

10 What does it take to remember episodically?

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10.1 Introduction

When we remember an experience, we can mentally travel back in time to relive that experience. The system that makes mental time travel possible is known as episodic memory. Episodic memory has several intriguing features distinguishing it from other types of remembering, such as semantic memory or recognition memory. On the one hand, with semantic memory, one could learn general facts about the world without first-hand experience. For example, I know that it rains a lot in London, but I have never been there. On the other hand, with recognition memory, one could identify many different types of cues such as faces, words, sounds, and objects without conscious recollection of encountering them earlier. For instance, I can recognise someone's face without remembering where we met before. In both of these cases, one can *know* that something is the case without *remembering* it. However, to remember episodically, one needs to have both first-hand experience and auto-noetic awareness of personally having this experience in one's past (cf. Michaelian 2016).

It is debated whether episodic memory is a uniquely human capacity. On the one hand, defenders of human uniqueness generally build their arguments around the mental time travel metaphor and emphasise various distinctive features of episodic recall, particularly auto-noetic awareness (Suddendorf & Corballis 2007; Tulving 1985) and meta-representation (Redshaw 2014). On the other hand, defenders of continuity across species reject defining episodic memory in ways that are not testable behaviourally and keep adding to their arsenal of evidence for memory-like capacities in various species (Crystal 2010; Salwiczek, Watanabe, & Clayton 2010).

I defend what Boyle (Chapter 9 in this volume) classifies as a kind sceptical view within this debate. I think non-human animals (hereafter: 'animals') have memories about their past experiences, but these memories are of a distinct kind than human episodic memory. Human episodic memories are organised differently from animal memories. In this chapter, I propose a distinction between perceptual and inferential contents of episodic memory to bring this crucial organisational difference to the forefront. As a first approximation, the perceptual content of memory consists of sensory information about observable

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elements and their relations taken from an experience. Inferential content, however, consists of unobservable relations that are inferred, such as temporal, causal, and teleological relations among past events. In my view, to reconstruct an episodic memory of a personal experience is to establish these types of *inferential relations* between past events. I argue that although animals have memories with perceptual content, only humans have episodic memories with perceptual contents organised by inferential contents.

In Section 10.2, I begin with a brief overview of the uniqueness debate. Then, in Section 10.3, I propose a distinction between perceptual and inferential contents of memory. Finally, in the following three subsections, I go over three different types of inferential contents in detail with an eye towards whether animals can make temporal, causal, and teleological inferences. I show in each case that, so far, there is no evidence either in memory or in other cognitive domains that animals can make these types of inferences.

10.2 Is episodic memory uniquely human?

Endel Tulving (1972) originally defined episodic memory as a capacity to recollect personal experiences that involve remembering what, where, and when something happened. This content-based definition is known as the WWW criteria. Tulving (1985) himself abandoned the WWW criteria before any empirical study of episodic memory in non-human animals, as it is neither necessary nor sufficient for episodic memory (Suddendorf & Busby 2003). On the one hand, WWW content is not necessary because one can remember an experience even if one cannot remember where or when it happened. For instance, even though I can remember a present that I received on one of my birthdays, I may not be able to remember which birthday it was. On the other hand, WWW content is not sufficient either. One can know what happened and where and when without remembering the experience. For instance, everyone knows where and when they were born, but no one remembers their birth. It seems as though the WWW criteria fail to capture distinctive aspects of episodic memory.

Yet, this did not stop comparative psychologists from adopting the WWW criteria to reveal that animals can also satisfy it. Perhaps the most famous example is Clayton and Dickinson's (1998) ingenious study on scrub-jays' caching and retrieval behaviour that demonstrated that these animals can form memories of what, where, and when food was cached. Clayton and Dickinson utilised scrub-jays caching and recovering behaviour for food items that do perish and that do not perish over a retention interval. Birds learned that worms but not nuts decay over a 124-hour retention interval in several training trials. In the test trials, then, birds were given a choice between locations where they had hoarded worms (their preferred food) and locations where they had hoarded nuts. Birds preferred worms over nuts at 4 hours as their preferred food item. However, birds reversed their preference at 124 hours, when worms were degraded. Clayton and Dickinson interpret their results to show that birds remember what

they cached (worms or nuts), where, and when they were cached. They argue that jays have a memory system akin to episodic memory, which they call episodic-like memory.

Although there may be some exceptions, it would be fair to say that philosophers are generally sceptical of rich interpretations of results such as these. At the far end of the spectrum, *capacity sceptics* argue that animals do not have any memory capacity. Hoerl and McCormack (2019), for instance, argue that animals are cognitively stuck in time, and they have no way to revisit the past. They think it is possible to explain away results such as Clayton and Dickinson's without postulating any memory capacity.

Others hold more moderate positions, which Boyle (Chapter 9 in this volume) refers to as *kind sceptics*. Unlike capacity sceptics, kind sceptics accept that animals have various memory capacities. However, they argue that the memory capacities of animals are different in kind from that of human episodic memory. In earlier work (Keven 2016), for instance, I propose a functional distinction between event and episodic memory. In my view, event memory is a snapshot-like memory for a change in the state of affairs, whereas episodic memory is a story-like memory for a course of events. I argue that the mnemonic abilities of animals (and young children) can be more appropriately captured by the notion of event memory. Mahr and Csibra (2018) concur to a large extent, although they have slightly different views about how to carve up this distinction. I will return to the event and episodic memory distinction in more detail later in the chapter.

Malanowski (2016) takes a different approach and raises a compelling line of ecological criticisms against Clayton and Dickinson's (1998) results. Based on evidence from the natural ecology of scrub-jays, she argues that scrub-jays do not need to remember what is cached and when they cached it in their natural habitat. She suggests that it is unnecessary to remember what is cached because observations in the wild reveal that scrub-jays exclusively cache either acorns or pine nuts depending on their respective regions (DeGange et al. 1989). It seems futile to keep track of what is being cached on each site if the food items are all the same. It is also unnecessary to keep track of when a nut is cached either, as nuts are not perishable. Even though scrub-jays eat worms, generally, they do not cache such perishable food items in the wild. They even check the quality of nuts before caching them to avoid spoilage from cracked or otherwise defective nuts. So, scrub-jays are quite meticulous.

Another reason why Malanowski thinks it is unlikely that scrub-jays would remember when they cached an item is their reburial behaviour. Scrub-jays frequently visit their cache sites to recover and rebury their caches without eating them. In fact, reburial is highly prevalent, with over 90% of recovered acorns reburied. It seems that, instead of a cognitively demanding strategy such as mentally travelling in time to visit each and every caching event individually, evolution favoured a far simpler behavioural strategy, namely physically travelling in space to revisit each cache site. Reburial helps scrub-jays to assess the quality of their nuts while reacquainting and rehearsing the birds with their

locations. Taken together, it seems that merely a capacity for cognitive maps would be sufficient for scrub-jays. There is no biological need for episodic recollection in the natural ecology of scrub-jays.

According to Malanowski, researchers need to be wary when interpreting results such as Clayton and Dickinson's (1998). In her view, what an animal can do in an experimental setting needs to be double-checked against what they actually do in their natural ecology. If the relevant cognitive capacity is unnecessary in the wild, this raises the spectre that laboratory animals might find other ways to succeed in the experimental setting. Here, experimental training and participation in prior experiments could be the likely culprits. For instance, she points out, the scrub-jays used in Clayton and Dickinson's study had been involved in two other studies, each with its own training and pre-training periods. Needless to say, scrub-jays are quite intelligent creatures. So, it is likely that these experiment-savvy birds have learned that they can receive rewards if they perform in the way that the experimenter wants them to perform. And the sheer amount of training that these experiment-savvy animals receive before each task makes it difficult to figure out how they actually succeed in any given task. This becomes especially worrisome when their less experimentally savvy counterparts in the wild have no need or use for the purported cognitive capacity.

Kind scepticism offers a plausible resolution to the debate. It suggests a viable way to reconcile a large body of evidence in comparative psychology with the arguments of mental time travel theorists. However, Boyle (Chapter 9 in this volume) argues against kind scepticism and defends *kind pluralism* instead. In her view, there can be more than one way to delineate cognitive kinds depending on different theoretical interests. According to Boyle, comparative psychologists should spread their nets widely to find how much episodic memory is shared across species. Therefore, she argues that comparative psychology could benefit from a sparser characterisation of episodic memory to be more inclusive. I agree that comparative psychology could benefit from such a characterisation, but that sparse characterisation deserves its own name to avoid unnecessary terminological confusion. In fact, kind sceptics already offer a sparse characterisation, namely event memory, and carefully distinguish it from episodic memory.

Boyle, however, insists on calling that sparse characterisation episodic memory and argues that kind sceptics set the bar too high when they define episodic memory. She seems to overlook the opposite problem, though. If comparative psychologists operate with a sparse characterisation of episodic memory, there could be instances where some animals thought to have episodic memory may not actually have it. If researchers set the bar too low, then there could be many false positives. Among other potential problems, this could have detrimental effects for biomedical fields in which animals are used as model organisms. Although Boyle downplays this aspect of comparative psychology, one of the most important theoretical contributions of comparative psychology is to help identify model organisms. It is not possible to figure out where to set the bar unless we can distil the essential features of episodic recollection. In what follows, that is what I shall do.

10.3 Perceptual and inferential contents of episodic memory

To remember a personal experience is to reconstruct a mental state with content. It might be helpful to distinguish perceptual and inferential components of this mental content. When I remember an experience, a significant part of what I remember consists of sensory information such as colours, shapes, movements, and various other features. For instance, I remember working hard for my logic final. When I inspect this memory, I remember my dorm room, table, chair, bed, and so on. I also vividly remember the thick black logic textbook, jotting down notes and proofs on its pages all night. All of these places and objects that I remember constitute the perceptual content of my memory.

Crucially, perceptual content is limited to *observable* elements and their observable relations. When I remember my dorm room, the things that I remember were available for inspection in the original experience. I use the term ‘observable’ quite liberally to include any feature that can be assessed or measured by some sensory modality. For example, I could visually inspect the spatial relationships between different pieces of furniture and see that my bed was *next to* my cupboard, and my desk and my chair were *in front of* the bed. I can also estimate the distance between various items if need be. All of these items and their spatial relationships were perceptually available to me at the time. Perceptual content of memory does not include any information over and above what was perceivable in the original experience.

In earlier work (Keven 2016), I refer to memories based on perceptual content as event memories.¹ Event memory is supported by a growing body of evidence on dynamic cognition that reveals that humans track changing features in their environment, individuate their perceptual experience in terms of discrete events accordingly, and better remember these events in turn (for a review, see Radvansky & Zacks 2014). It is not possible to repeat my arguments and evidence here, but a brief recap might be helpful.

Event memory provides a perceptual record of a change in the *state of affairs*. For example, suppose a creature encounters a predator. This is a notable change in the current state of affairs: The situation has changed from safe to dangerous. The predator’s appearance is thus an event for the creature. Events can be discriminated at a fine grain by tracking every minor change, or they can be discriminated at a coarse grain by tracking only major changes. Various organisms can discriminate different events at different grains of segmentation, depending on their capacities, tasks, needs, upbringing, and so on. For instance, many migrating animals track changes in the earth’s magnetic field as a guide to navigate, but, for us humans, such a feat is not even conceivable. We, humans, parse bodily movements of our conspecifics into recognisable and discrete intentional acts to navigate our complex social world. To each their own.

Event memory utilises snapshot-like depictive representations. These snapshots are likely to be instantiated by using some form of mental imagery (e.g., Kosslyn 1994). Snapshot-like representations can be quite valuable for memory as they preserve much implicit information that can be recovered retrospectively.

From a snapshot, it is possible to retrieve a piece of information that was not explicitly considered during encoding. For example, how was the furniture layout in my dorm room? That was not part of my recollection initially, but I can visualise the room to answer. The layout information is implicit in my mental snapshot of the room, even though it was not considered at the time of encoding.

Whereas event memory provides snapshot-like records of a change in the *state of affairs*, episodic memory is primarily concerned with *course of events*. Thus, an entirely different kind of content is required to bind various events into a unified episode. In my view, to construct an episodic memory of a personal experience is to establish certain *inferential relations* between past events. In particular, these inferences can be temporal (e.g., event X happened before/after event Y), causal (e.g., event X occurred because of event Y), and/or teleological (e.g., event X occurred to bring about event Z). Episodic recollection, therefore, goes beyond perceptual content and snapshot-like depictive representations.

To give a simple example, reconsider the logic class example. To reconstruct such a straightforward memory, a bewildering array of inferences needs to be made. Besides retrieving perceptual contents of events, the memory systems need to infer across temporally distant events that I worked before the final, not afterward, that I worked hard because of the final and that I worked hard to pass the course. These types of temporal, causal, and teleological inferences bind a sequence of events into an episode. In my previous work (Keven 2016), I refer to this inferential process as *narrative binding*, as it is closely tied to our uniquely human storytelling capacities. These types of narratively bound episodes are the primary bearers of the inferential content of episodic memory.

Crucially, these inferential relations between events are not directly observable and cannot be provided by perceptual experience alone. In the logic class example, all I perceived was a series of perceptually distinct events scattered over different times and places. I took the final one day after I worked, I worked in my dorm room but took the final in a classroom, I passed the course many days after the final, and many other events happened before and after taking the final. So, constructing episodic memories requires selecting a specific set of events from memory. These are then placed into a sequence by establishing the proper temporal, causal, and teleological relations between those events. In other words, at its base, to reconstruct an episodic memory of a personal experience is to bind perceptually scattered events into a sequence of events. Event memory can support making these inferences by providing a temporary buffer for the construction of episodic memories. Unlike event memory, however, the mental states of episodic memories include both perceptual and inferential contents.

10.3.1 Temporal information and memory

It might be helpful to go over these inferential relations in more detail. Let me start with temporal information, which is the most basic inferential content type. Remembering when an event happened is usually treated as if it is a unitary

construct. However, there could be many different ways to encode temporal information. Friedman (1993) distinguishes three different types of temporal information that can be utilised in memory. Firstly, one can track how long ago an event occurred. This type of temporal information provides a record of the distance of an event from the present time. It is generally referred to as *elapsed time*. Secondly, one can remember when an event occurred within a time scale. This is akin to a temporal tag such as a date that locates an event in a time frame, such as a calendar. Following Friedman (1993), I refer to it as *chronological time*. Finally, one can remember the order in which two or more events occurred in time. This is remembering whether an event happened before or after another event. I will use the term *sequential time* to refer to this third kind of temporal information.

For recent events, we can remember all three types of temporal information at the same time. We can easily remember how long ago an event happened, which date it happened, and whether it happened earlier or later than some other events. However, as time passes, these different types of temporal information deteriorate at different rates. Although sequential time seems to be the most stable of the trio, it is still possible to confuse the temporal order of various events, especially when the events are distant in time. Similarly, as time passes, elapsed time tends to lose its precision quickly, whereas chronological time is likely to be forgotten entirely. In fact, many studies reveal that chronological time is a very poor retrieval cue for the memory of an event (Barsalou 1988; Brewer 1988), which suggests that memories are not time-stamped during encoding. So, I will focus only on elapsed time and sequential time information, as chronological time does not seem relevant for memory.

Aside from different rates of deterioration, elapsed time and sequential time differ from each other regarding their content type. Whereas sequential time is inferential, elapsed time information appears to be perceptual. Elapsed time information can be observed or measured by two main sensory mechanisms (Staddon 2005). The first one is based on circadian rhythms, which is the daily cycle that governs feeding, sleeping, and other activities based on light onset and offset. The other one is interval timing, which can track how much time has passed since a particular event at intervals on the order of seconds and minutes. The exact nature and neural mechanisms of interval timing are debated, but according to a popular theory, interval timing is based on the accumulation of pulses emitted from a pacemaker (Gibbon 1977, 1991). Regardless of whether elapsed time information is based on observations of day and night cycles or whether an interval timing mechanism measures it, its content appears perceptual. Unlike elapsed time, however, sequential time cannot be observed or measured. The essential difference between elapsed and sequential time is that the temporal order of events is an *ascribed* relationship that needs to be inferred from memory after the fact.

Sequential time can be inferred based on many different types of information. One obvious candidate is the elapsed time itself. If elapsed time information is available for two events, based on the difference in elapsed time, it would be possible to infer which event happened earlier. These types of inferences can be

beneficial when ordering recent events. Another strategy might be to use a salient event as a temporal marker and infer whether a particular event happened before or after that salient event. Such a strategy might be helpful for distant events. In some cases, it can be possible to exploit typical or logical relations between events. For instance, for the logic class example, it is possible to use typical relations such as people generally study before an exam, not afterward; taking the final is usually required to pass a course; and so on. Semantic memory can assist these types of inferences. Naturally, these different methods of inferring sequential time are not exclusive; they can be used in tandem to strengthen the inference. This is not meant to be an exhaustive list either; there could be other ways to infer sequential time as well.

Episodic memory reconstructions would cease to be about past experiences if they did not have sequential time content. Memory reconstructions would turn into a hodgepodge of events with no resemblance to the actual experience if the events do not unfold in their proper sequence in time. Without sequential time content, memory reconstructions would represent past experiences as much as a scrambled jigsaw puzzle represents its printed picture. Even if you have all the pieces, those pieces cannot represent the whole picture if they are not placed in the right place. Similarly, even if you remember all the events, those events cannot represent your past experience unless placed in the proper temporal sequence. To turn this hodgepodge of events into episodic memory, past experiences need to be organised in a memory reconstruction representing when specific events occurred in relation to each other. It is, therefore, this inferred sequential time that gives memories their episodic quality (cf. Cheng & Werning 2015).

Can animals infer sequential time in their memory reconstructions? Ample evidence indicates that animals are sensitive to time. For example, they can learn to go to specific places for food at a particular time of the day or learn to measure short periods precisely. However, closer scrutiny of these and similar cases reveals that their temporal sensitivity is based solely on elapsed time information. It is beyond the scope of this chapter to review all the relevant evidence (for such reviews, see Hoerl and McCormack 2019; Martin-Ordas 2020; Roberts 2002). Here I will consider just one example to illustrate how explanations usually go.

Let us return to Clayton and Dickinson's (1998) work with scrub-jays. Clayton and Dickinson's results have been interpreted to suggest scrub-jays can remember when an event happened. However, as we have seen, there are different types of temporal information that can be utilised in memory reconstructions. The critical question to ask here is whether scrub-jays use elapsed time or sequential time information. In Clayton and Dickinson's task, there is no need to encode caching events in relation to each other to reconstruct a temporally organised memory. If scrub-jays can keep track of how much time has passed since they cached worms, they can retrieve worms within a specific interval and retrieve nuts otherwise. Therefore, elapsed time information would be more than enough to succeed in this task. Scrub-jays only need to learn that a particular interval time is a good predictor of edible worms. And, as Malanowski (2016)

points out, these highly intelligent and experiment-savvy animals go through many training trials to pick up these types of subtle cues, and they are highly motivated to do so. Therefore, scrub-jays in Clayton and Dickinson's study could only be using elapsed time information (for similar explanations, see Hoerl & McCormack 2019; Keven 2019).

Episodic memories are essentially temporally ordered. Sequential time provides the most basic form of inferential content, which binds events in episodic memory. Without such content, it is hard to see how a creature could construct episodic memories. I argued further that so far, there is no evidence to suggest that animals can use sequential time information in their memory reconstructions.

10.3.2 *Causal inferences and memory*

Inferences based on sequential time arrange events as one event following another. This is quite different from inferring that an earlier event causes a later event. Since causes precede their effects, in a sense, sequential time content is a prerequisite for causal inferences. But reconstructing episodic memories requires more than mere temporal ordering.

Consider the logic class example once again. The content of my memory includes more than me studying and then taking the final and passing the course. I do not just remember these events happening one after another, as mere temporal succession would have it. Crucially, my memory also incorporates the proud fact that I passed the course *because* I studied hard. Without this causal content, my memory would lack a crucial ingredient. Many memories include these types of cause-effect relations. I remember being late for a class because my alarm did not ring, I remember being stuck at home because of the coronavirus pandemic, and so on. In all of these and like cases, events are routinely causally related to each other in memory reconstructions, and the causal content of memory plays a vital role in binding events.

Various theories have been proposed to explain the psychological basis of causal inferences. On the one hand, according to one strand of theorising in psychology, humans infer the causes of events by identifying the pattern of elements that covary with the target effect (Cheng & Novick 1992). The idea behind the covariation approach is that a cause is an element that is present when the effect is present and absent when the effect is absent as well. Thus, the covariation approach is especially suited for learning new causes by identifying the pattern of elements that covary with the target effect. However, it seems ill-suited for memory reconstructions because episodic memories are generally about unique one-time occurrences. This makes observing a covariation difficult. On the other hand, according to the mechanistic approach to causal reasoning in psychology (Ahn & Kalish 2000), two events are causally related to each other when a plausible mechanism capable of transmitting causal power in that particular situation is recognised, recalled, or imagined. This process generally involves postulating a *causal mechanism* that explains the transmission of causal power.

The covariation and mechanism approaches are the two main views on causal inferences in psychology. In philosophy, David Lewis's (1973) influential counterfactual theory of causation offers a third, and perhaps the most plausible, alternative. According to the counterfactual theories of causation, if a later event is causally dependent on an earlier event, then the later event could not have happened without the earlier event. In other words, if the earlier event had not occurred, the later event would not have happened. That was certainly the case for my logic final. I know that had I not studied hard that night, I could have failed the course. Note that earlier events may not be sufficient to bring about later events, as there may be other causes. I did not pass logic solely because I studied for the final. I also attended all the classes, took the midterm, and so forth. But earlier events are counterfactually necessary for the occurrence of later events.

Covariation, mechanism, and counterfactual views all offer different but somewhat related ways to infer causes. And there are other theories of causation as well. It is hard to discern which approach is utilised in memory reconstructions, as there may not be an exclusive strategy. Instead, it is more likely that different methods (or various combinations of them) are employed in different recollections. However, it is worth mentioning that the counterfactual approach is the most plausible candidate in the case of episodic memory. The ability to construct possible events that could have happened in our past but did not happen is called *episodic counterfactual thinking*, which is psychologically and neurologically affiliated with episodic recollection (De Brigard et al. 2013). Episodic counterfactual thinking can help discern counterfactual dependencies between past events. When people reminisce about their past experiences, it is quite natural to wonder whether a later event could have occurred if an earlier event had not occurred. In our recollections, whereas some events seem to occur in due course, others seem to depend on the occurrence of certain events. Perhaps causal inferences in memory reconstructions are based on these types of episodic counterfactual thinking.

Can animals make causal inferences? A large body of evidence has accumulated on causal reasoning in comparative psychology since Wolfgang Kohler's famous studies at the turn of the last century on the ability of chimpanzees to stack boxes to reach an overhanging banana. Many animals are sensitive to causally relevant features, especially in the domains close to their natural tool-using behaviour. However, despite their sensitivity to causally relevant features, they usually fail to make causal inferences to unobservable features for outcomes they have observed. For instance, Povinelli and colleagues systematically studied chimpanzees' understanding of physical causal mechanisms (Povinelli 2000). They concluded that when various tool-use tasks are carefully reconstructed to tease apart observable and unobservable relations, chimpanzees predominantly focus on the observable relations and ignore unobservable causal mechanisms. Schloegl and Fischer (2017) provide an overview of more recent studies on causal reasoning in animals. Like Povinelli and colleagues, they also concluded that many animals, including most apes, have a relatively limited understanding of cause-effect relationships between two objects even though they are sensitive to causally relevant features.

To give one striking example, Call (2007) studied apes' understanding of how hidden objects influence the orientation of other objects. In one study, a food item was hidden under a small board. Given a choice between an inclined board and the other lying flat on the ground, the apes showed a clear preference for the inclined board. So, they seem to be aware that objects can influence the inclination of other objects. In the next phase of the study, the apes were allowed to choose between a small piece of banana and a large piece of carrot. They clearly preferred the banana. The same food items were then hidden underneath the boards. This time the apes were given a choice between two boards, with the one hiding the large carrot clearly having a steeper inclination than the one hiding the small banana. However, the apes failed to infer where the small banana was. Instead, they went for the board with the steeper inclination. Here a hidden food item needs to be inferred from the board's inclination, but apes fail to make this inference despite their awareness that objects can influence the inclination of other objects. Thus, the inclination of the board covaries with the size of the food item hidden behind; the larger the hidden item, the steeper its inclination will be. Apes, however, seem to be oblivious to this particular covariation relation.

Animals' causal reasoning over object-object relationships seems to be rather limited. Based on these types of evidence, what can we say about their causal reasoning abilities over event-event relationships from memory? It is quite likely that animals' causal reasoning over event-event relations would be even worse because causal reasoning over object-object relations is not as cognitively demanding as causal reasoning over event-event relations. First of all, causal reasoning over object-object relationships involves objects that are present, whereas event-event relations involve working on events that are absent. Although the food items were hidden, the boards and their respective inclinations were perceptually available to the apes to visually inspect in Call's study. In contrast, causal inferences in memory involve reasoning about event-event relationships among mental representations that are not perceptually available anymore. Unlike object-object relationships, event-event relationships are ephemeral. Episodic memories consist of unique one-time experiences that are non-recurring. So, in contrast to causal reasoning over object-object relations, an extra memory demand is added in the case of causal reasoning over event-event relations.

When I remember the logic final, none of the perceptual content of my memory is directly available to me anymore. Yet when I remember, I can causally infer that my behaviour in my dorm room caused my performance in the classroom and consequently resulted in my grade. Here, inferences form a causal chain across different times and places, in which one cause triggers an effect that triggers another one. These inferences are carried out on mental representations of events that lasted a short amount of time, never recurred, and are long gone. Yet, those ephemeral and nonrecurring events without any perceptual overlap are causally connected through the inferential content of my memory.

The second reason why causal reasoning over object-object relations is not as cognitively demanding as causal reasoning over event-event relations is that

there is no temporal distance between cause and effect in the former case. In Call's study, for instance, the food items immediately cause differences in inclination when placed behind the boards. This may seem like a trivial observation, but it becomes quite significant when considering causal inferences from memory. As the temporal distance between cause and effect increases, it becomes harder to infer a causal relationship between them. One can almost perceive causality in events such as a billiard ball striking another. In contrast, it is challenging to establish a causal relationship between, say, smoking and lung cancer, where the effect appears years later. Although causes can be immediately followed by their effects in some cases, events have their effects delayed in many others. Therefore, it is much more challenging to decipher the cause of an event among many different circumstances and many different events that precede it.

10.3.3 Teleological inferences and memory

So far, I have considered temporal and causal inferences in memory. In this section, I will consider the last inferential content type, namely teleological inferences. Memory reconstructions are infused with teleological inferences simply because remembered events include various actors doing things with specific goals in mind. People remember themselves and others doing things for reasons, which are revealed through their beliefs and desires. In fact, human memory seems to be tuned to remember living creatures (Nairne, VanArsdall, & Cogdill 2017). Animacy is a critical cue for human episodic memory because the animacy status of an item seems to be one of the best predictors of its later recall. Across many different studies, people remember living targets better than matched non-living targets.

Whenever I remember something that I did or witness something that someone else did, a resort to teleological explanation is inevitable. A teleological explanation of why an event occurred is to say that it occurred *so that* a second event should occur or in order to produce a specific result. For instance, the man ran in order to catch the train. Here, the second event, catching the train, is the goal of running. Like causal inferences, teleological inferences also seek to answer the why-did-this-happen question. However, teleological inferences accomplish this by answering a prior what-is-its-goal question. They generally involve invoking psychological causes, namely mental states, to achieve this. For example, I worked hard for my logic final simply because I *wanted to* pass the course. To explain something teleologically is to cite the goal towards which it is naturally tending. Teleological explanations have a forward-looking character in this sense.

Two features of teleological inferences are worth emphasising. Firstly, teleological inferences characteristically involve attributing mental states such as beliefs, desires, suppositions, aims, drives, needs, and so forth. Mental states help explain what an actor is trying to do, what state of the environment she is trying to bring about, and what her goal is. If you see a man running towards the train station as a train is approaching the station, you infer that the man *wants to* catch the train. Here an unobservable mental state establishes a connection between two observed

events. Similarly, what connects the events of studying in my dorm room and passing the course weeks later is an unobservable mental state. These events are spatiotemporally distinct, but they are connected in memory via my mental state of wanting to pass the course, which binds my memory into a whole. I wanted to pass the course, studied hard, and finally did it. Teleological inferences attribute mental states to establish relationships between observed events.

Secondly, teleological inferences are *recursive*. Recursion allows humans to embed different levels of mental representations when reconstructing the past (Redshaw & Suddendorf 2020). To be clear, some recollections can consist only of a simple goal that is achieved based on one attempt, and no recursion is needed in such a memory reconstruction. But more often than not, memories consist of more challenging goals and require a plan accompanied by a series of attempts until the desired outcome is reached. These plans usually involve devising subgoals, and in some cases even sub-subgoals, to overcome the obstacles encountered along the way. Several studies have shown that humans can represent up to five orders of embedded reasoning about mental states (Oesch & Dunbar 2017). If an attempt to achieve a goal fails, a new plan must be made to achieve the goal. These types of struggles with a back-and-forth between attempts and failures make great memories afterward. Passing the logic course was such a struggle for me, making my last-ditch effort at the end of the semester all the more memorable for me.

Can animals make teleological inferences? We can try to answer this question step by step by looking at whether animals can attribute mental states first, and then we can ask whether they can reason recursively. In a seminal paper, Premack and Woodruff (1978) asked whether chimpanzees can attribute mental states to others, and one of the most famous debates in comparative psychology ensued. Unfortunately, the debate could not produce a satisfactory answer to this question after over 40 years. I agree with Heyes's (2015) assessment that after countless studies on whether animals can understand various mental states carried out by different research groups, research methods, unfortunately, lost their vigour and rigor over time, and the debate stalled.

The animal mind-reading debate produced a plethora of findings that are difficult to interpret in their entirety. Although proponents favour rich interpretations (Call & Tomasello 2008) and sceptics continue to defend lean interpretations (Penn, Holyoak, & Povinelli 2008), both sides agree that mind-reading capacities of chimpanzees and other animals are nowhere near the belief-desire psychology of humans. It seems unlikely that animals can attribute unobservable mental states such as beliefs and desires to other animals. Nonetheless, some animals are quite socially savvy. Especially in food competition contexts, some animals can act in accordance with what a competitor animal can see or know (e.g., Clayton et al. 2007; Hare et al. 2006). Although these types of evidence do not support an explicit mind-reading capacity, they point towards the presence of some implicit social competence. Therefore, recent years have seen an increased interest in dual-process accounts that distinguish various implicit forms of behaviour-reading from explicit mind-reading abilities to reconcile

these discrepant findings (for examples, see Butterfill & Apperly 2013; Gómez 2007; Whiten 1996). These kinds of dual-process accounts offer a promising avenue for future research.

Can animals embed events within events in a goal plan hierarchy? Recursion in animal cognition became a contentious issue after Hauser, Chomsky, and Fitch (2002) declared it the property that makes language uniquely human. Since then, it is debated whether animals' abilities in non-linguistic domains, such as hierarchical reasoning abilities in the navigation or tool-use tasks or their knowledge of dominance hierarchies in matrilineal kin groups, can count as evidence of some form of recursion in the animal kingdom (Parker 2006). Resolving the debate has proven to be difficult because, empirically, it is hard to distinguish recursion from similar processes such as embedding, iteration, and cognitive grouping (Martins 2012). However, it seems clear that no animal communication system exhibits true recursion in the sense of hierarchical embedding of linguistic structures (Corballis 2007; Jackendoff & Pinker 2005).

Taken together, these results suggest that animals would be highly unlikely to attribute mental states to establish event-event relations and embed events within events in a goal plan hierarchy. To reconstruct a goal sequence requires parsing an actor's behaviours in a way as to infer what the actor tries to achieve with that particular behaviour. Without an explicit mind-reading ability, animals cannot parse a continuous stream of behaviours into discrete actions by assigning them mental states to render them intentional. Moreover, without a capacity for recursion, it is not possible to turn these discrete actions into a hierarchically embedded goal sequence in which various subgoals and sub-subgoals are devised to achieve a principal outcome. Therefore, it seems highly unlikely that animals can make teleological inferences in their memory reconstructions.

10.4 Conclusion

In this chapter, I distinguished the perceptual and inferential contents of memory and analysed three different types of inferences that are essential in episodic memory reconstructions. I argued that to show that animals have episodic memory requires showing that their memories also have inferential content, that they can remember whether a specific event happened before or after another one, that they can distinguish which one caused the other and why these events happened. In other words, to show that animals can remember episodically at a minimum requires to show that animals can make temporal, causal, and teleological inferences. The evidence for memory-like abilities in animals only shows that animals can retain and retrieve perceptual content for some time. So far, however, there is no evidence of inferential content in animal memory.

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Note

- 1 Rubin and Umanath (2015) also use the term ‘event memory’ to distinguish memories based solely on scene construction from episodic memories that are event memories accompanied by a sense of reliving involving the self. Actually, ‘scene memory’ would be a more apt term for their theory, as they are more concerned with scenes rather than events. Regardless, it seems that we both share the same intuition that there is a more basic memory type than episodic memory. However, we disagree as to the nature of that basic memory type. Rubin and Umanath take scene construction as fundamental. In contrast, I think we can go even lower, all the way down to perceptual event segmentation processes and reserve constructive processes for episodic memory. Moreover, they think the main difference between episodic and event memory is the presence or absence of autoeic consciousness. In contrast, I think episodic memories require an entirely different kind of organisation than event memories based on a different kind of binding process

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