

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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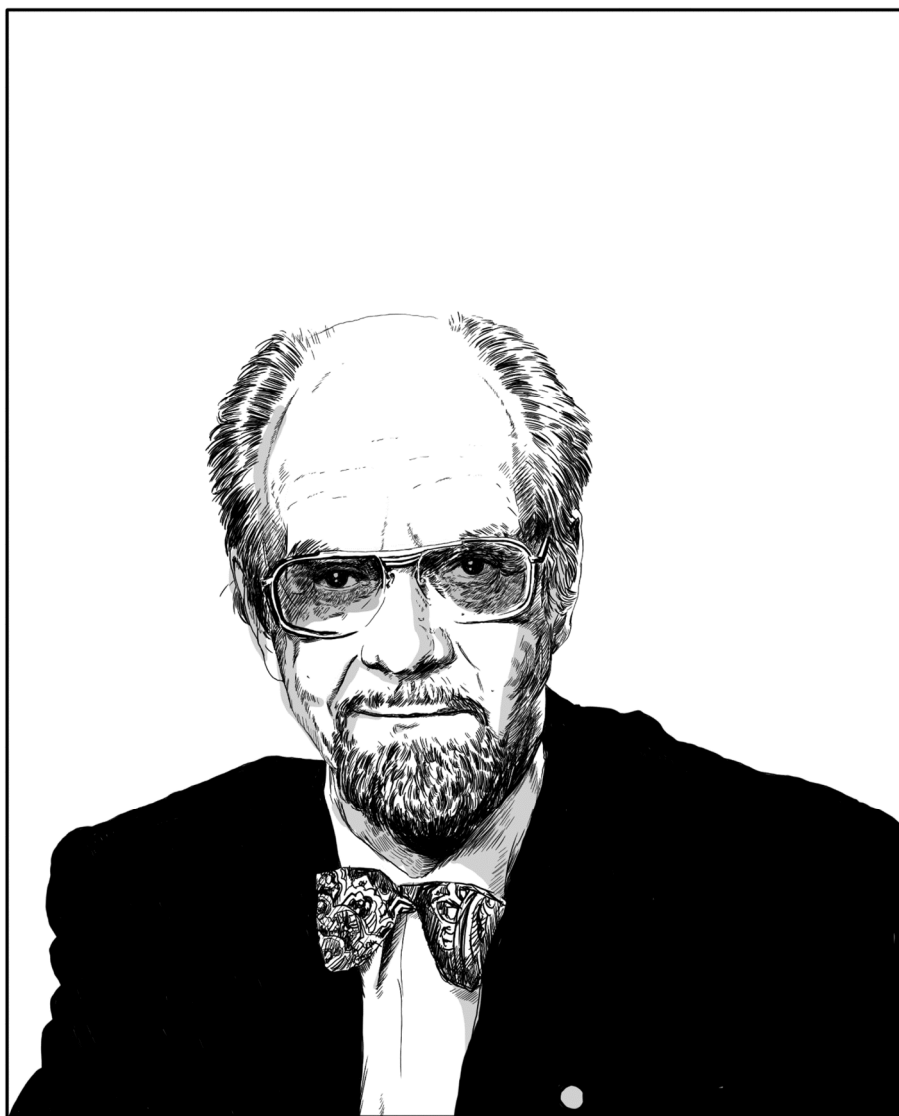


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BECAUSE OF A MILLION LOVES

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: Trigel, 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 anecdotal 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 neuro-cognitive 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 kinds¹.

Ontogeny wise, SM is developed first in early childhood, and it is a pre-requisite 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 breadth 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 prospectations, 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”

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.

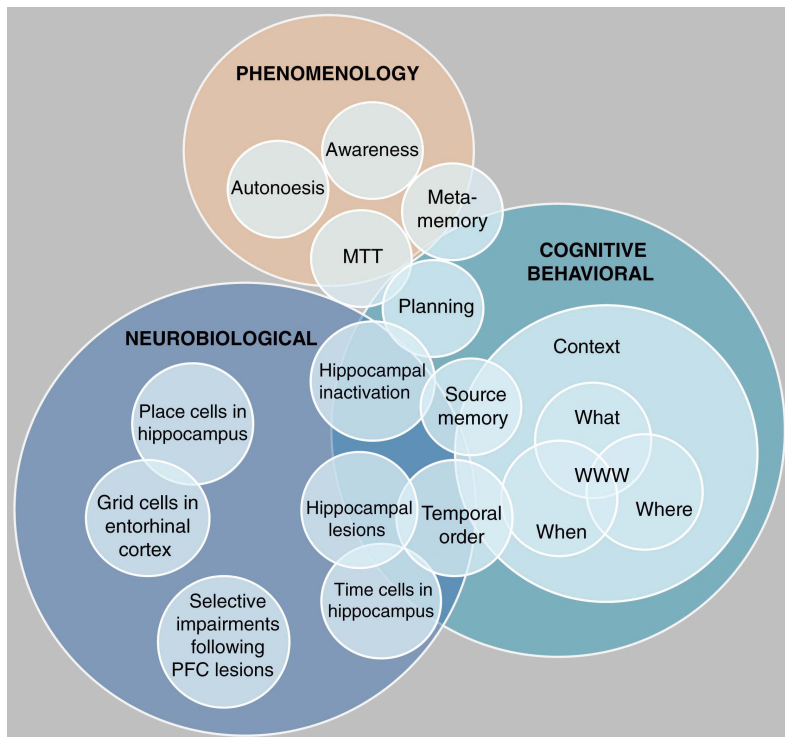


Figure 1: “Constellation of mnemonic features of episodic memory”. Reproduced with explicit permission from the authors (Templer, Hampton 2013: 802) and from ©2013 Elsevier Ltd. Published by Elsevier Inc. License number 5822470574821.

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.

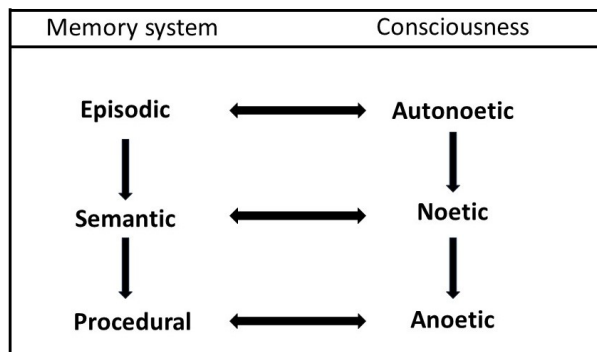


Figure 2: “A schematic diagram depicting the relations between memory systems and varieties of consciousness”. The figure reproduces the original version by Tulving (1985a: 3) with permission from ©Canadian Psychological Association.

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 auto-noetic '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 auto-noesis 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 auto-noesis or the autobiographical awareness of EM (lasting a lifetime). This multisystemic orchestration is known more generally as the Memory System Framework³:

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

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 travelers. 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).

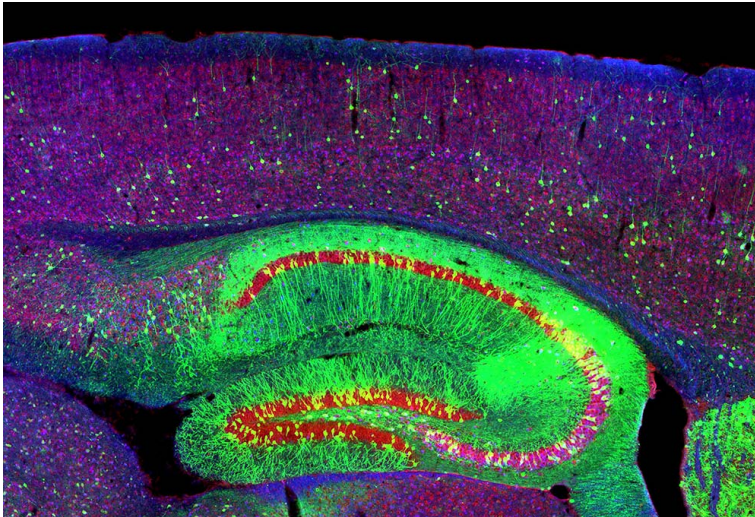


Figure 4: "Hippocampus and neurons of mouse with the neurodegenerative disease". Credit: Eunice Kennedy Shriver National Institute of Child Health and Human Development (NICHD).

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 fashion⁴.

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 inter-related 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., autooiesis 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, auto-noetic 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) (Crystal 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).

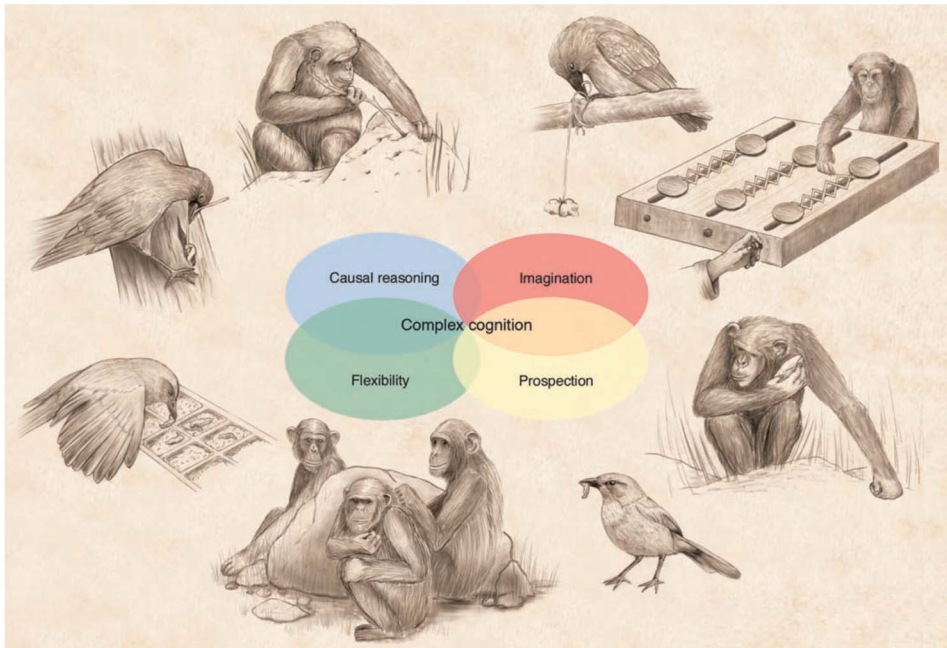


Figure 5: “Illustration of the four nonverbal cognitive tools displayed by corvids and apes, which are proposed as the basis for complex cognition”. Reproduced from Emery and Clayton (2004: 1906), including drawings by C. Cain, and reprinted with permission from the American Association for the Advancement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

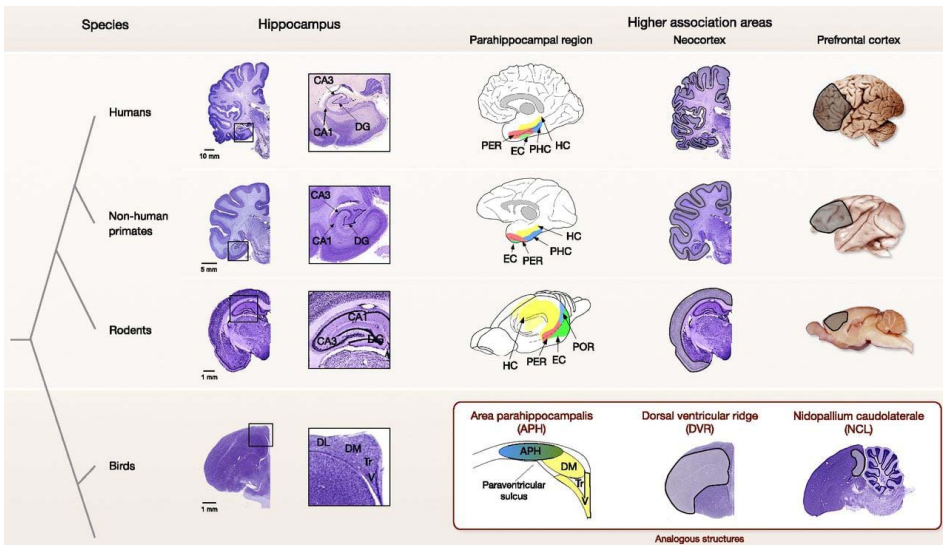
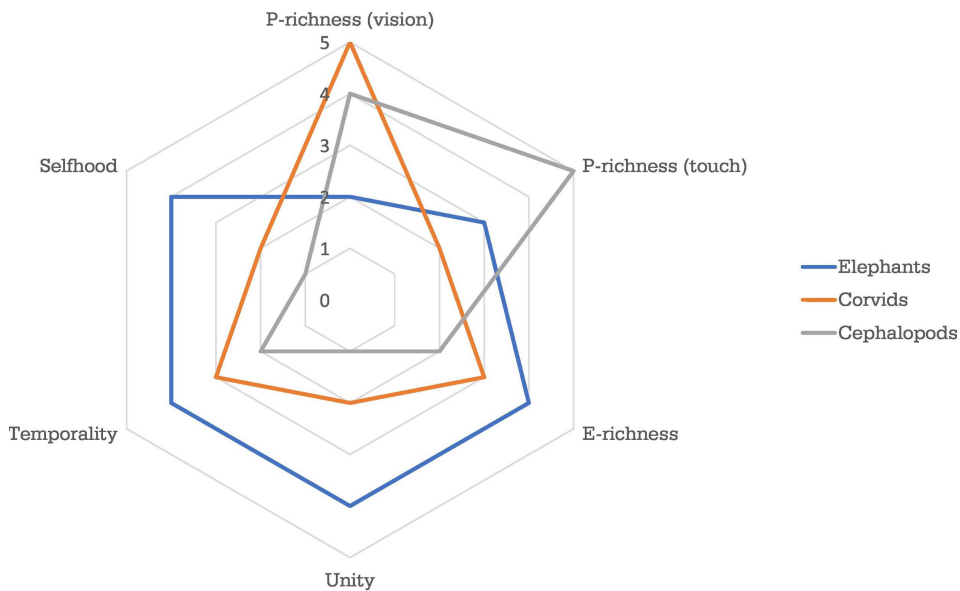


Figure 6: “Brain regions important for episodic memory”. Reproduced with permission from Allen and Fortin (2013: 10381) and © 2024 National Academy of Sciences.

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.



Trends in Cognitive Sciences

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
<ol style="list-style-type: none"> 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. 	<ol style="list-style-type: none"> 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 auto-noetic 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 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 reinstatement 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 pheno-

menological. 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 correlates 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 semiotic 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 semiotic relation, the causality of the sign is objective or specifying causality. [...] What makes an act semiotic, 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 ($Od1 \rightarrow Oi \rightarrow S \rightarrow Ii$) and displaying present-oriented “resolutions” in the form of “episodic simulations” ($Id \leftrightarrow$). If2 was dubbed “Actualiter”, a mode of cognition informing a Memory Content ($Ii \leftarrow S \leftarrow Oi \leftarrow Od2$) and enacting past-oriented “implementations” in the form of “episodic actions” ($\leftrightarrow Id$). And If3 was dubbed “Habitualiter”, a general mode of cognition controlling a Memory Flexibility ($Id \leftrightarrow If3 \leftrightarrow Id$) 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 $If1 \rightarrow Od1 \rightarrow Oi \rightarrow S \rightarrow Ii \rightarrow Id$. It means that a habit of experience or Virtualiter (If1) visualizes a Memory Structure ($Od1 \rightarrow Oi \rightarrow S \rightarrow Ii$) in the form of a neurophenomenological simulation ($\rightarrow Id$). Second, Nevi retrieves the snack in an actual W-W-W/W scenario (a past-oriented action). This could be modelled as $Id \leftarrow Ii \leftarrow S \leftarrow Oi \leftarrow Od2 \leftarrow If2$. It means that a habit of conduct or Actualiter (If2) proceeds with a MeC ($Ii \leftarrow S \leftarrow Oi \leftarrow Od2$) in the form of a bodily action ($\leftarrow Id$). 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 ($Id \leftrightarrow If3 \leftrightarrow Id$). 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 envisionser’s world, insofar as to achieve a plausible end-state or goal.

The “baker’s dozen” ($\mathbf{If1} \rightarrow \text{Od1} \rightarrow \text{Oi} \rightarrow \text{S} \rightarrow \text{Ii} \rightarrow \text{Id} \leftrightarrow \mathbf{If3} \leftrightarrow \text{Id} \leftarrow \text{Ii} \leftarrow \text{S} \leftarrow \text{Oi} \leftarrow \text{Od2} \leftarrow \mathbf{If2}$) 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 \rightarrow present \rightarrow future), as it is about the pragmatic ordering or enacting of lived episodes (e.g., the anticipatory becoming present \leftrightarrow future \leftrightarrow 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 (\leftrightarrow future \leftrightarrow) that precede *and* succeed ($\text{Id} \leftrightarrow \mathbf{If3} \leftrightarrow \text{Id}$) 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.

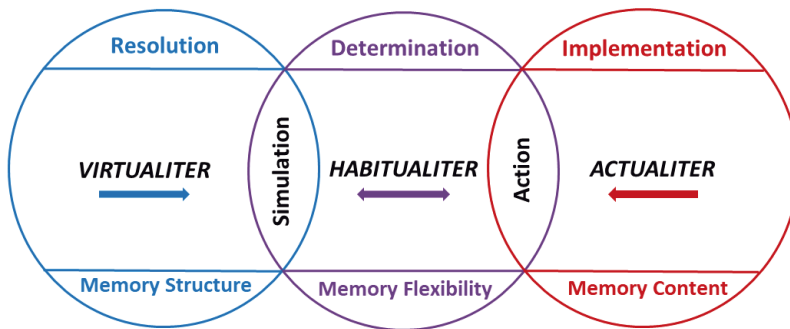


Figure 8: “A multispecies cognitive model explaining episodic behaviour as the result of an irreducible meaning-making process between three modalities of virtual habits”, reproduced from Miyamoto (2024b).

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 intermediary or Habitualiter: $If1 \rightarrow Od1 \rightarrow Oi \rightarrow S \rightarrow Ii \rightarrow Id \leftrightarrow If3 \leftrightarrow Id \leftarrow Ii \leftarrow S \leftarrow Oi \leftarrow Od2 \leftarrow If2$. Extrapolated to figure 8, this form of episodic semiosis maps as follows:

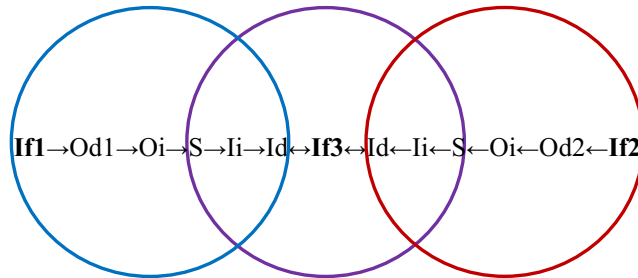


Figure 9: “The baker’s dozen of episodic semiosis” models the interdependent relationships between 13 semiotic correlates in AEM. The blue circle refers to the Virtualiter’s memory structure, the purple circle refers to the Habitualiter’s memory flexibility, and the red circle refers to the Actualiter’s 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:

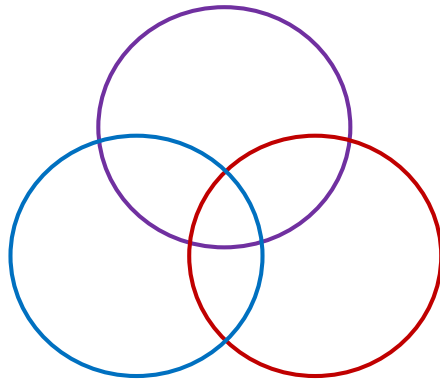


Figure 10: a ruled-out configuration of the AEM model in Miyamoto (2024b), which has been suggested independently by several colleagues, either for aesthetic or diagrammatic reasons.

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 dynamism 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 depict 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’ states⁵. 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

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 semiotic 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 rememberer’s experience. It is the rememberer’s controlled MTT that collaterally activates those patterns 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 multi-causal 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 Auto-noesis), 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 auto-noesis), 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 Trangel, 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 spatio-temporal 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 mälestusest 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, koostas 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.

PUBLICATIONS

CURRICULUM VITAE

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Education:

2020–2024 PhD in Semiotics and Culture Studies – Tartu University

2018–2020 M.A. in Semiotics – Tartu University

2013–2015 M.A. in Communication – National Autonomous University of Mexico

2007–2011 B.A. in Communication and Journalism – National Autonomous University of Mexico

Career:

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2011–2019 Freelance science journalist

2017–2018 Part-time lecturer at National Autonomous University of Mexico (UNAM)

2015–2018 Digital content creator at Mexican Network of Science Journalists (RedMPC)

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2019 Award for best graduate student presentation at NASS 2019

Affiliations:

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International Association for Visual Semiotics (IAVS)

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Mexican Network of Science Journalists (RedMPC) – cofounder

Selected publications:

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.

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2. “Mental Time Travel as a spatio-temporal modelling system”. Semiotic dimensions of spaces & literacies: Tartu Semiotics Summer School 2019 (Tartu, August 2019).
3. “The ‘movie’ inside our heads: a phenomenological approach to Mental Time Travel”. Visual semiotics goes cognitive: 12th Conference of the International Association of Visual Semiotics (Lund, August 2019).
4. “Semiotic modelling of episodic memory in alloanimals as biotranslation”. 20th Gatherings in Biosemiotics (online, Nov 2020).
5. “A biosemiotic interpretation of corvid episodic memory”. 21st Gatherings in Biosemiotics (online July 2021).
6. “A biosemiotic model of alloanimal episodic memory”. Biosemiosalong, Funktionskreis & the Biosemiotic Signifieds (Tartu, July 2021).
7. “The Memory System Framework as a semiotic model of biotranslation”. The Complexity of Social-Cultural Emergence. Biosemiotics, Semiotics and Translation Studies (online, August 2021).
8. “Animal senses as a window to the actual potentialities of the world: Zoo-semiotics meets Paul Ricoeur”. Meaning in Perception and the Senses: XII conference of the Nordic Association of Semiotic Studies (Vilnius, November 2021).
9. “The Semiosphere as a cross-species model of animal cultures”. Juri Lotman’s Semiosphere (Tallinn/Tartu, February 2022).

10. "Peirce goes 'interstellar': the hyperbolic continuum and the diagram of the IT". *Synecheia: Spring Semiosalong 2022* (Tartu, April 2022)
11. "Five dimensions of complexity in the Memory System Framework". 4th Conference of the International Association for Cognitive Semiotics (online, June 2022).
12. "Questions concerning certain faculties claimed for semiotic selves". 22nd Gatherings in Biosemiotics (Olomouc, July 2022).
13. "Umwelt beyond Earth: Ecosemiotic insights on NASA's astrobiology program". *Semiotics in the Lifeworld: 15th World Congress of the IASS-AIS* (Thessaloniki, September 2022).
14. "Corvids as subjects of a lifetime: bioethical insights from the biosemiotics of animal episodic memory". *Feeling – Skill – Knowledge: 13th conference of the Nordic Association for Semiotic Studies* (Helsinki, June 2023).
15. "Mediating univocity and equivocity: Mauricio Beuchot's analogical hermeneutics". *International Semiotic Summer School in Prague: Visual Metaphor* (Prague, July 2023).
16. "Tales of semiotic freedom". 23rd Gatherings in Biosemiotics (Copenhagen, August 2023).
17. "Habits of the future: episodic memory as virtual memory". *Coming soon: Tartu Semiotics Summer School 2023* (Tartu, August 2023).
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, May 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, June 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* (Warsaw, September 2024).

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International Association for Semiotic Studies (IASS)
Nordic Association of Semiotic Studies (NASS)
Mexican Network of Science Journalists (RedMPC) – kaasasutaja

Valitud publikatsioonid:

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

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1. “A travel to the future: chronesthesia as anticipatory semiosis”. Anticipation and change: 11th conference of the Nordic Association for Semiotic Studies (Stavanger, juuni 2019).
2. “Mental Time Travel as a spatio-temporal modelling system”. Semiotic dimensions of spaces & literacies: Tartu Semiotics Summer School 2019 (Tartu, august 2019).
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14. “Corvids as subjects of a lifetime: bioethical insights from the biosemiotics of animal episodic memory”. *Feeling – Skill – Knowledge: 13th conference of the Nordic Association for Semiotic Studies* (Helsingi, juuni 2023).
15. “Mediating univocity and equivocity: Mauricio Beuchot’s analogical hermeneutics”. *International Semiotic Summer School in Prague: Visual Metaphor* (Praha, juuli 2023).
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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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