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Bridging Philosophy and Neuroscience: How Behavioral Experiments Inform a Recent Theory of Animal Consciousness

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Introduction

Consciousness is a loaded term and can mean many different things to different people. Indeed, the ambiguity of the term consciousness is a large part of why many people shy away from studying it in a scientific manner. The goal of this paper is to investigate animal consciousness with an emphasis on rats.

Understanding whether animals have consciousness is an interdisciplinary question that is deeply rooted in philosophy but also requires behavioral experiments to make progress. To answer this question, we need philosophers who are willing to conduct neuroscience experiments or neuroscientists who are serious about consciousness. I will attempt to bridge the philosophical question about animal consciousness and the neuroscience question about animal behavior together for the purposes of this paper. First, we will investigate different ways of approaching the problem of animal consciousness. Next, we will examine, a recent theory of animal consciousness in detail and examine neuroscientific evidence to support animals possessing the features described in the theory. Then, we will discuss the phenomenon of insight and how it is similar and different to consciousness. Finally, we will examine our behavioral experiment in rats to support insight.

Section 1: Defining Consciousness

Prior to exploring various theories of consciousness, it is crucial to establish a working definition of consciousness. For the purposes of this research paper, we will operationalize consciousness into three distinct categories: phenomenal consciousness, access consciousness, and self-consciousness. While this division is not the only conceivable categorization, it is the framework that we will employ to guide our investigation.

Phenomenal consciousness, sometimes referred to as subjective or qualitative consciousness, pertains to the experiential aspect of consciousness -- the raw sensations, feelings, or 'qualia', associated with conscious experience. For instance, the unique, unexplainable sensation one experiences when witnessing the color red is an instance of phenomenal consciousness. To explain this complex concept, consider the following analogy: Imagine a robot designed to cook food. In order to prevent heat from damaging the robot's components, we install heat sensors, programmed to retreat from excessive temperatures. If the robot encounters a heat source and subsequently retreats, we wouldn't infer that the robot undergoes a painful experience. The subjective sensation, the feeling of pain in response to excessive heat, is missing in this artificial being. This discrepancy points to the essence of phenomenal consciousness, the experiential quality that transcends mere data processing.

The second category, access consciousness, encapsulates our cognitive abilities. This aspect can be described as the cognitive processing that enables information to be accessible for use by higher cognitive processes such as reasoning, planning, and action execution. In other words, access consciousness entails the computational processes that permit conscious entities to respond to their environments in a flexible, adaptive, and purposeful manner.

Lastly, we consider self-consciousness, which refers to the awareness of oneself. This type of consciousness can further be subdivided into several categories: somatic or bodily self-awareness, cognitive self-awareness, and social self-awareness ("*Animal Consciousness,"* 2016). Somatic self-awareness involves the perception of one's own physical body and its states. Cognitive self-awareness, on the other hand, pertains to the awareness of one's own mental states, including thoughts, feelings, and perceptions. Lastly, social self-awareness refers to the recognition of oneself and others within a social context, including an understanding of others' perceptions and expectations.

Each of these forms of consciousness - phenomenal, access, and self - are interconnected and mutually informative, yet distinguishable in terms of their characteristic features and functions. By providing a clear conceptualization of these categories, we set the foundation for a more nuanced and comprehensive investigation of consciousness, particularly in the realm of animal cognition.

Phenomenal Consciousness in Animals

One of the central inquiries in the study of animal consciousness pertains to the question: Do animals exhibit phenomenal consciousness? Inherent in the definition of phenomenal consciousness is its subjective and private nature, which poses a significant methodological challenge. As such, no direct evidence can conclusively verify the existence of phenomenal consciousness in animals. Nevertheless, there are two potentially viable avenues to address this predicament. The first is that if phenomenal consciousness precipitates observable behavioral effects exclusive to its presence, then this could substantiate its existence in animals. Alternatively, if a certain characteristic of a mental state, which inherently leads to phenomenal consciousness, manifests observable behavioral effects, then this could also serve to validate its existence in animals.

The first approach necessitates the rejection of epiphenomenalism about consciousness, the theory which asserts that consciousness does not exert any observable effects. The second approach, however, does not require such a rejection. Provided that we can identify behavioral effects of the mental state giving rise to phenomenal consciousness, we should be able to infer the presence of phenomenal consciousness in animals.

Neuroscientific evidence serves as a compelling starting point for our exploration. Investigations have shown that the MT/V5 region in the brain is integral to motion perception. Damage to MT/V5 in humans has been found to result in a loss of motion perception. Furthermore, when the MT region in monkeys was stimulated while they observed moving dots, the monkeys' motion judgments were affected (Block, 2005). This finding remained consistent across a range of experimental manipulations. Consequently, the MT/V5 region could potentially be considered a neural correlate of consciousness for the 'as of motion perception.' This suggests that monkeys exhibit this particular form of phenomenal consciousness. It is critical to note, however, that this conceptualization posits that phenomenal consciousness is not a binary phenomenon, but rather exists on a continuum.

Although these neuroscientific findings do not definitively establish that animals possess consciousness (as they do not fulfil the specified criteria for any theory of consciousness), they nonetheless provide a strong indication of its possible presence, thereby warranting further in-depth investigation. Additionally, these studies do not conclusively demonstrate that these particular brain regions are solely responsible for the experience associated with a specific stimulus. It is plausible that another system is accountable for the experiential aspect, while

MT/V5 mediates the neurological facets of motion perception required for an experience. Hence, our measurements may not be capturing phenomenal consciousness per se, but rather neural systems that are requisite for specific types of experiences.

The investigation into whether animals exhibit access and self-consciousness will be discussed in subsequent sections due to its extensive nature. It is crucial to note that these facets of consciousness present their own unique sets of challenges and intricacies that require careful consideration and analysis.

Section 2: Different Ways of Approaching Animal Consciousness

Anomalies of Consciousness

To better comprehend the intricate nature of animal consciousness, it is crucial to explore the intriguing anomalies that arise within human consciousness, as they provide invaluable insights and serve as crucial points of reference. These peculiarities challenge conventional notions of awareness and offer a critical lens through which we can investigate and understand animal consciousness. Among the fascinating phenomena that shed light on the complexities of conscious processing, blindsight stands out as a compelling subject of study.

Blindsight, observed in individuals with damage to their visual regions, presents a remarkable condition where patients exhibit evidence of information processing within their visual system despite their inability to consciously perceive visual stimuli (Block, 1995). This phenomenon unveils a distinctive aspect of conscious processing, as it showcases the existence of subconscious awareness and information processing mechanisms operating below the threshold of conscious perception. Understanding the intricacies of blindsight, including the specific brain regions that are affected, becomes essential in unraveling the neural underpinnings of conscious processing.

When investigating blindsight, it becomes evident that the primary visual cortex (V1), responsible for initial visual processing, plays a pivotal role in transforming visual stimuli into meaningful representations that can be consciously perceived. Damage to V1 impairs conscious visual perception within the corresponding area of the visual field (Lebrecht & Tarr, 2011). The absence of conscious visual experiences in patients with blindsight highlights the significance of intact V1 functionality for conscious awareness. By identifying the specific brain regions that are damaged in blindsight patients, we can gain insights into the regions that are likely responsible for conscious processing. This information contributes to our understanding of animal consciousness by shedding light on which brain regions may be crucial for conscious processing in non-human animals.

Furthermore, studying other anomalies in human consciousness, such as prosopagnosia, the condition commonly known as face blindness, can also provide valuable insights into conscious processing. In prosopagnosia, the impairment lies in the fusiform face area (FFA), a region dedicated to processing facial identity (Haeger et al., 2021). Prosopagnosic individuals face difficulties in recognizing familiar faces solely based on facial features. Instead, they rely on alternative cues like voice, mannerisms, or clothing to identify individuals (Block, 1995). Interestingly, this condition does not impair their ability to perceive facial features accurately. Despite their inability to consciously recognize faces, patients with prosopagnosia can discern individual facial details with the same precision as individuals with normal vision. They can even identify faces belonging to the same person when presented with a series of images captured under different conditions (Block, 1995). This indicates the presence of unconscious processing mechanisms, where facial details are perceived and processed without conscious recognition. In addition, the inability to consciously recognize familiar faces in prosopagnosic patients indicates the importance of the FFA in conscious face perception.

Moreover, studies on priming experiments provide compelling evidence that information not consciously processed can still influence behavior and future cognition. This suggests that not all cognitive processes within an organism necessarily reach the level of conscious perception, yet they can significantly impact behavior and cognitive processes. These findings further deepen our understanding of conscious processing and hint at the existence of complex mechanisms operating beyond conscious awareness.

The investigation of peculiarities within human consciousness, such as blindsight and prosopagnosia, opens a gateway to understanding the intricacies of conscious processing and its potential manifestation in animals. By studying the specific brain regions affected in these conditions, we uncover valuable information about conscious processing, paving the way for an in-depth exploration of animal consciousness. These insights broaden our understanding of conscious experiences and contribute to ongoing research aimed at unraveling the mysteries of consciousness in non-human organisms.

Neuroscientific Methods

One method of investigating animal consciousness involves examining phenomena in humans where consciousness is lost and assessing if animals exhibit similar responses. By studying situations where humans lose consciousness but can still utilize information for forced choice tasks, we can explore potential parallels between human and animal consciousness. An effective approach to explore this is through manually induced blindsight, such as by inducing lesions in the primary visual cortex (V1). Studies on monkeys with induced blindsight have demonstrated that they do not report conscious perception of stimuli in their visual field, yet they are able to accurately guess the features of the stimuli in forced choice tasks (Cowey & Stoerig, 1995). These findings suggest that animals may possess the ability to process visual information and utilize it in decision-making tasks, even without conscious awareness.

By employing this method of manually induced blindsight and studying animal behavior in analogous situations to consciousness loss in humans, we can gain valuable evidence regarding the conscious processing capacities of animals. The investigation of whether animals respond similarly to humans in these situations offers insights into potential conscious processing mechanisms in animals. This research approach provides a valuable opportunity to examine the presence of consciousness in animals through analogical reasoning based on human experiences. Expanding upon this line of research, it would be beneficial to conduct further experiments and investigations involving other animal species, such as rats, to explore whether similar patterns of behavior emerge. By systematically examining the response of animals to induced blindsight and assessing their ability to utilize information in forced choice tasks, we can deepen our understanding of animal consciousness and the potential parallels with human conscious experiences.

The method of examining phenomena related to consciousness loss in humans and assessing if animals exhibit similar responses provides a valuable avenue for investigating animal consciousness. Employing techniques like manually induced blindsight and studying animal behavior in analogous situations to consciousness loss offers insights into the conscious processing capabilities of animals. Further research in this direction, including studies involving different animal species, will contribute to our understanding of the nature of animal consciousness and its relationship to human consciousness.

Another method of investigating animal consciousness involves examining cognitive tasks that are closely associated with consciousness in humans and applying them to animals. One such example is trace conditioning, a classical conditioning paradigm widely used in human research.

In trace conditioning, a neutral stimulus (known as the conditioned stimulus or CS) is presented for a brief period and followed by a time gap, known as the trace interval, before the presentation of an unconditioned stimulus (US) that elicits a response (known as the conditioned response or CR). The crucial aspect of trace conditioning is the temporal gap or trace interval between the CS and US, which requires the participant to maintain a representation of the CS in memory during the delay period. This process relies on conscious awareness and active cognitive processes, as the participant must consciously maintain the mental representation of the CS during the trace interval to associate it with the subsequent US.

Trace conditioning has been extensively studied in humans and has provided insights into the cognitive processes associated with conscious awareness and memory. However, its application in animal research is challenging due to the difficulty in directly assessing conscious awareness in animals. Nonetheless, researchers have adapted the trace conditioning paradigm to explore similar cognitive processes and potential manifestations of consciousness in animals.

In animal studies, trace conditioning tasks often involve training animals, such as rats, to associate a neutral stimulus, such as a tone or light, with the delivery of a reward or an aversive stimulus. During the training phase, the neutral stimulus is presented, followed by a trace interval, and then the presentation of the reward or aversive stimulus. Successful learning in trace conditioning tasks requires the animals to maintain a conscious representation of the neutral stimulus during the trace interval to form an association with the subsequent outcome.

Assessing the performance of animals in trace conditioning tasks provides valuable insights into the cognitive processes and potential consciousness-related mechanisms involved. Animals that demonstrate successful trace conditioning, exhibiting a conditioned response during the trace interval, suggest the presence of conscious awareness and the ability to maintain representations in memory over time. Conversely, animals that struggle with trace conditioning or fail to exhibit a conditioned response during the trace interval may indicate limitations in conscious awareness or the cognitive processes required for maintaining representations in memory.

Given these experimental methodologies such as trace conditioning tasks, a foundation for assessing consciousness-related cognitive abilities in animals is laid. By exploring cognitive processes, researchers can gain insights into conscious awareness, memory, and the ability to maintain mental representations over time. However, understanding the full complexity of animal consciousness goes beyond experimental evaluations alone.

The multifaceted nature of animal consciousness necessitates an integrative approach to its study. Through different lenses such as evolutionary biology, neurobiology, and behavioral science, we can start to piece together a more holistic understanding of this complex phenomenon. This broad perspective complements and enriches the findings of experimental methodologies, providing a comprehensive view of animal consciousness.

From an evolutionary perspective, it is crucial to acknowledge that consciousness is not a binary attribute, but rather, it may exist on a spectrum, possibly emerging gradually through different stages of evolution (“*Animal Consciousness,”* 2016). It could be argued that consciousness arose with the evolution of complex brains, particularly those capable of self-awareness and advanced cognitive processing. However, it's essential to note that consciousness may not be an all-or-nothing attribute, and that simpler forms of consciousness may have existed in earlier evolutionary stages. Consequently, it is potentially overly simplistic to group all non-human animals together as either possessing or lacking consciousness, considering the vast array of cognitive abilities and sensory experiences present across different species.

The neurobiological perspective emphasizes the structural and functional similarities between human and non-human animal nervous systems as evidence for the possible existence of animal consciousness (“*Animal Consciousness”*, 2016). For instance, the study of pain in rats provides compelling evidence due to the shared neurobiological mechanisms of pain pathways. Furthermore, the similar effects of pain-relieving drugs across species, and the analogous behavioral impairments observed in humans and monkeys with damaged visual cortexes, both support this viewpoint (“*Animal Consciousness”*, 2016). However, it should also be noted that structural and functional similarities do not guarantee identical subjective experiences, given the significant differences in brain complexity and processing capabilities across species.

Lastly, the behavioral perspective relies on observable behaviors as indicators of potential consciousness (“*Animal Consciousness”*, 2016). For instance, pain-related cognitive impairment, observed both in humans and rats, can be mitigated with analgesics. Such behavioral parallels suggest the presence of a degree of conscious experience in animals, consistent with the inferential view of consciousness attribution. Nonetheless, it should be kept in mind that behavioral similarities do not unequivocally prove the presence of similar conscious experiences, as behavior can be influenced by a variety of factors, including instinctual and conditioned responses.

Through the integration of these various perspectives, a comprehensive and nuanced understanding of animal consciousness can be achieved. However, it's important to recognize the challenges and limitations inherent in each approach, as the exploration of consciousness involves probing deeply into experiences that, by nature, are not directly observable or fully knowable.

Philosophical Methods

The questions surrounding animal consciousness present a plethora of issues for both philosophical and scientific consideration. These issues intersect with our intuitions about animals' cognitive states and our philosophical theories that speak on the matter. One key question that has been posed is whether philosophical constructs regarding animal consciousness should mold our intuitions about animal consciousness, or should it be the other way around? Should our philosophical tenets that back a particular viewpoint - for instance, an animal lacking consciousness - bear more significance than our experiential interactions with the said animal that seem to suggest they are indeed conscious?

To unravel the problem of animal consciousness, some approaches lean on human intuitions, which are commonly classified into two main views: perceptualism and inferentialism (“*Animal Consciousness”*, 2016).

Perceptualism posits that we can directly perceive the mental states of others, with these mental states forming a component of our perception. This suggests that "mental states are manifested in modes of action." For instance, when we see a person crying, we ascribe the mental state of sadness to them, because, in this view, mental states are integral to our perception. However, perceptualism runs into several issues. Consider a situation where a man cries after witnessing a dog's death, and this event is observed by two individuals. The first individual, from a culture that reviles dogs, interprets the crying as an expression of joy. Conversely, the second observer, from a dog-loving culture, views the crying as an outpouring of sorrow. In the frame of perceptualism, the crying man simultaneously exhibits both happiness and sadness - a paradoxical situation. Further complications arise when we consider animals drastically different from us, like spiders. How are we to quantify and understand the perceptual or mental states of such creatures? Daniel Dennett suggests that perceptualism can lead to illusory interpretations, but it could be argued that just as photographs don't diminish our understanding of physical objects, perceptual illusions should not completely discredit our understanding of others' mental states (“*Animal Consciousness”*, 2016).

Inferentialism, on the other hand, posits that our understanding of others' mental states comes from observing behaviors and inferring the associated mental states. This view suggests that we never directly perceive the mental states of others but make educated guesses based on behavioral cues. However, inferentialism also has its problems. For example, if one were to look outside and see a child crying with blood on her leg, inferentialism might suggest that there is no justifiable epistemic warrant for the belief that the child is in pain, since the mental state of "pain" is an inference made from the visual cues of the distress on the child’s face and blood. This can lead to a seemingly endless loop of skepticism about the reliability of our perceptions and inferences.

These two perspectives, along with others, continue to frame the discussion on animal consciousness. Balancing intuition, direct perception, and inference is a challenge, and the complexity of the task is further amplified when studying animals with cognitive systems vastly different from our own.

Section 3: Theory of Animal Consciousness

One recent theory of consciousness attempts to create a consciousness profile for different animals in an effort to create a formalized system of determining how consciousness an animal is. Although animals cannot be compared to one another unless one is greater in every category. Categories are perceptual richness, emotion, untity, integration across time, and self-consciousness (Birch et al., 2020). They propose that consciousness in animals is not a binary state but rather a spectrum and there is no way to determine which category should be given more weight than another.

If we wanted to try and compare the relative phenomenal consciousness of species, we would run into some complications. If we compare two animals: A and B and A had more phenomenal NCC than B we would not be able say that A is more phenomenally conscious. That is because this would also assume that each phenomenal NCC is weighed equally. However, there is no way of knowing if the phenomenal experience of color for example should be given more, less or equal weight of the phenomenal experience of motion. Also, it could be possible that one organism has more information for a given phenomenal experience. For example, one organism may have a larger field of vision than another or one organism may see more colors than another. When comparing two animals, only if one animal has phenomenal NCC that encompass all the phenomenal NCC of the other animal can we say it is more conscious.

Let’s delve into each category a little more and investigate the aspects to his animal theory of consciousness.

According to Birch and his team’s theory of animal consciousness, the complexity and richness of an animal's sensory perception – its P-richness – is a vital aspect of its overall consciousness. Consciousness, in this view, is essentially the subjective experience of the world, formed and shaped by the diverse array of sensory inputs and how they are processed and interpreted.

Each animal species has its unique set of sensory modalities – visual, auditory, olfactory, tactile, and others – that it uses to navigate its environment (Birch et al., 2020). These modalities aren't merely passive receivers of information; they actively shape an animal's perception and, by extension, its conscious experiences.

But perceptual richness isn't a uniform quality. Within each sensory modality, it can be further divided based on certain aspects such as bandwidth, acuity, and categorization power (Birch et al., 2020). Bandwidth refers to the breadth or range of perception within a modality, while acuity denotes the degree of precision within that range. Categorization power, on the other hand, pertains to the ability to sort the information perceived into meaningful categories that can be acted upon or stored for future use.

In essence, P-richness provides a measure of the quality and depth of an animal's sensory world. It represents the sum total of the animal's perceptual experiences and offers a window into its subjective world.

E-richness

The next category is E-richness (evaluative richness). E-richness measures the affective response of an animal, for example, fear, anger, sadness, regret, etc. Instead of focusing on particular emotions found in humans, the authors believe that a more useful categorization is whether the affective response has a positive valence or a negative valence. In order to grade animals, the authors use the complexity of an animal’s evaluative system (Birch et al., 2020).

In neuroscience, evaluative systems are neural systems that evaluate and integrate information about the environment, internal body states, and prior experiences to produce predictions and guide action. These systems are responsible for assessing possible rewards and risks in the environment and making decisions that maximize well-being.

Evaluative systems play a crucial role in processing emotional inputs by determining the importance and relevance of stimuli, which in turn triggers the appropriate emotional response. For example, when animals detect a possible threat, evaluative systems like the amygdala are activated, leading to fear reactions. Similarly, animals, like humans, experience positive emotions or pleasure when they detect potential rewards, and this is facilitated by the involvement of evaluative systems such as the nucleus accumbens. These evaluative systems are vital for understanding how emotions are generated and expressed in both animals and humans. Subdivisions include bandwidth and acuity like for P-richness.

The authors believe that experiments which present the animal with motivational tradeoffs can help us measure animal’s evaluative systems. For example, a positive valence path that leads to less reward or negative valence path that leads to more reward and the animal has to choose one path to travel on (Birch et al., 2020).

Self-consciousness

The next category is Self-consciousness. This is the ability to recognize your own experiences as distinct from the world and others. Birch and his colleges believe there are different degrees of self-consciousness. The first level is just the understanding that the self if different from others and the environment (Birch et al., 2020). Most animals have this understanding in order to survive and navigate the world successfully. If an animal did not acknowledge others as different from itself, it would likely get eaten by a predator.

The next level of self-consciousness is awareness of the self as an ever-present object (Boyle, 2018, as cited in Birch et al., 2020). One method to test for this is the mirror-mark test. This is a procedure whereby a mark is put on the animal in questions body and the animal is put in front of a mirror. The animals need to recognize the mark on its body in order to pass this test. This is usually inferred from the behavior of the animal so, for example, if the animal tries to touch or remove the mark. However, even if the animal does not pass this test, we cannot say that the animal does not possess self-awareness. It could be that the animal does not care or is not motivated to interact with the spot in anyway even though the animal sees it and understands it is on their body.

The final level of self-consciousness is theory of mind (Birch et al., 2020). Theory of mind has many different aspects, but the focus of the authors is inward mindreading. To be able to “mindread” one needs to understand that other individuals have beliefs much like themselves. Using this knowledge, one should be able to predict what the other individual would do in a situation that they have been in. Studies have shown that great apes are able to “mindread.” These apes were able to infer that others would not be able to see objects on the other side of an opaque barrier after having experienced the barrier themselves (Birch et al., 2020).

Inward mindreading or metacognition refers to the ability to understand oneself as the subject of one’s own mental states. As of yet there has been no convincing evidence of this in nonhuman animals (Birch et al., 2020).

Unity

The next category is unity. Whenever we observe something, our conscious experience is unified. In other words, all of our memories and experiences take place from the perspective of a single observer. We do not mistake one of our memories for someone else’s or have greater than one distinct consciousness (Birch et al., 2020). We can measure this in animals by taking inspiration from split brain patients. The authors propose showing objects in various locations in the animals visual fields, and see if there is integration across different regions of the visual fields to test unity. Another test is investigating which animals have unihemispheric sleep, that is one of their hemispheres is unconscious an and another is awake when the animal sleeps; dolphins and some birds exhibit this behavior (Mascetti, 2016).

Temporality

Next is temporality or integration across time. When we experience the world it is a constant stream of consciousness. Our experience is connected rather than being a disjointed collection of experiences (Birch et al., 2020). One way of testing temporality for short timescales is by seeing situations where our brain creates a continuous conscious stream from a discontinuous stream. In humans, the color phi illusion is used to test this. The color phi illusion involves two flashing disks of different colors and separated by a short distance. One disappears and the second appears after a short time (<100ms). However, we see it as a disk moving from one side to the other and switching color partway through. In other words, the brain constructs a cohesive representation of the stimulus's dynamic changes instead of just perceiving two static stimuli as a single moving stimulus.

We can apply this framework to animals by training them and seeing if they respond differently to continuous and discontinuous stimuli and run the color phi illusion to see if they possess temporality over short timespans. However, this method is not full proof. Seeing the color phi illusion is not a necessary condition for temporality but rather a piece of supporting evidence.

Episodic Memory

Next, we turn to temporality over longer timescales, for example, episodic memory and future planning. Let us first discuss episodic memory.

Episodic memory is often referred to as past mental time travel. This is because you are essentially traveling back in time mentally to put yourself in the shoes of your past self to recall an experience. For a long time, episodic memory has been the method used by researchers to test for animal consciousness. Although there are no definite criteria for episodic memory, some of the most widely agreed upon criteria are knowing the content of the memory, having temporally dated memories and knowing their spatial relationship. However, even if an animal fulfills all of these requirements, we still cannot say they possess episodic memory only episodic-like memory. That is because there is still no guarantee that the animals are engaging in a mental time travel. The animal could store what, where, and when information without recalling the experience. But because humans use episodic memory to recall these three types of information in one memory, there is good reason to believe animals do the same thing if they recall the same information as we do during episodic memory.

There has been much difficulty in trying to figure out an experimental design that shows animals have episodic memory. This is because there is usually a simpler explanation available that can provide a reasoning for the animal's behavior that does not require positing episodic memory. Therefore, an experiment needs to be constructed such that no simpler alternative explanation can be used to explain the animal's behavior. One example, where an alternative explanation could be found is the famous experiment performed with monkeys (Griffiths & Clayton, 2001). The monkeys were trained to select the objects that were the same or different from an object they previously saw. At first, it appeared that the monkeys were using episodic memory to remember the old object and use that information to select which object was the same. However, a simpler alternative explanation was that the monkey was just selecting the object that was the most familiar and avoiding the object that was less familiar (Griffiths & Clayton, 2001). If we look back to our criteria, we can see that the monkeys did not have to know the temporal spatial relations of the recalled object. They could get away with just remembering features of the object.

Studies performed on Scrub jays suggested that they have episodic-like memory (Sato, 2021). There were two types of foods, wax worms and peanuts. Scrub jays preferred wax worms over peanuts, however, wax worms become inedible after 5 days due to degradation. In the wild, scrub jays cache different foods and store them in different locations for later. The scrub jays were allowed a period of time to cache both peanuts and wax worms. The birds were then moved to a separate cage and recover their cached foods after either a 4 hour or 124-hour period. The results found that scrub jays preferred to recover wax worms after the 4 hour period but peanuts after the 124 hour period (worms were degraded) (Sato, 2021). Because the scent of the foods could help the birds recover the food instead of using memory, the same experiment was run but the foods were removed before the bird was allowed to recover the cached foods. The results found that the scrub jays would attempt to recover wax worms after the 4-hour period but preferred to recover peanuts after the 124-hour period which is consistent with the previous results (Sato, 2021).

This study provides strong evidence for episodic-like memory in scrub jays. The scrub jays had to know what food they cached and in where they cashed it (spatial component) in order to recover their preferred food, wax worms. In addition, the scrub jays had to know when they cashed the food (temporal component) in order to avoid the worms after 124 hours when they become inedible.

After episodic-like memory was found in scrub jays, there were significant efforts made by neuroscientists to adapt the procedure and test to see what other animals possess it.

Recently, experiments on rats have suggested that they possess episodic-like memory. An experiment was performed where rats were shown 16 different odors in two different contexts and when presented with two odors the rats had to choose the new odor in context (Panoz-Brown et al., 2016). Meaning, the rats had to choose the order plus the associated context they had not seen before. For example, suppose a rat experienced odor 1 in context A and odor 2 in context B. Next the rats were given the choice between odor 2 and odor 1 in context A. The rats would have to select odor 2 in context A because they have not experienced it in that context before.

Before examining the results let's look at an example trial in detail if a rat were to choose all the correct options. First, context A is presented the rat experiences odor 1. Next, the rat is presented with odor 1 and odor 2 and the rat chooses odor 2 because it is new. Then, the rat is presented with odor 3 and 1 and the rat chooses odor 3 because it is new. This process is repeated until the rat has experienced half of the odors in context A. In this example trial, let us say odor 16 is never experienced in context A.

Next, the rat will repeat the same procedure except in context B. In context B, let us suppose that the rat experiences odor 1 in the penultimate selection followed by odor 16 in the last selection.

Next, the rat is reintroduced to context A and presented with odor 1 and odor 16 in the same selection. Assuming the rat is using episodic-like memory, the rat should choose odor 16 because it has not been experienced in context A before.

This design is smart as it eliminates the possibility that the rat is using relative familiarity to select the correct scent (Panoz-Brown et al., 2016). If odor 1 is experienced more recently than odor 16 in context B, using a heuristic of least familiarity would allow the rat to select odor 16 in context A which is the correct choice. However, by having the rats experience odor 16 more recently than odor 1, it prevents relative familiarity from being correct.

The results found that when odor-in-context and relative familiarity were at odds like in the example trial illustrated above, the rats chose the correct option, odor-in-context, significantly above chance (Panoz-Brown et al., 2016). This provides strong evidence for episodic-like memory in rats because in order to perform the task correctly the rats had to remember the "what and when", the type of scent and whether they had experienced it previously that day or not, in addition to "where", the context each sent was experienced in.

Future Episodic Thinking

The next type of long-term temporality is future episodic thinking. This can be divided into many components including simulation, prediction, intention, and planning. Let's look at an example to see all of these components in action. An example of this would be reasoning through hypotheticals. For example, imagine you visit an Indian restaurant, and it is raining outside. They usually serve your favorite food, but today it is poorly made. The next day you visit the same restaurant, and it is sunny. It serves delicious food. This trend continues for weeks. The next week, you walk outside, and it is raining. You think back using episodic memory and decide that because it is raining you will avoid the Indian restaurant and instead choose a different one. In this situation you simulated a mental representation of the restaurant in the future and because it was raining you assumed the food would be poorly made based on past experience. You used some element of prediction by assuming the food will be poorly made because every time it was raining outside, and you visited the restaurant the food was poorly made. You also created an intention, the fact that you will travel to a different restaurant today. Finally, you did some planning. In order to fulfil your intention, you had to think about what steps you will take to get to an alternative restaurant such as getting into your car, setting up navigation, and driving there.

Because future episodic thinking requires using many different cognitive domains including episodic memory, it is a great test for consciousness and is a higher bar to clear than traditional episodic memory which relies on past mental time travel.

Evidence from Martin and Schacter shows that the same brain regions are responsible for both episodic future thinking and episodic memory. These brain areas include the hippocampus, medial prefrontal regions, the lateral temporal cortex, the medial and lateral parietal cortex's posterior regions, and the medial temporal lobe (Schacter, 2007; Martin, 2011). This is further evidence that future episodic thinking requires episodic memory.

Wilson and Crystal attempted to show rats have prospective memory. Particularly they were measuring if the rats anticipated a future event as the event got closer in time (Crystal, 2013). They hypothesized that if the rats did indeed have prospective memory their performance on a task would decrease when they are anticipating the future event. To test this, they had a control group and an experimental group. In both groups the rats had to perform a bisection task. In the experimental group, the rats were rewarded with food after 90 minutes had elapsed since the task started. The results found that task performance for only the experimental group decreased as the time approached 90 minutes (Crystal, 2013). Because only the experimental group rats had impaired performance, it is likely that the anticipation of the reward took some attentional resources and resulted in worse performance. This makes sense as anticipation should increase as time gets closer to the time of reward delivery, which corresponds to decreasing task performance with a function of time.

There are a few limitations with this task. First, in prospective memory in humans, we have temporal specificity, that is we are able to simulate the future at a particular point in time. In addition, we have lots of flexibility when planning. We are able to change our future plans and adapt them with new incoming information. These two features were not measured for in the above-mentioned experiment. In addition, this experiment only demonstrates that the rats were thinking about some general event that will take place in the future. It does not provide evidence for simulation because there is no need to create a mental representation of the future world. Rather the same effects would be observed if the rats were just thinking about the pleasure they were going to experience when the 90 minutes had elapsed. If there was a simulation then it was likely very basic. There is also no prediction being made: the rat is always rewarded, and the rat has no choices to make. As for intention it is unclear if the rats had this or if it was more unconscious. Having an intention involves setting a goal that is achieved through planning and action. From the experiment we cannot say for sure that the rats had any such intentions. It is more likely that they were merely anticipating something good that would happen in the future. Finally, we come to planning. Prospective thinking is a prerequisite to planning about the future.

The rats had some general idea of what was going to happen in the future and were anticipating it. However, there were not multiple steps that needed to be made in order to achieve the future they were anticipating. The only steps they had to make was to travel to the food trough. This is evidence for some rudimentary level of planning.

Behavioral Experiment

Because there was a lack of experiments for future episodic thinking and non-actual possibility representations in animals, Catherine Holland, a PhD candidate at Dartmouth College, made an experiment for testing this in rats that I am assisting her with. In what follows I will briefly explain the procedure and preliminary results.

The basic setup consisted of a maze with three paths that loop back to a start box. The start box is where the rat starts and ends the experiment. The rat also has to return to the start box after every trial to start the next trial. At the end of every trial the rat gets rewarded at the start box.

First, I will explain the first phase of the experiment. Each path had a different reward value associated with it: small, medium, and large. The results found that the rats preferred the paths with the highest reward values. This illustrated that the rats would exploit the best rewards when possible.

Next, I will explain the second phase of the experiment. The rats will hear a cue only during the start box which will be associated with a state of the maze. For example, low pitched means the left path door is closed, medium pitched means the middle path is door closed, and high pitched means the right path door is closed. All doors are closed until the rat stands in front of a door and breaks the infrared sensor. That door will open if the associated cue for that door was not played. As a result, the rat cannot use visual information to see which path to travel and needs to memorize the association between a cue and a state of the maze. The rat will get to perform two choices for each trial so that they have the opportunity to experience every open door if they perform optimally. Going through the same arm a second time results in no reward delivery. In addition, the rat will either randomly perform the task from the left or right side. There are two electronic doors, one of which will open each trial.

If the rats perform this phase correctly it gives evidence for future episodic thinking. Because the sound only plays in the start box, the rats have to create an intention while in the start box for which path they want to avoid or travel to. Then they have to construct a plan in order to reach the correct paths. This planning is very limited because they only need to vaguely remember the spatial positions of the paths they want to travel on and take those paths. However, because they can approach the paths from either the right or left side, they cannot just rely on using a directional heuristic with respect to their body to travel to the correct paths. They need to understand the position of the path in three-dimensional space. Next, it provides evidence for simulation as the rat has to imagine the maze and which path he is going to take while in the start box before actually seeing the choices he has to make. Lastly, there is no evidence for prediction in this experimental design.

Current preliminary results are still unclear. There is possibly evidence for one rat learning the meaning of the tones, but further trials need to be performed in order to draw any conclusive evidence.

There are a few limitations of this study. All the rats need to do in order to perform the task successfully is associate the tone with one path being closed or two paths being open. In humans, future episodic thinking is characterized with being able to reason through different future possibilities and choosing the best one. There is also lots of flexibility in future episodic thinking. We can take in new information and change our models of the future. The rats do not need to do any reasoning outside of avoidance.

Futures experiments

In order to add more complexity to this experiment, phases 1 (differing reward values) and 2 will be combined. Each path will be associated with a different reward value. In addition, a sound will be played which the rat needs to associate with one of the paths being inaccessible. For the rats to be successful in this phase, they need to associate the tones with a path being unavailable and out of the available options, reason through which path gives the most reward and take that one. For example, if the path with the highest reward value is closed, then the rat should choose the path with the second highest reward. This would require the rats to reason through different hypothetical situations in order to perform the task successfully. This would provide strong evidence that rats are capable of future episodic thinking.

A future study is proposed to see if the rats can understand two sounds being played, meaning that two doors are closed. One thing to note is that it is entirely possible that the rat is not associating the sound with one of the paths being unavailable but rather two of the paths being available. This may create some extra complications depending on the rat’s strategy. The same framework from the previous phase would apply but with the addition of two sounds being played one after another in the start box to denote that two paths are unavailable. For example, if the high-pitched sound is played followed by the medium pitched sound, the right and middle doors would be inaccessible. If the rats are associating the sound with the doors being open, then they wouldn’t be able to know which door is open. For example, when the high pitched sound plays the rat would assume that the left and middle doors are open. When the medium pitched sound plays the rat would assume that the right and left doors are open. If the rat takes all the information at face value, he will assume that all the doors are open. Alternatively, he could become confused at the absurd information and choose at random. Unfortunately, it is also possible that the rat will choose the door which is said to be open twice resulting in choosing the correct option. But regardless, if that rat thinks of the sounds signaling two doors being open instead of one closed, it will make this phase more difficult to complete for the rat.

Criticisms

I believe only "categorization power" should be a category. To me it doesn't seem reasonable to be more or less conscious based on bandwidth. Just because you have more information does not mean that consciousness increases. For example, if we are processing some information unconsciously, we wouldn't say that someone is more unconscious if they are processing a greater amount of information this way. Similarly, consciousness is separate from how much information it is receiving, and the detail of the information being received. Consciousness is the capacity to use information to create rational thought. Even if less information is being sent to the system it doesn't mean it has less capacity to create rational thought. I believe there is a threshold for the amount of information required but additional information does not affect the consciousness. In addition, bandwidth and acuity can occur even without consciousness. They are essential for many unconscious processes and would be necessary for the processing of objects during blindsight which is an unconscious process.

It is important to note that I believe, acuity and bandwidth are necessary inputs for consciousness to exist, but they are not consciousness. That's because you can't categorize information if you have no information to perform an operation on. It this sense they are deeply connected to conscious processing, however, I do not believe they should be part of an animal theory of consciousness that grades bandwidth and acuity and then says whether something is more of less conscious because of them.

Section 4: Insight

The concept of "insight" forms a fascinating subset within the field of animal learning and cognition, offering a unique perspective on the cognitive abilities of animals. Insight refers to the sudden realization or understanding of a problem's solution, where learning occurs not through gradual trial and error but rather through a rapid shift in understanding that leads to a substantial enhancement in performance. This rapid learning typically follows a period of rest or a change in circumstances and stands in contrast with other, more gradual learning forms such as associative learning.

Insight as a phenomenon has been extensively studied in humans, largely due to the ease with which humans can communicate their thought processes and mental states. Such communication allows researchers to track the point at which an individual experiences an insight moment and to understand the shift in understanding that occurs at that point. However, despite the challenges inherent in studying non-verbal species, researchers have made significant strides in investigating the occurrence of insight in animals. Experimental work in this domain has often relied on tasks that involve missing information crucial to problem-solving, and where repeated trials do not inherently bring the animal closer to the solution.

A seminal study in the field of animal insight was conducted by Köhler in the early 20th century. Köhler observed chimpanzees and noticed that they could solve complex problems suddenly after a period of unsuccessful attempts, suggesting the presence of insightful understanding. In one of his most famous experiments, he presented a chimpanzee with a banana hung out of its reach and provided boxes that the animal could stack and climb to reach the food. Despite the animal's unsuccessful attempts to reach the banana directly, the monkey eventually used the boxes to solve the problem, demonstrating an instance of insightful behavior.

This experiment not only demonstrated the presence of insight in animals but also introduced the concept of problem-solving as an indicator of cognitive abilities in animals. This experiment served as a precursor to a range of studies aimed at exploring insightful behavior across various animal species, including birds and other primates.

Several more recent studies have continued to build upon Köhler's work. For instance, a study by Epstein, Kirshnit, Lanza, and Rubin (1984) replicated Köhler's experiments with pigeons, providing further evidence for insightful problem-solving in non-primate species. Similarly, researchers have demonstrated evidence of insight in crows, which are capable of using tools in novel ways to access food sources. These and other studies have enriched our understanding of the cognitive capacities of animals and the potential presence of insightful problem-solving across various species.

However, it's essential to note that the interpretation of animal behavior as insightful learning remains a topic of debate within the field of animal cognition. Some researchers argue that behaviors interpreted as insight could be the result of simpler cognitive processes or intensive trial and error learning. Therefore, further research is necessary to determine the presence and nature of insight more definitively in animals. Despite these ongoing debates, the study of insight in animals continues to offer intriguing insights into the richness and complexity of animal cognition, particularly when we consider this phenomenon within a broader framework of consciousness.

This framework divides consciousness into five aspects: perceptual richness, evaluative richness, unity, integration across time, and self-consciousness. Insight learning, as observed in animals, can be seen as a striking manifestation of perceptual richness, one of the key features of consciousness. This aspect refers to the depth and detail of our sensory experiences. In the context of insight learning, animals display a deep understanding of their environment and the elements within it, leading to the sudden resolution of a problem. This reflects a rich perceptual awareness that goes beyond simple, conditioned responses to stimuli.

Further, insight also embodies evaluative richness, which involves the ability to assess and respond to environmental stimuli based on subjective preferences or needs. The ability of animals to modify their behavior suddenly and adaptively, as seen in insight learning, suggests a capacity for evaluation and decision-making that contributes to consciousness.

The unity of consciousness can be inferred from the integrated and coordinated behavior displayed by animals experiencing insight. Their actions suggest a unified understanding of the problem at hand and its solution.

Integration across time is another crucial aspect of consciousness that insight potentially illustrates. Insightful behavior often follows a period of unsuccessful attempts or rest, suggesting a cognitive process that integrates past experiences with present circumstances to produce an optimal response.

Lastly, while self-consciousness is traditionally difficult to demonstrate in non-human animals, moments of insight may hint at this aspect of consciousness. The sudden understanding and application of a solution to a problem could be seen as an indication of a self-aware cognitive process, where the animal applies knowledge about its own capabilities to resolve a problem.

In essence, the phenomenon of insight could serve as an additional layer of evidence for animal consciousness. Insight, in its spontaneous and complex nature, encompasses several elements that are considered central to the concept of consciousness. By incorporating this phenomenon into our understanding of animal consciousness, we can further enrich and complexify our views on this subject.

Our Behavioral Experiment

We decided to run an experiment to see how rats would learn a rule without being queued about the rule. The results of the experiment appear to resemble insight. The experimental setup was identical to the experiment described above by Holland and the same equipment was used. This was performed prior to the rats performing the experiment to test nonactual possibility representation in rats. This experiment also acted as a familiarization phase to the structure of nonactual possibilities experiment.

In this experiment, the rats were allowed to freely explore the maze. All the automated doors were in their closed positions. However, they would always open upon breaking the infrared sensor in front of them. No matter which paths the rats chose they would be rewarded. However, they were only ever rewarded for the first two path choices. After this, upon entering the reward zones in at the middle of the path no reward was delivered. All other variables in the maze were identical regardless of how many choices the rat made. In order to reset the reward delivery system, the rat had to return to the start box which would signal the start of a new trial. Note that the rat always gets rewarded at the start box at the beginning of each trial. The rats received no assistance to help them learn the rules of the experiment. They had to figure them out by themselves.

Every time the rat made more than two choices before returning to the start box it counted as a “multiloop.” If the rat made exactly two choices before returning to the start box, then is counted as a “single loop.” The rats were allowed to perform as many trials as they could within a 20-minute period which we refer to as a session. After, they were sent back to their home cage. Each rat performed two sessions each day at approximately the same time each day. The rats were fed after finishing the second session. The rats were food restricted to provide ample motivation during the experiment. When the rats had single loop performance exceeding 80% for at least two sessions, we considered learning to be sufficient and they stopped performing trials. There will always be some baseline level of exploration that the rats will engage in to see if the rules have changed. As a result, we believed 80% was a good threshold.

Data Analysis

Upon close inspection of Figure 1, an intriguing pattern emerges with regards to Rat 210. It appears that a defining moment of 'insight' occurred following the 11th session of observation. Leading up to this session, the rat exhibited what could be described as a static performance curve, indicating that it was not incrementally learning over the course of the sessions. However, in a dramatic shift, following session 11, there was a significant increase in the rat's learning capabilities, with it surpassing the predetermined performance threshold within merely four sessions. This remarkable shift called for further examination.

To delve deeper into this potential shift in learning capabilities, a linear regression analysis was employed to scrutinize the data accumulated both prior and subsequent to session 11. The 11th session was conjectured to be the final one before the occurrence of the potential moment of insight. The results from the linear regression analysis were telling; the change in slope from before session 11 to after was 0.028, demonstrating a statistically significant difference ($p = 0.008$), a result significant at the $p < 0.05$ level. Further, the analysis yielded a relatively high R-square value of 0.85, indicating a strong correlation between the variables considered.

A critical point to consider is that throughout the data analysis, we worked under the assumption that there would be a smooth transition, i.e., no sudden jumps at the cutoff session. We believed the data from before and after the cutoff session could be connected smoothly, thereby enabling a continuous analysis. Concurrently, we operated under the notion of robust standard error, acknowledging that the variance in outcomes across all observations may not be uniform. While we acknowledged the statistical significance of the p-value, we considered the practical significance, or the size of the change in slope, to be of greater import. This was due to the inherent complexities involved in defining and quantifying a rather nebulous concept such as 'insight', and the recognition that our method of measurement represents just one among many possible approaches.

Similarly, Rat 211 displayed a possible moment of insight after the 5th session. This was followed by an abrupt improvement in performance, with the rat achieving above the threshold within just three trials. The swift progression posed a challenge; it was difficult to distinguish whether this was a case of early insight or simply a faster learning curve relative to the other rats. As with Rat 210, a linear regression analysis was performed on the data before and after session 5, the presumed final session before the insight moment. The change in slope came out to be 0.035, with a statistical significance at the $p < 0.1$ level ($p = 0.098$), and the R-square value was 0.94, indicating a high correlation.

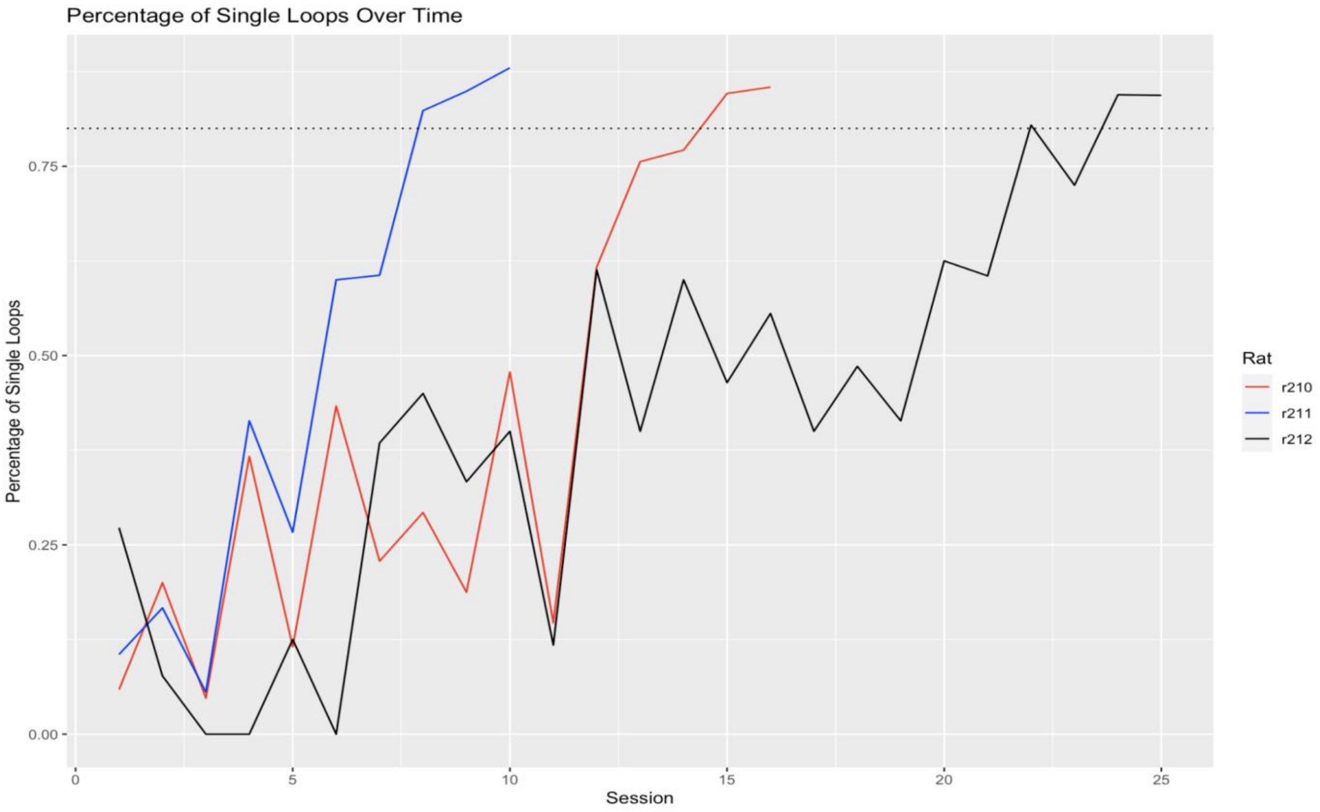
The third subject, Rat 212, also exhibited what could be construed as a moment of insight, this time following the 19th session. Following this session, Rat 212 achieved above-threshold performance in only three trials. However, an additional three trials were required to meet the requirement of two consecutive above-threshold performances. Prior to session 19, Rat 212's performance could be classified as ordinary, with no significant improvement past session 12. A linear regression analysis was performed on the data both before and after session 19. This session was hypothesized to be the final session before the insight moment. The results were slightly less conclusive than the previous instances, with the change in slope being 0.004, but with a non-significant p-value (p = 0.236). The R-square value obtained was 0.76.

A broader analysis was conducted to observe potential differences in learning patterns across the rats. This was achieved by comparing the slopes obtained from separate linear regression analyses for each rat. The slopes and their standard errors were as follows: Rat 210, slope 0.051, standard error 0.009; Rat 211, slope 0.010, standard error 0.012; Rat 212, slope 0.031, standard error 0.004. Subsequently, a series of t-tests were performed to evaluate the statistical significance of the differences in slopes. The results indicated non-significant p-values when comparing the slopes of Rat 210 and Rat 211 (p = 0.54), Rat 210 and Rat 212 (p = 0.81), and Rat 211 and Rat 212 (p = 0.63). This suggests that, notwithstanding differences in timing and rate of learning, the rats exhibited a similar overall learning trajectory.

In conclusion, our data suggest the possibility of moments of insight in each of the three rats studied. Evidence of an increase in the learning curve slope following the hypothesized insight moments insinuates a change in the rats' learning strategy. However, these findings are not definitively conclusive. Further research is required to determine whether rats indeed experience moments of insight during learning processes involving abstract rules, where the task goals are relatively ambiguous.

Figure 1

Percentage of Single loops Over Time



Note. This figure shows the percentage of single loops that three rats (r210, r211, r212) performed during each session. Each session lasted approximately 20 minutes. Once each rat performed over the threshold (80%) for two sessions in a row, they stopped performing sessions.

Criticisms

One might argue that the rats grew more familiar with the experiment as time went on and there is not any evidence for insight. A proponent of this view might argue that each time the rat is exposed to a trial he will be receiving information that reinforces that he should only make two choices. This is because the rat is only rewarded twice no matter which door he travels through. However, this type of learning would not explain the significant increase in slope that occurred after a specific session for each of the rats. If the rats were truly learning through a reinforcement learning method, we should see a progressive increase in performance characterized with a regular slope. If there is a significant slope increase it would be seen towards the beginning of the curve when the animal first gets introduced to the experiment. However, we see the opposite. The rats' rate of performance increase went up during one of the later sessions and the rat completed the task very soon after this increase. In addition, the learning curve for rat 210 and 212 started to flatten out before the hypothesized insight and sudden slope increase. This is not characteristic of reinforcement learning. We suggest that this increase is due to "insight." However, future studies need to be conducted to verify this.

Conclusion

The exploration of animal consciousness is a complex and multifaceted endeavor that necessitates an interdisciplinary approach. Understanding animal consciousness requires integrating philosophical inquiries with neuroscientific investigations and behavioral experiments. By bridging the gap between philosophical questions about animal consciousness and neuroscience inquiries about animal behavior, we gain valuable insights into the complex nature of animal cognition and its potential connections to consciousness.

In the first section, we established a working definition of consciousness, encompassing phenomenal consciousness, access consciousness, and self-consciousness. We discussed the challenges of studying animal consciousness due to its subjective and private nature, as well as the interconnectedness of these different forms of consciousness. While direct evidence of phenomenal consciousness in animals is elusive, neuroscientific evidence offers valuable insights into the potential presence of conscious experiences in animals.

The second section examined different approaches to investigating animal consciousness, focusing on anomalies of consciousness, neuroscientific methods, and philosophical perspectives. Anomalies such as blindsight and prosopagnosia provided valuable insights into conscious processing and the neural mechanisms involved. Neuroscientific methods, including manually induced blindsight and cognitive tasks, allowed for the examination of animal behavior and its potential relation to conscious awareness. Philosophical perspectives, such as perceptualism and inferentialism, offered contrasting viewpoints on how we understand and attribute mental states to animals.

In the third section, we delved into a recent theory of animal consciousness, which proposed a consciousness profile consisting of different categories such as perceptual richness, evaluative richness, self-consciousness, unity, and temporality. We discussed the challenges and limitations of this approach, particularly in assigning relative weights to different categories and determining the level of consciousness across species. Episodic memory and future episodic thinking were explored as important cognitive processes for assessing animal consciousness, but the distinction between true episodic memory and episodic-like memory remained a challenge.

By integrating these insights, we gain a more comprehensive understanding of animal consciousness. The investigation of animal consciousness requires careful consideration of the subjective experiences and cognitive abilities of different species. It is essential to recognize the limitations and complexities involved in studying consciousness, particularly in non-human animals.

Within the realm of cognitive abilities, insight stands out as a fascinating phenomenon. It represents a sudden shift in understanding and problem-solving, distinct from gradual trial-and-error learning. Insight learning has been extensively studied in humans, and researchers have made significant strides in investigating its occurrence in animals. Studies with chimpanzees, pigeons, crows, and rats have demonstrated instances of insightful behavior, where animals display deep perceptual awareness, evaluative decision-making, unified understanding, integration of past experiences, and potential self-awareness.

Our own behavioral experiment with rats aimed to explore the presence of insight in their learning processes. The results revealed intriguing patterns in the rats' performance curves, suggesting potential moments of insight. Linear regression analyses provided further evidence of significant changes in learning capabilities following specific sessions. Rat 210 showed a notable increase in learning slope after the 11th session, while Rat 211 exhibited a similar pattern after the 5th session. Rat 212 displayed a potential moment of insight after the 19th session, although the statistical significance was less conclusive. These findings indicate the possibility of insightful problem-solving in rats and highlight the need for further research to confirm and better understand these moments of insight.

By incorporating the phenomenon of insight into our understanding of animal consciousness, we gain a deeper appreciation of the cognitive capacities of non-human species. Insight learning aligns with key aspects of consciousness, including perceptual richness, evaluative richness, unity, integration across time, and self-consciousness. The occurrence of insight in animals suggests a complex cognitive process that goes beyond simple associative learning, indicating a deeper level of understanding and problem-solving ability.

However, it is essential to recognize the ongoing debates and challenges associated with interpreting animal behavior as insightful learning. Some researchers argue that alternative explanations, such as simpler cognitive processes or intensive trial-and-error learning, could account for behaviors interpreted as insight. Therefore, further research employing rigorous experimental designs, control conditions, and comprehensive analyses is necessary to gain a more definitive understanding of the presence and nature of insight in animal cognition.

In summary, our exploration of animal consciousness and insight learning provides valuable insights into the richness and complexity of non-human cognitive processes. By considering the theory of animal consciousness, examining instances of insight in different species, and conducting our own behavioral experiment, we contribute to the broader understanding of animal cognition and its potential relationship to consciousness. Through ongoing research and interdisciplinary approaches, we continue to unravel the mysteries of animal consciousness, paving the way for a deeper understanding of the cognitive world shared by humans and other sentient beings.

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