IDENTIFYING CORE CONSCIOUSNESS IN ANIMALS

by

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Proving whether animals are either capable or incapable of feeling (i.e. core consciousness) is a problem that is difficult to address because mental states cannot be directly observed. Many animals exhibit behavior similar to our own, and consequently it is easy to attribute to them corresponding mental states. The assumptions underlying these attributions, however, are subject to error; there is no absolute rule by which mental states correlate with behavior, and we have no means of verification through verbal reports. A different approach must therefore be taken. Revealing the presence in animals of the neural structures responsible for producing core consciousness in humans would essentially prove that such animals too are capable of feeling. Unfortunately, at present little is known about the biology responsible for producing core consciousness in humans. At best general regions containing the necessary structures are slowly being located. Based upon similarity of structures, evidence suggests that at least mammals are core conscious and perhaps all other vertebrates as well.

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Chapter 1: Introduction

This thesis approaches the problem of animal feelings from a neurobiological perspective. Specifically, are animals capable of a basic feeling state? Ignoring the content of feelings entirely, this thesis begins by analyzing what assumptions are made when making broad statements about animal mental states. Chapters two and three then clearly define a practical use of the word "feeling," and with this definition describe what is known about the requisite biology in humans. Finally, given this information the fourth chapter discusses what inferences regarding the minds of animals we can reliably make, and outlines some broader implications these conclusions might have.

The relationship that humans have with animals is a subject of great cultural and individual importance (Diamond, 1997). Throughout history, humans and animals around the world have been in close contact. We know innately both the role of hunter and hunted. We have domesticated species for various reasons- as sources of food, labor, transportation, protection, communication, and for companionship. The development of society has depended upon these interactions (Diamond, 1997) . It is not surprising then, that animals are a very important part of our culture, present in our daily lives and represented in everything from religion to books, sports, art, and television.

Our relationships with animals are not always merely practical and functional, such as when we use them for food or labor, but can also be emotional. It is easy to develop close, loving bonds with animals especially pets that in many ways are identical to those we have with other humans. To a great extent, these relationships rely upon assumptions that animals experience feelings that correspond to those we feel. When a dog wags its tail and jumps to greet its owner, it is assumed that it is experiencing a feeling of happiness and excitement similar to what we feel when experiencing a happy reunion. Furthermore, when a kitten dies, we assume its mother is sad and mourns its loss, because this is what we would feel in its place. We do not imagine that animals are as intelligent, creative, or clever as humans. After all, they cannot solve complex math problems, use verbal language or create art as we can. However, most people do (unthinkingly perhaps) presume that animals experience *feelings* just as we do.

From a scientific perspective, the study of feelings, even in humans, has been neglected for most of the 20th century due in large part to the prevalence of *behaviorism*. This movement began first in 1912 through the influence of psychologist John B. Watson. He claimed that because the internal subjective states of a mind are inherently private and unknowable, they cannot be empirically measured and should therefore not be the focus of scientific study (Hauser, 2006). He thought that studying subjective experiential states could provide no unique insights into the behavior of an organism (Panksepp, 2005).

Instead, Watson claimed that science should "take as a starting point, first the observable fact that organisms, man and animal alike, do adjust themselves to their environment" and "secondly, that certain stimuli lead the organisms to make responses" (Watson, 1912). The principles of behaviorism were founded upon Pavlov's famous studies of classical conditioning (Hauser, 2006). According to this view, behavior can be described simply in terms of a stimulus from the environment and the corresponding response of the organism. An animal can be *conditioned* to respond to otherwise independent phenomena. In Pavlov's studies, dogs were repeatedly fed only after hearing a bell, and were thereby conditioned to respond to the bell sound with anticipation of food, namely by salivating. To Pavlov and the later behaviorists, behavior is both predictable and readily manipulated (Hauser, 2006). From a behaviorist viewpoint, an animal does not think and certainly does not feel; it merely responds. Studying behavior in terms of the laws of classical conditioning appealed greatly to behaviorists because recording public and observable events, not private internal ones, allowed psychology to become entirely an empirical and measurable process.

By the mid 20th century, behaviorism was largely abandoned with respect to human psychology (de Waal, 2004). This shift occurred principally because humans clearly do have subjective experiences and mental lives, and these *are* important to consider when seeking to understand our behavior (de Waal, 2004). For scientific studies of animal behavior, however, the rules and principals of behaviorism have remained strongly influential (Panksepp, 2005). Scientists still

tend to interpret animal behavior according to behaviorist laws of stimulus and response. A rat is dehydrated, and so seeks water. This rat is not *thirsty*, however, even though it may exhibit behaviors that remind us of a thirsty state in humans. To claim that it is thirsty is anthropomorphism, the projection of human-like qualities to non-human things. The use of anthropomorphism in this manner is not scientific, and has long been considered taboo (de Waal, 2001). It is easier and safer to assume that an animal is simply reacting appropriately to its environment then to infer any internal mental state. And from a behaviorist viewpoint, what good does it do; what new knowledge can be gained by such inferences?

Such hard-nosed thinking can be troublesome for those who closely examine animal behavior. It is difficult to fathom that animals are really mindless creatures that simply respond predictably to stimuli. Does a dog actually not enjoy being scratched on its belly? Is it the dog organism merely reacting according to laws of conditioning? Are all animals other than humans no different than biological machines? How can such a theory adequately describe the incredible diversity of behavior found in animals or the continuum we usually see across evolutionary trees when looking at a given trait? What makes human brains so different from all others as to be entitled the possession of consciousness, feeling, and thought? Is it really more parsimonious to assume that even though animals and humans share so many behaviors, only humans are in possession of corresponding internal mental states?

There is considerable opposition among scientists and philosophers to the behaviorist notion of a mindless animal. Much literature exists citing evidence of complex behavior that claims to prove that animals must feel and be conscious in a way similar to humans (Panksepp, 2005). Most of this evidence, however, is purely anecdotal; recounted stories of wild animals acting compassionately towards people, of elephants mourning their fallen offspring, or of birds having fun playing. Such evidence is not scientific; it cannot be repeated, tested and verified, and it relies upon the necessarily subjective observations of highly impressionable viewers.

In Theodore Xenophon Barber's book, *The Human Nature of Birds*, he outlines a great body of anecdotal evidence detailing why he believes not only that birds can feel, but that they possess a degree of intellectual sophistication that in many ways exceeds that of humans. In one story about a sociable jackdaw, Barber describes the bird in highly anthropomorphic terms "When the Leeks tried to lock him in a cage for the first time, he expressed his anger very clearly, and they never considered it again. It was also obvious when he was frustrated or upset; he might, for instance, tear a newspaper to shreds. By his expressions and body language the family could see how he felt and could anticipate what he was going to do" (p. 76).

If the bird did indeed act as described, it would be easy and tempting to see its behavior in this manner, using words that reveal its mental state (i.e. anger, frustrated). This language paints a vivid picture of the bird's behavior that is in-

tuitively understood. As Franz De Waal points out, using anthropomorphic language is often a very useful tool that allows for a more precise and accurate description of behavior than a straightforward, non-metaphoric one (de Waal, 2001). Saying that the bird was angry conveys more information than explaining that it was moving in a jerky, energetic manner, often pecking at one's skin, etc. Alone, these descriptive words do little to clarify the animals' behavior. Don't birds always move like that? How would its movement be described when it wasn't angry? Making subtle distinctions about complex behaviors can quickly become a difficult task. The words angry and frustrated imply all of those actions, and make them more cohesive by providing meaning and direction.

Though anthropomorphic language can be useful for describing behavior, it is risky because it also assumes that when the bird is acting angry that it is also feeling angry. Such conclusions can be misleading. What evidence is there that it is actually angry? Might it instead be experiencing something more like excitement? There are certainly other equally valid interpretations. In fact, the anecdote alone provides no evidence that would counter the logic of a behaviorist. Barber suggested that the family could predict the bird's behavior by watching its body language, a notion that actually complements the behaviorist concept that behavior can be predicted and manipulated. The bird could just as easily be feeling nothing at all as it could be feeling angry.

Interpreting mental states in others is difficult due to several fundamental problems. One is that most complex organisms have unique reactions to identical

stimuli. Though two people just saw the same movie, one was moved to tears while the other felt nothing at all. One bird flies away at the sight of a man while the other stays and watches. Furthermore even in humans where we openly accept that others are conscious, the expression of comparable feelings can vary drastically between individuals. A person can be happy and show it by laughing or crying. Alternately, a person can be sad and react in the same way. Sometimes people show no emotions at all though are experiencing strong feelings. Attributing mental states to other beings by looking at expression of emotions alone is troublesome because expressions of emotion may not be consistent. This is enough of a problem with humans, but is even worse with animals for which there is no broad acceptance of any mental states at all.

As difficult as it is to interpret the mental states correlated with complex behaviors, it should be noted that even the mental states accompanying simple behaviors such as reflexes are easily misinterpreted. For example, in response to being pinched, a woman automatically jerks her arm. This reflex can occur via two separate neural pathways. At a low threshold, one path can be activated that has a simple tactile feel without any accompanying pain. If the pinch is strong enough, however, another pathway can be activated that conveys information about pain to the brain. Two distinct mental states can be represented by a single behavior. An outside observer could not possibly differentiate from the reflex alone whether the pinch resulted in the woman feeling pain or not.

In reality, people have little difficulty describing the mental states of other humans. If a man is acting angry, it is generally assumed that he is angry. Most of the time we are probably right. Through various tests it might be found that his pulse and blood pressure are elevated, and that if his brain were scanned, it would reveal activity generally corresponding with the state of anger. Such a combination of evidence may in most circumstances be entirely accurate for judging the emotional state of another person, but it is not definitive. Behavior and physiology appropriate to a given mental state are not *proof* of that mental state; they are only correlates.

The central problem is that a purely causal relationship between internal and necessarily subjective mental states and the concrete physical activities of a brain is not understood. In other words, we may know what happens in the brain when we feel happy, but we do not know how this neural activity *causes* the feeling of happiness. How does the firing of neurons ultimately produce feelings and images that are "owned" by that organism? What lends them their first-person quality? This is known as the mind-body problem, and is a question that has long troubled philosophers (I will address it more fully in chapter three). Without an understanding of how and why it is that feelings and consciousness arise, it is impossible to conclude *anything* about the mental states of another living organism, even whether they exist at all.

This lack of knowledge concerning the nature of our selves and of feelings could pose a problem if people did not automatically make some basic assump-

tions. We cannot define what our minds or our feelings are. Is the self an illusion, a mere effect of neural activity? We cannot say in which way we "exist." Despite this, it is hard to argue that we don't have a subjective mental state, regardless of its true nature. We accept that other humans have feelings and that they are comparable to our own. There is more to reality than what we ourselves perceive; other people's perspectives also apply. Society exists because we are satisfied with the correlative evidence around us and do not question its validity. That is, we do not require definitive proof that others possess consciousness, as it is ludicrous to assume otherwise.

Given these assumptions, it is easy to learn about the mental states of other humans. It is not possible to know exactly what these mental states feel like, but this is not important so long as they correspond appropriately with our own (that is, sadness entails approximately the same behaviors in all individuals). As described earlier, most of the time we are very good at predicting what other humans are feeling, though sometimes we misread behavior and make mistakes. Fortunately, however, it is possible simply to ask the person to describe his or her mental state. While even this evidence provides no concrete proof, it is as definitive as possible, and far better than observation of behavior alone.

Animals are not capable of complex communication in the sense that humans are. It is therefore impossible to know the mental state of an animal like we can for another human. Since we cannot ask how animals feel, and we do not even know if they *do* feel, we must try to infer this knowledge based on external

behavior and internal neural activity. As described this is a difficult task necessarily fraught with error and uncertainty.

This thesis examines the topic of animal consciousness at the most basic level, not trying to ask what animals are feeling and thinking, rather whether they are thinking and feeling at all. What can be said with certainty about animal consciousness? Must we abide by behaviorist thinking and remain agnostic as to the presence of a mental state? Given the remarkable similarities between humans and animals, both in terms of behavior and biology, are basic judgments regarding consciousness well grounded? At what point does it become a more intelligent generalization to assume that an animal has a mind rather than to be only a living machine?

Chapter 2: Defining Feelings and Consciousness

Perhaps one reason why there is so much debate on the question of whether animals possess feelings stems from confusion about what is meant by the word itself. Feelings bring to mind many separate concepts, including emotional reactions, a general understanding of something, a tactile sensation, or even the immediate result of other types of perceptual stimulation (hearing, sight, etc). Some uses of feeling are elusive and defy straightforward definition, like the feeling of being in love, or the feeling of a given color. Feelings can also be more simple, describing perceptions alone, as in the feeling of touching cold water, or burning a finger on the stove. Conflating the various uses of the word

in regards to animal mental states is problematic because it potentially disregards the possibility that there is a continuous spectrum along which different organisms and individuals are capable of experiencing varying complexities of feelings. If by feelings we mean that an animal can experience empathy and sadness, then it is possible that no animals in fact feels. However, if by feelings we are claiming that animals have at least some subjective mental states representing basic perceptions, the possibility that a broad range of animals may feel is more likely open. A more precise definition of feelings is clearly needed to make progress on the topic.

The definition of feelings that I use in this thesis places feelings as the most fundamental aspect of conscious experience; they are "irreducible on a mental plane" (Russell, 2003). This definition is inclusive of all other uses of the word, and in fact can be considered the "primitive" that makes up more complex mental events like emotions (Russell, 2003). In seeking to further refine this definition it is helpful to consider what their use may be. Why have feelings at all? What evolutionary advantage do they provide? All feelings possess a subjective quality with an intrinsic value (Russell, 2003). This value can lie anywhere on a spectrum with two dimensions: activation-deactivation, as well as pleasure-displeasure (Russell, 2003). Activation-deactivation (i.e. arousal) describes the intensity of the feeling, and can vary from sleep to drowsiness, alertness and excitement (Russell, 2003). Pleasure-displeasure denotes the other subjective quality, namely to what extent a feeling is "good" or "bad". On one extreme lies agony, on the other, ecstasy (Russell, 2003). At any given point, a feeling is an indicator of the condition of the organism that can be described in terms of these two spectrums (Russell, 2003;

Damasio, 2003). Displeasurable feelings arise when an individual faces harm or potential harm, and pleasurable feelings arise with the arrival or anticipated arrival of something beneficial. According to neurobiologist and philosopher Antonio Damasio, because feelings have these subjective values, they serve as invaluable guides that help direct us towards advantageous behavior (2003). That is, we seek pleasurable feelings and avoid displeasurable ones.

A further defining feature of all uses of the term feeling is that they are phenomena of which we are consciously aware. Consciousness is a requisite of feeling. If a crayfish feels pain, for example, then it must be conscious. Unfortunately, as described in the last chapter, it is impossible to prove that another organism can feel based upon its behavior alone (the trick is that it might merely behave in a manner that is roughly analogous to behavior associated with pain in humans, without having any feeling at all). However, further analysis will allow us to show that the reverse of the above statement is also true. Namely, the presence of consciousness implies that animals are also capable of feeling. Therefore, even though we cannot know if the crayfish feels pain by observation alone, if we can establish that it is conscious we can be certain that it feels something which serves the same function as the feeling of pain we all experience. Importantly, recognizing this allows the question of whether animals have feelings to instead be whether animals possess consciousness, a question which can be systematically approached by studying the brain's biology. As will be seen, however, this too is an extremely difficult task; presently the mechanisms responsible are not even understood in humans.

Consciousness, like feeling, is a term that has no single widely accepted meaning and can represent many concepts depending upon the context. Certainly humans are conscious in a way that is unique. We are keenly aware of the state of our bodies, of our pasts and futures, of our thoughts and desires, and of the minds of others. We have imaginative and creative abilities, and memories that can recall rich and detailed information. Human consciousness, however, should not be thought of as an irreducible monolith (Damasio, 1999). Like every other aspect of biology, it has reached its current remarkable state through a slow evolution in which complexity has arisen as new adaptations developed from preexisting structures. For example, the eye is an immensely complex structure that certainly did not arrive in one step; instead it started as a simple photo cell and evolved slowly to discriminate increasingly more information from the environment. Similarly, it makes more sense to assume that consciousness arrived in stages rather than in a single moment at which point the brain had suddenly evolved sufficiently. When describing consciousness in other organisms we will inevitably need to do so in terms that relate to our own consciousness. However, human consciousness should not be considered the starting point. Rather, if other animals are conscious, it is likely that they would be so at a more simple and fundamental level. It is likely that animal consciousness is built of many of the necessary basic components that are elaborated and added to in human minds (Crick, 1998).

DEFINING CONSCIOUSNESS

While little is known about the mechanics of consciousness, scientists and philosophers have made progress in defining and conceptually understanding various aspects of what consciousness is. A full review of this progress is beyond the scope of this work, however, I will outline some of the ideas as they relate to more fundamental aspects of consciousness possibly found in animals.

There are many theories about how to subdivide and categorize consciousness into separate manageable concepts. The most basic use of the word consciousness is the term "creature consciousness" (Clark, 1998). This term describes an organism in its wakeful state (as opposed to being asleep or in coma) that is able to respond appropriately to its environment. Most vertebrates and many invertebrates including fish, reptiles, and amphibians possess creature consciousness. It identifies such creatures as being alive. Creature consciousness is a requisite state for all higher forms of consciousness, but is not very useful in identifying feelings in animals because it does not say anything about internal mental states.

A more useful distinction currently made regarding aspects of consciousness is the separation of *explicit* and *implicit* consciousness. Explicit or phenomenal consciousness is the experiential aspect of consciousness. It is what allows for identity and self; without it there is no "me", there is merely a functional organism without an owner. Explicit consciousness is everything that we know about our selves, our senses, and the world around us. It is everything of which we are aware, and importantly it is the con-

nection of this information with "the idea of me", as Russell puts it (2003). Our explicit selves allow us to make decisions and to weigh options. Our explicit selves constitute the "we" that knows about the body and can act in its best interest. A more direct definition is difficult at this point because scientists still are unclear as to what explicit consciousness is. When looking for feelings in animals, we must look for the presence of explicit consciousness.

Implicit consciousness refers to the functions of cognition that occur without awareness. Though the behavior of a person who has implicit knowledge of something may be altered by that knowledge, this occurs without awareness. No intentional choice is made. Our implicit selves regulate our bodies, process and store information, and guide our behavior. In fact, most of who "we" are is implicit; as Lewis explains "I have no knowledge of a large number of my motives- organized, coherent thoughts and ideas that have been called unconscious- that control large segments of my life. I have no explicit knowledge of how my thoughts occur" (Lewis, 2003, p. 106). We cannot be aware of all the information that our bodies process; it would be overwhelming to always feel what each part of our body was doing, focus on every memory that we possess, and think about each action we carry out. An example of implicit consciousness would be when driving a car, our visual systems may process and act upon information without any awareness. The presence of a car to the right, for example may go completely unnoticed, though we make sure to avoid running into it. If someone directed our attention to the car, it could become the focus of our attention and enter explicit consciousness. Implicit consciousness does not satisfy the general notion that to be conscious is to be aware. To

be implicitly conscious is to have a brain that computes and allows one to be functional and react appropriately in the environment.

Some scientists have emphasized the importance of implicit consciousness such that the role of explicit consciousness in cognition is drastically diminished (Chalmers, 1999; Block, 1995). It is true that psychological studies of humans have demonstrated that a great number of our cognitive functions occur implicitly (Berridge, 2003). Also, in addition to this "cognitive unconscious" there exists an "emotional unconscious", where both the causes and effects of emotions remain outside of awareness (Berridge, 2003). The degree to which the implicit self contributes to overall behavior, though a subject of ongoing investigation, could indeed be significant. Some even would say that implicit processes alone could feasibly drive any complex behavior, allowing for a so called "philosophical zombie" (Chalmers, 1999). In this case it could be true that animals operate entirely implicitly, without any feeling self. Regardless of how important the implicit self may be, however, humans undeniably *do* have an explicit self. This leaves open the possibility that other animals also possess explicit consciousness, which like in humans would play a coordinated role with the implicit self in behavior.

Explicit consciousness, however, is itself a complex concept that can be separated into more fundamental components. As mentioned earlier, consciousness is not an irreducible monolith. We have many different types of consciousness, including forms that are associated with vision, pain, hearing, self-consciousness, and so on (Crick, 1998). These forms can function independently, such that loss of one does not affect the performance of another. With damage to the visual cortex, for example, a person may lose

the ability to form mental visual images, yet retain other forms of consciousness. Although there is definite separation between different forms of consciousness, the underlying mechanisms for each system likely function identically (Crick, 1998), and furthermore all forms at some level probably share some structural features (Damasio, 1999). It is therefore possible to describe the workings of any one system and apply this knowledge to all other forms of consciousness.

Each form of consciousness can be further divided into various levels corresponding with different complexities and layers of awareness. There is no clear division between these forms of consciousness; more likely awareness increases in complexity and intensity gradually with increased mental capacity. The existence of a primary conscious state requisite to all higher forms of consciousness has been theorized independently in the disciplines of biology, psychology, and philosophy. This concept has been labeled in various ways, including core consciousness, bare awareness, and primary-process consciousness, though all are essentially identical (Damasio, 1999; Johnson-Laird, 1988; Panksepp, 2005). The most basic aspect of core conscious experience is feeling, or "raw sensory-perceptual feelings" (Panksepp, 2005). It is the most fundamental level of consciousness; it can be thought of as the "light" that turns on and differentiates an individual capable of experience and "knowing" from a mindless organism that merely reacts. Core consciousness is "the very evidence, the unvarnished sense of our organism in the act of knowing" (Damasio, 1999, p. 125). The act of knowing is itself a feeling; therefore to be core conscious is by definition also to feel (Damasio, 1999).

As the most basic level of consciousness, it follows core consciousness would be the most widely distributed level of awareness among animals. The precise mechanisms responsible for core consciousness are not known, however, so it is impossible to say when it first evolved. Perhaps it is a structure that originated in distant ancestors common to many animals. It could also be a capability unique to mammals, primates, or even alone the human brain. This problem will be addressed in the following chapter along with a discussion of the neural structures necessary for core consciousness.

Building upon the basic awareness of core consciousness is secondary consciousness, a concept that describes the ability to make thoughts about experiences, usually in reference to how external events relate to internal events (Panksepp, 2005). That is, with secondary consciousness, one reflects on sensations not with words or other symbols, but with "perceptual images" (Panksepp, 2005). Imagine non-verbally recognizing the pain of a cut thumb.

The human mind is capable of the most advanced level of consciousness, called tertiary consciousness. Tertiary consciousness is a sort of meta-consciousness; the ability to have thoughts about thoughts. Specifically, it requires the ability to make linguistic and other forms of symbolic representations of simple thoughts and memories. It is widely accepted that no animals are capable of tertiary consciousness, with the possible exception of perhaps some great apes (Panksepp, 2005).

In this study it is necessary to establish what actual evidence supports the existence of core consciousness. Is core consciousness a biological state that can be physically distinguished from higher forms of consciousness, or is it merely a theoretical con-

struct that is useful in describing the mind? Damasio believes it can in fact be distinguished biologically. He bases this claim upon years of clinical work, a route not commonly taken in consciousness studies (Crick, 1990). Damasio's basic hypothesis states that core consciousness can exist alone, but when coupled with additional cognitive functions also allows for higher forms of consciousness, which fall under the umbrella term "extended consciousness" (1999). Importantly, when core consciousness is impaired through brain damage, extended consciousness is also lost (Damasio, 1999) (when core consciousness is impaired, the person enters a vegetative state). When extended consciousness is impaired, however, core consciousness can remain intact. Additionally, it seems the same mechanisms (structures) of core consciousness are required for every type of sensory awareness. That is, it is possible to lose consciousness in a sensory modality through damage to the cortex without losing core consciousness, though damaging any of the select structures necessary for core consciousness impairs all consciousness entirely. I will address which structures these are in the next chapter.

According to Damasio, an important aspect of core consciousness is that the brain creates representations in the mind that have the quality of being owned by the organism making them. This inner sense, he claims, is based upon mental images of a feeling that describes the relationship of an object and the organism. Namely, these images describe how the state of the organism is changed, moment by moment, by the object. A conscious state arises through the process of the neural mapping of the body state, the object (which come from sensory perceptions), and the mapping of their subsequent relationship. He again comes back to the feeling-grounded nature of consciousness by asserting

that because of the "body-related nature" of these maps, the consequent mental images that arise are feelings (Damasio, 1999, p. 170).

It seems unlikely that a person may exist who is only capable of core consciousness, but Damasio describes one patient, David, who comes close to such a description. David suffered severe damage to several regions of his brain necessary for creating new memories as well as accessing past memories; he was the most severely amnesic patient ever recorded (1999). His perception of the world exists entirely in the moment; there is only a vague sense of the past, and absolutely no sense for a future upon which to relate current experiences. David lacks what is known as an "autobiographical self." However, David is not a zombie- from his behavior it is evident that he forms images in his mind from all sensory modalities, and that these images have the quality of being owned by him. He is aware, capable of sustained attention, and able to experiences all primary emotions; "in terms of core consciousness, David is as conscious as you or I" (Damasio, 1999, p. 118). In fact he is capable of speech, can make simple comments about his surroundings, expresses basic likes and dislikes, and can even play checkers (he can't name the game or explain the rules). Though David's extended consciousness is not entirely lost, as is evident by his ability to use language, etc., his mental life probably consists of little more than a purely core conscious state. His unique case illustrates how the basic structures required for feeling and consciousness are independent from the additional cognitive activities that consummate a normal mind.

It can be difficult to comprehend what core consciousness "feels like" because humans have highly developed conscious states that can represent things simultaneously

on many levels. There are times, however, when it is easily recognized. Take the example of the cut finger. While the pain may be re-represented in higher forms of consciousness and further elaborated and manipulated by memories of similar feelings, these higher-order mental processes are separate from core consciousness. Alone the aching feeling of pain constitutes core consciousness. Similarly, when looking at a face it is the visual information alone that constitutes core consciousness, not the accompanying affective feelings that might arise from recognizing the person as a friend or as a source of danger.

Core consciousness includes the notion of feeling and a sense of self. It does not include what Damasio calls the "autobiographical self" (1999). That is, it is does not include all the aspects of self that are made available with the addition of memory, reasoning, and other higher cognitive functions. These in conjunction with core consciousness contribute to extended consciousness, a concept which also encompasses all the variations on secondary and tertiary consciousness (Damasio, 1999). Certainly the ability of an organism to focus on an object increases with extended consciousness, as may the intensity and meaning of feelings experienced as they are related to memories of previously experienced feelings. The sense of self that is generated by core consciousness, however, alone is enough to make an individual. An organism capable of core consciousness can know pain and pleasure, feel tired or awake, and everything in between, even if only transiently. When questioning whether animals are individuals capable of feeling, establishing the presence of core consciousness is sufficient. From this starting point, more inves-

tigation can then be made to discern what additional functions the animal might have that could contribute to a richer extended consciousness.

The following section is devoted to the physical aspects of the problem of consciousness, specifically as they relate to what little is known of core consciousness. With a knowledge of the physical features necessary for core consciousness in humans, we will be able to look at other animals, and given the presence of analogous structures, be able to infer in them the presence of core consciousness and feelings.

Chapter 3- The Biology of Core Consciousness

To attain proof as to the existence or absence of feelings and core consciousness in animals, it is not enough to observe behavior and neural activity alone; the biology of consciousness must be understood. This, however, must first be established in humans, a problem as difficult as any in biology (Chalmers, 1999). Until the early 1990's, consciousness had been almost entirely ignored by biologists and neuropsychologists, considered a subject not worth scientific study (Horgan, 1999; Watt, 2004a). Through their seminal paper "Towards a neurobiological theory of consciousness," Francis Crick and Christoph Koch helped make consciousness an area of active research by arguing successfully that progress on the problem is possible through an intelligent approach (Horgan, 1994). While there have since then been advances in theoretically conceptualizing what consciousness is, the underlying biology remains as elusive as ever.

There are myriad difficulties associated with the study of consciousness in humans. The most fundamental problem is that experiential states by nature cannot be studied as can other problems in science (MacLennan, 1995). All other biological processes can be observed and objectively measured, but because of their personal and internal nature, mental states cannot. The only evidence of mental states available are verbal reports and behavior. By necessity, the study of consciousness is subjective and indirect.

This fundamental problem limits our ability to study exactly what experience is from a physical perspective. The best that we can do is observe the brain during a given mental state and record patterns of activity. This, however, is difficult because it is impossible to induce experiential states directly; instead, indirect methods must be utilized such as exposure to stimuli or having a subject concentrate on a given feeling or memory (Cleeremans, 1999). This presents two major problems when looking for neural correlates of consciousness. First, there is much uncertainty as to the actual state a subject is experiencing after such inductions. Second, when observing a brain supposedly in a happy state, for example, many processes not directly involved in the conscious awareness of happiness will also be highlighted, since the brain is always simultaneously engaged in multiple parallel activities, and these must be carefully teased apart from the essential correlates (Cleeremans, 1999).

Philosopher David Chalmers has framed the study of consciousness as consisting of numerous “easy” problems and of one “hard” problem (Chalmers, 1999). The easy problems, he claims, are not in fact easy, but rather labeled easy because they are foreseeably worked out using conventional reductionistic scientific method. These problems all

deal with "objective mechanisms of the cognitive system," and can be solved by uncovering how these mechanisms operate (Chalmers, 1999, p. 289). This includes questions such as: how does the brain discriminate between sensory stimuli, and how does it use this information appropriately? (Chalmers, 1999). How is the brain able to verbalize internal states? What are the processes that lead to behavior, and to what extent are these controlled implicitly versus explicitly? How are perceptions from various sensory systems blended into a coherent understanding of a single object (this is known as the "binding problem")? What are the neural correlates of consciousness? What structures and processes are needed to produce experience?

The hard problem, by contrast, cannot be studied by conventional means. Also called the "explanatory gap" and the "mind-body problem," it is unlike any other question in science. Why should patterns of activity in the brain lead to experiences? How can subjective qualities (qualia) be explained in physical terms? How could one possibly describe how warmth feels or what a shade of blue looks like in terms of the firing of neurons? Chalmers does not refute the notion that consciousness arises from processes in the brain, he simply states that the link between experience and the physical world is not one which can be explained by any set of laws currently known.

There is a large and diverse group of philosophers and scientists dubbed "the new mysterians," who for various reasons believe that the mind-body problem is insoluble (Horgan, 1999). Mysterians claim that mental states cannot be fully explained in terms of physical properties alone (Horgan, 1999). Some claim that the problem is related to quantum mechanics, which creates "nondeterministic effects that classical theories of

physics (and neuroscience) cannot" (Horgan, 1999, p. 300). Other philosophers argue that the while the problem of consciousness is technically soluble, human intelligence is not developed enough to comprehend it (Glynn, 1999). Chalmers remains agnostic on the issue, though has suggested the need for a new set of fundamental laws which relate "experience to elements of physical theory" (Chalmers, 1999, p. 292). According to his thinking, the concept of information might be the link that can bridge the explanatory gap. Information can be thought of as a "set of separate states with a basic structure of similarities and differences between them" (Chalmers, 1999, p. 294). Everything in the physical world can be described as an information state, and so can conscious experience. He suggests that a single information state may describe both the physical and experiential aspect of something. Therefore experience is an intrinsic quality not to be explained by mechanisms, but rather that exists independently.

Whether soluble or insoluble, the mind-body problem will likely continue to concern philosophers into the foreseeable future. While the attention the mind-body problem receives from philosophers is valuable, some point out that there are perhaps more productive areas of study upon which to focus. Crick and Koch claim that endlessly arguing over the solubility of the problem gets us nowhere, and in fact inhibits progress in other areas (1990). They admit that to gain a full picture of consciousness, the mind-body problem must be understood. However, this understanding, if at all attainable, will only come after further studies of neural mechanisms. Once the neural mechanisms of consciousness are understood (that is, the easy problems), we will be in a far better position to approach the hard question.

Although the mysterians are correct that the true nature of consciousness may never be discovered, science can still arguably give great insight into the problem. In my view, understanding *what* processes give rise to mental states is more important than understanding *why* mental states arise from these processes. It is conceivable that through future research we may discover precisely the structures, even the specific cells, in the brain necessary for any given aspect of consciousness, and further we may learn what physical processes take place neural activity. We may also learn how a unified sense of self arises given the fact there exists no single place, or "Cartesian Theater" (Dennet, 2003), from which consciousness arises. Even without answering the hard question, understanding the neural correlates of consciousness should reveal much about what experience is, and will give insight into the nature of our own existence. Furthermore, only with this knowledge will we have the tools necessary to make any conclusions regarding the minds of non-human animals. The existence in animals of neural systems analogous to those which produce core consciousness in humans would prove that such animals are capable of feeling.

There is, however, little agreement currently about what processes are necessary for core consciousness (Cleeremans, 1999). Various theories exist but none is yet satisfactory (Chalmers, 1999). This is due both to the tremendous difficulty of the study and also to the relatively short time that it has received attention. Chalmers has compiled a list of 20 such theories representing many diverse ideas (1998). One theory introduced by Crick and Koch states that synchronized oscillations in various regions of the brain at a high frequency range between 40 and 150 Hz might "underlie feature integration" and

be the substrate for core conscious awareness (Rees, 2002). They support this notion by noting that certain cognitive functions thought to be closely related to awareness can alter the overall patterns of synchronized neural activity (Rees, 2002). A vastly different view on consciousness is that awareness originates not from entire brain systems, but in fact from individual neurons (Sevush, 2005). According to this view, the electrical activity of the dendritic portion of neuron determines the content of its consciousness. The more complex the activity, the more complex the content of the conscious experience. An organism's overall conscious experience is the result of interactions from all neurons in the brain, with some regions being more important than others (Sevush, 2005). Interestingly this view would support the notion that animals possess feelings.

Other ideas are grounded upon varying degrees of evidence and offer at best plausible explanations for overall patterns of neural behavior. It should be noted that none, however, address the mind-body problem; experience is simply an emergent property that results from neural activity (Chalmers, 1999). This is true of the single neuron hypothesis, where experience simply occurs in the dendrites. There is no explanation of how or why; indeed the author claims that the evidence does not necessitate the conclusion, only that it fits with it (if only very loosely) (Sevush, 2005). The oscillatory theory, which notes that such synchronous firing often occurs when one is aware, also does not address the mind-body problem. It is not claimed that the oscillations *cause* awareness, or that they are even *sufficient* for awareness. In fact, there is no hard evidence that says what their true significance is; at best pure speculation is possible. Regardless, the aim of these theorists at present is not to solve the mind-body problem but to isolate the proc-

esses and mechanisms requisite for awareness. There is clearly much still to be done in this pursuit.

Precisely identifying the neural correlates of core consciousness, i.e. the mechanisms by which various structures interact, in humans is necessary in order to definitively assess whether animals are capable of core consciousness. As this has not been accomplished, such an assessment is currently not possible. A more immediately achievable goal is to identify the basic structures that correlate with various aspects of consciousness, specifically those that are responsible for core consciousness. Although not definitive, the presence of equivalent structures in other animals would strongly support the notion that they too are capable of feeling.

What research has been done regarding *where* in the brain consciousness occurs? This question has received more attention than any other regarding the neural correlates of consciousness, yet remains largely unanswered. One major point under scrutiny is to what extent the neocortex plays a role in creating consciousness compared to other parts of the brain. The neocortex is the evolutionarily newest part of the brain found only in mammals, and is presumed by many to be the structure responsible for producing consciousness in humans (Panksepp, 2004; Watt, 2004b). It is involved in many higher cognitive functions including motor commands, sensory perception, spatial reasoning, and language (Kelly, 1991). Physically, the neocortex accounts for about 80% of the human brain's mass, is situated at the outermost section of the brain, and consists of six layers that fold into numerous sulci (grooves) and gyri (wrinkles) (Kelly, 1991).

The notion that conscious awareness (analogous to core consciousness) occurs principally in the neocortex has been supported by the work of Christoph Koch's group (Rees, 2002). He has identified various structures that are needed to produce specific aspects of visual awareness. Importantly, damage to ventral visual cortical areas that are responsive to specific aspects of the visual environment cause corresponding impairment of those aspects of consciousness (Rees, 2002). For example, damage to the motor cortex, V5/MT, which responds to visual movement, leads to the condition known as akinetopsia, in which moving objects cannot be perceived (Rees, 2002). Damage to ventral areas of the occipitotemporal cortex, which are sensitive to specific colors, can cause achromatopsia, the inability to perceive colors (Rees, 2002). Work by Erik Lumer suggests that the parietal and prefrontal cortices (found in the neocortex) also play an important role in visual awareness, specifically in transitioning attention between precepts (1998). From this data, Rees has suggested that these two cortices, in addition to the ventral visual cortices, comprise the necessary neural substrates of visual core consciousness (2002). The general notion is that core awareness for other sensory modalities is produced analogously with the prefrontal, parietal, and respective sensory cortices in the neocortex.

It is important to understand that while the above does pinpoint certain structures needed for given aspects of consciousness, the data do not necessitate the conclusion that consciousness is *produced* in those regions. Perhaps these structures are merely part of a chain of components that allow for our conscious perceptions of the world. Certainly these areas are needed to compute and organize aspects of the environment into useful

and recognizable forms. It is possible, however, that they function more as a lens that brings various aspects of consciousness into focus, rather than comprising the entire mechanism necessary for experience. Might consciousness occur in lower brain structures even if it is dependent upon processes from the neocortex?

Antonio Damasio offers a different interpretation from Rees based upon his own research and understanding of what core consciousness is. As explained in chapter two, Damasio hypothesizes that core consciousness emerges in second-order neural maps that relate current mappings of the condition of the organism to maps that describe an object at any moment. In other words, core consciousness stems from the process of continuously describing in the form of neural mappings, how the body is affected by an object. From this hypothesis, it follows that only the three types of structures corresponding with these mappings are required to produce core consciousness: those of the organism, those of the object, and those that relate the two. The structures involved in mapping the organism's body state (which Damasio calls the proto-self) are dispersed throughout the brain, within a few parts of the neocortex as well as many evolutionarily older subneocortical regions. Included are several brain-stem nuclei, which, in addition to regulating the body, are the first point at which the overall state of the organism is mapped. The hypothalamus, a structure in the forebrain (below the cortex), also contains a map of the body state and maintains homeostasis by regulating pH and levels of circulating chemicals such as glucose. Finally, regions of the neocortex also contribute to the proto-self, including the insula, the S2, and the medial parietal cortices. These regions seem to provide the most integrated overall mapping of the body (Damasio, 1999).

The maps that comprise the proto-self are combined with mappings of an object (from early sensory cortices) in structures containing second-order maps. Structures thought to contain second-order maps include the superior colliculi located in the mid-brain, the entire cingulate cortex (which is below the neocortex), the thalamus, and finally some prefrontal cortices in the neocortex. Damasio hypothesizes that these second-order structures cooperate to varying degrees in producing consciousness. Most likely complex cross-signaling patterns among many structures are needed to produce consciousness, rather than there being any one structure that alone holds the "supreme second-order pattern" (Damasio, 1999, p. 177). He recommends that future research focus on discovering exactly what role each region plays and in what precise manner they interact (1999).

It should be noted that Damasio's hypothesis is consistent with results that led Rees and others to conclude that consciousness is produced in the neocortex. Core consciousness can be activated when any sensory input reaches the second-order maps. Therefore, the fact that damage to specific sensory structures impairs consciousness in those modalities is not surprising. Koch has not located neural correlates of consciousness, rather sensory structures whose direct input is needed to produce core consciousness in secondary structures.

Jaak Panksepp also hypothesizes that core consciousness is grounded upon a current mapping of the body and not simply the external world interpreted in sensory structures, as claims Rees and others. Additionally, however, he argues that the neocortex does not contribute directly to this process. In fact, he claims that all of the basic mechanisms are located in sub-neocortical structures common to all mammals and many other

animals including birds. The neocortex is responsible for higher forms of consciousness (secondary, tertiary, extended), our introspective abilities, and our unique cognitive capacities (Panksepp, 2005).

Panksepp bases this inference on a diverse groundwork of reasoning and evidence. Importantly, it has been demonstrated that when the brain is cognitively active (i.e. the cortex is active), affect is reduced, while with more intense feelings of emotion and affect, subcortical regions are predominantly activated (Panksepp, 2005). This piece of evidence in particular does not prove that core consciousness is produced in subcortical areas, just as the activation of the visual system does not prove that it is produced in the neocortex. However, it has also been proven through a variety of clinical cases that almost all structures necessary for consciousness are subcortical; most illnesses in which consciousness is impaired are due to damage to subcortical regions (Watt, 2004b). Furthermore, though the neocortex is necessary in a functioning adult mind, subcortical regions alone are sufficient to produce core consciousness and affect before the brain fully develops. Children with damage to large portions of their neocortices at birth are conscious and develop functioning emotions, even though comparable damage to adults would result in a persistent vegetative state (Panksepp, 2005). In combination, this evidence supports the concept that subcortical regions are primarily responsible for core consciousness, while neocortical regions facilitate extended consciousness.

From a logical perspective, Panksepp finds it hard to fathom that the information needed for core experiential states present in subcortical regions require the higher cognitive abilities of the neocortex to be “read-out” into conscious states (2005). That con-

sciousness emerges gradually, beginning from simple levels rather than all at once as the result of complex cognition, seems logical given the evidence pointing to the importance of subcortical systems in consciousness. This idea also makes more sense evolutionarily, since the most parsimonious explanation for the development of consciousness is that it developed gradually, beginning by representing the basic condition of the body through core consciousness in the subcortical regions, to eventually allowing an organism to cognitively reflect on thoughts and have an understanding of the past and future through development of the neocortex.

If Panksepp is correct claiming that core consciousness occurs sub-neocortically in humans, then there is a strong argument that many animals are capable of core consciousness. The subcortical regions he deems necessary are not only present in many vertebrates, including all mammals, but have diverged little among classes of animals (Panksepp, 2005). In fact this would include all vertebrates, including mammals, birds, reptiles, and fish. It would not include any invertebrate animals such as insects or crustaceans. Without knowing the exact processes that contribute to consciousness, we cannot be certain that these regions are performing the exact same functions, but the evidence would regardless overwhelmingly support the conclusion.

If Panksepp is wrong, however, if consciousness is dependent upon higher neocortical processes, then there is still a strong argument that at least all mammals, which also posses a neocortex, are capable of core consciousness. Admittedly, the neocortex is far more developed in humans than in all other mammals, but there is no evidence for anything fundamentally different that might allow for consciousness to occur in humans

alone (Panksepp, 2005). Additionally, it is possible that core consciousness is dependent upon neocortical activities in humans while in other animals it is not, since humans are capable of core consciousness even when the neocortex is damaged. Perhaps core consciousness originally evolved without the few neocortical structures demonstrated by Damasio to be necessary for core consciousness in normal adult humans. Maybe as human consciousness developed other structures were integrated in order to accommodate and enhance the growing cognitive abilities. There is only a strong argument against animals being conscious if one assumes that the concept of a core conscious state is flawed. That is, if consciousness only emerges as a result of higher cognitive abilities as some claim, (Rolls, 1999; LeDoux, 1996) then no other species, with the possible exception of other primates, can be conscious. This notion, however, is most likely flawed (Damasio, 1999; Watt, 2004b; Panksepp, 2005); consciousness is a multi-tiered process dependent upon structures widely evolutionarily conserved among animals.

Chapter 4- Conclusions/Implications

The question of animal feelings has a wide range of important implications. If it can be proven that animals are conscious, our interactions with other species will be given new and greater meaning. We are far more likely to relate to and respect an animal that is conscious and feeling like a human than one that is unfeeling and mindless. While this may not affect our relationships with our pets, which we may already consider to be feeling, it could alter the way many humans interact with animals in nature. Currently,

there seems to be a widespread mentality in which sacrificing the natural environment for human needs is deemed acceptable. Even natural areas kept off limits to development are often saved for the benefit of humans; a forest may be saved for its beauty, for example, rather than preserving it in consideration of nature itself. This is a perfectly valid mentality if we do not consider other species to have any identity of their own. If it was known that animals had feelings, however, there may be more incentive to treat nature in a more respectable way. Just as humans feel obligated to treat other humans in a decent manner, perhaps we would also treat other animals and their habitats with renewed respect and compassion.

From a more practical standpoint, Jaak Panksepp (2005) argues that by making the assumption that animals are core conscious, valuable insights into understanding the human mind can be made, especially with regard to the systems underlying emotion and attention. Understanding the biology of these phenomena in humans is currently restricted to observing neural correlates, i.e., recording which parts of the brain are active during a given state. Panksepp points out that mammals display emotional behavior that is strikingly similar to that of humans. Furthermore, animals can be studied far more directly then can humans; slight changes to physiology produce effects on emotional or attentional behavior that can be measured, as can the direct effects that changes in behavior have on neurons in the brain. If we accept that the behavior of mammals actually reflects internal states like our own, the potential for studying the underlying mechanisms behind our own feelings and emotions may be greatly increased by studying those of mammals (Panksepp, 2005).

The formal study of animal feelings has until recently been essentially neglected in modern science. This neglect is a result of the difficulty associated with studying mental processes, which is enormous in humans and even more formidable in other animals because we cannot confirm findings with verbal descriptions of mental state. Neurobiologists have spent much of the past century simply trying to grapple with the basic structure and function of the human brain; mapping its complex architecture, understanding how neurons function, slowly discovering how sensory systems represent the outside world, and so on. The field has been far from able to even approach uncovering the biological basis of feelings. Furthermore, psychology ignored the content of the mind for much of the 20th century due to the influence of behaviorism, which advocated studying only observable behaviors. Only since the early 1990's have psychology and biology come together to formally study human consciousness and the nature of the mind. The advances made since then also allow animal feelings to be approached for the first time, though both fields remain in their infancy.

One major difficulty in trying to study animal feelings is that it is not entirely clear what feelings are. We do know what feelings are *for,* namely that they serve as a means of guiding an organism to appropriate behavior (Damasio, 2003), but beyond this, there is little agreement about exact definitions. The view taken in this thesis is that feelings are the experience that arises through the processes of core consciousness, the most basic level of awareness. Put in another way, feelings are the fundamental content of consciousness. One cannot have consciousness without also feeling, and one cannot feel

without being conscious. Therefore, when trying to decide whether animals have feelings, it is appropriate to instead ask whether animals are capable of core consciousness.

How might it be possible to determine whether or not an animal is core conscious? Trying to analyze the content of a mind is exceedingly difficult because unlike everything else in science, experience cannot be observed and measured (MacLennan, 1995). We cannot look at a brain and see experiences, we cannot know from the outside what or even *if* an organism has a mental life. From our own experience we know that certain behaviors correlate very well with various feelings, and we depend upon this for our daily interactions with each other. When animals behave in comparable ways, it is easily assumed that they too have a corresponding experience. This is especially true regarding mammals, our closest relatives. It is difficult to observe any mammal, whether a dog, a squirrel, or an otter, and imagine that the creature has no experience accompanying its behaviors, which are so reminiscent of our own. As described in Chapter One, however, behavior alone is not a reliable indicator of a mental state because any given behavior may have various alternative causes, some of which may not involve any consciousness at all. Unfortunately, unlike with humans, we cannot verify our interpretations of mental states with a verbal report. Therefore many scientists from the behaviorist school would rightly argue that it is wrong to infer mental states in animals.

Despite this uncertainty, however, as discussed in chapter one, many animals undoubtedly do seem to have mental lives. It seems fair to push the question further; if we cannot verify mental states by behavior alone, might revealing the presence in animals of neural structures known to produce experience in humans suffice? If in addition to acting

in ways analogous to humans, animals also have similar brain structures and undergo similar neurophysiological changes, the weight of evidence would strongly support the notion that animals also are capable of feeling and experience.

Currently, the biological processes underlying consciousness remain almost entirely unknown. Various hypotheses attempt to explain overall patterns of behavior seen in the brain that seem to correlate well with conscious experience. As there is no real idea of what the physical correlates of consciousness should be, however, it is difficult to comprehend the true importance of these patterns of activity. Much careful research is necessary in this pursuit.

A more practical area of research involves simply locating the structures necessary to produce core consciousness. One of the most contested issues is whether these exist primarily in the neocortex, which is unique to mammals and largest in humans, or in subcortical regions more widely evolutionarily conserved. Arguments favoring the role of the neocortex are grounded on research done on the visual system indicating that certain regions show patterns of activity which correlate well with conscious experience (Rees, 2002). This logic presumes that there exist many structurally independent types of consciousness. Others would argue that while the neocortex is involved in awareness and cognition, it does not participate directly in producing consciousness; rather subcortical structures carry out this function (Damasio, 1995; Panksepp, 2005; Watt, 2004b). This implies that although there may be many structurally independent facets of consciousness corresponding with different modalities existing in the neocortex, all forms stem from a unified group of neural structures. This conclusion is based upon many observations, in-

cluding the fact that most disorders that involve impaired consciousness are due to lesions of subcortical structures (Watt, 2004b) and that consciousness can exist to some extent without the neocortex (Panksepp, 2005). Importantly, Antonio Damasio has outlined a testable hypothesis for how consciousness might come about which predicts primarily the participation of certain subcortical structures (1999). Though the issue is by no means resolved, arguments favoring the importance of subcortical regions in producing consciousness are, in my opinion, stronger than those supporting the importance of the neocortex alone.

In order to make any inferences about whether or not other animals are capable of feeling, we must be able to show that they possess neural systems capable of producing core consciousness. The underlying logic is that if animals possess structures analogous to those responsible for consciousness in humans then they too are conscious. If the exact structures required in humans were known, we could make confident inferences about the presence of feelings in other animals. Unfortunately, at this point it is not known what these precise structures are, though as discussed, we may soon be able to recognize general regions in the human brain which contain the precise structures. Therefore we can at present at least make tentative inferences about animal minds.

What these inferences might be depends upon whether consciousness is a relatively recent adaptation that requires the participation of newer neocortical systems, or if it is an evolutionarily older ability inherent to the widely conserved subcortical regions. If consciousness requires the participation of the neocortex, then it is probable that all mammals are core conscious, as they possess neocortices not fundamentally different

from our own (Panksepp, 2005). If, like Panksepp suggests, only subcortical structures are required, then a far larger number of animals that share subcortical structures very similar to our own could be included, namely all birds, fish, and reptiles (2005). Invertebrates such as insects or crustaceans do not possess even rudimentary forms of vertebrate subcortical regions. This does not mean that they necessarily lack core consciousness, only that we have no way of guessing based upon general similarity of structure.

While the presence of these regions in other animals would strongly suggest that they too are capable of core consciousness, it is flawed to assume that this is proof. We can say with the greatest confidence that other mammals are core conscious because they possess the probable requisite structures according to all views on consciousness. It could be, however, that even though other mammals also posses neocortices, they do not have the same function; perhaps only the human neocortex can produce consciousness. The same is true regarding subcortical structures. Put another way, even though other animals may possess the general regions necessary for consciousness in humans, perhaps they lack some additional adaptation within these structures that has not yet been recognized. Currently, all statements about the neurobiology of animal consciousness are based on evidence citing general analogies of structure and must therefore take these limitations into account. Only when the precise neural structure necessary for consciousness in humans are determined will it be possible to identify with certainty which, if any, other animals are core conscious. In the mean time, behavioral and neurobiological evidence strongly suggests that at least mammals are core conscious, if not all other vertebrates as well.

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