

Distress in Animals: Is it Fear, Pain or Physical Stress?

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Abstract:

Both fear and pain can cause suffering. When pain is being studied, experiments must be designed to separate the variable of fear from the variable of pain. Some investigators claim that a sharp cut off line exists between those animals who experience pain and suffering, from those who do not. These arguments are based on the assumption that the capacity to suffer is related to the size and complexity of the brain, i.e., small brained animals feel less pain and potentially suffer less than animals with larger more complex brains. This paper refutes these claims and explains the concept that all hierarchical levels of the nervous system are built according to the same functional principles. The ability of an animal to suffer from pain may be related to the amount of associative neural circuitry linking sub-cortical structures to higher levels of the nervous system. A reasonable criteria for assessing pain induced suffering is does the animal actively seek pain relief. We propose that animals who protect injured parts, reduce activity when sick, or self administer opiate and non-opiate drugs are capable of suffering from pain. Some investigators claim that many mammals are in a "gray area" when it comes to suffering from pain. We propose that only fish, amphibians and reptiles may represent the "gray area" of understanding, pain, but they may suffer from fear because they will avoid a place where an aversive event has taken place.

Fear operates in a more primitive subcortical brain circuit than pain. When the cortex is removed, an animal will no longer suffer from pain but it can still learn a conditional fear response. A review of the literature indicated that prefrontal cortex activation tends to increase pain perception but reduce fear responses. Fear is extremely aversive and it is likely that it causes suffering in all vertebrates and possibly invertebrates such as the octopus that has a well developed nervous system. Pain perception requires more higher association circuits than responses to fear. Therefore it is likely that as the phylogenetic scale is descended there may be animals which would suffer from fear but not pain.

Experiments need to be conducted to determine if lower vertebrates will seek pain relieving medication in the same manner as warm blooded animals.

INTRODUCTION:

When studying distress one must differentiate between pain and fear. Both are highly aversive and the mechanisms for pain and fear are different. In your own experience you have probably been in situations where you experienced pain without fear and vice versa. For example, when I was in high school a plane I was on had to make an emergency landing. In this situation I experienced fear but no pain. A stubbed toe will cause pain but not fear. There are some situations where both fear and pain can be experienced such as getting in a car accident.

It has long been argued that the capacity to experience pain and suffering is associated with the size and structure of an animal's brain. Iggo (1984) suggested that although animals have similar brain structures, the size of those structures may be related to the capacity to experience pain. In this framework, a rat would suffer less than a cat, and a cat less than a dog. We disagree. More recently, Bermond (1997) proposed that an animal must possess a well developed prefrontal cortex and right neocortex. In this framework, only humans, higher apes and possibly dolphins can experience suffering. This paper provides evidence to refute these claims and offers suggestions for a more objective approach to assessing criteria used to decide whether an animal is capable of suffering. Whereas Bermond (1997) thinks many mammals are in a "gray area" when it comes to suffering from pain, we are proposing that only fish, amphibians, and some reptiles may represent the "gray area" of understanding for suffering from pain but that all vertebrates can suffer from fear.

Association Circuits and Aversive Stimuli

Although scientists have extensively studied and mapped the types of neurons that transmit pain stimuli to the brain (Short & Poznak, 1992; Wall & Melzack, 1994), there has been relatively little discussion about how signals are interpreted in the higher association areas of the cortex, and the emotion circuits in the limbic system. For example, Heavner (1992) reviewed the early work by Loeser and Black (1975) on the five levels of pain. This review contains a concise description of the lower three levels, detailed with all the nociceptive circuits below the cortex outlined. Noiception is the physiological response to painful stimuli and it does not involve the highest parts of the brain and pain proper. There is widespread agreement on the circuitry involved in the lower three levels, however, levels four and five on this chart contain question marks on how the limbic system and neocortex respond to pain signals. It has long been known that an intact cortex is required for the full extent of suffering. In his studies on the neurology of noiception, Woolf (1983) removed the cortex of rats to "obviate" the problem of suffering from pain. Even now, it is not well-understood how higher association areas in the brain interpret subcortical input. There is evidence in humans that the prefrontal cortex is involved in suffering from pain (Freeman and Watts, 1950; Smith and Boyd, 1991; Rainville, et al 1997; Fulbright et al., 2001). Human patients with chronic pain have a hyperactive prefrontal cortex (Apkarian et al., 2001). The prefrontal cortex is connected widely with subcortical structures such as the amygdala, and shares reciprocal connections with the parietal cortex, occipital cortex and the temporal cortex (Smith and Jonides, 1999; Ledoux, 1996). The amygdala is intimately involved in processing fear (Rogan and LeDoux, 1996; Medina et al., 2002; Ledoux, 1996). Fear is processed in a subcortical circuits and the amygdala is the fear center. Lesioning the amygdala will block both learned and unlearned fear responses (Davis 1992). Lesions in the amygdala will reduce emotionality and have a taming effect on both rats and cats (Kemble et al., 1984). Stimulation of the amygdala will increase plasma corticosterone (stress hormone) in both cats and rats (Matheson et al., 1971 AND Redgate and Fahringer, 1973). Fear conditioning takes place in a subcortical circuit and it can occur in an animal where the cortex is removed (Medina et al., 2002). For an animal to associate a certain place with an aversive stimulus the hippocampus must be intact (Rogan and LeDoux, 1996). The prefrontal cortex is required for an animal to extinguish or unlearn a conditioned fear response (Rogan and LeDoux, 1996). Several studies show that in humans, panic attacks or post traumatic flashbacks occur when frontal cortex activity is decreased (Villareal and King, 2001; Fisher et al., 1998). In both mammals and people, the frontal cortex reduces responses to stimuli that elicit

fears, but it increases suffering from pain. Fear operates in a low more primitive brain system than pain. The prefrontal cortex which is the most highly evolved brain region helps an animal to control its reactions to fear provoking stimuli, but heightens pain perception. It has the opposite effect on pain and fear.

The question is, how much circuitry linking subcortical and higher association areas is needed for an animal to suffer from pain? To make an analogy, the vast literature on pain tells us how the telephone lines and the switching equipment works, but it does not tell us how the cortex of an animal is interpreting this information. All the research on "wiring" and "switchboards" does not tell us if the animal suffers. A brief review of the higher association areas in the brains of mammals is followed by discussing possible ways to gain insight into the subjective experience of pain proper which Smith and Boyd (1991) define as; "the conscious emotional experience of pain which involves nerve pathways to the highest parts of the brain and cerebrum." There will also be a discussion on fear and suffering.

Evolution and Functions of the Prefrontal Cortex

The existence of pathways linking prefrontal and subcortical regions of the brain have been known for decades. In humans, the PFC (prefrontal cortex) is known to control executive functions and was long thought to be the most recently evolved structure in the brain (Krasnegor et al 1997). The two major functions are selective attention and task management (Smith and Jonides, 1999)The present consensus is that the PFC mediates executive functions which include advanced higher mental processes, such as directing attention, accessing various memory systems, coordinating sensory and motor information, and modulating emotional states (Krasnegor, et al 1997). In humans, the prefrontal cortex must be intact in order to experience the emotional sensation associated with pain (Freeman and Watts, 1950). However, neurobiologists long believed that the PFC is a recent evolutionary acquisition and is unusually large in the human brain. Recent advances in the study of prefrontal cortex find no justification for these beliefs. Jerison (1997) conducted a formal analysis of similarities and differences between species and provides evidence that the PFC is an ancient part of the mammalian brain, is put together in all mammals pretty much the same way, and it's functions are basically similar. The percentages of frontal cortex in relation to the rest of the brain are 29% in humans, 17% in chimps, 7% in the dog, and 3% in the cat (Broadman, 1912, Fuster, 1980). Although cats have less PFC compared to dogs, we would argue against any suggestion that cats suffer less from pain than dogs, or that rats suffer less than cats. It is likely that the cat has sufficient frontal cortex circuitry to have the minimum required amount to fully suffer. After all, a computer is either capable of word processing or it is not. It can not do half way word processing. Using a computer analogy of an evolutionary scenario, Jerison (1997) states; "If the basic computer has only enough capacity for word processing and it is required to run computer assisted drafting (CAD) programs, its required adaptations includes an increased processing capacity, an enlargement involving more memory to store information, and additional storage space for the set of instructions in the CAD program." On the question of size, the PFC in humans is very large, but not disproportionately large. In other words, as a brain becomes larger and more complex it requires more circuits which can associate and merge inputs from many different parts of the brain. A small brain requires a less complex "control room" than a bigger brain.

2003 Update

There has been some controversy in the scientific literature on the evolution of the prefrontal cortex. Some of the controversy may be caused by differences in how the prefrontal cortex is defined. Wood and Grafman (2003) contains an excellent map of prefrontal cortex and its connections to other parts of the brain. The ventromedial prefrontal cortex is old from an evolutionary standpoint. It has direct connections to the amygdala (emotion center). The dorsal lateral frontal cortex developed later and it integrates inputs from many parts of the brain and it makes it possible for an animal to engage in more abstract behaviors. It receives emotional information via the more primitive ventromedial prefrontal cortex (Wood and Grafman 2003).

Some scientists consider the dorsal lateral prefrontal cortex to be the "true" prefrontal cortex.

Lesion Studies and Pain

Observations of patients with frontal lobotomies provided some of the first evidence that the frontal cortex was involved in pain perception. Before the invention of psychotropic drugs, lobotomies were used for treating schizophrenia, manic depression, and reducing chronic pain in non-psychiatric patients. Psychosurgery (lobotomy) was performed by severing the prefrontal cortex from the rest of the brain. In the early part of this century, psychosurgery was crude and the whole prefrontal cortex was cut (Freeman and Watts, 1950). By 1946, a method of cutting just the frontal parts of the prefrontal cortex was introduced (Freeman and Watts, 1950). This procedure called cingulotomy, is still used today to treat intractable pain in some cancer patients (Sweet, 1982). Cingulotomy is more effective and causes fewer side effects compared to the old style of lobotomy.

After a lobotomy, patients with chronic pain or depression often regained the ability to function normally and retained their general intelligence, but they lost all emotional depth and feeling (Freeman & Watts, 1950; Foltz & White, 1962; Hurt & Ballantine, 1974). Their emotional experience was greatly reduced after lesioning of the prefrontal cortex, and patients with the largest areas of the prefrontal cortex disconnected had the greatest effects. However, lobotomy patients retained normal pain reflexes and would pull away when a doctor manipulated an injured area of their body. They "disliked momentary pain yet were indifferent to the pain of their disease" (Freeman & Watts, 1950). A patient might scream when a doctor manipulated a tender body part, but the next minute he was smiling after the painful manipulation was stopped. Their behavioral reactions seemed disjointed. Lobotomy patients experienced pain, but did not experience the emotional feeling of pain. The patient's reaction to a painful medical procedure was entirely in the present. They seemed to have lost the fear of pain.

More recently, pain research on humans show that a mildly painful stimulus applied to the hand increases blood flow in the frontal cortex (Smith and Boyd, 1991), and a PET scan study by Rainville, et al (1997) provided direct experimental evidence linking the PFC with the emotional component to pain. By using hypnotic suggestions to both increase and decrease a pain sensation, significant changes in pain-evoked activity was found in the anterior cingulate cortex. This is consistent with the clinical observations made in lobotomy patients. A more recent study on chronic pain which causes long-term suffering showed that activity in the frontal cortex was increased (Apkorian et al., 2001). Fulbright et al. (2001) found that pain and basic sensory input are processed in different parts of the brain. A painful cold water stimulus activates the anterior cingulate and a non-painful cold stimulus only activates sensory areas.

Lesion studies in rats indicate that the frontal cortex has similar functions in rodents and humans. Lesions in the frontal cortex of rats impairs behavioral flexibility and the organization of species typical behaviors (Kolb and Tees, 1990). In both humans and rats, frontal cortex lesions cause behaviors to become disjointed and fragmented (Freeman and Watts, 1950; Kolb and Tees, 1990). Even the small frontal cortex in the rat brain performs the same functions as mammals with more complex brains (Kolb and Tees, 1990). Therefore, it is likely that the frontal cortex in rats is involved in pain perception in a similar manner as humans.

Assessing Criteria for Pain

Although some fundamental uncertainty exists when it comes to assessing subjective experiences such as pain and suffering in mammals, certain criteria can provide insight. For example, when an animal shows protective behavior towards an injured part, such as limping after an injury to a leg, going off feed because of abdominal injury, or actively seeking relief from pain by ingesting both opiate and non-opiate analgesics, such responses can indicate that something more complex than a simple reflex is taking place. All mammals pain guard after an injury. Dogs, cats, rats and horses limp and avoid putting weight on an injured limb. Poultry also engage in pain guarding after beak trimming and will peck less (Duncan, et al 1989, Gentle, et al 1991). Pain guarding occurs even when a limb is structurally sound and capable of bearing weight. Some may argue that nothing more complex than learning an association between neutral and noxious stimuli is involved. However, Colpaert et al (1980, 1982) performed a series of very important experiments which showed that rats with chronic inflammation of the joints will drink water containing an analgesic instead of a sweet solution that control rats preferred. The rats intake of fentanyl analgesic followed the time course of arthritis that was induced with an inoculation with *Mycobacterium butyricum* (Colpaert et al., 2001). This study clearly shows that the rats drank the medication to reduce pain and not for its rewarding effects. Because the rats choose water containing an analgesic which possibly tasted bad compared to the highly palatable sweet solution shows that self-administration of pain relief may be taken as evidence that rats experience pain and suffer in a way similar to humans. When the frontal cortex is removed from a person, they still seek aspirin for their pain, but they no longer ask for narcotics such as morphine (Freeman and Watts, 1950). The patients feel a disagreeable sensation which aspirin relieves, but they no longer want morphine. The fact that animals respond to morphine and other opiates indicates that they have something the lobotomy patients do not have. The lobotomy removed the need for morphine.

The ability to learn complex associations seems to be a prerequisite for “a human like” suffering to occur in other mammals. Even the smallest mammals seem to have the required associative circuitry to learn complex associations. Holland and Straub (1979) made rats ill by injecting them with lithium chloride after eating a type of food they had previously learned to associate with a tone. Afterwards, the rats approached the feeder much slower after hearing the tone compared to rats made ill without any association with the food. It appears that the tone reminded the rats of the food, which then reminded them of feeling ill. Although interpreting evidence of declarative representations of knowledge in animals is difficult, it is most relevant when considering criteria for suffering. The rats in the Colpaert et al (1980, 1982, 2001) experiments must have “known” that even though the analgesic solution was unpalatable, drinking it would make them feel better.

Fear or Pain

When animals are faced with prolonged stressors, a pattern of nervous and hormonal activity produces a variety of physiological changes which help the animal adapt. In assessing criteria for suffering, psychological stress which is fear stress, should be considered as important as suffering induced by pain. Bateson and Bradshaw (1997) studied the physiological effects of hunted red deer and found that deer hunted by hounds were subjected to great physiological stress, compared to non hunted deer cleanly shot by professional hunters. The study found that the blood and muscles of the deer were damaged, but the authors neglected to fully discuss the damage caused by psychological stress. The cortisol levels in the hound hunted deer were very high and they never mentioned the word fear. Beringer, et al (1996) found that 12% of white tailed deer captured with a rocket net die within 26 days. Fear stress is highly aversive and subjecting an animal to intense fear stress would be very detrimental to welfare (Grandin, 1997).

Grandin (1997) and Bateson (1991) stress the importance of separating fear stress from physical stress such exertion from running or overheating. Fear has a powerful ability to override pain in the chicken. The work by Gentle and Corr (1995) shows that a chicken that was pain guarding by holding it’s leg up will stop pain guarding when it is placed in a scary novel place. When electric shocks are used as an aversive stimulus on cattle, the effects of fear can not be separated from pain. When wild cattle that are not accustomed to handling are held in a restraining device for branding, the fear stress induced by restraint will raise their cortisol levels almost as high as the hot iron branding (Lay, et al 1992a, 1992b). In tame cattle who do not react fearfully to restraint, the pain from branding is probably the main component of the animal’s distress because branding will increase cortisol levels significantly more than restraint. Training an animal to voluntarily allow itself to be restrained can almost eliminate or greatly reduce fear stress (Phillips, et al 1998; Grandin and Deesing, 1998; Boissy, 1998; LeDoux, 1994).

Research with humans and monkeys indicates that the old primitive fear system will operate independently of the prefrontal cortex and more complex emotions such as anxiety or worry depend on the prefrontal cortex. Lesioning the amygdala in a monkey will reduce its response to an unconditional fear stimuli such as a snake, but this lesion has little effect on the behavioral and physiological responses that characterize an anxious temperament (Kalin et al., 2001). However, in humans a larger anterior cingulate is associated with more anxiety and worry (Pujol et al., 2002). Therefore, the anterior cingulate in the frontal cortex may have a dual role of helping to shut off primitive fear responses but it may increase a more complex generalized anxiety.

The second author’s observation of pain guarding in horses is an example of chronic pain related behavior that is definitely not caused by fear. When horseshoes are put on a horse, nails are driven through the insensitive hoof wall. A fine line exists where nails can be driven safely, but sometimes a nail may pierce the sensitive tissue. When this happens, the horse may or may not react. It depends on how deeply the nail pierces the sensitive tissue. This is like the difference between getting a small sliver versus a large sliver under your fingernail. You may or may not feel pain at the time, but within twenty-four hours the area becomes infected and starts to hurt. Immediately after shoeing the horse walks normally and there is no pain guarding. It is the next day when infection sets in that the horse begins to limp. This may happen while it is quietly grazing. As the abscess grows the limp gets worse. Because the abscess begins to cause pain twenty-four hours after the shoeing, the horse’s reaction is not due to fear. This is an example of true pain guarding that is not reflex. Since the pain occurs the next day, the horse would not associate it with shoeing. The horse is reacting to pain and not fear. The reaction is not just reflex like jerking your hand off a hot stove. As the foot heals the horse will limp less and less. It has a graded response to the pain. Reflexes tend to be all or none. The reflex is either performed or it is not performed.

Suffering in Reptiles and Birds:

After reading many articles about frontal cortex anatomy in warm blooded animals, we became convinced that rats, cats, dogs, horses and cattle can suffer from long term pain which is true pain. The fact that rats with chronic pain will actively seek analgesics is convincing evidence of suffering, or serious discomfort. What about birds, reptiles and fish? Research on de-beaked chickens shows they pain guard after the procedure and will reduce food intake. De-beaked chickens are reluctant to use their beaks. Sometimes a neuroma forms on the end of the beak after it heals. Neuromas can cause pain in man (Gentle, et al 1990). Chickens with neuromas reduce the number of pecks at feeding (Gentle, et al 1990; Duncan et al 1989). We agree that mammals from rats, cats, and dogs would have similar degrees of suffering when subjected to a painful procedure. However, it is likely that birds may experience pain differently. Recent work by Gentle (1997) show that decerebrate chickens will still pain guard legs injected with a substance that causes pain. The results suggest that in chickens, pain from chronic arthritis is organized in the brainstem. However, if the chicken’s beak is trimmed and the frontal area of the brain is removed, pain guarding and other pain related behaviors are absent. But, if the beak is trimmed six days after the frontal area of the brain is removed, the chicken continues to pain guard (Gentle, et al 1997). It appears that chickens are unable to process two emotions simultaneously. Chickens may suffer from chronic pain when they are undisturbed, but when disturbed or frightened, the pain ceases and the chicken can only attend to the fear (Gentle and Corr, 1995). Prelying behavior and feeding motivation can completely suppress pain coping behaviors in arthritic chickens (Gentle and Corr, 1995; Wylie and Gentle, 1998). Turkeys with degenerative hip disorders reduce spontaneous activity and sexual activity (Duncan et al 1991). The authors conclude that the different systems in a bird’s brain may be less integrated than in higher mammals. A bird may be more mono channel and operate only one system at a time. The bird would probably be suffering if the pain or fear channel is operating.

Do reptiles or amphibians suffer from pain? Research shows that the nervous system of amphibians responds to analgesic drugs. Amphibians will respond to a painful stimulus applied to the skin. Many different types of analgesic drugs will reduce the response (Stevens et al., 1994; Stevens et al., 2001). Is this true suffering from pain or is it just a reflex like touching a hot stove?

Do reptiles and amphibians pain guard or seek analgesics? Both these areas need to be researched. The anecdotes below may provide some insights for guiding future research. Discussions with reptile specialists indicate that reptiles may or may not pain guard. Friend (1998 personal communication) indicates that iguanas will walk on a severely damaged leg and make no attempt to reduce weight on the damaged limb. Iguanans are physically capable of lifting a leg to favor it, but they do not. Lizards react to noxious stimuli which may cause acute pain, but may have little reaction to injuries that would cause long term pain. However, Friend (1998) was adamant that reptiles experience pain, but when we discussed pain guarding behavior and chronic pain, she stated; "I never thought about that before." Discussions with Dr. Fredrick Fry a reptile veterinarian at the University of California indicated that there are signs of pain guarding in other reptiles. A tortoise with a sore mouth will not eat and if it has a sore toe it will not walk. This is likely to be true pain guarding. Snakes with a damaged mouth may refuse to eat or lie on their backs to avoid pain. A tortoise with an abscess in it's head will refuse to eat. Eating resumes shortly after the abscess is drained. Even fish pain guard. Dr. Steve Kestin, University of Bristol states that a fish with an inflamed gut will reduce activity. Maybe this can be explained by weakness from sickness. However, the fish will swim normally when it is chased with a net. Dr. Kestin also says a fish will avoid the place where it has been hooked or shocked. Rakover (1979) reports that fish can easily learn to avoid an aversive fear arousing stimulus by swimming away. In these situations it is impossible to separate fear from pain. Feelings of fear are very aversive and subjecting any animal to situations which cause it to be highly fearful would be very detrimental to its welfare.

2003 Update on pain in fish

Research by Lynne Sneddon at the Roslin Institute indicates that fish engage in true pain related behavior. Fish that had acetic acid injected into their lips engaged in more pain related behaviors such as rubbing their lips on the gravel and rocking compared to saline injected controls. There were no differences in swimming activity. Administering morphine reduced the pain related behaviors.

The author concludes that the pain related behaviors were not simple reflexes (Sneddon, 2003). Sneddon et al. states that the pain receptors in fish have the same properties as the receptors in mammals. The fish also engaged in true pain guarding behavior. Fish injected with acetic acid took significantly longer to start feeding compared to saline injected controls. These studies indicate that to insure a reasonable level of welfare providing pain relief should be considered for fish.

This excellent research study separated the variables of pain from fear by having a saline injected control. Further studies on long term chronic pain are needed.

Studying of pain guarding behavior in different animals may help separate the variables of stress and fear from pain. Due to ethical concerns, pain guarding behavior and reactions to chronic pain in mammals should be studied under field conditions or in veterinary clinics. Individual cases can be observed when clients bring their animals in. This would avoid deliberately subjecting animals to chronic long term pain. Careful observations of painful conditions in client animals and farm animals subjected to routine painful husbandry procedures may provide added insights. Pain guarding should be studied using a video camera when the animal is undisturbed. Many animals, especially prey species such as cattle and horses will stop pain guarding when they are threatened or excited. The need to escape from a predator overrides the need to prevent further damage to the injured limb. We observed this behavior recently in a bull that was being castrated with a large rubber band. When he was unaware of being watched, he laid on his side and was moaning. As soon as he saw us, he jumped up and behaved as if he was not in pain until we left.

Reactions to Analgesics:

Mammals and birds reduce pain guarding behaviors when they are given pain killing drugs. Both narcotic and non-narcotic medication will reduce pain. Kestin and Fry both observed that morphine will reduce pain in reptiles and fish. Kestin (1994) reported that administering morphine directly into the brain of a gold fish will reduce it's reaction to electric shock. Is this due to reduced pain or sedation? This is a difficult question. In reptiles, Dr. Fry states that morphine will change the animal's behavior, but he said it was subjective. He is unaware of any formal experiments. .

Conclusions:

Our review of the literature on frontal cortex development enables us to conclude that all mammals, including rats, have a sufficiently developed prefrontal cortex to suffer from pain. In birds and reptiles which have some analogous frontal lobe structures and functions (Nottenbohm, 1977; Jerison, 1997), suffering from pain may be more likely to be overridden with fear, but they appear to suffer from pain, especially chronic pain. There is a great need to do more experiments on determining if different animals will actively seek analgesic medication. The observations of the lobotomy patients suggest that there may be differences in seeking of opiate or non-opiate analgesics. Experiments similar to Colpaert, et al (1980, 1982, 2001), need to be done in birds, amphibians, reptiles and fish with both opiod and non-opiod analgesics. To separate the variable of pain responses from fear responses or reflexes, more research needs to be done on pain guarding behaviors such as limping which persist for hours or days after an injury. To prevent fear from masking pain guarding, video cameras should be used so that animals can be observed when people are not present. A pain guarding behavior such as limping caused by pain is easy to study, because it is not caused by some other disagreeable sensation such as nausea, dizziness, or weakness from sickness. True pain guarding appears to occur in some reptiles and fish, but there is a need for more study. Some definitive research needs to be done on suffering from pain in fish and reptiles. Would performing a "lobotomy" on fish and reptiles affect their response to painful stimuli or seeking of analgesic drugs? This operation would have to disable parts of the brain that are analogous to a frontal cortex (Echteler & Saidel 1981), without shutting down the basic abilities to learn and interact with the environment.

The authors hypothesize that an animal will suffer from pain if it has sufficient circuits that merge pain signals with structures involved with emotion. Even if scientific research were to prove that some reptiles or fish perceive pain in a manner similar to the lobotomy patients, there would still be a need to avoid subjecting them to stimuli that causes fear. Fear inducing stimuli are very aversive and fish will avoid them. Fear is an old primitive emotion and the authors speculate that fear may cause suffering further down the phylogenetic scale than pain. For example, a fish might have attenuated perception of pain but it could suffer greatly from fear. Whereas a dog would suffer greatly from both pain and fear and a chicken could suffer greatly from either pain or fear depending upon the situation. We propose that there is probably a certain minimum amount of associative circuits between circuits processing emotion and the cortex are required for an animal to suffer from pain and even fewer association circuits are required to suffer from fear. It is our opinion that animals that display true pain guarding behaviors and actively seek analgesic drugs have this required minimum. A further analogy can be made to computers. Both the cheapest personal computer and a super computer can do word processing. They both do it equally well, but a calculator can not do word processing under certain conditions. An animal that has prefrontal functions at the "calculator" level may suffer less from pain than an animal with the "cheap computer" level. It appears that the chicken is different than mammals. Possibly it suffers fully from pain when it is undisturbed,

but pain is easily overridden by fear or feeding motivation. It is likely that it's small associative circuits can only process one emotion at a time.

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