extended temporal awareness, a constituent of EM according to Tulving, has experimentally been tested in terms of *chronesthesia*, "a form of consciousness that allows individuals to think about the subjective time in which they live" (Nyberg et al., 2010, p. 22357). Far from being a terminological coincidence, I argue, these parallelisms deserve to be explored. Hence, I reflect on the compatibility between Peirce, the father of Pragmaticism, and Endel Tulving, the father of EM theory, specifically regarding their ideas about a lived subjective *time*.

As I will later observe, Peirce laid the foundation for a temporal phenomenology of what today is generically called "Mental Time Travel" (MTT) (Perrin & Michaelian, 2017, p. 228), the main body-mind process associated with EM. Moreover, I will make the case that experimental studies on episodic MTT have the potential to test and apply Peirce's semiotic hypothesis about the inferential and representational relation between consciousness and time.

MTT is the neurocognitive ability that allows us to intuitively recreate our lifetime according to a virtual narrative of mental 'images', 'scenes', and 'sequences'. This happens every time we 'replay' an autobiographical episode where, in turn, we evoke the unfolding of its sensations, actions, and intentions. Similarly, planning via MTT enables our 'mind's eye' to logically project or simulate the what-when-where of an expected spatiotemporal situation (e.g., socioenvironmental demands), with the potential to virtually adopt the allocentric (intersubjective) perspectives of other participants (West, 2018, p. 92).

When it comes to this multimodal ability, decades of interdisciplinary research show that EM is the *central* meaning-making or interpretative system at stake. The term EM was coined by the Canadian-Estonian neuroscientist Endel Tulving (1972, pp. 382–402), alluding to a hypothetical cognitive apparatus that would account for the clinical observation that *recollecting* a lived event (e.g., the sequential happenings and actions during our wedding) is phenomenologically and neurologically different from simply *knowing* facts and concepts (e.g., our wedding's date, location, and guest' names). According to Tulving's most complete, revisited definition:

> Episodic memory is a recently evolved, late developing, and early deteriorating brain/mind (neurocognitive) memory system. It is oriented to the past, more vulnerable than other memory systems to neuronal dysfunction, and probably unique to humans. It makes possible mental time travel through subjective time—past, present, and future. This mental time travel allows one, as an "owner" of episodic memory ("self"), through the medium of autonoetic awareness, to remember one's own previous "thought about" experiences, as well as to "think about" one's own possible future experiences. The operations of episodic memory require, but go beyond, the semantic memory system. Retrieving information from episodic memory ("remembering") requires the establishment and maintenance of a special mental set, dubbed episodic "retrieval mode." The neural components of episodic memory comprise a widely distributed network of cortical and subcortical brain regions that overlap with and extend beyond the networks subserving other memory systems. The essence of episodic memory lies in the conjunction of three concepts—self, autonoetic awareness, and subjective time. (Tulving, 2005, p. 9)

EM, or 'remembering memory', is no longer considered a hypothetical neurocognitive system. It has been consistently found that EM gives meaning to personal lived events, including the *context* of their memories' acquisition (Squire et al., 1993, p. 459). But, more importantly, it is argued that episodic cognition evolved adaptively to allow *anticipatory* behavior (Suddendorf & Busby, 2005; Schacter et al., 2007; Klein, 2013; Szpunar et al., 2013; Schacter & Madore, 2016). In this context, it is said that MTT is a spectrum of constructive and creative processes that comprise different types of simulation, prediction, intention, and planning (Szpunar et al., 2014, p. 18415). Due to its close connection with imagination and inference-making capacities, episodic MTT has also been evaluated in terms of "enactive imagination", among other terms (cf. Michaelian, 2016, p. 5).

Although EM as such was first defined by Tulving in 1972, EM was accidentally discovered in 1958 by the Danish-American neurologist Johannes Maagaard Nielsen (1890–1969) when he noticed a distinction between *categorical* amnesia and *temporal* amnesia in a patient (Tulving, 2002, p. 11). In Nielsen's words:

> A study of pathways of memory formation has revealed a basic fact not suspected when this study began—there are two separate pathways for two kinds of memories. The one is memories of life experiences centering around the person himself and basically involving the element of time. The other is memories of intellectually acquired knowledge not experienced but learned by study and not personal. (Nielsen, 1958, p. 25)

The conscious or declarative relation among these two memory pathways was further explored by Tulving in amnesic patients as well (Klein et al., 2002), giving birth to the modern distinction between Semantic Memory (SM) or 'knowing' memory' and EM or 'remembering' memory. The co-discovery of EM may be the most important breakthrough in the interdisciplinary study of consciousness insofar as it has reshaped the memory system framework, which is our best cognitive model for understanding the multimodal orchestration of mnemonic subsystems as a whole (Squire & Dede, 2015, p. 11). The latter, as I will argue in the next section, could be understood in terms of semiosis or meaning-making, specifically when it comes to EM.

If Tulving is famous for coining the term EM, Peirce is known for coining the term *semiosis*: “an action, or influence, which is, or involves, a cooperation of three subjects, such as a sign, its object, and its interpretant” (CP 5.484). I observe a promising application of this concept to EM as both notions deal with meaning-making on behalf of a subject or, as I prefer to call it, an *interpreter*.

Semiosis, as a concept, explains the role of *inter*pretation as a cognitive mediation that brings together two relata that would otherwise not necessarily be implied. On the one hand, we have the representamen or ‘representational vehicle’; on the other, we have the object or ‘entity’ that is being mediated or ‘translated’ by the representamen. More specifically, it is said that the representamen or ‘sign’ is:

> something which stands to somebody for something in some respect or capacity [...] The sign stands for something, its object. It stands for that object, not in all respects, but in reference to a sort of idea, which I have sometimes called the ground of the representamen. (CP 2.228)

In terms of Tulving’s definition of EM (2005), MTT indeed requires a ‘somebody’ (the “owner” of episodic memory or “self”) to make an interpretation, inference, or choice (“through the medium of autonoetic awareness”), about something (one’s own previous “thought about” experiences). In terms of semiosis, then, we could say that EM (as interpretant) is the mediator causing episodic imagery (as representamen) to stand for absent spatiotemporal scenarios (as object) in some capacities or intentions (as ground) to an interpreter or, as Tulving would put it, a “traveler” or “rememberer” (2002, pp. 2–3). In turn, the ‘ground’ or ostensible aboutness of episodic MTT could be considered iconic, indexical, and/or symbolic. With this Peircean jargon, I mean that our memories *do relate* in several ways to the semiotic reality in the spatiotemporal scenario they are about.

First, through the formal *recognition* of qualitative aspects. The envisioned episode and its multisensorial vividness have the potential to be virtually ‘similar’ or ‘iconic’ with respect to the qualia experienced during an actual episode (e.g., its colors, temperatures, textures, shapes, sounds, smells, proprioceptive sensations, etcetera). For instance, the wetness, freshness, and scent of the sea are potentially elicited during the remembrance of the occasion we swam in it; and even the painful emotions of a traumatic event may be evoked unintentionally at the moment of its recollection.

Such iconic ground, through the familiarity of a sensorial equivalence, is present-oriented or *abductive* (works as a hypothetical intuition) insofar as we ‘can’t help’ but to emulate those qualitative aspects as a phenomenal *simultaneity* (e.g., a perceptual ‘snapshot’) that is a structural part of the imagistic representamens through which we (re/pre) experience nonpresent spatiotemporal scenarios.

Second, memories relate to their semiotic reality through an effective *correlation* of exerted actions. Namely, the replayed episode may virtually recreate a motion relative to the co-presence of actors, objects and locations, all of which could be treated as ‘indicators’ or cues that allow us to trace back or infer the actual happenings that *took place* during a materialized episode (e.g., the actions, vection, order, placement, and the directional unfolding between a given cause and its effect). For example, the procedural sequence of our behavior can be inferred when we are trying to remember the stages of a culinary recipe we once followed; and we can find our way back to a familiar location by remembering the order of involution of the directions we took from there.

Such indexical ground, through the spatial connection (a co-presence) of a causal influence, is said to be past-oriented or *inductive* (goes from the particular to the general) inasmuch it is susceptible of leading to 'true' or 'false' semantic beliefs based on a succession of events propositionally connected in our memory in terms of "earlier" and "later" (e.g., 'scenes' in motion). Revisiting the wedding example, we could indeed 'fact-check' if it is true or false that "the embarrassing toast speech happened *before* serving the cake" (e.g., by looking at video recordings or even by asking several witnesses).

And third, memories relate to their semiotic reality through the law-like or natural *regularity* of a habit. As we pointed out earlier, episodic MTT is also anticipatory and flexible. This way, a particular episode (including its iconic sensations and indexical connections) might be imputed a *general* meaning or conceptual character (cf. W2, p. 294) and become a symbol representing future re-instantiations that may have such imputed character (e.g., the tendency or recurrence of certain scenarios and practices belonging to the same conceptual class or abstract type). Our wedding, again, may become a generic symbol of similar festive events of the same kind that might happen in the future.

Such habitual connotation in mnemonic symbols may arise conventionally and consciously but also naturally and unconsciously (cf. Belucci, 2021, p. 174; Nöth, 2010, p. 83). For instance, a particular (unique) episode of us walking our dog in the park may evolve to acquire the categorical status of a symbol of the general routine of replicating that activity, or even as a symbol of other associated outdoor practices. A constant or paradigmatic element in the scenario (e.g., our dog's image) might, thus, represent other optional purposes or final causes *preceding* or motivating the walk (e.g., getting fresh air, doing grocery shopping, jogging, or even the wish of not having to clean up after the dog at home). Such symbolic ground, through the repetitive but dispositional regularity of a habit (MS 797, p.4), is said to be future-oriented or *deductive* (goes from the general to the particular), as it pertains to plausible scenarios *not yet realized*, but that we might (arbitrarily or flexibly) implement and plan *should* concrete circumstances demand it.

As such, MTT is an example of a grounded, multi-level semiosis inasmuch as something *virtually* present in the memory of an interpreter has the potential to diagrammatically *stand for* something physically nonpresent, either a personal past (e.g., in retrospection) or a personal future (e.g., in prospection). This optional *bi*directionality in "the reality of the mind" (Tulving, 2002, p. 2) is usually dubbed as the 'two arrows of time' metaphor, which contrasts with the otherwise deterministic, unidirectional flow of physical reactions.

2 Semiosis as the Crossroads of Time

In “The Origin of the Universe”, Peirce pondered that time is something systematic, having its own organization and laws (CP 6.214). Similarly, in “The Problems of Metaphysics”, he further speculates on the reality of time and its thermodynamic tendency to make spatiotemporal events progress in one direction (CP 6.6). In “The Law of Mind [Excursus on the Idea of Time]”, Peirce proposes that time is a “hyperbolic continuum” in the sense that “the infinitely past and the infinitely future are distinct and do not coincide” (W8, p. 134).

This amounts to saying that time by itself is a system where the ending of a physical chain of events does not diachronically affect its beginning. Put differently, a spatiotemporal event ‘A’ causally influences its subsequent event ‘B’. In like manner, event ‘B’ will influence its subsequent event ‘C’. However, ‘C’ will never causally affect ‘B’, and ‘B’ will never affect ‘A’. In short, it seems that “the present is connected with the past by a series of real infinitesimal steps” (W8, p. 137).

Peirce also observes, however, that a physical event could, in theory, work backward (CP 8.330). For instance, we could artificially invert the spin and momentum of a particle, reverse a swinging pendulum, or regress an hourglass. Consequently, he argues in “Topical Geometry”, the mathematical difference between a past state and a future state is not meaningful when it comes to energy conservation and matter (NEM II: 481). Peirce goes on to argue in “Analysis of Time”:

> One of the most marked features about the law of mind is that it makes time to have a definite direction of flow from past to future. The relation of past to future is, in reference to the law of mind, different from the relation of future to past. This makes one of the great contrasts between the law of mind and the law of physical force, where there is no more distinction between the two opposite directions in time than between moving northward and moving southward. (CP 6.127)

Peirce observes, then, that our mind’s phenomenology – “phaneroscopy” (CP 1.284) in his own terms – is intuitively different from the mathematical symmetry of physical time (cf. Reynolds, 2002, p. 65). In his words: “temporal causation (a very different thing from physical dynamic action) is an action upon ideas and not upon existents” (CP 8.330). Similarly, he notes that “in the flow of time in the mind, the past appears to act directly upon the future, its effect being called memory, while the future only acts upon the past through the medium of thirds” (CP 1.325). Semiosis, as I have tried to highlight, is such a triadic medium that allows a ‘symmetry-breaking’, as it were, in the temporal causation upon ideas.

Our current interest lies in the above fact: our mind – particularly during episodic MTT – operates with the conscious intuition that a *lived*, enacted past (e.g., “earlier”) is meaningfully different from a future *yet-to-be*-lived and enacted (e.g., “later”). In Wittgensteinian terms, we continuously live in a subjective or present-centered “memory-time”, where there are only *earlier* and *later* times, which in turn contrast with the more objective or physical “information time”, where there are *past* and *future* times that are publicly observable as a selfless chronology (cf. Rizzo, 2016, p. 137). In this existential sense, we say that a lived (memory) time is pragmatically ‘irreversible’ in semiosis.

Put differently, episodic retrospection does not need our mind’s eye simulations to be causally ‘rewound’ as a tape or ‘work in reverse’ as an engine, nor be ‘inverted’ as an hourglass. During MTT, conversely, chronesthesia allows us to *intentionally* ‘jump’ from one episode to the other and, then, ‘replay’ or (re)construct them in a *forward* flow (Clayton & Wilkins, 2017, p. 5). As reported by Panoz-Brown et al., “vivid episodic memories in people have been characterized as the replay of multiple unique events in sequential order” (2018, p. 1628).

Time and memory are, notably, two meaningful ‘sides’ of consciousness. We know this, as noticed earlier, because episodic MTT and its associated chronesthesia (the subjective positioning between an ‘earlier’ and a ‘later’) are impeded by certain types of amnesia (Klein et al., 2002) and even by Alzheimer’s disease (Han & Pöppel, 2009).

MTT, therefore, happens at the subjective crossroads of two “arrows of time” in semiosis (De Tienne, 2015, p. 42). One of those arrows actually goes from past to future (e.g., a thermodynamic or efficient causation), and the other virtually moves from future to past (e.g., a teleonomic or final causation). These forms of temporal causation have been dubbed, respectively, as “eotemporality” and “biotemporality” (Fraser, 2007, p. 46). The latter arrow is the one that demands an *anticipatory* phenomenology of time. On this subject, Peirce wrote in 1902:

> To say that the future does not influence the present is untenable doctrine. It is as much as to say that there are no final causes, or ends. The organic world is full of refutations of that position. Such action [by final causation] constitutes evolution. But it is true that the future does not influence the present in the direct, dualistic, way in which the past influences the present. A machinery, a medium, is required. Yet what kind of machinery can it be? (CP 2.86).

‘Mental Time Travel’ is, in my view, a fitting metaphor for such a *controlled* and *directional* cognitive process. Indeed, Tulving (2002) has argued that the paradigmatic example of such teleonomic ‘machinery’ or ‘medium’ is episodic MTT, which is a form of semiosis for us. This is the case because we do not necessarily ‘rewind’ or ‘forward’ episodic narratives with a physical logic, but we ground them semiotically, starting with (but not stopping at) the ‘here and now’. As a natural consequence, our remembrances or simulations need to, indeed, make re-creative and re-interpretative “errors” (Devitt et al., 2016).

Because time is observer-dependent or interpreter-dependent (Dalla Barba, 2016, p. 121), semiosis could work as a model to account for the relativistic lived temporality of MTT. In episodic MTT there is, indeed, an interpreter or ‘autonoetic self’ whose EM (interpretant) makes use of a sensible medium (mental representamen) to characterize an absent or nonpresent scenario (spatiotemporal object) in some respect or capacity (an iconic, indexical, and symbolic ground). In causal terms, notably, this implies that the triadic mediating influence of the interpretant (EM) already *precedes* the bidirectional connection between the representamen and its object. This is why I said earlier that MTT involves a diachronic passage from interpretant (EM) to representamen (multisensorial imagery) and from representamen to object (spatiotemporal scenario).

It may seem paradoxical, to say the least, that semiosis in MTT is both an anticipatory and a retrospective process. Such a nuance deserves further clarification at this stage. On the one hand, we say that episodic MTT is *preemptive* or anticipatory because a potential or inactual episode (e.g., a ‘future’ or inferred ‘later’ time) is premediated or preenacted during the ongoing present (e.g., in the flexible form of a simulation). After all, future conduct is, naturally, the only possible *controllable* conduct (CP 5.461). As a consequence, we would think that the present ‘influences’ the future, but this is not true.

The future is not a physical object or result out there, passively being acted upon (e.g., a deterministic ‘fate’). By the future I understand a ‘dormant’, unrealized reality, or the latency of the virtual that may be *instantiated* actively only during the here and now. The future’s general reality *in potentia* is realized and embodied through constrained *act*ions taken by living interpreters or agents during their lifetime. For something to be episodically ‘real’ it does not suffice to be merely possible but to have actual consequences during the present, which are brought about by the optional realization of a habit or a law-like regularity or recursivity. In short, it is the potential (future) that virtually influences the actual (past) by means of the phenomenal (present).

In Peircean jargon, the above could be seen as a form of semiotic causation, where “relations of Thirdness occur in and with the establishment of a connection between the universe of possibilities that is Firstness and the plethora of events that is Secondness” (Hoffmeyer, 2008, p. 67). In other words, the generality of many possible episodic ‘futures’ tends to *become* one episodic ‘present’; and it is the continuous, ongoing, infinitesimal present from which the episodic past draws its actuality. Episodic semiosis is, in this way, the triadic medium that allows our chronesthesia to infer that future becomes present, and present becomes past. Arguably, such is the (retro)causality of meaning-making in memory (cf. Nomura et al., 2019) and, more generally, in consciousness:

> Consciousness appears to be carried backwards, to the moment which preceded the moment of explosion, retrospectively interpreting all that has occurred. The real process in the past is substituted by a model generated by the consciousness of the participant to the act. (Lotman, 2009 [1992], p. 16)

This implies again that the habitual disposition of an interpretant (e.g., EM) *precedes* the act of us iconically recognizing the *simultaneity* of a visualized representamen (e.g., a mental image) as something present that stands for the indexical *succession* of a particular spatiotemporal scenario (e.g., a re-lived or pre-lived episode). In a manner of speaking, our goals, our plans, and our intentions come *from* a general future through the action of final causes. We can only aim for what is not yet/anymore here and now. How could it be otherwise?

By the time we become declaratively aware of such a retroactive memory process, thus, the interpretant has already dealt with the meaningful (semiotically motivated) connection between the perceived representamen and its absent object. This could be seen as the inferential passage from an unconscious habit to a conscious belief (cf. Stjernfelt, 2016, p. 254). On this, Peirce might add that the influence between consciousness and time is, in other words, a matter of *discovering* our continuity with the future during the present. As Peirce put it in "Law of Mind. Early Try, 1892":

> What does the difference between past and future consist in? Past ideas are those which are associated with consciousness. Future ideas are those which are not so associated. So the flow of time by which the future becomes past, consists in the continual increase of associations, or the tendency of thoughts to become more and more connected. (W8, p.128)

Accordingly, Fernández notes that:

> Peirce correlates the three relata in semiosis, the representamen, its object, and its interpretant, with the three "dimensions" of time. Present time corresponds to the representamen, past to the object, and future time to the interpretant. The present is the infinitesimal cross-section that separates the future realm of possibilities from the facticity of the inalterable past. (Fernández, 2010, p. 294)

However, rather than being a separation between past and future, the phenomenal present serves as the transient 'crossroads' of chronesthesia or memory-time, making it possible for retrospection and anticipation to coexist and mirror each other during MTT. In like manner, the representamen serves as the sensible, vivid medium of semiosis, affording the interpretant to (pre/re) mediate an otherwise abstract object. The imagistic immediacy of the representamen in EM is a qualitative gateway, the plasticity of which allows the interpretant to direct itself to different types of temporal objects flexibly. In terms of semiosis, De Tienne explains that:

> The object is both an **efficient cause** and a **final cause** of sign processes. The arrow that goes from the **past to the future** is related to the object viewed as an initiating or efficient cause. The arrow that comes from the **future through the present** down but forward into the past is better associated with the object viewed as a final cause (De Tienne, 2015, p. 42).

In terms of the wedding example, the past-oriented (indexically grounded) memory of the object (already enacted scenario) inductively represents the *efficient* causes by virtue of which we are still married in the present. While the future-oriented (symbolically grounded) simulation of the object (yet-to-be enacted scenario) deductively represents the *final* cause or goal by virtue of which we will *opt to* get married sometime in the present.

The efficient (past-oriented) arrow of time is inferred by retrospective MTT, and the final (future-oriented) arrow of time is inferred by prospective MTT. However, both are connected in EM. I have elsewhere explained this bidirectional logic in terms of the "Thirdness↔Firstness↔Secondness extrapolation" (Miyamoto, 2020, p. 31). But, for the purposes of this section, it should suffice to conclude for now that episodic semiosis (e.g., Interpretant ↔ Representamen ↔Object) is the phenomenal crossroad for biotemporality or 'memory-time' (e.g., a subjective and individual Earlier↔Now↔Later) to coexist with the passage of eotemporality or 'information time' (e.g., an intersubjective and social Future↔Present↔Past). Either in its retrospective or prospective forms, MTT cannot bypass the sensitivity of the relative *pre*sent: MTT begins and ends in our phenomenal present as a transient (re)presentational ‘afterimage’.

How is it, then, that finite intervals of time (e.g., separated episodes) can be connected at all? This is to ask, how can the transient, ephemeral nature of the present instant, then, afford the long-term continuity of EM? Peirce was likely aware of the problem of permanence when stating that “consciousness is carried along from one time to another, and is able to compare what is present to it at different times. Such we may suppose to be the process of memory” (CP 7.466).

If presented with neurocognitive evidence on chronesthesia (e.g., Nyberg et al., 2010), Peirce might argue that this type of temporal consciousness explains the three possible associations or ‘punctuations’ of time: *precedence*, *contemporaneity*, and *succession*. Peirce proposed these as the “Temporal Expressions of Stage” in a metaphysical diagram (W1, p. 530). Arguably, Tulving and company have shown us that EM is one meaning-making system that allows us to organize and structurally link such ‘punctuations’ within our lifetime as a whole.

Similarly, Peirce might recur to his “Subjective and objective modality E” to understand chronesthesia in terms of the intellectual *purports* and feelings associated with a future or a “later” (e.g., prospection), a present or a “now” (e.g., perception), and a past or an “earlier” (e.g., retrospection), as the “general determinations of time” (CP 5.458).

Nowadays, the above is comparable to saying that memory processes are not instantaneous nor crystallized but *transient* and having distinct durations. Evidence shows that EM is not a single, absolute ‘entity’ but a modeling system flexibly tuned to the timescales of other mnemonic subsystems (West, 2019, p. 65). For instance, EM is informed by multisensorial qualia from sensory memory (lasting around 100 ms); it is directed by the attention of working memory (lasting about 10 s); and builds upon conceptual knowledge from semantic memory (lasting years), and upon skills expressed by procedural memory (lasting a lifetime). Because of this, Peirce might say, episodic MTT is a chain of semiosis or a “continuous flow of inference through a finite time” (W8, p. 138).

In his lecture “Causation and Force”, Peirce made the hypothesis that “[…] time is the form under which logic presents itself to objective intuition” (RLT 217). Between time and mind, there are, in other words, a set of logical relations or a “logical dependence” (MS 446). Such dependence is not coincidental because, as put in “Time and Thought” (W3, p. 70), our mind requires infinitesimal but *connected* intervals of physical time in order to operate as a continuous system.

Indeed, Cabeza and Moscovitch report that “functional neuroimaging evidence suggests that memory processes are supported by transient interactions between a few regions called process-specific alliances” (2013, p. 49). Accordingly, Başar and Düzgün have referred to memory processes as some sort of “hypermemory” that works with a synchronized “timespace” of almost 500 milliseconds (2016, p. 205). In light of this, the following claim in “The Law of Mind” becomes especially relevant to further connect Peirce with Tulving’s EM theory:

> Consciousness must essentially cover an interval of time; for if it did not, we could gain no knowledge of time, and not merely no veracious cognition of it, but no conception whatever. We are, therefore, forced to say that we are immediately conscious through an infinitesimal interval of time. (W8, p. 137)

Overall, "consciousness" for Peirce seems to be a flow of inference or a chain of semiosis that presupposes *continuity*, *duration* and *subjectivity* (W8, p. 138). This, I have argued, applies especially to EM insofar as consciousness of time belongs to a "genuine synthesis" (CP 1.384). This cannot be overlooked since it exhibits fundamental parallelisms with the phenomenological features of what Tulving (2005, p. 9) called "autonoetic awareness" or the "subject's temporally extended self" (Michaelian et al., 2016, p. 46). Nonetheless, autonoesis by itself offers an incomplete picture of how different types of memory systems are consciously and/or unconsciously *controlled*.

3 The Looking Glass of Memory

Autonoesis is the characteristic "self-referencing" awareness (Crystal, 2018, p. 105) attributed to episodic MTT insofar as it "allows us to reflect upon our memories, knowing that we are the authors and owners of those thoughts" (Clayton & Wilkins, 2017, p. 2). In this sense, autonoesis could be compared, metaphorically speaking, with the habitual act of watching our reflection in a mirror.

First, it involves the sensorial possibility of *seeing* the image coming from the mirror. Secondly, it consists in *correlating* that image with our actual co-presence in front of the glass. This could be seen as a passage from a first-person experience (supported by our own sense of sight) to a second-person perspective (supported by the physical opposition of the mirror). The becoming of an image into a presence is caused, however, by a *projection*, a self-recognition or inference that the moving picture 'out there' corresponds to something more general (ourselves). Every time we recognize our characteristic image in a mirror, we will already have anticipated and interpreted it as an instantiation or replica of ourselves. Hence, our reflection has become more than an icon and an index; it has naturally become a symbol, an assertion or argument about our imputed existence. In this analogy, the 'looking glass' of autonoesis could be said to comprise a *projection* that links *visualization* with *correlation*.

According to Tulving, EM works in a similar way. He theorized a hierarchy of different types of consciousness that, in turn, control various types of memory systems. He called them *autonoesis*, *noesis*, and *anoesis*. In our metaphorical terms, autonoesis is the projection stage, noesis is the correlation stage, and anoesis is the visualization stage. This famous "class-inclusion hierarchy" (Tulving, 1983, 1985, p. 2) has been referred to as a "continuum of stages" in consciousness (Vandekerckhove & Panksepp, 2009, p. 1018). As depicted by Tulving's original model (1985) (Fig. 1):

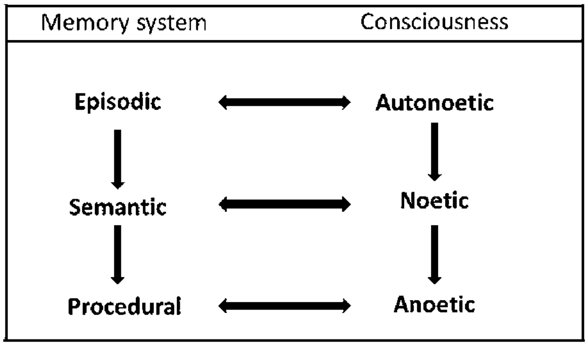

Fig. 1 A schematic diagram of the relations between memory systems and varieties of consciousness by Tulving (1985, p. 3)

This hierarchical model observes that anoesis (aka ‘unknowing’ awareness) unconsciously controls procedural memory (e.g., sensorial and preconceptual information); noesis (aka ‘knowing’ awareness) consciously controls SM (e.g., categorical, propositional, and spatial knowledge); and autonoesis (aka ‘self-knowing’ awareness) self-consciously controls EM (e.g., the projection of autobiographical episodes). These, according to Tulving (1985), are said to be sub-types of the more general phenomenon of consciousness.

Just like in the looking-glass metaphor, constructive seriality is observed by Tulving in his model. Anoesis is a neurocognitive prerequisite or basis for noesis, and noesis is a neurocognitive prerequisite or basis for autonoesis. Among other things, this means that the loss of episodic autonoesis does not necessarily cause the loss of semantic noesis, as clinically noted by Nielsen. Tulving refers to this as the “SPI (serial, parallel, independent) model that postulates process-specific relations among the memory systems” (1995, p. 839). If Peirce had lived to see this evidence-based hierarchy and its applied iterations (cf. Henson & Gagnepain, 2010), he might have framed it in terms of semiotic thresholds of consciousness. As he already speculated in “The Triad in Psychology”:

> Granted that there are three fundamentally different kinds of consciousness, it follows as a matter of course that there must be something threefold in the physiology of the nervous system to account for them (CP 1.385)

The rest of this section will attempt to explore these parallelisms in more detail. Roughly speaking, I will argue that, in memory processes, anoesis could be explained as an iconic threshold of recognition, noesis as an indexical threshold of correlation, and autonoesis as a symbolic threshold of habituation. These are said, respectively, to be bound to the simultaneity of a visualization, the succession of an action, and the precedence of an intention.

Resuming Tulving’s concept of **anoesis** (1985, p. 3), Vandekerckhove et al. have found more compelling evidence that anoesis is, indeed, an organismic and normative awareness responsible for “perceptual, motoric-procedural and various primal emotional, homeostatic, and sensory affective states” (2014, p. 1). More specifically, they report anoesis as:

> The autonomic flow of primary-process phenomenal experiences that reflects a fundamental form of first-person "self-experience," a vastly underestimated primary form of phenomenal consciousness (2014, p. 1)

This is, anoesis controls the unconscious (nondeclarative) processes of perception, which is representamen-oriented, as I have earlier put it. In Peircean semiotics, this could be discussed as an *iconic* type of awareness. In Jamesian terms, we could say anoesis oversees the perceptual features of the specious or phenomenal present. This could also be tagged as the "timelessness" of the instant (Wittgenstein, 1961, 6.4311). Anoesis could be characterized more broadly as the awareness responsible for our interpretation of iconic, qualisignic, and rhematic relations. This, in turn, could be seen as the abductive formation of immediate interpretants (CP 8.315), dealing with *formal* causes as a simultaneity of qualities of feeling or qualisense (CP 8.303).

Also, the above definition suggests that anoesis operates with the shortest but fastest interval in our memory workspace. This would make the 100 milliseconds threshold of sensory memory a recognition window (cf. Kull, 2018, p. 139), where we experience the phenomenal present in an unconscious, yet *perceptive*, fashion. Anoesis, then, receptively deals with qualia that have already been mediated but not *effectively* associated yet, with more lasting and declarative forms of memory, like SM and EM.

On this, evidence shows that sensory memory does not necessarily need episodic autonoesis or semantic noesis to be retained at the first-intentional organismic level (Cowan, 2017, p. 23). In contrast, as theorized below, SM and EM require forms of long-term awareness that *transcend* the temporal boundaries of the immediate present.

Anoetic qualities or percepts are quickly perceived by sensory memory as an iconic model of recognition (e.g., colors, shapes, temperatures, and sensations in themselves). Thus, if iconicity is the primary form of memory or mental representation (Deacon, 2012, p. 77), the anoetic present starts with memory having the possibility of visualizing the *formal* cause or structure of those iconic relations. Such iconic relations are perceptual *judgments*, "the first premises of all our reasonings" (CP 5.116), which "have icons as their predicates" (CP 5.119).

In short, the anoetic present is grounded in iconicity inasmuch as "the icon is, through its timeless similarity, apt to communicate aspects of an experience in the present instant" (Stjernfelt, 2007, p. 29). And, because abduction is grounded on iconicity (Beuchot, 2007, p. 22), the anoetic present exhibits our tendency to formally *feel* stimuli and emotional interpretants before attaching semantic and episodic meanings.

When it comes to **noesis**, it is found that it controls semantic and spatial information (Michaelian et al., 2016, p. 7). The latter is said to be propositional, factual, and categorical in nature. As Tulving puts it, the noetic control of SM handles information that is:

> Representational and can be, even if it need not be, described in propositional format. The representational information has truth/false value: it corresponds to objects, events, relations, and states of the world. (2005, p. 12)

If noesis is responsible for semantic and conscious (declarative) processes, it could be discussed as an *indexical* or object-oriented type of consciousness. Given the correlational nature of SM (the aboutness or coexistence of something with respect to something else), noesis could be characterized more broadly as the control of indexical, sinsignic, and dicent relations. This could be seen as the *inductive* formation of *dynamic interpretants* (CP 8.343), dealing with a factual succession of relations or molition (CP 8.303). Noesis, or knowing awareness, consolidates, and manipulates our knowledge about the world through beliefs and categories.

Because induction is grounded on indexicality (Beuchot, 2007, p. 22), noetic awareness implies the cognitive passage from the particular to the general. We access the world of 'consolidated' facts, or 'settled' beliefs, through the particularity of indexes and their orientation to a past object. In Stjernfelt's words, "the index is turned toward the past: the action which has left the index as a mark must be located in time earlier than the sign" (2007, p. 29). Semantic noesis on its own, as Tulving (2005) points out, is not yet sufficient to anticipate future re-instantiations of a past episode, which are symbolically and habitually projected.

In turn, **autonoesis** could be discussed as a *symbolic* type of awareness grounded on the generality of a future-oriented habit (MS 797: 4). "The symbol itself is a [...] general recipe for the production of similar instantiations in the future", Stjernfelt writes (2007: 30). Given the anticipatory or algorithmic-like nature of EM, autonoesis may also be identified as the interpretant-oriented consciousness responsible for expressing or asserting symbolic, legisignic, and argumentative relations, which have pragmatic or anticipatory consequences in terms of controlled, goal-oriented, behavior. This corresponds to a deductive formation of *logical interpretants* (CP 8.343), making possible the conscious recognition of habits or a habituescence (CP 8.303).

It is only when a future (anticipated) episode materializes itself in the present that its potential resemblance with the past is retroactively realized. This predictive passage from the general to the particular is a deduction, which is grounded on symbolicity (Beuchot, 2007, p. 22). If the future becomes present, and present becomes past, the past holds the potential to 'become' future, in the sense that it may be repeated (re-instantiated) to some extent and in some relevant capacities. Autonoesis transcends the semantic fixation of a past-oriented belief by flexibly drawing meaning from the unrealized (future-oriented) disposition of a habit, evolving accordingly. Final causes in semiosis cannot be reduced to individual, efficient causes. Coming back to the example of walking our dog in the park, we could summarize the above points as follows.

(1) During perception, semiosis grounds representamens as icons because the present is formally memorized as a *simultaneity* of felt qualities (e.g., the trees' shadows, our dog's panting, and the smell of grass). These static images or

‘shots’ may iconically or virtually stand for a ‘now’ as a potential and timeless *formal* cause, where there is still no ‘earlier’ and ‘later’.

(2) During episodic retrospection, semiosis grounds representamens as indexes because the ‘past’ is efficiently reconstructed as a *succession* of consolidated actions (e.g., letting the dog out, walking it and, finally, bringing it back home). These moving images or ‘scenes’ may indexically or semantically stand for a ‘past’ as necessary *efficient* causes, which have propositional ‘true’ or ‘false’ values.

(3) During episodic prospection, semiosis grounds images as symbols because the ‘future’ is habitually memorized as the *precedence* of optional purposes (e.g., the intention of getting fresh air or the wish to get some physical activity). These consequential goals symbolically or pragmatically stand for an open future as an optional *final* cause.

In short, we can iconically *perceive* not only the present moment but also anticipate the symbolic *potentialities* of the future and infer the indexical *actualities* of the past, insofar as we *re-present* or simulate them during MTT and its virtual reality. This could elsewhere be further developed in terms of virtual, actual, and habitual forms of cognition (cf. Stjernfelt, 2016, pp. 253–261); or, in even more Peircean jargon, in terms of a *habitualiter* (CP 5.441), a *virtualiter* (CP 6.372), and an *actualiter* (CP 8.18).

4 Conclusion

As a whole, the paper framed Tulving’s theory of Episodic Memory (EM) in terms of Peirce’s concept of semiosis (involving an interpretant, a representamen, an object, a ground, and an interpreter). This ‘crossover’ definition of EM was further clarified and used in the later sections of the article, sketching an interdisciplinary approach between semiotics (e.g., phaneroscopy) and neurocognitive sciences (e.g., a neurophenomenology).

The section “The Pierce–Tulving continuum” reviewed the importance of *time* for semiotics and EM theory when it comes to accounting for the dynamicity of consciousness. Namely, we observed that Peirce’s phenomenology of time is not only compatible with Tulving’s neurocognitive findings on EM but also that the latter provides evidence in favor of the former.

In response to the above, the section “Semiosis as the crossroads of time” integrated the concepts of semiosis and MTT. It did so by explaining why EM requires an *anticipatory* phenomenology. One that can be further described as the passage from interpretant to representamen and from representamen to object, or “a motion that moves from the future forward into the past” (De Tienne, 2015, p. 36). In short, this section observed the importance of *subjective* time for Peirce and Tulving when it comes to accounting for the ‘retrocausal’ or ‘retroactive’ dynamics of mind and memory.

Up to this point, the main argument of the paper was that memory processes diverge from the selfless, symmetric logic of mechanical causation. This is to say, because physical systems are virtually reversible, in them, the ontological difference between a past state and a future state is *non-existent*. In contrast, memory processes make a pragmatic (meaningful) *distinction* between an actual, lived past (e.g., via retrospection) and a potential, yet-to-be-lived future (e.g., via prospection).

In "The Looking Glass of Memory", we explored the parallelisms between Tulving's famous triadic class-inclusion hierarchy (1983, 1985) and Peirce's speculations about different types of consciousness. Based on this, we theorized about how MTT transiently orchestrates anoesis and noesis by means of autonoesis. More concretely, we hypothesized that anoesis could be seen as an iconic threshold of recognition, noesis as an indexical threshold of correlation, and autonoesis as a symbolic threshold of habituation. This is the main move in the chapter insofar as it proposes an interdisciplinary way to test Peirce's hypotheses on consciousness through current neurocognitive research on memory systems.

The correspondence between both triadic hierarchies, however, is still an open question that might be enriched by looking into Peirce's concepts of self-control and virtual habit, as West has already done (2018, 2019). After all, as I tried to highlight, this is the main argument put forward by Tulving's hierarchy: different types of consciousness excert a teleonomic control over their correspondent memory processes, while the latter (semiotically) ground the former.

There is no question that Tulving's EM theory made a cognitive leap from the classical computational paradigms of memory (e.g., Atkinson & Shiffrin, 1968). In my view, this is because Tulving explains time and memory as two inseparable sides of autonoetic consciousness. My goal, in such a context, has been to examine how different types of temporalities and memory coincide, in more than one way, through Peirce and Tulving.

This becomes historically relevant if we consider that Peirce had a very limited understanding of the neurocognitive relation between memory and brain: "We do not know more than that if anything happens to the hemispheres, memory is deranged. It is a most wonderful thing if all we remember is really preserved in the cells of the cerebrum" (CP 6.520). Perhaps he would be surprised to discover the "biological reality" (Tulving, 2002) and neural substrates of EM and, just as importantly, the mental complexity of EM, which nowadays is a matter of a heated philosophical debate (cf. Michaelian et al., 2016, p. 13). Tulving would have a lot to discuss with Peirce when it comes to the latter's speculations about how to temporally and artificially induce amnesia in a person, to test if selfhood and memory can be ontologically separated at all this way (CP 6.521).

On a less speculative note, I envision research lines on the Peirce–Tulving continuum. Namely, Peirce's ideas on "virtual cognition" (CP 2.398) and self-control (cf. Stjernfelt, 2021) could be used to account for recent evidence on animal EM behavioral studies (cf. Miyamoto, 2021), which necessarily deal with the "self-referential" aspect of consciousness (Crystal, 2018, p. 105). Similarly, we could further explore the compatibility between the Peircean concept of *virtual habit* (West, 2018) and the Simulation Theory of memory, which states that:

Content is acquired only through the "habits of action" that accompany the production of episodic thoughts, which include, in particular, "habits of judging" certain things to be the case about the episodes that are their objects. (Michaelian & Sant'Anna, 2021, p. 318).

These connections should be elsewhere developed in detail since they may have the potential to bridge the current gap between Pragmaticism (which is representational) and radical enactivism, which is explicitly anti-representationalist and avoids recurring to meaning-making (semiosis) as a causal explanation of some long-term memory processes (cf. Hutto, 2022). Experimental studies on EM theory still have a lot to offer to cognitive semiotics in this regard.

Charles Peirce's concept of semiosis is applicable to Endel Tulving's concept of Episodic Memory by means of discussing the phenomenology of time as a meaning-making process.
Semiotics could use the experimental power of neurocognitive sciences in order to ground and test hypotheses about the ostensible relationship between consciousness, memory and time.
Memory processes make a pragmatic (meaningful) distinction between an actual, lived past (e.g., via retrospection) and a potential, yet-to-be-lived future (e.g., via prospection).
Semiotics of memory systems is yet-to-be developed. However, one possible starting point is to combine Tulving's triadic class-inclusion hierarchy with Peirce's speculations about different types of consciousness.
Based on the above ideas, it was argued that anoesis could be seen as an iconic threshold of sensorial *recognition*, noesis as an indexical threshold of semantic *correlation*; and autonoesis as a symbolic threshold of episodic *habituation*.

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III

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The virtual habits underlying the behavioural hallmarks of alloanimal episodic memory: a Peircean model

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Abstract

Experimental studies of animal episodic memory test the behavioural expression of a what-where-when 'memory content'. This is to say, autobiographical memory in some species (mainly birds, rodents, and great apes) has been understood on the basis of how the subject's actions demonstrate their long-term awareness of already enacted and yet-to-be enacted scenarios. However, such behavioural focus has come at the expense of discussing the interdependent role of two equally important episodic hallmarks: 'memory structure' (mental representations), and 'memory flexibility' (adaptive choice-making).

This paper provides a semiotic characterization of those less discussed hallmarks, in terms of the Peircean concept of *virtual habit* or the mental enactment of non-present episodes. It is argued that the behavioural expression of a 'memory content' (as object in a process of semiosis) cannot be accounted for without understanding the phenomenological or experiential support of memory structure (as a representamen), and the teleological or purposeful self-control of memory flexibility (as interpretant). Based on this, a new cognitive model of animal episodic memory is proposed, consisting of interrelated modalities called Virtualiter, Habitualiter, and Actualiter. Capitalizing on multispecies evidence, possible applications and new directions of the model are proposed.

Keywords: Animal Episodic Memory; Virtual Habit; Peircean semiotics; Phenomenology.

1. THE SEMIOTIC GAP IN ALLOANIMAL EPISODIC MEMORY STUDIES

Before introducing the model per se (Figure 1), it is pertinent to briefly contextualize the interdisciplinary knowledge gap it aims to address. This will be crucial to later make a case for its future ethological applications as an evidence-based model, and its future directions in the broader context of philosophy of memory.

Human Episodic Memory (EM) is classically defined as a prelinguistic, long-term, neurocognitive system, which allows individuals to consciously recollect and anticipate a non-present autobiographical scenario (Tulving 2005). Namely, EM is needed to relive the last occasion you met with your best friend, including the unique contextual features of the encounter. This type of experiential elicitation goes beyond Semantic Memory (SM), which is responsible for knowing pieces of factual and conceptual information (e.g., proper names, calendar dates, and physical locations). In contrast, EM allows your 'mind's eye' to sequentially recreate or relive the meeting's unfolding of occurrences as a *binding* of images, intentions, and actions. In this sense, EM is said to be a "representation-hungry" form of cognition (Kiverstein and Rietveld 2018: 147).

A growing body of comparative evidence (Colombo et al. 2017; Hirata et al. 2021) suggests that a variety of species besides humans possess analogous (equivalent) forms of EM or "episodic-like memory". Such is the case of, for example, gorillas (Schwartz et al. 2005), chimpanzees and orangutans (Martin-Ordas 2016), monkeys (Hoffman et al. 2009), rats (Panoz-Brown et al. 2018), mice (Fellini and Morellini 2013), dolphins (Davies et al. 2022), dogs (Fugazza et al. 2020), elephants (Chusyd et al. 2021), pigeons (Zentall et al. 2008), jays (Clayton et al. 2001), magpies (Zinkivskay et al. 2009), and crows (Boeckle et al. 2020). In the light of this, memory studies are turning to definitions of EM that consider humans and other animals:

> Episodic memory is the remembrance of one's own previous experiences and can be done by both human and non-human animals. Episodic memory is supported by a distributed network of cortical and sub cortical brain regions, but requires the involvement of the hippocampus unlike other memory systems. Mental time travel, the re-experiencing or imagining of a sequence of events, is dependent on episodic memory. (Madan 2020: 189)

Animal EM displays species-specific features (Templer and Hampton 2013), but it is posited as a case of convergent evolution (Emery and Clayton 2004; Seed et al. 2009). Crystal (2010, 2018 and 2021) has comprehensively reviewed and discussed how to evaluate such evidence in a comparative context. In biosemiotics, more particularly, such multispecies studies have been used to coin the acronym "Alloanimal Episodic Memory (AEM)" (Miyamoto 2021)[1].

A myriad of non-semiotic AEM models is on offer, including computational models based on information processing and neural networks (Brea et al. 2023); neurocognitive models mapping a psychological hierarchy of overlapping body-mind subsystems (Templer and Hampton 2013); and behavioural models

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[1] The term "alloanimal", on its own, originally refers to all other animals or "animals besides the human animals" (Deely 2015: 19). It was coined by Count (1973) but was incorporated into biosemiotics by Anderson (2016 and 2019) and Kemple (2019).

predicting experimental outcomes by capitalizing on ethological observations (Applegate and Aronov 2022).

The latter type of models test the aforementioned what-where-when Memory Content (MeC), demonstrating that the consistency of the subject's *actions* would not be possible without the prospective and/or retrospective awareness of (1) the items and individuals involved (what), (2) the locations and movements involved (where) and, most importantly, (3) the unique temporal order in which those two elements *combined* in the past or will be combined in the future (when).

Evidence of MeC mostly comes from rodent studies testing hippocampal replay in relation to maze-solving tasks (Panoz-Brown et al. 2018); hominid studies testing cued recall and unexpected questions in relation to contextual tool use (Martin-Ordas et al. 2010); and from corvid studies testing food-storing strategies in social contexts (Salwiczek et al. 2010). As first put by Kort et al:

> The jays remember the what-when-where components of a caching episode (content), these components are integrated (structure), and can be updated and generalized over situations (flexibility) […] The utility of this 'what-where-when' criterion is that the simultaneous retrieval and integration of information about these three features of a unique experience can be demonstrated behaviorally in animals. (2005: 159–161)

This criterion, proposed by Clayton and Dickinson (1998), is the most consistent standard of AEM. So much so, that it has been extrapolated to other species besides California scrub jays (*Aphelocoma coerulescens*). Understandably, due to such replicability, AEM studies have deemed it more objective to focus on testing "the content of episodic memories, rather than the subjective experiences that may accompany episodic memory" (Crystal 2018: 105). In comparison, Memory Structure (MeS) —the representational binding of mental imagery— and Memory Flexibility (MeF) —the pragmatic adaptability of decision-making— have been characterized to a lesser extent (Allen and Fortin 2013: 10380).

This is the case, perhaps, because behavioural approaches tend to postpone the discussion on the so-called "problem of other minds" (Harnad 2016), despite presupposing sentience, creativity, and consciousness in their experimental subjects. Moreover, behavioural studies tend to endorse the idea that "a phenomenological characterization of episodic memory is widely agreed to be useless, when it comes to investigating episodic memory in animals", which has been criticized by Boyle (2020: 64)[2].

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[2] In the context of Peircean semiotics, "phenomenology" and "phaneroscopy" are henceforth used as synonyms, insofar as they pertain the *a posteriori* study of lived experience (CP 1.284). More broadly, this conception is compatible with Umwelt theory and Uexküllian phenomenology (cf. Tønnessen 2015), as the study of a 'first person' perspective or an experienced world shared by the members of a species. Also, Peircean phenomenology has been compared and contrasted with Endel Tuliving's idea of Mental Time Travel (Miyamoto 2024).

Admittedly, some non-semiotic studies have addressed key phenomenological questions in AEM such as imagination (Zacks et al. 2022), mental imagery (Blaisdell 2019), and sensorial richness (Birche et al. 2020), suggesting that the inferential support of 'internal' or mental representations (Gruber et al. 2019; Zlomuzica and Dere 2022) is crucial in explaining conscious and flexible episodic behaviour, just like it is the case with human EM (Dawes et al. 2020). Similarly, the model herein proposed endorses a representational view of episodic cognition, as opposed to anti-representational views such as radical enactivism (cf. Steiner 2014).

Against this interdisciplinary background, the "semiotic gap" in AEM studies (Miyamoto 2021) refers to the unacknowledged semiotic connection between MeC, MeC, and MeF. In response, this paper proposes an integrative explanation for the cognitive interdependency between the three hallmarks of AEM. The behavioural expression of MeC, it will be argued, cannot be accounted for without understanding the phenomenological support of MeS (e.g., as some sort of multisensorial imagery explicitly evoked in the 'mind's eye'), and the teleological control of MeF (e.g., adapting future behaviour by recombining MeS and MeC).

2. EPISODIC MEMORY AS VIRTUAL HABIT

What distinguishes EM from other forms of memory is its capacity to derive practical bearings from a mental simulation (e.g., recollection and prospection) that is *subjectively* experienced (Tulving 1983: 84). Far from opposing, the subjectivity of an autobiographical ('internal') stream of events and the objectivity of a spatiotemporal ('external') scenario coincide logically through the notion of *virtuality*. In Peircean semiotics, the virtuality of an episodic simulation could be understood as "A virtual X (where X is a common noun) is something, not an X, which has the efficiency (virtus) of an X" (CP 6.372). As put by Esposito:

> A virtual X is not a potential X because a potential X is "without actual efficiency". However, a virtual X is a potential X in a universe that empowers potential Xs to become actual Xs. Without such empowerment it is merely potential in an abstract and less philosophically interesting sense. So, to speak of virtuality in Peirce's sense is to be concerned with certain very fundamental metaphysical properties about the universe at large and not exclusively with the world of human constructs and conventions. (Esposito 2003: 1)

In this sense, human EM has been semiotically studied in terms of a Virtual Habit (VH) or the "pre-enactment of specifically framed episodes in the inner world" (West 2017: 61). Furthermore, episodic VHs have been described as "implicit image-propositions", "propositional imagining", "pre-action images" (West

2016a; 2018a; 2018b; 2019; 2022), and “creative hallucinations” (EP 2: 192). More specifically, it is said that:

> In virtual habit Peirce expresses his clearest model of how abductive reasoning emerges—demonstrating how viable inferences hatch and how they become packaged in action templates to resolve previously unexplained consequences. It traces early implicit decision-making—determining which hypotheses have promise to conquer particular real-world problems. In the process of generating a running event picture in the mind, virtual habits determine which beliefs are more viable. These specific spontaneous moving images supply abducers with pre-experiences to feel the potential effects of specific hypotheses. (West 2016: 13)

Building on the above, VH in AEM will be theorized in terms of three cognitive modalities called “Virtualiter” (underlying MeS), “Habitualiter” (underlying MeF), and “Actualiter” (underlying MeC)[3]. Nevertheless, these relational modes of VH ought to be understood as an irreducible continuum even if Figure 1 is geometrically partitioned.

2.1 The Virtualiter and Memory Structure

MeS is oftentimes referred to as a *binding* (Beran 2014) or *integration* of internally generated representations, which allows the formation of coherent ‘scenes’ during recollection (Crystal and Smith 2014: 2957). Such binding is represented in Figure 1 by the Virtualiter, encompassing the categories inside the blue circle. The Virtualiter is herein theorized as a cognitive modality having the virtue of representamens in semiosis[4], which allows episodic interpreters to preview their potential actions as a coherent ‘stream’ of events. This representamen-like modality of VH serves the meaning-maker as a panoramic lookout, as it were, to make *resolutions* about what they want to do, where they can do it, and when.

By **resolutions** I mean (1) the *vividness* or imaginative clarity (MS 620: 26) with which something is iconically visualized by the ‘mind’s eye’ (e.g., the ‘high’ or ‘low’ resolution of an episode’s multisensorial details); (2) an *intention* about a likely future episode (e.g., a ‘reminder’ or ‘command’ issued to one’s future self); and (3) an *elucidation* or creative realization about how to solve a present situation (e.g., an abductive inference or ‘eureka’ moment that could be followed by a consequential course of action).

The Virtualiter underlies the MeS discussed in behavioural experiments insofar as “the information about the event and its context is integrated in a single

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[3] These three terms are exapted from Peirce’s ideas on virtual cognition (W2: 311), which were initially built upon the Scotic theory of universals (Stjernfelt 2016: 252–253).

[4] A “representamen” is a sign-vehicle or cognizable medium potentially standing for something *other* than itself to an interpreter or meaning-maker.

representation" (Allen and Fortin 2013: 10379) . The Virtualiter, as a phenomenal or experiential mode of cognition, displays the qualitative aspects of representamens in their formal Firstness[5]. By means of experienceable resolutions, thus, "the mind perceives likenesses and other relations in the objects of sense, and thus just as sense affords sensible images of things, so the intellect affords intelligible images of them" (EP1: 92). However, such a sentient potentiality does not stop there, but is already being simulated or evaluated in terms of its practical verisimilitude within a *possible* world as a pre-tested hypothesis.

Acknowledging this modality of VH implies that MeS would provide no information without the subjective capacity to virtually re-experience simultaneous (present-oriented) sensations, which are necessary for the later recognition and differentiation between similar lived episodes. The Virtualiter does not 'calculate' the statistical probabilities of physical reactions 'out there', but it creatively visualizes and informs the *possibilities* of sequential actions.

In more neurocognitive terms, the Virtualiter controls episodic **simulations,** also known as "hippocampal replay of experience" (Denovellis et al. 2021): those experiences diachronically elicited despite the absence of the what-where-when scenario or actions that MeS is *about*. This virtual re-enactment or pre-enactment of non-present situations is, thus, a conative recreation *of* something other than itself (a semantic or meaningful correlate). As it will be later explained regarding the Actualiter, the animal interpreter possesses a declarative sensitivity or awareness that can aptly distinguish between their retrospective simulations (*re*presenting actions already enacted) and their prospective simulations (*pre*senting yet-to-be taken actions).

The Virtualiter's sphere maps the abductive or *creative* role of mental representations, which are not necessarily limited to visual aspects. Instead, the Virtualiter is an imagistic dimension that contemplates the possible spectrum of alloanimal sentience, considering Firstness as a "principle of spontaneity, which is just that virtual variety that is the first" (CP 1.373). Rather than being a psychological concept, the Virtualiter is thus to be understood semiotically as a representamen-like dimension, because it models an infinitesimal part of a broader shared *umwelt*, or reality as experienced by a species through sign-based processes (Tønnessen et al. 2018).

In this sense, the Virtualiter gives form or structure to the inexhaustible and indeterminate plurality of scents, flavours, temperatures, sounds, textures, proprioceptive sensations, vibrations, and all sort of qualitative impressions (qualisigns) possessing practical or inferential bearings on the interpreter's future conduct. The reality of virtual cognition, as put by Stjernfelt "comprises the whole universe of possible forms that the mind may possibly address" (2016: 253).

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[5] In Peircean phenomenology, Firstness is a mode of lived experience as an indeterminate present-oriented *recognition*, where ego-non ego, subject-object, and internal-external distinctions have yet not been made (CP 5.469).

Because environmental or 'external' information is always incomplete in some regard, MeS *re*creates, binds, and self-contains idiosyncratic representations to deal with the occluded aspects of an ongoing scenario, such as food caches, tools, conspecifics, or environmental cues. Under this logic, the phenomenology of MeS is fundamental to account for the behavioural plasticity of AEM, because interpreters mentally contemplate and perform virtual what-where-when's that would not be memorable without multisensorial representamens, as supported by a hippocampal-dependent neural reactivation (Bevandić et al. 2024: 1072). For example, this is true for the role of odours in rodent EM, which allows the "replay of multiple unique events in sequential order" (Panoz-Brown et al. 2018: 1628).

The Virtualiter underlies MeS because it formally exhibits suggestive or iconic representamens (e.g., images, diagrams, and metaphors), acting as the sensible (present) medium standing for a latent subtext with worldly possibilities (a non-present scenario where resolutions *could be* implemented). In short, as VH, the Virtualiter is an unrealized but *resolute* structure expressing the logical terms of a yet-to-be enacted goal. The Virtualiter, thus, structures or binds the embryonic what-where-when syntax of "proto-behavior schemes, ordaining workable courses of action" (West 2016: 18), which would otherwise be formless and, therefore, meaningless or unintelligible for the animal interpreter.

2.2 The Actualiter and Memory Content

The right sphere of Figure 1 depicts the Actualiter, a cognitive modality having the virtue of objects in semiosis[6], encompassing the categories inside the red circle. This object-like modality of VH is the Virtualiter's fallible correlate by means of which episodic interpreters *implement* their preconceived resolutions, empowering them and putting them to the test via volitional efforts.

By **implementation** I mean (1) the *affordances* (skilful know-how's) that the animal interpreter is capable of realizing despite environmental constraints (e.g., knowing a series of procedural steps or movements to accomplish a goal in a situated setting); and (2) the *semantic* or conceptual knowledge pertaining correlational and factual information. Based on Tulving's characterization of SM —which subserves both human EM and AEM— it could be said the Actualiter proceeds according to information that is "representational and can be, even if it

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[6] The Peircean concept of 'object' is twofold (cf. Jappy 2020: 121). On the one hand there is the *dynamic* object, which is an ostensible entity —either physically existent, virtually possible, or habitually necessary— that the representamen aims to substitute (e.g., a past or future action). However, the representamen's finite formal qualities sensibly communicate what is known as the *immediate* object (EP2: 495), which is just *some* intelligible qualities or characters of the dynamic object, as formally imputed by the sign's structural features. The Actualiter deals with both objects.

need not be, described in propositional format. The representational information has truth/false value: it corresponds to objects, events, relations, and states of the world" (Tulving 2005: 11).

In this way, the Actualiter's implementations are 'asserted', 'proposed' or 'objectified' as MeC, since the "the individual remembers information about the event ("what") and its context of occurrence (e.g., "where" or "when" it happened)" (Allen and Fortin 2013: 10379). The Actualiter, as a factual mode of cognition, corresponds to the quantitative aspects of objects in their effectual Secondess[7], the predictability of which is necessary for the reliable and lifelong development of a VH (West 2013: 117–118).

Moreover, the Actualiter controls episodic ***actions***: the bodily and neurophysiological performance exerted in relation to worldly objects, which may have been pre-mediated during simulation to a certain degree. Actions are the (enactive) expression of (virtual) simulations, the veracity and life-like qualities of which are being now asserted and contested in a concrete scenario. Actions are not the same as implementations because the latter are the affordances (habits of action) and propositional pieces of knowledge logically *leading to* the former. While simulations are virtual resolutions being exhibited as Virtualiter (e.g., displaying a binding of what-where-when 'internal snapshots'), actions are implementations in motion being embodied as Actualiter (e.g., physically acting in a succession of what-where-when 'external scenes').

Recognizing this object-like modality of VH implies that MeC would be pragmatically meaningless without the necessity of acting on objective (past-oriented) socioenvironmental solicitations, by truthfully inferring their likelihood and feasibility. As such, the Actualiter does not 'execute' mechanistic reactions, but it implements volitional actions based on its confidence on procedural skills and semantic beliefs which, additionally, have been earlier solicited by the Virtualiter's abductions or creative hypotheses (West 2019: 65).

In this way, the Actualiter contains the declarative or conative knowledge whose truth or false values have already been tested in some capacity (e.g., in the form of the Actualiter's past actions). In corvid cognition, one example of the Actualiter's implementations based on conscious propositional knowledge is "the very memorizing of storage caches, often close to small landmarks, constitute so many Dicisigns: 'This place contains food'" (Stjernfelt 2014: 155). In turn, retrieving the cache would be the volitional action corresponding to such declarative and implementable belief.

By "declarative" not only I mean that the interpreter knows something, but also that the interpreter themself knows that they know (or do not know) something that is relevant for the ongoing context (Beran et al. 2015). In this sense, both SM

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[7] In Peircean phenomenology, Secondness is a mode of lived experience as a quantitative past-oriented *correlation* or co-presence, where cause-effect, subject-object, and before-after distinctions have already been made.

and EM are said to be forms of ‘know what’ memory. Unlike implicit or automatic forms of (‘know how’) memory, like procedural memory, declarative forms deal with information or beliefs that animals may voluntarily retrieve and share with others (Griffin 2001). According to Squire and Dede, such information is “available as conscious recollection, and it can be brought to mind as remembered verbal or nonverbal material, such as an idea, sound, image, sensation, odor, or word” (2015: 2).

Even though MeS truthfully aims to characterize a what-where-when MeC, the Actualiter does not perfectly ‘reconstruct’ the physical existence of static things out there, nor the outcome of events that happened to a passive observer. Instead, the Actualiter is the Virtualiter’s *objectual* correlate in semiosis, insofar as it affords to act by capitalizing on its conscious but approximate knowledge of non-present objects.

Before moving on to the Habitualiter, a clarification should be made regarding how objects in semiosis are not only conceived by the Actualiter but also by the Virtualiter. Even though the Virtualiter is said to have a representamen-like virtue, its simulations (which are in constant communication with actions) do conceive *immediate* objects or the what-where-when qualitative characters of a more general but absent spatiotemporal scenario.

The Virtualiter, as theorized here, characterizes immediate objects through a special spectrum of representamens in their formal Firstness, such as *qualisigns* (abstract sensations), *hypoicons* (images, diagrams, and metaphors), and *rhemes* or non-linguistic terms (predicates with an indefinite or yet-to-be asserted subject). In a general sense, the Virtualiter’s MeS could be said to be *iconic* or present-oriented insofar as “the icon is, through its timeless similarity, apt to communicate aspects of an experience in the ‘present instant’” (Stjernfelt 2007: 29).

Conversely, even though the Actualiter is said to have an object-like virtue, its actions afford and reach for concrete *dynamical* objects through a special spectrum of representamens in their correlational Secondness, such as *sinsigns* (an individual existent item, or an actual event which is itself a sign), *indexes* (signs signalling their spatiotemporal copresence with their object), and non-linguistic *dicisigns* (Stjernfelt 2015) (a proposition or logical assertion expressing a belief structure with either truth or false values). The Actualiter’s MeC, more broadly, could be said to be *indexical* or past-oriented since “the index is turned towards the past: the action which has left the index as a mark must be located in time earlier than the sign” (Stjernfelt 2007: 29).

In short, the Actualiter is not ‘confined’ within the representational content of SM, but it affords to act on worldly objects that *precede* the stage of action. In like manner, the Virtualiter is not confined within an inconsequential mind-wondering activity, but it empowers immediate objects through a *simultaneous* efficiency in the ‘here and now’.

2.3 The Habitualiter and Memory Flexibility

Virtualiter and Actualiter operate as distinct modalities in episodic cognition. But they are not mereological parts that can be separated, nor independent correlates that exist by themselves. They mirror and complete each other during a lifetime. On the one hand, simulations could be seen as mental actions in their own right (an enactive imagination characterizing its virtual or immediate object), as if the Actualiter was being introjected or visualized by the Virtualiter. On the other hand, actions could be seen as bodily simulations in a way (a creative action reaching for its dynamic object), as if the Virtualiter was being projected or embodied by the Actualiter.

Without the imagistic possibilities presently displayed by the Virtualiter (as representamen or virtual structure), the Actualiter would always stick to the same solicitations of already occurred contexts, being unable to preview the interpreter's tentative roles. And, without the procedural skills and explicit beliefs already learned by the Actualiter (as object or virtual content), the Virtualiter would never ground its eurekas and resolute abductions on factual correlations, and it would be unable to face environmental and bodily constraints that push back and impose their own reality regardless of how they are represented by MeS.

The crucial question is what enables the Virtualiter and Actualiter to communicate in such a flexible but consistent way during a lifetime? Put otherwise, what can account for the fact that episodic interpreters are able to effectively relate the MeS with something other than the memory itself (MeC) in the long-term? We know this is the case, because experimental subjects display MeF insofar as "the memory can be expressed to support adaptive behavior in novel situations" (Allen and Fortin 2013: 10379).

As observed by Kort et al (2005: 159–161), the capacity of *generalization* in MeF seems to be the most vital aspect of AEM, because it shows that animals do not axiomatically follow the same 'method' or course of action over time. For instance, based on mental expiration dates, a crow will not bother retrieving an already expired (and therefore inedible) snack from his secret pantries, and will instead *opt to* retrieve the ones he knows are still fresh. Or, if the time is still right, he will hurry retrieving the soon-to-be-expired caches (e.g., worms and mussels), and postpone the items with longer shelf lives (e.g., nuts and seeds). This 'rule' of retrieving first the almost expired caches could be seen as a habit of action (Michaelian and Sant'Anna 2021: 318) that, nonetheless, tends to have exceptions.

The middle section of Figure 1 depicts the Habitualiter, a cognitive modality having the virtue of interpretants in semiosis[8], encompassing the categories inside

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[8] "Interpretant" is herein understood as "the mental action on the Object that the Sign excites" (MS 854: 59). The Habitualiter, as modelled here, is said to operate via interpretants in their

the purple circle. This interpretant-like modality of VH underlies MeF insofar as it motivates future conduct through choice-making and planning. This habitual or dispositional mode of cognition corresponds to the general Thirdness[9] of interpretants or "all that the Sign can signify, mean, or itself convey of new, in contradistinction to what it may stimulate the observer to find out otherwise, as for example, by new experience, or by recollecting former experiences" (MS 640: 9).

Put differently, the Habitualiter is an anticipatory modality of VH that determines both habit-taking (to provisionally adopt interpretants without the immediate need of new experience) and habit-changing (to wilfully adopt novel choices when beliefs are superseded by the contingencies of new experience).

By **determination** I mean (1) the *self-control* necessary to constrain our long-term behaviour (e.g., a focus and force of will observing the accomplishment of one's intent), but also (2) the *agency* and freedom necessary for flexible choice-making (e.g. opting for certain courses of action, or absence of action, instead of others); and more broadly (3) the lifetime-habituation and rule-like *arbitrariness* governing the communication between the Virtualiter's simulations and the Actualiter's actions.

As put by Peirce, "a determination is a virtual habit… So, a determination is not a habit, since it does not result from repeated performances on the same occasions" (MS 620: 24–25). Determinations are, thus, the general and optional *causes of* repeatable episodic behaviour rather than the individual effect of it. Acknowledging this interpretant-like modality of VH implies that MeF would be mechanistic (e.g., acting as a physical law with no exceptions) if the interpreter did not have the fallible ability to make goal-oriented choice-making.

Because VH are rather *fallible*, they also need to be flexible. They suggest themselves as would-be's or verisimilar 'plans of action', determining their own future instantiations, even if some of them never come into to being exactly as premediated (West 2016b). In this sense, the Habitualiter tests its own validity or 'reasonableness' by series or *replicas* of trial-error and doubt-belief, which could be equated with the animal's continuous necessity to guess right despite the fallibility of their creative reasoning (CP 2.753). Indeed, interpreters may or may not accomplish their scried goals, but they do so mostly by their conscious self-control or "habituescence" (West 2013: 124). The Habitualiter not only learns from mistakes, but it also presupposes them consciously.

AEM studies tend to be agnostic about animal autonoesis (van Woerkum 2021), the characteristic form of subjective self-awareness needed to remember

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relational Thirdness, especially *logical* interpretants (cf. West 2017: 64), which also presuppose emotional interpretants (e.g., in the form of simulations) and energetic interpretants (e.g., in the form of actions), but are more *general* and purposefully lead to habit-change.

[9] In Peircean phenomenology, Thirdness is a mode of lived experience as an optional future-oriented mediation, where habitual forms of feeling, action and thought are operative as rule-like dispositions.

an ‘autobiographical’ past. In contrast, the concept of Habitualiter, as herein proposed, advocates for autonoesis as the best hypothesis to account for the degrees of long-term self-control and generalization observed in MeF. Similarly to human EM, thus, Figure 1 endorses the view that “the primary competency requisite to ascertaining the logical interpretants necessary for virtual habits include episode-building via autonoetic consciousness. This involves projecting egocentric and allocentric perspectives into sequential event frames” (West 2018a: 92).[10]

What is more, this Peircean way of accounting for the purposeful and future-oriented nature of MeF suggests that the Habitualiter builds on but also *supersedes* the Virtualiter’s iconicity and the Actualiter’s indexicality. The vividness of a simulation, and the succession of an action can only provide so much information. Episodic interpreters anticipate future episodes as the *replicas* of mental symbols, the objects of which are *general* and are interpreted on the basis of an innate or acquired habit (cf. Bellucci 2021). As put by Stjernfelt, “the symbol itself is a […] general recipe for the production of similar instantiations in the future” (Stjernfelt 2007: 30). In like manner, logical interpretants, as above explained, would account for how future episodes become symbols in Habitualiter by representing consistent but flexible habits of action:

> the logical interpretant of a symbol belongs to “the species of future tense…, the conditional mood”; it acts as a “would-be” (CP 5.482, 1905). In contrast to the icon and the index, the symbol hence conveys more about its object “than any feeling… more, too, than any existential fact, namely, the ‘would-acts’, ‘would-dos’ of habitual behavior” (CP 5.467, 1903). (Nöth 2010: 86)

All in all, the rule-like disposition or determination of a VH is said to govern episodic *act*ions (not reactions), which accounts for the pragmatic plasticity with which interpreters arbitrarily opt to act in the face of incomplete information. Without the recursive self-control of the Habitualiter, thus, the Virtualiter would envision every episode as if was the very first one of its kind; and the Actualiter would conclude every action as if it was the very last one. But this is not the case since the Habitualiter’s autonoesis asserts symbolic replicas of what-where-when scenarios, connecting (but also superseding) the iconic potentialities of MeS and the indexical actualities of MeC.

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[10] A satisfactory discussion on alloanimal autonoesis is beyond the capacity of the current study. However, it is worth pointing out that zoosemiotic and phenomenological models are ethically relevant to support animal advocacy and its evidence-based arguments for self-awareness in a variety of animal species, such as The Cambridge Declaration on Consciousness of 2012 (cf. Birch, Schnell & Clayton 2020) and, more recently, The New York Declaration on Animal Consciousness of 2024. It should also be pointed out that my Peircean understanding of autonoetic consciousness in AEM, as herein proposed, conflicts with Tulving’s original thesis that autonoesis is uniquely human (2005: 74).

As put by Michaelian and Sant'Anna, "content is acquired only through the 'habits of action' that accompany the production of episodic thoughts, which include, in particular, 'habits of judging' certain things to be the case about the episodes that are their objects" (2021: 318). In this particular sense, the Peircean notion of *habit* seems to be compatible with distributed accounts episodic cognition (cf. Michaelian and Sutton 2013), since habits are not discontinuous nor situated (e.g., they are not discrete bits of information being 'retrieved' or 'encoded' in a brain). Instead, habits are said to be lifelong dispositional regularities that flexibly coordinate mind and body and are 'extended' in time and space (West 2013: 117–118).

3. SYNCHRONICITY AND DIACHRONICITY: TWO READINGS OF THE MODEL

Horizontally speaking, the model depicts a *bidirectional* process where the Habitualiter's centrality is to be read as the most crucial link. The three spheres are connected, thus, as an inferential continuum (→↔←). On the one hand, the Virtualiter's simulations *inspire* (→) the Actualiter's actions through the Habitualiter. And, on the other hand, the Actualiter's actions *ground* (←) the Virtualiter's simulations through the Habitualiter. This linear way of depicting the influence between the three modalities of VH may seem mechanistic to say the least. However, the above design is motivated to show two paradoxical but complementary aspects of AEM's temporal phenomenology.

First, it depicts the **synchronicity** of simulation and action when it comes to the Habitualiter's bidirectional and extended perspective (↔), which acts as a general, overarching, determination by virtue of which the Virtualiter's resolutions stand for the Actualiter's implementations. Put otherwise, the Virtualiter's terminological vividness (as premises) and the Actualiter's propositional veracity (as conclusions) are motivated to come together only when they are reasonably asserted by the Habitualiter's validity (as an argument).

The Habitualiter, therefore, acts as an inferential mediator or precursor (↔) that flexibly *informs* the Virtualiter's simulations, and *constrains* the Actor's actions at the same time, and over time. The Habitualiter is a long-term or 'dilated' double consciousness, so to speak, that keeps track of the Virtualiter's simulations and the Actualiter's actions, even if both happen (1) *parallelly* (e.g., procedural actions may be performed in coordination with ongoing simulations as led by working memory), or (2) in a more *delayed* fashion (e.g., some simulations may not be immediately followed by their corresponding procedural actions). The latter case could be said to account for anticipatory behaviours related to strategic future planning.

Figure 1 also depicts the **diachronicity** between simulation and action. The Habitualiter's purposeful determinations would be extremely general (e.g., too polysemic and uncoordinated) if it did not have the ability to individuate or become more differentiated during distinct *stages*. In this sense, the Virtualiter's prospective or retrospective simulations are said to *precede* the Actualiter's actions; and the latter are said to *succeed* the Virtualiter's simulations. In this case the Habitualiter's determinations act as *legisigns* (symbolic rules of self-regulation) or as a "behaviour algorithm" that is, in a way, "issuing a command to one's future self" (West 2017: 56).

Strictly speaking, meaning-makers can control only future actions (CP 5.461). But once this anticipatory determination resolves, the Actualiter's consolidated actions then become a retrospective precedent (←) for the Virtualiter' simulations (→) in a new but more developed cycle of episodic semiosis (→↔←→↔←)[11]. Indeed, the general potentialities of the future are recognized and imagined in constant relation to the concrete actualities of the past (Schacter and Madore 2016). As put by West, "cognitions are in the mind habitualiter after drawing upon previously acquired knowledge, later integrating present with past cognitions" (2016: 14).

This is how MeF, via choice-making, resolves the incompatibility of simultaneously available courses of action and states during the interpreter's lifetime. Namely, a hooded crow (*Corvus cornix*) very well knows (1) when a particular cache has already been retrieved, or (2) if it is still awaiting to be retrieved (Sonerud and Fjeld 1987). As simple as it may seem, the capacity to make such a logical distinction is no banal feat. The temporal incompatibility between both events is causally understood by the crow: one necessarily precedes *or* succeeds its counterpart as an *existential* contradiction (CP 1.493).

This could be further explained as follows. If the crow is to fashion his future-oriented actions in flexible ways (aka prospection), then the Habitualiter's determination *chooses to* turn the Virtualiter's simulations into the Actualiter's actions in some future capacities (which could be dealt with later). This is a prospective arrow episodically moving from Virtualiter to Actualiter (→→) by means of the Habitualiter (I→III→II) and could be equated with the idea of a present simulation (as Firstness or potentiality) optionally becoming a past action (Secondness or factuality) by means of the habituality of a future determination (as Thirdness or generality).

In this first arrow of semiosis, the animal interpreter uses the iconic potential of a visualized MeS to conceive *indeterminate* courses of action yet to be enacted. The crow, thus, knows he *could* retrieve the cache through a subsequent action,

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[11] De Tienne (2016) presents a similar view when making a phenomenological distinction between two different arrows of time in semiosis. In terms of Figure 1, the representamen's Firstness (in Virtualiter) is said to be present-oriented, and the object's Secondness (in Actualiter) is said to be past-oriented; while the interpretant's Thirdness (in Habitualiter) is said to be a future-oriented or anticipatory causal influence in semiosis (cf. Fernández 2010: 294).

instead of merely recreating an inconsequential past scenario upon which he cannot act anymore.

Conversely, if the crow is to inform his past-oriented simulations in accurate or veridical ways (aka recollection), then the Habitualiter's determination *needs to* turn the Actualiter's actions into the Virtualiter's simulations in some past capacities (which have been dealt with earlier). This is a retrospective arrow episodically moving from Actualiter to Virtualiter (←←) by means of the Habitualiter (I←III←II) and resembles the way a past action could be effectively repeated or resumed in the present.

In this second arrow of semiosis, the animal interpreter uses the semantic knowledge and indexical facts of MeC to conceive *determinate* potentialities already enacted. The crow aims to truthfully elucidate through a past-oriented simulation whether he *actually* retrieved the snack, so that he may act accordingly in the present.

Two final clarifications are in order when it comes to reading Figure 1 as a Peircean model. First, Figure 1 differs from Endel Tulving's classic "SPI (serial, parallel, independent) model" (1985: 2; and 1995: 839) which explains the neurobiological ontogenesis of EM and its subserving mnemonic subsystems. In contrast, Figure 1 aims to depict AEM in action as an irreducible semiotic *process*.

Therefore, the general spheres of Figure 1 do not have their smaller sections as existential or compositional prerequisites. Instead, the smaller categories contained within the spheres are said to be the *instantiations* in which the three modalities of VH individuate or 'deconstruct' due to their synchronic and diachronic interactions as symbiotic modes of cognition. Under this logic, Figure 1 could be compared with the processual spirit of Uexküll's functional cycle, and even with the diagrammatic spirit of Peirce's existential graphs.

The second clarification concerns how Figure 1 differs from Peirce's 1908 'standard' model of hexadic semiosis. The latter is said to be an irreversible *causal* chain (Jappy 2020: 116–121) that is triggered by the dynamical object, unidirectionally determining the immediate object, representamen, immediate interpretant, dynamic interpretant, and final interpretant.

Figure 1, in contrast, could be said to be a model of a bidirectional form of semiosis, where the Habitualiter's interpretant-like virtues (as mediator) possess a higher agency due to their centrality in a cyclical or recursive meaning-making process. The Habitualiter episodically *recombines* the Virtualiter's representamen-like virtues (as medium) with the Actualiter's object-like virtues (what is being mediated) every day over a lifetime.

Read in this way, Figure 1 does not depict an abstract psychological process, but a form of semiotic causation where "relations of Thirdness occur in and with the establishment of a connection between the universe of possibilities that is Firstness and the plethora of events that is Secondness" (Hoffmeyer 2009: 67).

The Habitualiter is theorized, thus, as a modality that is not the result of 'summating' the veritable bearings of objects in Secondness 'plus' the experiential immediacy of representamens in Firstness, but as a purposeful influence or rule-like self-control that *precedes* them and brings them together in the form of ever-evolving replicas or cycles.

In this causal sense, the Virtualiter's sphere represents the *formal* causes of episodic semiosis as a simultaneity of self-contained qualities of feeling (EP2: 315-16); and the Actualiter's sphere represents the *efficient* causes of episodic semiosis as a succession of factual occurrences. Because the interpretant's Thirdness is said to belong to the teleological world of final causation (Reynolds 2002: 57), the Habitualiter's sphere represents the *final* causes of episodic semiosis as flexible goals, which virtually precede the expression of episodic behaviour.

4. FURTHER DIRECTIONS AND APPLICATIONS OF THE MODEL

Figure 1 could enter in dialogue with discussions in the philosophy of memory, such as the *actuality claim* in Mental Time Travel (MTT) studies, which argues that EM is actuality- or inactuality- sensitive. Such claim postulates two different types of objects: "the object of episodic anticipation, as of any thought about the future, is inactual (possible)", and "the object of an episodic memory, as of any thought about the past, is actual" (Perrin 2016: 47). Notably, such claim seems to be compatible with Peirce's view that past is logically actual (CP 5.459), and future is logically inactual (CP 2.148).

Taken to the ontological ground, Figure 1 could be used to outclass dichotomic debates about the reality of episodic content as either being the result of an 'imaginary' simulation, *or* the causal result of a 'real' experience. For example, a reading of Figure 1 as a model of MTT may account for how AEM is able to temporally connect the ontological universes of "Possibles" (e.g. imagination), "Existents" (e.g. things and facts), and "Necessitants" (e.g. habits and laws) (EP2: 478-479). In this way, it would be unproblematic to state that episodic semiosis is a process by which the formal qualities of a lived present simultaneously and continuously stand for both the existents of an enacted past, and the virtual possibilities of a future.

If the above Peirce-Perrin parallelism is tenable, it could be argued that the dynamic object of episodic *anticipation* is pre-experienced as inactual, but not because the future has not physically occurred yet on its own as some deterministic 'fate'. It is inferred as inactual because the Virtualiter's simulations display a potentiality that can ultimately be tested through optional actions *yet to be* taken. In like manner, the dynamic object of episodic *retrospection* is re-experienced as actual, but not because the past is physically still existing 'out there' on its own. It is inferred as actual because the Actualiter's propositional truthfulness has been contested through volitional actions *already* taken.

Reading the actuality claim in such a semiotic way would imply that, just like in human EM, the lifelong semantic sensitivity, and everyday pragmatic pertinence of AEM engages with "veridical" and "false" remembering in relation to "past" and "future" imagining (Nyberg et al. 2010: 22358). Under this logic, Figure 1 could be used to support the idea that AEM's phenomenological aspects are fallible and testable. Instead of making information or computational 'errors', the Habitualiter is constantly testing the validity of its own argumentative pertinence, as in an inquiry or abductive process in a virtual relation with the world at large.

This view, in turn, seems to be compatible with the Simulation Theory of Memory (Michaelian 2016). More concretely, a Peircean understanding of AEM opens the possibility that animal meaning-makers may also fall 'victims' of some types of past-oriented misremembering, as characterized by Michaelian on the basis of "the accuracy of the memory representation, the reliability of the memory process, and the internality (with respect to the remembering subject) of that process" (Michaelian 2016: 1).

For example, in the case of veridical relearning, Figure 1 could aid in developing experiments that test how alloanimals relearn *true* dicisigns critical for their survival (e.g., in the face of abrupt environmental changes and unexpected relocation). In the case of falsidical relearning, Figure 1 may help in describing how alloanimals relearn *false* dicisigns and develop more suspicious or cautious attitudes in response (e.g., in mimicry and deception strategies, or in cases where they confuse food sources with pollutants). And, even in falsidical confabulation, Figure 1 could help developing cognitive strategies for the relocation of endangered species, and in the development of better artificial but realistic habitats for captive populations (cf. Magnus and Mäekivi 2023).

The quintessence of AEM, nonetheless, seems to be future-oriented rather than being just past-oriented, since its widespread evolutionary success is due to its anticipatory determinations (Klein 2013). With such a premise, Figure 1 could have more explanatory power on the realm of truthful memory 'achievements' and could be implemented as a comparative version of the future-oriented cognitive spectrum of human MTT (Perrin and Michaelian 2017: 228).

MTT is said to encompass different types and degrees of *simulation*, *prediction*, *intention*, and *planning* (Szpunar et al. 2014: 18415). In like manner, MTT in AEM could be researched as an equivalent multispecies spectrum, encompassing varying degrees of resolution, determination, and implementation, which ultimately *lead to* a simulation-based action, or are *led by* action-based simulations. In this way, Figure 1 could be applicable in the above hypothetical experiments, provided that "it may be possible to develop novel, strictly behavioural tests of these additional features of episodic memory, without recourse to language, that could be tested in animals (e.g., future planning)" (Muñoz and Morris 2009: 1173).

Anthropomorphising or not, such comparative perspective could be pragmatically applied to findings on how, for instance, wild chimpanzees plan their breakfast type and location (Janmaat et al. 2014), how New Caledonian crows strategize for specific future tool use (Boeckle et al. 2020), and how rats are able to episodically anticipate future scenarios (Crystal 2013). Against this background, Figure 1 could evolve into an ethological tool that may complement behavioural tests that compare the non-linguistic convergent hallmarks (Jelbert and Clayton 2017; Bevandić et al. 2024) of EM between humans and other species. As foreseen by Templer and Hampton:

> The most productive way forward is likely a combination of neurobiology and sophisticated cognitive testing that identifies the mental representations present in episodic memory. Investigators that have refined their approach from asking the naïve question "do nonhuman animals have episodic memory" to instead asking "what aspects of episodic memory are shared by humans and nonhumans" are making progress. (2013: 801)

Under such a pluralistic view, corvids, rodents, and hominids (among other species) indeed display the analogous what-where-when pragmatic essence of episodic behaviour. This is the case not because they have identical umwelten nor identical brains, but because AEM could be said to be a natural kind of memory type (Kelemen and Fenton 2013; Cheng and Werning 2016).

The social aspects of AEM could be considered in the future, including forms of bonding, teaching, playfulness, cooperation, and cultural habits. There is every reason to suspect that some aspects of AEM are communicable and intersubjective between conspecifics. Like groups of people, alloanimals may share a pre-emptive awareness of all sorts of what-where-when-who-how's involving not only egocentric (subjective) but also allocentric (intersubjective) perspectives (West 2018a: 92). For example, some matriarch elephants teach younger members of the herd a traditional route and methods to find water during drought times (Fishlock et al. 2016). In short, Figure 1 could also help in understanding the social aspects of AEM as a form of umwelt, and even as a form of collective memory (Michaelian and Sutton 2019).

CONCLUSION

How to account for the episodic behaviour consistently displayed by different alloanimal species? There is more than meets the eye when trying to address this question from behavioural and neurobiological perspectives alone. With the help of multispecies evidence, section **1** argued that AEM makes more sense when we start speaking about *interpreters*, the living meaning-makers whose (future-oriented) goals, (present-oriented) sensations, and (past-oriented) actions are habitually related during their lifetime via semiosis.

Building on semiotic accounts of human EM, section **2** applied the Peircean concept of VH to AEM. Nonetheless, this comparative approach accounted for VH as a process displaying three cognitive modalities called Virtualiter, Habitualiter, and Actualiter. The latter were said to be instantiated or individuated, respectively, in the form of *resolutions* (vividness, intentions, and solutions), *determinations* (self-control, agency, and regularity), and *implementations* (procedural affordances and semantic-indexical knowledge).

These modalities not only underlie the simulations and behaviour observed in AEM neurocognitive studies, but also account for their long-term connection and re-instantiation. In other terms, the hippocampal ‘replay’ or ‘stream’ of experience (elicited during recollection and prospection), and the flexible behaviour of experimental ‘subjects’ were explained as being two ‘sides’ of one and the same process dubbed as ‘episodic semiosis’.

More particularly, it was argued that episodic semiosis is a process by which (1) the Virtualiter’s simulations inspire the iconic vividness of MeS; (2) the Actualiter’s actions ground the declarative confidence and indexical veracity of MeC; and (3) the symbolic replication between simulations and actions is *caused* by the Habitualiter’s goal-oriented self-control of MeF.

Section **3** explained Figure 1 as depicting a process that unfolds in real time and over time. The three spheres or modalities of VH were said to be a continuum of stages between Firstness, Thirdness, and Secondness (“I↔III↔II”), where the Habitualiter’s long-term arbitrariness (e.g., in the form of symbolic legisigns) *precedes* the bidirectional transformation between the Virtualiter’s simulations and the Actualiter’s actions. As the most crucial and general category in the model, the Habitualiter was theorized not as a ‘composite’ resulting from superposing Virtualiter and Actualiter, but as an irreducible and lifelong ‘double consciousness’ that communicates them in ways of which other memory systems are incapable.

This threefold process suggests that a metaphysical teleology (aka ‘autonoetic consciousness’) is not disconnected from physical conduct (aka body); and mental representations are not ‘computed’ perception nor externalized as ‘physical reactions’, but they are the very inferential *conduit* of memory and its practical bearings. From this processual reading, Figure 1 was said to be different with respect to neurocognitive models of EM, such as Endel Tulving’s classic ontogenetic hierarchy.

Section **4** suggested new directions for applying Figure 1 as a comparative model of MTT in AEM studies. The Actuality Claim and the Simulation Theory of memory were said to be possible gateways to stablish such unexplored connections. All in all, rather than reducing AEM to a single homogeneous model, a ‘semiotic turn’ in AEM studies has the potential to bring the experiential aspects of memory to the foreground by discussing their very phenomenology as part of episodic semiosis, the meaning-making relations virtually connecting intentionality, sentience, and agency as a lifetime subjectively experienced.

Understood in such a way, semiosis in AEM was theorized as a cross-species cognitive phenomenon that, nonetheless, affords a plurality of intentions, sensations, and actions that are not necessarily homologous but *analogical* (e.g. culminate in equivalent consequences from a pragmatic perspective). Such complexity was tackled with a Peircean approach, consisting of three modalities of VH, three modalities of lived experience, nine forms of sign-vehicles, two types of objects, and three forms of interpretants in episodic semiosis.

This terminological repertoire, however, could be further refined and simplified, and applied versions of Figure 1 ought to go beyond the terminological 'correctness' of Peircean scholarship by taking into account the jargon of contemporary AEM studies. More concretely, reiterations of Figure 1 ought to take the next step by describing the actual meaning-maker in question in a more personalized fashion: its Habitualiter's long-term preferences (e.g., its ontogenesis as a unique lifetime or 'autobiography'), its Virtualiter's perceptual thresholds (e.g., its species-specific sensory systems, and organism's health), and its Actualiter's socioenvironmental demands and affordances (e.g., its everyday context-dependent tasks).

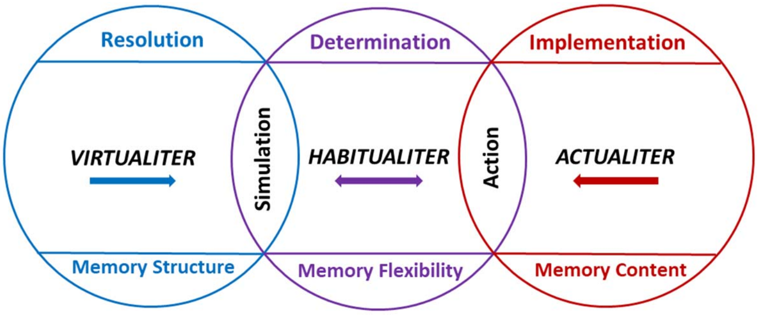

Figure 1: a multispecies cognitive model explaining episodic behaviour as the result of an irreducible meaning-making process between three modalities of virtual habit.

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BIONOTE

Oscar Miyamoto's main research interests are animal episodic memory, and the visual pragmatics of scientific diagrams. Being a science journalist by training, he aims at using semiotics as an interdisciplinary theory to advance and communicate evidence-based research. He holds a PhD in Semiotics and Cultural Studies from University of Tartu, Estonia.

IV

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Questions concerning certain faculties claimed for semiotic selves

Oscar S. Miyamoto Gómez

Despite their astonishing diversity and varying degrees of complexity, life forms share a semiosis-based and umwelt-dependent subjectivity. This Sebeokian-Uexküllian hypothesis posits that sign processes are not disembodied, decontextualized, and isolated, but always contingent to the *relational selfhood* of interpreters: Cognizers attuned to themselves, to others, and to their environment, via meaning-making. From this biosemiotic perspective, Semiotic Self Theory (SST) necessarily becomes an intrinsic part of phenomenology and an existential part of semiotics. Beings *are* insofar as they interpret, for life ceases when the interpretative capacities of self-control and choice-making stop. With such a premise I revisit the concept of Semiotic Self, arguing that the latter goes beyond the psychological and nominalist notion of the human ego (e.g., the ontogenesis of individuality and personality). Instead, the ungraspable idea of *self* becomes more understandable and pragmatically relevant when we take into account the collective faculties of living *beings*, in which experience cannot be accounted for in the Cartesian terms of a unidirectional and dichotomous subject-object relation (e.g., a mind-dependent “internal” reality directly perceiving an “external” mind-independent reality).

Namely, I will observe that semiotic selves are (1) normative or value-making; (2) multi-layered or multi-voiced; (3) communicative or relational; (4) extended or distributed; (5) teleonomic or agential; (6) anticipatory or future-oriented; (7) incomplete or open-ended; and (8) autopoietic or self-organizing. While these eight features might deviate from Wiley’s (1994) classic work on the (human) semiotic self, they encompass further developments in biosemiotics showing that selfhood, regardless of its complexity, is grounded on/in interpretative sign relations. The conclusions explore some evidence-based applications of SST, as well as interdisciplinary research lines wherein phenomenology and ontology coincide through a “semiotics of being”, rather than through a semiotics of selfhood.

1. Biosemiotic basis of Semiotic Self Theory

Semiotic Self Theory (SST) is a multifaceted theoretical framework known for constantly pondering the tension between two existential domains; a *duality* that seems to be an intrinsic constituent of selfhood. Notably, Sebeok's (1979: 263–267) first treatment of Semiotic Self (SS) as a concept makes emphasis on two basic levels of self-preservation: The immunological level (homeostatic), and the semiotic level (social). As summarized by Navickaitė-Martinelli in a broader historiographical context:

> Several authors in the field of semiotics have been dealing with the concept of semiotic self, which consists usually of two aspects: an inward and outward side within the subject. Among these dualities, we have, for instance, the "I" (self as such) and "Me" ("I" in the social context), as used by George Herbert Mead; Moi and Soi by the French authors (Ricoeur, Sartre, and Fontanille use these concepts in their writings); controlling, deeper self versus critical self by Charles S. Peirce; or the Bergsonian differentiation between the "superficial" and the "deep" ego. (Navickaitė-Martinelli 2015: 774)

In addition to the above, we may consider an intersubjective world or public dimension of SS (e.g., a species-specific umwelt), in contrast with a more unique reality or private dimension of SS (e.g., an organism-specific innenwelt). Similarly, we could speak of exosemiotic and endosemiotic processes (Kemple 2019: 168), or ego-centered judgements (egocentric views) and intersubjective judgements (allocentric views) (West 2018: 92). Some of the above oppositions summarized by Navickaitė-Martinelli (2015: 774) may give the impression that the dynamics of SS are dichotomous or dyadic (e.g., individual vs collective; conscious vs unconscious; peripheral vs nuclear; etc.). However, the biosemiotic spectrum of SST sees SS as an embodied *semiosis*, in tune with the Peircean idea that meaning-making is a relation between representamens (e.g., a sensible *medium* or 'carrier' of meaning) and objects (e.g., a grounded meaning that is being *mediated*) by the *mediation* of interpretants (e.g., a normative choice-making or a natural habit-taking). Such processual ideas also rest on Uexküllian phenomenology and on the Sebeokian premise that life is, even in its most minimal expressions, a semiosis-dependent phenomenon (Sebeok 1986: 73; Sebeok 1991: 22).

We can think of semiosis as an economic function or relation between a coin and a value, one that is realized during a payment. In this metaphor the coin itself (as representamen) is linked to an actual value (as object) *through* the habitual or conventional validity of the coin as a payment (as interpretant). Both correlates or relata (coin and value) are only together as a sign-function thanks to a value-making contextual act: An optional "transaction" or "exchange" with different degrees of arbitrariness and flexibility. In short, the coin or representamen is the medium; the value or object is what is being mediated by the coin; and the *validity* of the coin is the mediation or interpretant between coin and value. Under the same token, semiotic selves would be interpreters, the economic intermediators or agents making the actual transactions (e.g., as buyers or sellers). This triadic nuance is particularly relevant for reconstructing the biosemiotic basis of SST, because SS acts as the overall *mediator* between correlates that come together only from an agential, existential, stance. This applies, ostensibly, to every known life form in the sense that "the process of message exchanges, or semiosis, is an indispensable characteristic of all terrestrial life forms" (Sebeok 1991: 22). This premise could be applied to biosemiotics at large, including zoosemiotics, phytosemiotics, mycosemiotics, endosemiotics, and microsemiotics (cf. Suryna 2014 for a biosemiotic revision of SST).

Indeed, it is argued in SST that the (living) self *is* grounded on a triadic sign mediation (Petrilli 2013: 8). As put by Thure von Uexküll in Peircean terms, SS is the *interpreter* (the "somebody") to whom a sign stands for something in some respect or capacity (1995: 102). Accordingly, Sebeok defined SS as follows:

> The clandestine interpreter of symptoms is, by definition, the semiotic self. This interpreter corresponds to what Jakob von Uexküll identified, on the cellular level, as 'Ich-tone', usually rendered into English as 'ego-quality'. (Sebeok 2001:134)

Elaborating on Sebeok's view, Maran (2010: 324) observes that "the essential property of a semiotic self is an ability to make distinctions, first to distinguish between the self and the other, or in other words, a semiotic self is characterized by an ability of self-recognition". Along the same lines, Tarasti (2015: 137) argues that biological normativity arises from a perspectival relation between identity (self) and alterity (non-self): "a world view is a kind of Ich-Ton, Me-Tone or principle which determines which signs an organism accepts from its surroundings corresponding to its identity, and which ones it interprets alien and to be rejected". Nonetheless, such definition raises the psychological objection of whether cellular selfhood involves self-awareness per se, or, in our metaphorical terms, realizing of its own semiotic role as an "economic intermediator" within a more general communication system. This is to say, the capacity of distinguishing itself as (1) a unitary source of subjectivity in semiotic relation to (2) other cells as different sources of alterity. In my view, this objection poses a similar anthropocentric problem to John Deeley's notion of "semiotic animal" (cf. Rattasepp, Kull 2016; Deely 2005: 43). In this, we could provisionally argue that, if the living cell is the minimum expression of semiosis (Sebeok 2001: 126), then *normative choice-making*, organismic arbitrariness, comes as a more elementary faculty of selfhood that does not necessarily involve a meta-semiotic autonoesis (criteria 1 and 2). Instead of conscious *self*-recognition, selfhood starts with a subjective faculty of (re)cognition and awareness with respect to *otherness* (e.g., the aboutness of a sign, or the "value of a coin"). The latter, as observed by Maran and Tarasti, is grounded on *normative* or value-making criteria that already depend on a situated, perspectival, experience (e.g., an "internal" state of affairs *in relation to* a perceived "external" state of affairs).

Therefore, it is not problematic to state that the living cell fulfills the pragmatic criteria for being considered an *interpreter* insofar as it is capable of value-making (e.g. via sensorial and energetic interpretants), a process wherein sign-vehicles (e.g., different molecules) aptly stand for something other than themselves (e.g., the relevant presence/absence of desirable/undesirable internal/external states). It is reasonable to say, then, that the living cell is not consciously aware of its contextual role as the interpreter. But it sure acts as the cognitive "intermediator" to whom a "coin" stands for something other than itself in some respects or capacities. Thus, value-making – the pertinent use of sign-functions – may be deemed as the logical but "sub-personal" starting point of selfhood, although it is not sufficient for granting "self-recognition" in psychological terms. For now, it should be sufficient to say that the living cell, even though it is the "minimum" expression of an embodied semiosis (a "proto-self", perhaps), is already a fully-fledged interpreter or "an interpretant-interpreted relationship, as an incarnate entity, intercorporeal and intersubjective sign materiality that not only relates to external bodies and signs but is itself a body in semiosis, a body-sign" (Petrilli 2013: 7).

Even at the cellular level, selfhood cannot be evaluated in diachronic isolation. Cellular selves are not individual "customers", but more like a "stock market". Consequently, one could argue that "personal" selfhood in macroscopic organisms is *codependent* with the unconscious orchestration of trillions of its own cellular interpreters (e.g., in metabolism and circadian rhythms). As it will be noted later, semiotic selves not only are (auto)communicative, but also multilayered. That is, instead of being a bottom-up compound of "mereological" parts (e.g., cell populations, tissues, organs, and bodies "constituting" the "upper" levels of sentience, mind, and memory), semiotic selves require the synchronic orchestration of multiple irreducible top-down meaning-making processes (Nomura *et al.* 2018: 74). This is why semiosis is central to address the ontological complexity of selfhood in living beings, or, as I will later put it, the interpretative complexity of *being*. Semiosis is a sufficiently complex model for explaining the influence between phenomenology, physiology, and metaphysics. In my view, these three are respectively at stake in semiosis when we speak about: (1) how a SS senses itself and its environment (e.g., signs being the *possibilities* of perception); (2) how a SS directs its bodily behaviour (e.g., actions being an *actual* effect of interpretation); and (3) how a SS makes choices (e.g., interpretants being a *valid* cause of an object-oriented action). Semiosis, then, would be the underlying value-making process discussed in our explanatory models of different semiotic selves. For example, we could speak about how animals – humans included – make choices based on iconic values of recognition, indexical values of correlation, and symbolic values of habituation.

In semiosis, then, phenomenology accounts for the sign-vehicle (representamen) as a sensible medium of value; physiology accounts for bodily actions as object-oriented values; and metaphysics accounts for the teleonomy of the value-making process as a cause. Resuming the "coin" metaphor, selfhood in "economic" agents makes more sense when we try to explain the evolving equivalence between coin and value itself, rather than describing the "personality" of consumers existing in a psychological black box. Similarly, selfhood in living beings, at large, cannot be dissociated from the meaning-making translation (between representamen and object) that semiosis is. My current point being that sentience and (re)cognition are not merely epiphenomenal effects of biological mechanisms, but the *causal* roots of purposeful behaviour in living interpreters. It is worth noticing that the metaphysics of semiosis, in this context, has been explained in terms of "semiotic causality" (Hoffmeyer 2008: 64), "semiotic freedom" (Wiley 1994: 15), and "self-control" (Stjernfelt 2012). This plethora of semiosis-based concepts account for final causation (e.g., intentionality) in SS beyond the dichotomous views of nominalism versus realism, voluntarism versus determinism, and idealism versus materialism.

The biosemiotic question of value-making as meaning in SST echoes Peirce's (1892) first elucubrations about the protoplasmic basis of sensation. As he put it elsewhere, "the free is living; the immediately living is feeling. Feeling, then, is assumed as a starting point" (CP 6.393). For us this means that the cognitive basis of SST is necessarily concerned with researching the origin of the biological ability to *feel* via semiosis, which is already a form of normative interpretation, "feeling of recognition", or a sensorial interpretant (CP 5.475). Needless to say, one must first be *alive* in order to *be*. And life is not possible without sensation or recognition (e.g., awareness mediated by qualisigns). Not surprisingly, studying the ontogenesis of life provides insights into the systemic basis for self-recognition, and its relationship with functional cycles and ecological dynamics (cf. Villalobos, Razeto-Barry 2020). Cognitive semiotics, in consonance with some forms of enactivism (cf. Ward, Stapleton 2012), seems to be compatible with the view, presented below, that living beings are cognizers, agents whose self-preservation and *self-control* is attuned to some sort of organismic arbitrariness in tension with environmental solicitations or constraints. Such attunement, in general terms, is done via habit-taking and habit-changing, insofar as the self is "a manifestation of a bundle of habits [which] implicates 'self-control'" (Anderson 2016: 8). This discussion is resumed further ahead in the section "Interpretative faculties of semiotic beings", since it will be relevant for proposing a non-antropocentric, non-psychologistic characterization of semiotic selves, one that relies on the idea of *being* (which is interpretant-based), rather than the notion of "selfhood" (which is identity-based).

2. Beyond the internalist-externalist dichotomy

Given the terminological amplitude of SST, the "selves" or "subjects" of its inquiries are not evident at first glance. Rather than being reduced to species, organisms, or purely-physical bodies, semiotic selves are often described in terms of processual relations. For example, as a non-ubiquitous and liminal transition-phase, one that "occupies the 'borderlands' of an organism, although it is not bound to a bodily surface or skin alone" (Suryna 2014: 43). As we have seen, similar descriptions usually refer to some sort of topological opposition between two mutually untranslatable domains (e.g., inner vs outer). It would seem that SST, on the other hand, recurred to a psychological and language-based notion of the human-ego (e.g., in the ontogenesis of individuality and personality). Namely, an inner speech asking: "Who am *I*, and how did I become *myself*?" This appears to be the case in psychological studies of social identity formation (e.g., Andacht, Michel 2015), especially if we take into account Wiley (1994) and his famous Peirce-Mead ideal type model[1], which relates "me-I-you" perspectives as the pragmatic foundation

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[1] Wiley identified six main properties of the semiotic (specifically human) self: (1) dialogical, (2) social, (3) horizontal, (4) egalitarian, (5) voluntarist, and (6) cultural.

of the SS (cf. Bakker 2011). Conversely, biosemiotics changes around the nominalist epistemology of the so-called prison-house of language metaphor (Colapietro *et al.* 2020: 188), and deals with the pre-linguistic notion of semiotic *reality* in the phylogenesis of umwelten. This is to say, SST is ultimately concerned with the public or *intersubjective* (Uslucan 2004: 96): The fact that life forms can universally feel, interpret, and act upon their environment via semiosis.

Put differently, the biosemiotic side of SST goes beyond individuals discovering themselves as an independent, "unique", consciousness via self-recognition. Rather, subjectivity is to be addressed as a natural kind of experience that springs from the communicative *relations* between minds, signs, and world. As stated by Colapietro *et al.* (2020: 186), "we begin in the world, and the world increasingly internalizes itself ever more deeply in our psyche (the world inhabits us at least as much as we inhabit it), so it is outside-in". Interestingly, this Peircean perspective of distributed cognition differs from internalist treatments of the human psyche, such as Tarasti's:

> Understanding is a kind of cognitive event within one's mind; its consequences may vary, but the event itself is always internal and thus difficult to investigate experimentally. Understanding cannot be merely a reduction of one level to another. For instance, the phenomena of cultural and psychosemiotics do not become more comprehensible if they are reduced to biosemiotic processes. (Tarasti 2001: 59)

Such internalist "black box" views would be in tune with Thure von Uexküll's (1995:102) claim that "the private character of signs and their hidden interpreter – 'semiotic self' – is the basis for 'identity' and 'individuality', both of them qualities, that can't be shared". This, along with the concept of a "clandestine interpreter of symptoms" (Sebeok 2001:134), seems to contradict the antinominalist and communal spirit of Peircean semiotics and its famous pragmatic maxim, which makes emphasis on the "practical bearings" of interpretation as anticipatory *actions* (cf. Wiley 1994: 20-21). According to this fallibilistic stance, *experience* (although being somehow "private") can indeed be scientifically researched through phaneroscopy (a semiotic phenomenology), because meanings have real causal effects as actions or purposeful behaviour (Marais 2019: 86). Perception and action are mutually translatable via interpretation, just like coin and value are "exchangeable" via value-making. In the bigger picture of Peirce's scientific metaphysics, this is the case because interpretants act upon the physical world, and conversely (CP 5.106). Namely, symptoms, along with many different types of interoceptive ("private") signs can be co-experienced by a plurality of interpreters, which inform a collective existence more transcendental than a private ego-quality. Once more invoking the "coin" metaphor, it makes more sense to look at economic relations as the *cause of* value than the other way around. Like meaning-making, economic value-making is not only "inside" a person's mind (e.g., as consumer's psychology), but also influenced by the extended, contextual, and conventional relations that support the validity of money as a whole.

Under this logic, I argue that the internalist-externalist dichotomy misses the actual point of SST, the premise that selfhood is relational and, therefore, irreducible to a single being discovering itself for the sake of itself. In the words of Tønnessen (2010: 377), semiotic thinking "restores subjectivity not as an internalist conception, nor as an externalist conception, but rather as a relational conception. Our self is social. A self is always bigger than itself." Such *relational* focus, then, abandons the idea of a unidirectional subject-object relation, or a mind-dependent "internal" reality "observing" a mind-independent "external" reality. This text, then, adopts a similar spirit or focus within SST at large.

Every living being capable of interpretative choice-making can be pragmatically considered a SS. In turn, this suggests that we have ethical and logical reasons to use "living being" and SS as general synonyms, as long as both refer to a mortal interpreter that can *feel*, *choose*, and *act*. Living beings are necessarily interpretative beings (semiosis-dependent), because interpretation can only exist in the perspectival but extended relation between representamens (acting as Firstness) and objects (acting as Secondness), as mediated by interpretants (acting as Thirdness). Put differently, semiosis is a cognitive influence of an *interpretation* or choice-making causing a sign to stand for something other than itself *to* a living cognizer (regardless of how conscious or unconscious this cognitive influence is)[2]. Thus, instead of "selves" we might just as well speak about *beings* (cf. Tønnessen 2010). Beings *are* insofar as they interpret, for life ceases when the possibility of interpretation or choice-making via semiosis stops. Of course, this does not imply that cultural semiotics and sociosemiotics (among other semiotic subdisciplines) may satisfactorily account for human selfhood purely in terms of (bio)semiosis. Rather, semiosis could be used as the terminological basis of a constructivist approach to cognition, rather than being seen as a minimalistic model.

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[2] Namely, Peirce argued that "consciousness is a special, and not a universal, accompaniment of mind" (CP 7.366).

Terminology-wise, "self" connotes a more "static", "definite", and "inwards" *identity*. "Self" is more attuned with the seemingly "selfish" internalist conception of Hegelian logic, the so called "*an-sich-sein* (Being-in-itself) and *für-sich-sein* (Being-for-itself)" (Tarasti 2015: 22). In contrast, "being" or "interpreter" more aptly connotes a processual, contingent, and public value-making relation, one that still leaves place for an experiential organism-specific subjectivity (which is different from an identity or social role). To be is to interpret, and to interpret is to live.

3. Interpretative faculties of semiotic beings

Instead of narrowing the minimal definition of semiotic beings, let us now look at the group of characteristics frequently ascribed to living beings within SST as a whole. SST, in my view, could make more interdisciplinary progress by looking at these inter-reliant features of selves as *living* beings, interpreters with the following faculties:

3.1. *Normative* or *value-making* (cf. Tønnessen 2010). Living beings choose and habituate in their best "interests" and priorities. For example, their preferences usually make their own death less likely. Indeed, semiosis presupposes continuity, but is not "infinite" or "unlimited", as life cycles are limited or "mortal" by definition. Otherwise, there would be no need for self-preservation.

3.2. *Multilayered* or *multi-voiced* (cf. Raggatt 2010). Living beings are composed of a myriad of memory-based systems. For instance, immunological, neurological, cognitive, ecological, cultural, and, in the specific case of humans, linguistic and historical, among others. What is more, such plurality could be already seen as an intrinsic part of semiosis itself, with its plethora of possible sign types, its three types of interpretants (emotional, energetic, and logical), and its two types of objects (immediate and dynamic).

3.3. *Communicative* or *relational* (cf. Colapietro *et al.* 2020: 192). Living beings cannot thrive in isolation, and need to actively perform message exchange (e.g., auto-communication and inter-agential communication). On the basis of Peirce (MS 283: 56), it is further argued that semiotic selves are not only communicative, but also *communal*, insofar as they establish a dialogue with their own multilayered self, and with other selves (Colapietro 1989: 22). This is another way of saying that living beings are contrapuntal with respect to otherness and their changing socioenvironmental demands. Hence, selfhood is better understood as being inter-corporeal, inter-personal, inter-subjective, interactive, interpretative, etc.

3.4. *Extended* or *distributed* (cf. Ward, Stapleton 2012). Like habits, cognitive processes are not completely "situated" in the brain or discretely "confined" to any particular body part. As a cognitive habit, then, semiosis is more a phenomenological problem than a physiological one. This is to say, subjectivity in living beings is not epiphenomenal, but phenomenal. Cognition may be necessarily embodied (e.g., via organisms) or physiologically "bound" to certain spatial coordinates (e.g., via environments), but semiotic habits are a *continuous* interplay between mind, signs, and world (cf. Heras-Escribano 2021: 342).

3.5. *Teleonomic* or *agential*. Living beings are driven by one particular type of final causation: Semiotic causation (Hoffmeyer 2008: 64). This is to say, they possess different degrees of intentionality or willfulness (not necessarily self-conscious), which are expressed in the form of goal-oriented *actions*. Thus, behaviour is not equivalent to a reaction, and needs to be accounted for in terms of teleodynamics, or end-directedness (Deacon 2012: 270). In short, selves are said to be agents with priority agendas, they are actors instead of mere passive subjects. This faculty is also understood in terms of Uexküll's general notion of "purpose" (2001), and Peirce's view of final causation (CP 1.211, 7.366), i.e., the *general* form of any process that *tends* toward an end state.

3.6. *Anticipatory* or *future-oriented* (cf. Kurismaa 2016). Although they are bound to different temporal horizons, life cycles unfold over time, and involve a future-oriented phenomenology (cf. Fraser 2007: 46), because interpretations necessarily have a temporary culmination through controlled actions (Wiley 1994: 15–20). The only controllable conduct is, logically, future conduct (CP 5.461). More explicitly:

> As the self moves down the time-line its semiotic process is constantly transformed, with a past interpretant becoming a present sign and then a future object […]. The self on this view is a constant process of self-interpretation, as the present self interprets the past self to the future self. (Wiley 1994: 14)

3.7. *Incomplete* or *open-ended*. Due to their intrinsic constraints of many kinds (physical, energetic, temporal, informational, etc.), life forms universally search for something absent (e.g., sources of nutrients and hospitable temperatures). These otherwise absent entities become "present" or sensed, first and foremost, thanks to the aboutness of the representamen or sign vehicle in semiosis. This is reinforced by the idea of "ontic openness" (Nors, Emmeche 2013: 22), referring to the fact that living systems are, roughly speaking, open systems. As argued by Petrilli:

> To recognize that subjectivity is made of signs ultimately means to recognize that subjectivity is in becoming; in other words, that the self gradually emerges as an ongoing and open-ended semiosic process, and that this process flows from the "logic of otherness". (Petrilli 2013: xxv)

3.8. *Autopoietic* or *self-organizing*. Resuming the thesis of multiple realizability (cf. Varela *et al.* 1974: 188), it is said that a living being "is, essentially, a body that produces itself, in the sense that it produces its own material components as well as the bodily physical unity that characterizes it" (Villalobos, Razeto-Barry 2020: 10). In this sense, the autopoietic *bodies* of living beings could be said to have three main characteristics:

(1) *Boundaries*: Bodies are physically discrete bounded systems, which can be distinguished from their "background" environment or dwelling medium. For instance, cell membranes and animal skin.

(2) *Unity*: Bodies are a dynamic collection of matter that molecularly sticks together regardless of external observations. Namely, a population of aspen trees may look like individual bodies (e.g., separated trunks), but in fact they belong to a single organism because their shared roots are continuous, and because they are homogeneous parts of a single genome. Such bodily unity, thus, is derived from organismic interactions of its own components, and not from external or contingent forces mechanically exerted (e.g., gravity).

(3) *Circularity* or recursivity: Bodies are environmentally attuned to looping dynamics (e.g., functional cycles). Thus, living beings are not absolutely self-sustainable, but they possess a *relative* autonomy to self-reproduce (e.g., healing, growing, cloning), and to self-maintain their own bodily structure through metabolism and normativity.

While these eight features might deviate from Wiley's (1994) classic work on the semiotic self, they encompass further developments in biosemiotics that bring SST closer to being an evidence-based theory. That is, closer to Deacon's concept of teleodynamics (2012: 270–271), and closer to Simondon's ontogenetic theory of individuation, which includes physical, vital, and psycho-collective levels (cf. Karatay *et al.* 2016).

Naturally, diverse accounts of SST differ in their terminology and objectives. Nonetheless, the above features are more often than not attributed and observed in the multifaceted selfhood of living beings (e.g., from cellular populations, to human interlocutors). In this context, SS could be further defined as an embodied being that feels, chooses, and acts by means of transient functional cycles, which are teleodynamically and habitually grounded on an ecosemiosphere (cf. Maran 2021). On the one hand, a more comprehensive definition of living being is still needed in SST. On the other hand, SST could benefit from developing a more precise typology of selfhood that recognizes species-specific features, and takes into account semiotic individuation (cf. Hoffmeyer, Stjernfelt 2016). Meanwhile, Pattee's minimalistic notion of *interpreter* may point us in the right direction when it comes to identifying a semiotic being:

> I would define an interpreter as a semiotically closed localized (bounded) system that survives or self-reproduces in an open environment by virtue of its memory-stored controls and constructions. That distinguishes interpreters from inanimate physical systems that evolve dynamically simply because they follow the memoryless state-determined laws of nature. (Pattee 2005: 536)

A broader ontological question arises in this regard: How did a prebiotic universe ruled by gravity, electromagnetism, and nuclear forces provided the evolutionary conditions for umwelten habituated by chemoreceptors, mechanoreceptors, photoreceptors, and thermoreceptors? Or, from a more minimalistic view, the question comes down to "what sort of process is necessary and sufficient to treat a molecule as a sign?" (Deacon 2021: 537). This type of evolutionary questioning might seem reductionistic, but in fact has proven to be crucial for understanding normativity and self-preservation in terms of environmental *adaptability* and thermodynamical regulation. Let's take the case of our last universal cellular ancestor (LUCA):

> LUCA does not appear to have been a simple, primitive, hyperthermophilic prokaryote but rather a complex community of protoeukaryotes […] adapted to a broad range of moderate temperatures, genetically redundant, morphologically and metabolically diverse. (Weiss *et al.* 2016: 1)

It is not a coincidence that SST has been concerned with issues like metabolic self-control and *semiotic evolution* (cf. Stjernfelt 2012). Under this logic, a biosemiotic take on SST constitutes the rediscovery of a similar existential question, the relevance of which cannot be overstated: How did affinity emerge amidst pure chance and from pure necessity? Alternatively put, how are optional habits acquired in a world where both stochastic indetermination and mechanistic determination are at stake? (cf. Kull 2014). As a matter of fact, Peirce's evolutionary cosmology and its phaneroscopic categories (CP 1.284) – Firstness, Secondness, and especially Thirdness – are an attempt to tackle such a daunting question in terms of the possible, general, modes of *being*. It comes as no surprise that SST inherits the anti-Cartesian spirit of "Questions Concerning Certain Faculties Claimed for Man" (Peirce 1868a) and "Some Consequences of Four Incapacities" (Peirce 1868b).

4. Conclusion: Applications and future opportunities for SST

SST usually functions as a *descriptive* theory (cf. Pelc 1997: 632) if we consider its cognitive role within semiotics at large. For example, SST might work as a "mirror-theory" where semiotics reassesses its own (meta)theoretical stance amongst other disciplines. Inevitably, SST leads us to ask "what does semiotics study that other disciplines and sciences do not?" Is SST a semiotic theory in its own right, or is it simply the incursion of other disciplines (e.g., psychology, biology, and sociology) into semiotics? The answers are not clear and posit a philosophical challenge in the clarification of SS as an actual operative concept in academic research. In other words, if every living being is a semiotic being, then (bio)semiotics becomes an overarching discipline concerned with every ontological aspect of any living system. Such a role also means that SST's conceptual advancements are mostly made on the basis of formulating the terminological nuances between "being", "subject", "interpreter", "agent", "cognizer", "individual", "organism", "consciousness", "mind", "identity", "individuality", "first-person perspective", "ego", etc. Put otherwise, SST, as a theoretical body of knowledge, tells us what it means to become, to be, to live, to experience, to interpret, to feel, and to act *with respect to* a semiotic reality hypothesized by different fields.

Sign reality or semiosis is seen, however, as contingent to the actual phenomenology of concrete beings, which usually escape the rigid classifications of historiography (e.g., "populations", "species", "persons", "communities", "societies", and "cultures"). Hence, the interdisciplinary nature of SST. On the other hand, it seems that SST also aims to be an *explanatory* theory in the sense that – besides renaming phenomena already explained by other theories – it deduces the *final causes* of phenomena and processes that have not been accounted for in terms of meaning-making or interpretation in other paradigms (e.g., in classical biology). Given its explanatory aspirations, SST's empirical applications are yet to be manifested more clearly. Along the lines of a pragmatic phenomenology, Tønnessen points out that this is possible either by "integrating phenomenology into an explanatory framework (so that phenomenology will ultimately be part of science), or simply studying phenomena that are also open to empirical investigation" (Tønnessen 2010: 383). This paper has argued that this is feasible if we shift our attention from atomistic and internalist views of selfhood to pluralistic and relational views of *being*. The biosemiotic question now becomes how to define *life* and living beings in such a way that different scientific fields *agree* on what type of experimental or observational data (e.g., purposeful behaviour) can be ascribed to them semiotically. Nonetheless, there are concrete examples of how SST might benefit disciplines other than semiotics itself. Most notably, there is a growing body of research in Dialogical Self Theory (DST) (Valsiner 2005: 202; Andacht, Michel 2015), as well as self-formation theory (Raggatt 2010). Similarly, there are sociocultural accounts of SST in musical performance (Navickaitė-Martinelli 2015); social psychology (Bakker 2011); and Vygotskyan developmental psychology (Gamsakhurdia 2021).

Uexküllian phenomenology, also, has inherited the pluralistic perspective of SST (cf. Jaroš, Maran 2019). Namely, the application of SST might be useful for the development of umwelt mapping in terms of "ontological diagrams" (Tønnessen 2010: 388), and also modelling human-animal relations (Tønnessen *et al.* 2018). In these studies, phenomenology and ontology seem to coincide through the processual concept of semiosis. On a more speculative note, we might envision SST being a bioethical and epistemological tool in fields where the notion of selfhood needs to be approached as an *intersubjective* phenomenon, rather than as a Cartesian "black box". For instance, in child development; experimentation with non-human animals; euthanasia; different types of amnesia and coma; and in the justification of existential, cognitive, and behavioural therapies in mental health. Also, translation studies, biopolitics, and multicultural diplomacy (e.g., in the form of semiotics of conflict, and Lotmanian semiotics) might benefit from SST insofar as they envision problem-solving as an interpretative synthesis, a translation, between identity and alterity. Colapietro *et al.* (2020: 184) point out that Peircean SST starts with recognizing the problem of "self-deception". Put otherwise, intersubjectivity is achievable even though we initially ignore the nature of our very beings (and that of others). Indeed, being/life may be a non-formalizable phenomenon – which makes it harder to constrain via inductive terminology – but this is no excuse for not transcending the speculative context in which it is used. This is to say, *beyond* the philosophical inquiry on the self at large, famously known for its elusiveness or "glassy essence", as famously resuméd by Peirce in a Shakespearean paraphrase (CP 5.317).

Finally, with the risk of overgeneralization, we could notice two main interpretations of SST. On the one hand, there are those inquiries focused on human beings as the only source of subjectivity and selfhood "per se". On the other, we have the biosemiotic interpretations of SST where human subjectivity is only *one* possible form of semiotic selfhood amongst many others. In this sense, ongoing lines of research examine the concept of "semiotic animal", a term that reinforces the solipsistic claim that humans are the only animals that purposefully and consciously use signs. Notably, this idea would reinforce the psychological objection (discussed earlier) about the living cell not possessing meta-semiotic self-awareness. Indeed, humans may be the only species known to be aware of meta-semiosis via semiotics, but this does not mean that we are "more" semiotic than other living beings that have a semiosis-dependent subjectivity or umwelt. In this regard, it would be fruitful to explore the possibility that the "semiotic animal" is merely a biased distinction. Namely, when Umberto Eco arbitrarily makes a separation between the lower and upper thresholds of semiotics, as a dichotomy between nature-dependent and culture-dependent forms of semiosis. Against this background, SST could examine more thoroughly the consequent reductionist gap between "culturalism" and "biologism" in the humanities (cf. Eagleton 2016). The transformativist view of a "semiotic animal" (e.g., based on the "human singularity" argument), would conveniently place semioticians as the "true" (meta-)semiotic selves because they have, as Morris (1948) would put it, the most notable terminological awareness about "signs about signs about signs". Moreover, seeing humans as the only actual "semiotic selves" endorses the fallacious view that we are the only animals that use symbolic (arbitrary, conventional, and habitual) forms of semiosis, the validity of which has been long contested by Peircean scholars (e.g. Colapietro *et al.* 2020: 193; Sebeok 1990: 42). In conclusion, SST still has a lot to offer in the realms of ontology of life. Its future directions seem to point towards holistic ideas from biosemiotics, like the "nature-culture continuum" (Lyons 2019) and the "ecosemiosphere" (Maran 2021).

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18. “Memory catcher”. Artwork displayed in the exhibition Poetics of Survival, as part of the literature festival Prima Vista (Philosophicum Hall Gallery, foyer of Jakobi 2; Tartu, mai 2024).
19. “How to help wild animals to remember better in the face of anthropogenic disruption?” Traces of Extinction: Species Loss, Solastalgia, and Semiotics of Recovery (Tartu, juuni 2024).
20. “Episodic memory and its universes of reality: an application of Peirce’s hexadic multimodal semiosis”. Signs and Realities: 16th World Congress of the IASS-AIS (Varssavi, september 2024).

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