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EDITORIAL

Editorial: causation in memory

1. Introduction

The last decade has seen renewed interest in the relationship between memory and causation. Much of this new literature has been driven by an empirically grounded skepticism about the viability of the classical causal theory of memory, which had long enjoyed the status of received wisdom. According to the theory, articulated by Martin and Deutscher (1966), remembering is constitutively tied to causation. A subject remembers an event if and only if her present representation of it is appropriately causally connected to a past experience of the event. The causal connection is appropriate only if it is sustained by a *memory trace*: a stored representation produced upon the experience of the event, preserved in a relatively unaltered form, and causally operative in its recall. By appealing to memory traces, the classical causal theory aims to specify a constitutive condition for kind membership. Remembering, unlike imagining, for example, necessarily involves trace storage and retrieval. At the same time, the appeal is explanatory, aiming to account for memory reliability. Memory is reliable precisely because it relies on stored representations formed in past experience.

The classical causal theory has recently come under sustained pressure. Drawing on findings from cognitive psychology and neuroscience, simulationists have argued that a common neurocognitive system underlies remembering and imagining (De Brigard, 2014; Michaelian, 2016, 2024). The system, the evidence seems to suggest, need not rely on memory traces to reliably generate (accurate) representations of events. This simple point informs the simulationist form of anticausalism, which rejects both key claims of the classical causal theory. Remembering does not constitutively involve trace storage and retrieval, so an appropriate causal connection to a past experience is *not* necessary for remembering. By the same token, memory is not reliable in virtue of its dependence on memory traces. Just like imagination, memory can draw on information from a variety of sources in constructing accurate representations. Indeed, simulationists argue that remembering and imagining are activities of the same kind.

The emergence of simulationism has reshaped philosophy of memory. While often met with an incredulous stare, it has also motivated the development of novel views that aim to vindicate some aspects of the classical

causal theory (e.g., Andonovski, 2024; Langland-Hassan, 2022; Perrin, 2018). Particularly notable in this regard is trace minimalism (Werning, 2020). According to trace minimalism, simulationists have gone too far in denying the necessity of memory traces. Like the classical causal theory, trace minimalism maintains that traces are required to secure the reliability of memory. Unlike the classical theory, however, it does not construe traces as stored representations of past events. Rather, it posits informationally sparse, i.e., *minimal*, traces that are causally operative in recall but do not carry representational content. Trace minimalism is supported not only by empirical evidence but also by more general considerations about the nature of memory reliability as well as by emerging neurocomputational models of memory encoding, storage, and retrieval (e.g., Fayyaz et al., 2022).

Importantly, unlike the classical causal theory, the contemporary theories have focused primarily on *episodic* memory, traditionally characterized as the memory for personally experienced events (Tulving, 1983). The restriction of scope is unsurprising, since the empirical bases for the theories are constituted by work on the nature and function of episodic memory. Yet, the focus on episodic memory is significant not only because it tracks the relevant empirical literature but also because episodic memory has been taken to enjoy a distinctive epistemic status. Rememberers are typically granted epistemic authority with respect to their personal past. Much of the appeal of the classical causal theory derives from the belief that this authority is grounded in the preservation of information acquired in first-hand experience. If the theory is under threat, however, so too is this belief. The responses to this problem have been varied. Some, like Craver (2020), have challenged the claim that empirical findings can overturn what is in essence an epistemic conception of remembering. Others, such as Mahr and Csibra (2018) have proposed a socio-communicative role for the attribution of epistemic authority to rememberers, without committing to the view that such attribution is justified. Finally, some (e.g., Andonovski, 2024) treat the epistemic status of episodic memories as a constraint on theorizing, seeking to reconcile it with the emerging empirical picture.

At the same time, recent developments in neuroscience have brought the notion of the memory trace back into focus by shifting attention to its potential biological realization. In particular, there is growing interest in the study of *engrams* in cellular and molecular neuroscience. Engrams are the hypothesized neural mechanisms or substrates of memory retention and have historically been linked to memory traces. A range of new tools for probing and manipulating brain function have brought unprecedented precision to the experimental investigation of these mechanisms (Tonegawa et al., 2015). Engram research has influenced the philosophy of memory in a number of ways. Unsurprisingly, some have taken it to vindicate the idea that episodic memory causally depends on trace-like

structures, even if only tentatively (Najenson, 2021; Robins, 2020). More significantly, perhaps, the research has broadened the scope of philosophical inquiry. It has prompted questions not only about the relationship of engrams to memory traces but also about their nature and distribution, their presence in different kinds of memory as well as their status as mental representations (Andonovski, 2024; Cao, 2022; Robins, 2023). It has also opened up space for further investigation of the relationship between memory and causation.

The aim of this special issue is to shed light on the range of issues outlined above. Its core is constituted by the contributions from six invited authors who participated in the workshop "Causation in Memory," held at the Center for Philosophy of Memory at Université Grenoble Alpes in July 2023 and supported by Nikola Andonovski's Marie Skłodowska-Curie's Postdoctoral Fellowship. The issue also includes five additional papers that further enrich the discussion and provide valuable insights into the many facets of the relationship between memory and causation.

2. Contents of the special issue

The papers collected in this special issue fall into four thematic groups: (2.1) Schwartz, Camillo, and De Brigard focus on the causalism-simulationism debate, assessing its current status and viability. (2.2.) Fayyaz, Righetti, Wiskott & Werning, Cheng, and Brown examine trace minimalism and its grounding in computational modeling. (2.3.) Najenson and Mace focus on the content and causal profile of engrams. (2.4.) Springle & Goldwasser, Bacharach, and Aronowitz open up new perspectives on memory causation through questions about representation, retention, and evidential status.

2.1. The causalism-simulationism debate

According to the simulation theory of memory, a common neurocognitive system underlies episodic memory and episodic simulation (such as imagination of counterfactual or future events), which therefore belong to the same natural kind. Episodic memory, like episodic simulation, does not require trace-sustained appropriate causation by a past experience.

Arieh Schwartz argues that the simulation theory is mistaken on both counts. Like standard arguments for simulationism, Schwartz' argument against simulationism is naturalistic, appealing to evidence from psychology and neuroscience pertaining to the mechanisms that underlie episodic memory. Adopting the homeostatic property cluster theory of natural kinds, Schwartz argues that, while there is much that is right in simulationism, there is also much that is wrong. What is right, he suggests, is simulationism's claim that there is a natural kind to which both episodic memory

and episodic simulation belong. What is wrong is its claim that there is no natural kind to which episodic memory but not episodic simulation belongs. The latter claim is wrong, Schwartz maintains, because it presupposes that natural kinds are discontinuous. The homeostatic property cluster theory does not entitle us to this presupposition, and the presupposition is manifestly false of biological natural kinds in general. Providing a detailed review of recent discussions of the distinction between episodic and semantic memory, Schwartz argues that it is false of episodic and semantic memory in particular: the fact that transitional forms exist between episodic and semantic memory does not entitle us to conclude that episodic and semantic memory do not constitute distinct natural kinds. He then argues that the presupposition is likewise false of episodic memory and episodic simulation: evidence from a variety of paradigms suggests that episodic memory relies on traces in a way that episodic simulation does not. Episodic memory, he thus concludes, is characterized by its being caused by a trace that is itself caused by an experience of the event that the memory represents, and it thus belongs to a natural kind to which episodic simulation does not.

Like Schwartz, **José Carlos Camillo** is concerned with the implications of empirical research pertaining to memory traces for the tenability of the simulation theory. Unlike Schwartz, he holds that the jury is still out regarding both simulationism and causalism, in that the relevant research provides evidence for and against both views. Camillo begins by interpreting the causalism-simulationism debate as a debate about the functional profile of the episodic memory system. According to causalism, he takes it, the episodic memory system functions so as to form a trace on the basis of an experience of a particular event and to enable retrieval of information about that event on the basis of the trace; the functional profile of the episodic memory system is thus characterized by appropriate causation. According to simulationism, in contrast, the functional profile of the system is not characterized by appropriate causation; instead, the episodic system, which is responsible both for episodic memory and for other forms of episodic simulation, functions so as to manipulate general event schemas and semantic information to produce simulations of particular events. Camillo goes on to review modeling, neuroimaging, and molecular research that provide evidence against simulationism's characterization of the functional profile of the system and in favor of causalism's characterization. He continues, however, by reviewing research on remembering nonexperienced events, generalization in consolidation, and coallocation processes that provides evidence against causalism's characterization of the functional profile of the system. In conclusion, he claims it would be premature to render a verdict about the tenability of either simulationism or causalism.

Felipe De Brigard advocates for philosophy of memory to move past the standard dichotomy between causalist and simulationist views of memory.

Even though De Brigard was himself an inaugural proponent of simulationism, his suggestion for a hybrid view that moves the debate forward starts by finding issues with both approaches to remembering. Causalism and simulationism are each in need of significant updating in order to engage with current ways of thinking about remembering and cognitive neuroscience. As these forms of updating occur, each view becomes decoupled from the means by which it explained remembering. For example, updating our views of the many ways in which a person could come to represent the past (which De Brigard proposes should be done via directed acyclic graphs) provides a more complete view of the causal nexus from which such activity arises but fails to illuminate any particular causal path as one that could be labeled "remembering." Similarly, evidence in favor of a common episodic construction system is much less clearcut than early versions of simulationism supposed. While it still appears to be the case that the default mode network supports episodic constructions of past and future, it also supports a range of other far more disparate activities, challenging any attempt to align the operations of this system with the function of episodic memory. To move forward, De Brigard proposes a new way of thinking about the process of remembering – as inverse causal inference – which does not neatly align with either causalist or simulationist approaches. To remember, on De Brigard's view, is to engage in causal inference, determining the most likely relation between cause and effect. While many cases of causal inference work prospectively, inferring likely effects from their causes, in the case of remembering it is the inverse: the most likely cause is inferred from the observed effect. This approach to memory causation aligns philosophy of memory with standard ways of thinking about causal inference in cognitive neuroscience, namely, as probabilistic Bayesian inference (Shams & Beierholm, 2022). Viewed from this new theoretical perspective, novel questions about the nature and significance of memory are likely to arise.

2.2. *Trace minimalism and computational modeling*

Trace minimalism posits informationally sparse, minimal, traces that are causally operative in recall but do not carry representational content. A key question the view faces, consequently, is whether a minimal trace can secure the reliability of episodic memory recall.

In their contribution, **Zahra Fayyaz, Francesca Righetti, Laurenz Wiskott, and Markus Werning** aim to answer this question affirmatively, thereby offering a proof of principle for trace minimalism. To this end, they evaluate a biologically inspired neurocomputational model on an episodic recall task requiring recall of previously encountered two-digit numerals in the presence of novel numeral shapes and held-out numbers. The model consists of three modules. The encoder module transforms an input image

into a compressed quantized vector. The trace module applies a mask that discards a percentage of the quantized vector and stores the resulting incomplete vector as a trace. This masking is crucial, as it allows the authors to manipulate the information capacity of the trace, mimicking attentional selection. The decoder module transforms the trace vector back into a quantized vector and then decodes it into an image. The results of the simulation show that recall reliability varies systematically with masking level and semantic completion during decoding. Without completion, performance rapidly deteriorates as masking increases. In contrast, with completion, reliability remains high across a substantial range of masking levels. Crucially, at a critical point of minimality, reliable recall is still achieved, even though the information capacity of the trace is only 3.16% of the capacity of the original image. The authors demonstrate that, thus characterized, the minimal trace is neither categorical nor compositional, as its informational content is insufficient to support reliable categorization or rule-sensitive combination on its own. Yet, when the trace is combined with learned statistical regularities, categoricity and compositionality are regained in the reconstructed representation. They take this to show that the representational content is not transmitted by the trace but arises from its interaction with semantic information, thereby vindicating a core claim of trace minimalism.

In "Causal and noncausal contributions to episodic memory," **Sen Cheng** argues that computational modeling offers valuable insight into memory systems by allowing researchers to simulate their dynamics and derive testable predictions about their organization and function. Surveying a wide range of modeling work, he proposes a shift from treating episodic and semantic memory as distinct systems to distinguishing instead between episodic and semantic *information*. While episodic information pertains to a particular episode, semantic information generalizes across different episodes. The two kinds of information have different neural representations and perform different functions. Computational models suggest that episodic information, which primarily engages the medial temporal lobes, supports context-based inference, one-shot learning, and replay learning. Semantic information, by contrast, depends on a range of cortical structures and supports the construction of world models used in inference, prediction, and decision-making. Importantly, episodic and semantic information are integrated in episodic memory, both contributing to the construction of event scenarios. Nevertheless, the two kinds of information retain different causal profiles. Whereas episodic information maintains a direct causal connection to a particular experience, semantic information does not. On this basis, Cheng argues that causal theories are more properly construed as applying to episodic information rather than to episodic memory. Building on prior work, he develops a view of episodic memory that integrates

insights from trace minimalism and the hippocampal indexing theory (Teyler & DiScenna 1986). On the view, episodic information is stored in the hippocampus in the form of activation pattern sequences. The sequences do not carry representational content, yet they activate semantic representations stored in the neocortex. Episodic memory emerges through a process of scenario construction that involves the coordinated activation of hippocampal and neocortical processes, combining the causal contribution of a minimal trace with semantic, model-like representations. Cheng further argues that this view is fully consistent with the observed neural overlap between memory and imagination, since both rely on scenario construction. What distinguishes episodic memory is that, unlike imagination, it requires reference to one and only one past episode.

Simon Alexander Burns Brown considers what happens when trace minimalism is extended beyond the form of memory on which it has been concentrated, shifting the focus from episodic to semantic memory. To do this, Brown starts with his own diagnosis of how trace minimalism achieves its status as a successful causal-simulationist hybrid, combining the virtues of each while avoiding their problems. Brown argues that it is the sense of information compression: encoding experiences in ways that extract patterns and remove redundancies, providing more efficient information storage. Next, Brown argues that this view of trace minimalism can be extracted from the particular approach to memory taxonomy endorsed by Cheng and Werning (2016). Trace minimalism is independent from Cheng and Werning's commitment to episodic memory as a natural kind, he argues, and can be used to ground a more general account that supports *trace pluralism*—the involvement of minimal traces in forms of retention and reconstruction beyond memory for experienced events. For semantic memory, minimal traces and their reconstruction could support inference and generalization rather than event simulation. Brown suggests that this approach could help to explain semanticization and other connections between episodic and semantic memory, as well as the advantage of encouraging philosophers of memory to explore the role of traces in even more disparate forms of memory. As philosophers of cognitive science are actively debating cognitive ontology, and memory scientists are increasingly willing to consider new taxonomies of memory, Brown's proposal for a minimal trace minimalism highlights a key way for philosophers of memory to contribute.

2.3. Engrams

The engram is the neural mechanism or change in the brain through which retention in memory is made possible. Once a mere theoretical posit, first proposed by Semon (1921), it is now widely thought to be a sparse neural

ensemble identified by a range of new intervention techniques for activating and imaging neural activity in vivo. Such tools provide many new opportunities for causal intervention, and bring a new level of precision to experimental work on these basic memory mechanisms. Alongside these advances new questions about memory's causal features arise. Specifically, there are many questions to be asked about how these basic neural mechanisms that can be manipulated experimentally relate to the animal's memories. The standard view that has emerged is to think of them as neural representations. As a form of representation, engrams would thus have both a content and a vehicle – what is represented and the physical structure through which that content is carried so that it can participate in causal interactions.

In "Engrams and Causal Specificity," **Jonathan Najenson** raises the question of how the engram's neural vehicle is identified. How do these new methods allow us to sort between engram and non-engram vehicles? This general question is made more complicated by the neural system in which engrams are instantiated. They are neural ensembles in broader neural networks, a set of associated neurons within a larger set of associated neurons, differentiated by the relative strength of the connections between them. In such a broad and dynamic system, making such discretizing differentiation is difficult. To address this problem, Najenson appeals to Woodward's interventionist framework, showing how it has the ability to identify the causal impact of particular nodes in an overall causal net, even when the effect of interest is several steps downstream. Najenson argues that Woodward's framework can be used to solve this causal specificity problem for engrams. What makes engram vehicle individuation possible are the two key features of engrams: their richness and distinctiveness. Engrams are rich in the sense that they are informationally dense characterizations of events. Engrams are distinctive in the sense that the information they contain is event-specific, rather than general. Together these two features give engrams a causal profile that makes them differentiable from the broader causal nexus of neural ensembles in which they are situated.

Engrams may be informationally rich, but what exactly is the information that they contain? How do we know that the event is represented one way rather than another? Which features, relations, and properties are included in the information and which are not? These problems of content indeterminacy are taken on by **Caitlin Mace**, in her paper "On a new content indeterminacy problem in neuroscience." Mace's paper begins from a framework for thinking about neural representation provided by Rosa Cao (2022), according to which the nature and content of neural representations can be sufficiently determined pragmatically, by the tools, tasks, and explanatory goals of the scientists who investigate them. In articulating this view, Cao makes use of engram research as a premier example of neural

representation. Mace endorses Cao's general approach to neural representation, but uses engram research to expose a limitation within the view. If content determination is restricted to the specific context in which an experiment is conducted, content will remain far too indeterminant to be of use to researchers. To achieve content determinacy, the representational pragmatism must expand to consider a broader context – specifically, the broader research framework within which the experiment is being conducted.

2.4. New perspectives

The final set of contributions shifts the focus from the mechanisms underlying episodic memory to its epistemic and representational character. The papers examine the kinds of epistemic achievement episodic memory affords and, in doing so, rethink the nature of its causal basis.

In "A minimalist approach to memory causality," **Julien Bacharach** argues that the causal theory is right with respect to the ordinary concept of remembering, but maintains that the causalist is under no obligation to provide an empirically supported account of appropriate causation in terms of memory traces. Recognizing that any claim regarding the necessity of appropriate causation will be vulnerable to the simulationist's challenge that we lack evidence that traces necessarily play the relevant role in remembering, Bacharach rejects the project of giving an analysis of remembering, which, he takes it, leads the causalist more or less inevitably to make such a claim. He nevertheless holds that the concept of memory is fundamentally causal in nature. He holds, moreover, that this concept makes an important contribution to our causal understanding of the world, even if we are unable to provide an account of the causal nature of remembering in terms of traces. This "minimalist" causalist approach, Bacharach points out, has something in common with older epistemic approaches that understand remembering as the retention of knowledge, the difference between them being that the minimalist causalist approach does not pretend that retention is not a causal process. Bacharach acknowledges that some naturalists might consider this approach to be suspect. He argues, however, that naturalism, broadly understood, can accommodate both empirically supported accounts and the approach he defends.

Alison Springle and Seth Goldwasser diagnose a tension between two central desiderata on theories of episodic memory: accounting for its *epistemic function* of providing first-hand knowledge of particular events, and its *experiential quality*, which it has in common with perception and imagination. Existing views, they argue, struggle to satisfy both simultaneously. To resolve the tension, they develop a novel account grounded in Springle's action-forward framework for intentionality (Springle, 2021;

Springle & Humphreys, 2021). On the framework, representation is essentially tied to action: to represent a target is to possess a capacity to access it practically and to respond to it in appropriate ways. Such access can be direct, when the target itself is available, or indirect, through surrogate representations that stand in for absent targets. Springle and Goldwasser build on this idea to argue that episodic memory is a form of *historytelling*, constituted by acts of retelling the remembering subject's initial experience of an event. Such retelling may be overt or covert and depends on three interrelated sub-capacities: discursive, expressive, and perceptual-recognitional. The relevant causal connection to the past is thus grounded in the retention of these capacities rather than in the storage of a representation that stands in for the original experience. According to the authors, the general capacity for historytelling is acquired through inculcation in socio-linguistic practices of joint recollection and historytelling. These practices constitutively involve discursive and expressive forms of retelling mediated by stand-in representations. A striking consequence of this view is that nonhuman animals, insofar as they lack such discursive and expressive capacities, lack episodic memory proper. For Springle and Goldwasser, this is not a bug but a feature of the account, reflecting the distinctive epistemic and phenomenological profile of human episodic memory. Episodic memory provides first-hand knowledge of particular events as it involves retention of history-telling capacities acquired in specific perceptual experiences. Constituted as it is by reenactment of those capacities, it is experientially continuous with perception and imagination.

In "Memories as data," **Sara Aronowitz** examines the causal relationship that allows us to access the same memory over time, even as our priorities and information change. She does so by drawing an analogy with legacy data in science: the use of information initially collected by a different team of researchers. Like legacy data, memories can support *radical reuse* in that they can be used as evidence to support different, and conflicting, sets of propositions at different times. That such radical reuse is possible, Aronowitz argues, provides support for an intuitively plausible but philosophically unpopular view of evidence. On this view, evidence is not propositional but is a class of objects. In the case of memory, the relevant objects are mental. Aronowitz demonstrates how memories can play the role of evidential objects, arguing that their reuse requires a kind of causally grounded coordination. Sensitive to both the changeability of memories and of our relations to them, she posits a criterion of memorial coordination on which accessing the same memory over time requires that the subject stands in a causal relation to the same numerical memory object. Importantly, the criterion does *not* require identity of causal relation to this object. Aronowitz acknowledges

that not all uses of memory fit the data view, yet insists that scrutinizing the uses that do enables a fuller appreciation of memory's complexity and its epistemic functions.

3. Concluding remarks

The causalism-simulationism debate has played a formative role in the development of philosophy of memory over the past two decades. It has been the primary vehicle through which traditional philosophical perspectives on memory have been confronted with more recent empirical discoveries in psychology and neuroscience, methodological shifts in the cognitive and social sciences, and theoretical developments in philosophy. The papers collected here in this special issue reflect the field's current concentration, but also suggest a range of ways in which the philosophy of memory in general, and the study of memory causation in particular, might move forward.

Notably, this issue lacks any papers defending either a purely causalist or simulationist approach. The papers which engage the debate between these perspectives tend to highlight the ways in which each view has strengths and weaknesses. This makes it seem as if the most promising views will be hybrid ones, which combine the features of causal and simulationist theories in new ways. Indeed, several of the papers here sketch views in this direction. As these develop, it is interesting to consider whether it will be productive to abandon the background causalism-simulationism framing from which these various hybrid views emerge. If the field begins thinking about memory in ways less attached to this dichotomy, it is possible that other, more novel views of memory will emerge. Features other than causation and memory traces could come to anchor the philosophical conception of remembering.

In a range of ways, the papers collected here have planted the seeds for how this bounty of new views could emerge. Some of that innovation has come from close engagement with recent discoveries in neurobiology, widening the scope of evidence considered relevant for an empirically informed view of memory. What other scientific perspectives could be added to further extend this scope? Others propose forms of innovation that come from updates to the models and analogies used to anchor our thinking about memory processes – file compression, historytelling, data reuse, and predictive inference all offer intriguing possibilities. Still others innovate by shifting the methods by which theoretical possibilities emerge, using computational modeling to generate new theories and demonstrations of how retention and retrieval could operate.

It is difficult to envision a future philosophy of memory where questions about causation fail to play a role. How much of a role it plays and how

causation is understood, as well as how it interacts with other questions that come to the fore, remains to be seen.

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