

# **Phylogeny of cognitive development and the capacity to suffer**

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## **Introduction**

The location of the seat of consciousness is a long established question in both philosophy and neuroscience. As humans we seek to find our place in nature particularly by comparing ourselves to other animals and to ask about the similarities and the differences. In science these answers give us a way of looking at the world which tries to explain natural phenomena in terms of underlying causes. These underlying causal relationships in science are required to be self consistent and to correspond with actual reality and differ subtly from the philosophical enquiries which inform the questions but not necessarily the answers. Whether or not other animals are conscious and can suffer informs the way we behave towards them especially if we assume guardianship for their wellbeing.

In this paper we address three main topics in the distribution of the ability to suffer amongst animal species. We have difficulties deciding which species to include in protective legislation yet the list of animals that we include has grown over the years. Implicit in decisions on which animals species 'suffer' is that we understand what it means to suffer in lower animals. To inform this discussion we consider what consciousness is in other animals. We then describe the central nervous architecture and characteristics required for animal consciousness. We review neural and other requirements for demonstrating the capability for suffering in fishes. Last we comment on evolution of vertebrates to ask how unpleasant experiences inform behaviours in an adaptive fashion of benefit to the species.

## **Consciousness**

There are several technical definitions of the word consciousness but many people believe that it is a matter of common sense that animals have conscious experiences. Multiple senses of the kinds of conscious experiences requires this common sense view to be unpacked to reveal what precisely is being discussed. Common sense often misleads us; it is not common sense that our genetic inheritance is contained in sequences of four base pairs organised up the length of a double helix, but it is true.

One sense of consciousness possessed by animals is not in dispute. Awake, unanaesthetised animals are conscious and perceive their environment. They react to selected features of it and a large number of animal taxa are consciously aware of these selected external and internal stimuli. In some animals this sensory input, or its neural representation, is broadcast to other parts of the animal, mostly the brain, to become available for access by other central nervous systems. In humans this access consciousness allows activities such as categorisation, planning and voluntary directed action to occur. This sense of consciousness meaning access to information in a “global workspace” (see Allen 2006) is not universally accepted as part of consciousness of all the taxa included in the sense above.

Phenomenal consciousness and self-consciousness are two further senses of consciousness that are accepted as concepts but which are less commonly attributed to animals. Phenomenal consciousness, which equates with sentience in our view, refers to the qualitative, subjective and experiential aspects of the consciousness. We believe that suffering is a phenomenologically conscious experience. Suffering according to Gregory (Gregory, 2004) represents “the mental state associated with unpleasant experiences such as pain, malaise, distress, injury and emotional numbness” and is very similar to the notion of pain as an “.. unpleasant sensory or emotional experience associated with actual or potential tissue damage..” (Iggo 1984). These experiences are broadcast, as described above, to a global workspace where activities such as planning and especially voluntary direction of attention may take place informed by these conscious experiences (Allen 2006). Nagel (1974) in his paper “What is it like to be a bat?” argues that there is “something it is like” to be another animal other than a human, in Nagel’s case a bat. To be a bat is to have a phenomenological experiences of bat-ness. We do not know what it is like to be a bat as we have no ways yet of asking this question, but Nagel argues that there is something specifically bat-like even though we can’t experience it. While not universally accepted, it is agreed that if a phenomenal consciousness exists, then it is more likely to occur in mammals and birds than in invertebrates and that fish represent a grey area in need of consideration.

Self-consciousness is the ability of an organism to refer to its own thought in a second order fashion; to think about its thoughts. There is considerable debate about whether animals attribute mental states to other beings. Most research about the theory of other species minds is with chimpanzees and great apes and their ability to suffer is not

in dispute. Self consciousness appears not to be a feature attributed to most animals and is not generally regarded as necessary for an animal to suffer although Carruthers (2000) regards self-consciousness as being required for phenomenological consciousness. If Carruthers is right, then young children, who most psychologists agree lack a theory of mind till between 3 or 4 years, are non-sentient. This position is difficult to sustain in the light of the evidence of behaviours of young children.

### **Neural requirements for consciousness and the capability for suffering**

We can ask what neural architecture, physiology and biochemistry is needed for consciousness? At cellular or subcellular levels there appear to be precious few differences in structure and functioning between the neurons of houseflies and humans that offer obstacles to attributing to animals a consciousness. Phenomenal consciousness has not yet been definitively identified with particular parts of the brain or waves of a particular power spectrum or frequency. If this were to be found, then determining which species enjoyed this cognitive capability would be relatively simple.

Other cognitive processes or functional attributes may signal the presence of a phenomenal consciousness. The access by other parts of the brain to primary sensory information has been claimed as evidence for a phenomenal consciousness (Dretske, 1995, Tye 2000). This position suggests that a phenomenal consciousness occurs in a wide variety of vertebrates and perhaps invertebrates. Others researchers require higher neuro-cognitive functions of recurrent feedback between neuropil layers and/or feed-forward into working memory as functional evidence of phenomenological consciousness (Prinz, 2005). These hypotheses, with evidence from mammals, support the idea that neuro-functional and cognitive characteristics of phenomenal consciousness reside within many if not all mammals. These conclusions, derived mainly from studies of cerebral cortical physiology, are less easily generalised to other brain areas or to lower vertebrate brains or invertebrate ganglia.

In mammals connections and neural interactions between the thalamus and neocortex (cortex = rind or outer pith, Gk) on the surface of the cerebral hemispheres are viewed as essential for consciousness (see Seth and Baars 2004). They suggest that the upper brainstem between the diencephalic basal ganglia and midbrain roof or tectum integrates the massively parallel and distributed information of the cerebral cortical representations into simpler, sequentially ordered commands for action required for coherent behaviour. In the fishes, there is no neocortex on the outer surface of the telencephalon (Nortcutt 1981) and thus there can be no re-entrant neural interactions

between thalamus and the absent neocortex and so the criterion above is of no help in deciding if fish have a phenomenal consciousness. Indeed, this fact has led Rose (2002) to suggest that fish cannot feel pain. However even in the oldest of vertebrates, the hagfish and lampreys, there exists layers of cells on the forebrain surface, the telencephalic pallium (pallium = cloak, L). More importantly these jawless vertebrates, and all vertebrates, have a thalamus and, with the striatal area, these serve to connect optic sensory area on the roof of the midbrain to the telencephalic pallium. Other sensory modes for olfactory and gustatory systems and even somatosensory projections in hagfishes (Ronan 1988) may also connect via this pathway. This brain stem tecto-pallial connection via the striatum, critical for consciousness in mammals, is present in all vertebrate animals (Butler and Hodos 2005). Birds, reptiles and mammals add to this tecto-pallial pathway by elaboration of the telencephalon into a neocortex. The upper brain stem is highly conserved through vertebrate evolution and is able to direct coherent actions in animals, including humans, in whom the cortex has been lost and generate a consciousness in humans born without a cerebral cortex (Merker 2007). People suffering from intractable pain who subsequently had frontal lobotomies can still feel the pain, but it no longer bothers them (Sweet 1971). Merker has stated that "The tacit consensus concerning the cerebral cortex as the 'organ of consciousness' may have been reached prematurely and may in fact be seriously in error" (Merker 2007). Thus we conclude that the central nervous architecture required for suffering is present in all vertebrates and is not dependent on the presence of a neocortical elaboration of the telencephalon.

Intentionality is a higher order commitment to behaviour that is much debated but which is closely related to consciousness and representational states. Intentionality is a feature of phenomenal consciousness in that the mind focuses and shows commitment of neural behaviour on some information accessible in the global workspace while leaving other information and sensory representations alone. While at the level of intentional behavioural outputs (such as animal migration) there may be some argument about the intentions of the animal, at the level of the brain, intentionality seems to be a key feature of the phenomenal consciousness in order for one sensory representation to get the attention of the organism.

### **Do fish suffer?**

Bateson (1991) provides guidelines for judgements about pain and suffering in animals. These are summarised by Sneddon in her review of nociception in *lower vertebrates* (our italics; Sneddon 2004) as:

- 1 Nociceptors
- 2 Brain structures
- 3 Pathways to higher brain structures
- 4 Opioid receptors and substances
- 5 Analgesics reduce nociceptive responses
- 6 Avoidance learning
- 7 Suspension of normal behaviour

Our discussion above of phenomenal consciousness is largely directed to the brain and its pathways in the above criteria (2 and 3). Nociceptors are a class of receptors reserved for noxious stimuli whereas we have considered a broader range of sensory inputs to the phenomenal consciousness. A shark may well 'suffer' when its electrosensory system, capable of sensing minute electrical fields the equivalent of a 1.5V battery with the positive pole 1000 km to the north and the negative pole 1000km to the south, is subjected to electrical fields from motors and electrical devices of vessels in the water in its sensory fields. The quality of this shark electrosensory suffering may be unknowable to humans who have no electrosensory system and may be as intractable as the essence of being a bat.

Lyn Sneddon (Sneddon 2004) reviewed the evidence for nociception in all groups of vertebrates including fishes against the criteria of Bateson (Bateson 1991). Since Sherrington (1906) conceptually separated our understanding of pain from nociception, the sensory physiology of nociception has developed alongside the cerebral and philosophical issues associated with pain perception. Nociceptors are associated with free nerve endings leading to small (0.2-3.0  $\mu\text{m}$ ) unmyelinated C fibres or larger (2-14  $\mu\text{m}$ ) A $\delta$  fibres. Lampreys have only unmyelinated fibres and physiological recordings (Matthews and Wicklegren 1978) show these to carry slowly adapting information about noxious heat and mechanical stimuli identified as nociceptors. Elasmobranchs appear to lack unmyelinated fibres and therefore have no C fibres but do have A $\delta$  fibres. Nociceptors of the gills have been characterised (Poole and Satchell 1979) but the fibre type for these branchial receptors was not described. No slowly adapting fibres responsive to temperature were identified in long tailed rays (Snow et al 1996). This is in contrast to teleost fishes in which nociceptors are well described (Sneddon et al 2003).

Opioid receptors and substances (see criterion 4 above) are found in elasmobranch and teleost fishes as well as other non-mammalian vertebrates (see Sneddon 2004 for

references) and there are some data showing enkephalin-like material is present in the adenohypophysis of the lamprey (Dores et al 2004). The distribution is comparable with patterns seen in mammals and this criterion for pain perception seems well satisfied for all vertebrates except the cyclostomes. Opioids in the spinal cord of elasmobranchs is interesting especially as they lack C fibres.

A number of studies have shown that teleost fishes can learn to avoid noxious stimuli (Yue et al 2004) and that this learning can be accomplished at lower noxious stimuli when opiate blockers such as naloxone are administered (Ehrensing et al 1982).

Sneddon's work (see Sneddon et al 2003, Sneddon 2004) on suspension of normal behaviour during noxious stimuli showed that rainbow trout given injections of acetic acid or bee venom showed physiological responses consistent with pain and abnormal behaviours such as rubbing the injections site on the tank substrate. Injected trout also failed to show a fear response to novel stimuli indicating higher central nervous system involvement. The learning experiments of Yue et al (2004) also suggest higher central nervous system processing is required and thus we propose that perception of noxious stimuli as pain is likely in teleost fishes at least.

### **Evolution of suffering**

Inheritance of genes which allow animals to suffer suggests that these traits are of value to either survival or reproduction. Suffering is a condition perceived as unpleasant and to be avoided to improve the wellbeing of the animal. Critical in this statement is avoiding the stimuli which generate suffering. To do this noxious stimuli must be differentiated from other intense but harmless stimuli which may also carry useful information. Second, learning that these and related stimuli are harmful and so avoiding them in the future is a very valuable strategy. Third, to act immediately and to give priority to actions so as to reduce further damage and suffering and also act so as to increase speed of recovery from the suffering, be it pain, stress or excessive exercise is clearly of value to animals. Many of these adaptive features involve actions in response to perceived unpleasant experiences. Vision serves to provide distal sensory control of actions the animal makes to survive and reproduce and has separate areas of the brain to enact movements of eye and body versus perception of the quality of the visual image which occurs in the visual areas of the neocortex of mammals (Milner and Goodale 1995). In order to understand suffering and its distribution across the animal kingdom, it will be necessary to look at not only the sensory inputs, internal and external, but also the motor outputs they effect and the

parts of the central nervous system from which they originate. Consciousness seems to have evolved to provide a stable platform from which to make motor commands in highly mobile animals whose sensory arrays deliver information that continuously changes as a result of self induced motion (Merker 2007).

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