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Inducing good behavior

van der Veen, A.

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A. Literature on the Boiling Frog Story

Currently, the correctness of the boiling frog story is questioned (Gibbons, 2002). On the basis of their work with other animals, contemporary zoologists think that frogs will try to escape irrespective of whether the heating occurs instantaneously or gradually.¹ There is, however, some tension between the current view and the 19th century investigations where frogs were actually heated in experiments.

Goltz (1869, p. 127-130) describes an experiment with two frogs, one decapitated frog and one normal frog. Goltz immersed the frogs in water leaving out only a small part of the frog. He raised the temperature of the water in about ten minutes from 17.5° C to 56° C. From a temperature of 25° C the healthy frog tried to escape from the water and died a terrible death at 42° C because the experimental setup did not allow the frog to get away. The decapitated frog scarcely moved until the temperature reached 56° C when it made some spastic movements.²

Notice that Goltz heated the frogs rather quickly. In fact, his aim was not to test the boiling frog phenomenon. Instead, he wanted to find the location of the frog's soul. Because he believed that it was seated in the brain, he wanted to find differences between how a brainless frog and a healthy frog reacted to being boiled and therefore he chose to heat the frogs quickly.

Heinzmann (1872) reports on experiments with in total 27 frogs. He set out to work with decapitated and brain damaged frogs. After his first trials where he heated the frogs locally with a leg in the water, he moved to a setup where the frog was seated on a cork floating in a cylinder of water. He heated the frogs in about 90 minutes from a temperature of about 21° C to about 37.5° C. (So he stopped short of literally frying the frogs because some pre-trials had convinced him that from 37.5° C the frogs became paralyzed until death entered). After thus fine-tuning the experiment, he continued to work with normal undamaged frogs. In his 12th trial he managed for the first time to heat a healthy frog from 23° C to 39° C without any movement of the frog, even though the frog could jump away from the setup at any moment if it wanted to. Two of the next three trials were successful repetitions of the 12th trial. Then Heinzmann set out to reach the opposite goal, that is, to gradually freeze frogs without a movement, and again, after some initial trials where he used damaged frogs he managed to accomplish his goal

¹In personal communication, Dr. Victor Hutchison, a Research Professor Emeritus from the University of Oklahoma's Department of Zoology, whose research interests include physiological ecology of thermal relations of amphibians and reptiles, formulated the current skepticism as follows: "It [the boiling frog story] makes a nice story, but it really is a myth. In fact, most animals, vertebrate and invertebrate (all we have tested) exposed to increasing heat respond similarly – they attempt to escape noxious conditions (chemicals, etc.) that could lead to their death. This is an expected survival response as logic might indicate."

²Goltz mentions a third decapitated frog that he does not boil and that serves as a control frog for the decapitated frog that is boiled.

with healthy frogs.

Unaware of the study by Heinzmann, Foster (1873) confirmed Goltz's finding that uninjured frogs become violent in their attempts to escape when the temperature is heated above 30° C. Foster carried out trials where he heated the water slowly and trials where he heated the water quickly. Unfortunately, he does not describe how fast he heated the water. The paper of Foster is mainly dedicated to explaining why Goltz's decapitated frog did not respond to the heating, a finding that Foster found puzzling.

Hall and Motora (1887) mention that Fratscher (1875) successfully repeated Heinzmann's results. Fratscher even succeeded in inducing rigor mortis in normal frogs by immersing only a small part of frog in the fluid. Sedgwick (1883) at Johns Hopkins is the person with an overview of the entire literature on the heating of frogs up until 1882. His intuition was that the variance in the speed of the heating explains the difference in Goltz's and Foster's results and Heinzmann's and Fratscher's results. In agreement with his intuition, he reports that he was able to replicate all previous results by varying the speed of the heating process. At the end of the 19th century, the consensus is that it is possible to boil frogs without movement if it is done sufficiently slowly (Hall and Motora, 1887; Schriptide, 1897).

A related question is whether rapid heating induces frogs to try to escape at lower temperatures than slow heating. Foster mentions this possibility, but says that he did not pay attention to this issue while he did his experiments. Arguably, this "lite version" of the boiling frog story is the more relevant one for Al Gore's analogy. As far as we know, the lite version of the story has not been tested with frogs, but there are some physiological studies with humans showing that the smallest perceptible change in weight of an object placed on the fingertip varies with the speed of the change in weight (Hall and Motora, 1887; Schriptide, 1897).