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Article

Pain perception in goldfish (carassius auratus)

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Abstract: This paper proposes two hypothetical experiments that explore evidence of pain perception of goldfish (Carassius auratus). Early anatomical studies find the presence of nociceptors in fish, evidence of the capacity to suffer. A 2003 study of rainbow trout (Oncorhynchus mykiss) provides evidence of pain perception in the particular species. Now, it is known that members of Infraclass Teleostei can sense pain, but not as much is known about pet goldfish in homes. In an endeavour to determine whether goldfish can perceive pain, this paper proposes two hypothetical experiments. The findings of the following experiments will provide insights into the evolution of pain perception in vertebrates, awareness and intelligence in goldfish, and motivation behind goldfish behaviour.

Keywords: pain perception; goldfish behaviour; experiment

1. Introduction

Pain sensation, which helps prevent further tissue damage, confers a survival advantage. It is recognized that most vertebrates, including humans, and some invertebrates, such as octopuses, can perceive pain. What has not been established in the early exploration of pain perception, however, is whether bony fishes, though they are vertebrates, can feel pain as other vertebrates do.

With discoveries of nociceptors, structures enabling the detection of pain, in bony fishes [1], it was recognized that fish have the capacity to suffer from pain. Studies also revealed that bony fishes possess spinothalamic tract and trigeminal tract, pathways that deliver pain signals to the brain. Furthermore, a 2003 study found evidence to support that rainbow trouts (*Oncorhynchus mykiss*) can sense pain. Still, few investigations are concerned about pain perception in goldfish (*Carassius auratus*). The following hypothetical experiments attempt to prove or disprove that goldfish can perceive pain.

1.1. Definition of pain

Because pain is a mental and emotional response on top of being a physical response, pain cannot be directly observed, but instead is manifested through observable behaviours. Therefore, it is imperative to conceptualize pain in terms of these observable behaviours.

1.2. International association for the study of pain (IASP)

In 1979, the IASP adopted the definition, “An unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage.” In 2020, IASP revised the definition to be, “An unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage” [2]. According to this definition, pain is a sensory and

emotional experience, yet both are not directly observable or informed of because goldfish cannot speak. Thus, an alternative definition is needed regarding observable behaviours.

1.3. Zimmerman

A biological interpretation proposed by Zimmerman states that pain is "an aversive sensory experience caused by actual or potential injury that elicits protective motor and vegetative reactions, results in learned avoidance and may modify species-specific behaviour, including social behaviour" [3]. Zimmerman's definition identifies the behavioural aspect of pain: according to him, evidence may only be conclusive if it can be reasonably inferred that the animal modifies its behaviour due to a complex, "aversive sensory experience" in addition to shock reflexes [3]. Therefore, it is crucial to distinguish between the effects of shock from that of pain.

The following experiments will adopt Zimmerman's definition of pain. In other words, modification in behaviour after pain-inducing treatments is regarded as the key indicator of pain. A challenge in the following experiments is to differentiate the effects of shock and that of pain. To best obliterate the effects of shock, the experiments will expose subjects to identical treatments, which would pose the same degree of shock on the animals. Then, the level of variation in goldfish behaviours is used to assess the possibility of pain taking effect.

2. Material and methods

Animals. Commercially bred stocks one year in age. The animals are randomly distributed to multiple tanks and receive a transition period of two weeks, fed once per day. Exposure to identical shock factors ensures that shock does not account for differences in observed behaviour.

Materials. 80-gallon tanks with transparent walls; diluted strong acid; wooden cotton swab; pain-killing substance that only block transduction of pain signal; syringe.

Experiment 1.

The first experiment uses an irritating substance (acid such as 0.10 M HCl) to cause damage and, thus, pain. Each tank is randomly assigned to the control, experimental, or reference group. Swabs are used to apply acid to the lips of goldfish in the experimental group and distilled water in the control group. The reference group is untouched as a benchmark for comparison. The goldfish are returned to their original tanks and their activities are monitored for six hours. Shock does not account for differences between the control and experimental group, as they are exposed to identical treatments. Potential indicators of pain include abnormal behaviour in the experimental group, such as goldfish rubbing their lips against the bottom of the tank and abnormally high level of activity after the control group is assumed to recover from shock (i.e., when the behaviour of goldfish in the control group is not significantly different from that in the reference group).

In the second part of the experiment, equal numbers of sterilized swabs previously used to apply acid/water are dropped into all tanks. The goldfish's activity is monitored for six hours. After the control group is assumed to recover from shock, if goldfish in the experimental group exhibit significantly different behaviour with

clear intents, such as conscious avoidance of swabs (i.e., do not move to within 10 cm of swabs), this observation supports the hypothesis that goldfish can perceive pain as they demonstrate "learned avoidance" after exposure to a harmful experience and object [3]. No significant difference between the three groups indicates otherwise.

Experiment 2.

In the second experiment, half of the goldfish in each tank are randomly selected to be the experimental or control group. Three tanks are left untouched as the reference group. Goldfish in the experimental group are injected with pain-killing substances and, in the control group, an isotonic saline solution. Equal numbers of goldfish in the experimental and control group are further randomly divided into two groups.

In the first group, each goldfish, once assumed to recover from shock, is relocated to an individual tank installed with a device that, when triggered by the goldfish, delivers an electric current strong enough to cause pain and a food reward. That goldfish in the experimental group repeatedly trigger the device in significantly shorter time intervals than goldfish in the control group indicates that factors that lead to "learned avoidance" in the control group are not present or do not take effect in the experimental group [3]. In ideal conditions, pain or an adverse sensory experience is the only factor accounting for this difference, supporting the hypothesis that goldfish can perceive pain.

In the second division, half of the goldfish in the experimental and control group receive an incision that causes pain but not muscle damage (need not be identical), and the other half of goldfish are exposed to the blade but have no tissue damage. If only the controlled goldfish with the cut exhibit abnormal behaviour (represented in **Table 1** below), such as significantly different postures, in an ideal setting, pain is the only factor accounting for the difference.

Table 1. Significant or no significant change in behaviour after exposure to treatments.

	Control	**Experimental**
Cut	Significant change	No significant change
No cut	No significant change	No significant change

3. Conclusion

The hypothetical experiments may yield results supporting or refuting the hypothesis that goldfish (*Carassius auratus*) can perceive pain. Either way, it is to be borne in mind that the results do not prove or disprove both possibilities. One can only make inferences from the data because pain is not directly observable. Furthermore, the experiments are designed in hypothetical settings and likely are inherently flawed. Realistically, factors such as inborn differences in individual animals would lead to varying observations, sometimes with outliers that misrepresent the group. Hence, data may be invalid to support any conclusion.

Also, one must be mindful that the methodology for the proposed experiments may not be ethical and should not be performed without assessment and approval. Failure to assess the ethicality of these procedures and abide by the ethical guidelines may have severe consequences.

Conflict of interest: The authors declare no conflict of interest.

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