The Effect of Fish Species on Learning and Memory with a T-maze

Sheridan Schaefer
Greendale High School

UNIVERSITY of WISCONSIN UWMILWAUKEE

ABSTRACT

A T-maze was utilized with zebrafish and fathead minnows to verify the hypothesis that **if zebrafish and fathead minnows are punished and rewarded accordingly, then zebrafish will successfully learn the correct side for a T-maze before fathead minnows because zebrafish have anxiety and the punishment will push them to learn the T-maze faster to rid them of their anxiety**. This experiment was run to conclude which type of fish would learn sooner or at all. The results display that Zebrafish learn faster because they take less trials to meet the criterion of five of six successful choices. The results also displayed the percent (over all the test days) of Fathead Minnow on average are able to successfully meet criterion more often than Zebrafish. When both of these conclusions are paired with the other they show that Fathead Minnow reached criterion slower than Zebrafish, but Fathead Minnow had a greater chance of meeting criterion at all compared to the Zebrafish. Displaying that either are a good model organism to use.

INTRODUCTION

Currently Zebrafish have been the main fish used in scientific studies over Fathead Minnows. This research is **important because it suggests that consideration between species should be looked at when using fish for various other experiments, this is because intelligence may prove to vary between species.** A study concerning zebrafish found that "collectively, our results confirm zebrafish as a valid, reliable, and high-throughput model of stress and affective disorders" (Egan et al., 2009, p. 38-44). This has also been found by other studies: "mounting evidence shows the suitability of zebrafish to model various aspects of anxiety-related states" (Stewart et al., 2012, p. 135-143). The lateral line system is defined: "lateral line of fish and amphibians is a sensory system that comprises a number of individual sense organs, the neuromasts, arranged in a defined pattern on the surface of the body" (Gompel et al., 2001, p. 69-77). Based on these findings, when zebrafish are put under acute stress, which would be provided by disturbing their lateral line system by agitating the water, they will want to choose the correct arm of the T-maze so they will no longer be negatively reinforced.

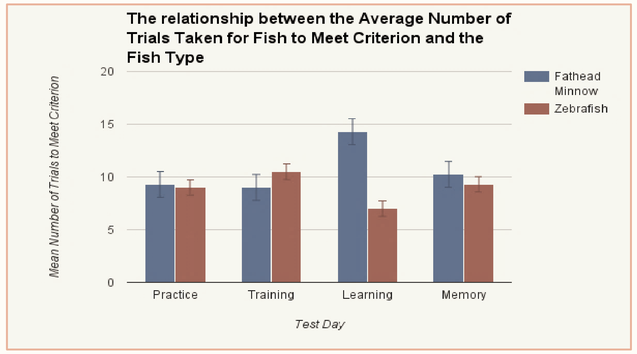
Furthermore, there is also reason for the fathead minnow to be less successful in the completion of the T-maze and achieving a passing rate of five of six trials correctly due to their susceptibility to parasites: "fathead minnows are a common intermediate host of Op (*Ornithodiplostomum ptychocheilus*), where metacercariae encyst in the minnow brain" (Pan et al., 2016, p. 248-55). It is also found that "these parasite-induced behavioral changes may render infected minnows more susceptible to predators" (Pan et al., 2016, p. 248-55). There could also be a correlation between the fathead minnow's ability to remember and complete the maze using its brain because the parasite is within control of the host.

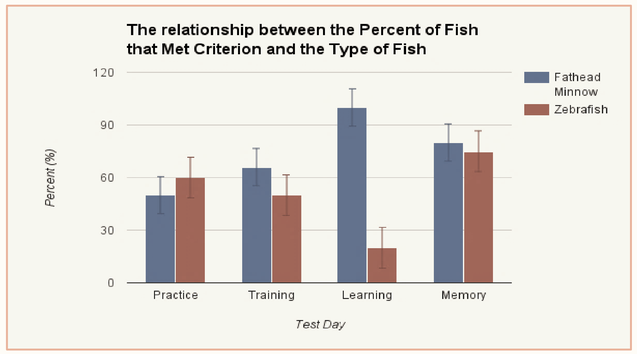
METHODS

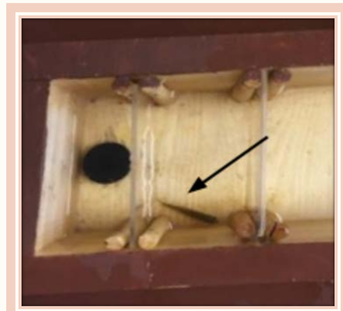
1. Set up all materials: fill T-maze with dechlorinated water and remove the fish from the cup and place it in the door area, make sure the gate is closed. Make sure the right side and left side gates are removed. Record what species fish you're starting with.
2. Let the fish acclimate for 5 minutes, after this set up to the starting position.
3. Open the entrance gate and release the fish. Observe what side the fish goes to (right or left). You may coax the fish down the column of the T-maze, using the bottom of a net, but don't coax pass the point where the top of the T crosses with the bottom. Note: this choice will be considered the "incorrect side" when you are teaching the fish and with the "correct side" being the opposite side. Take note/record which side the fish originally went to.
4. Using the bottom of a net coax the fish back to starting position with the entrance gate closed.
5. Let the fish sit in the starting position for 15 seconds.
6. Start trial 1 by opening the entrance gate and allowing the fish to swim to a side. Coax the fish down the column of the T-maze. Once the fish has chosen a side record which side the fish chose in the data table.
7. Then give a reward or consequence to the fish accordingly. You will reward the fish if the it swam to the correct side and give a consequence to the fish if it swim to the incorrect side. (Reward the fish by allowing it to swim around for 45 seconds. Be sure to gate off the other side of the T-maze. Then coax it back to starting position using the net.) (Give a consequence to the fish by closing off that side of the T-maze and then agitating the water for 10 seconds. Then remove the gate and coax the fish back to starting position using the net.)
8. After the reward or punishment using the bottom of a net coax the fish back to starting position with the entrance gate closed.
9. Let the fish sit in the starting position for 15 seconds.
10. Repeat steps 4-9 for up to 20 trials, recording the fish's choice each time along with what the correct choice would've been. (Note: if the fish is able to complete the T-maze successfully 5 out of 6 times within the 20 trials you will stop doing trials with that "correct side" because the fish will have "learned" at this point. Now have the "correct side" be the side that was previously incorrect and continue with the trials. Reversing the sides.) (Note: Do this reversal each time the fish has "learned" a side or got it correct 5 out of the 6 trials.)
11. Repeat steps 2-10 with the other species fish or when you switch days.

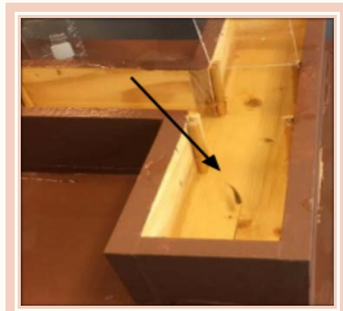
RESULTS

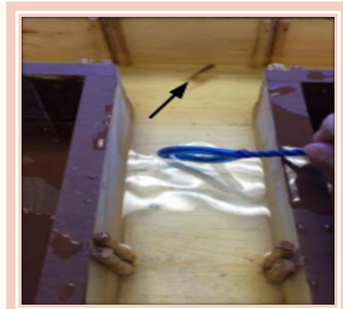
Fish species were tested in a T-maze over 4 days. They were tested for intelligence that was determined by if they had chosen the correct side five out of six trials and they had up to 20 trials to do so. The data showed that the Fathead Minnow took an average of 10.7125 trials to meet criterion compared to the Zebrafish's 8.95 trials. The median of the number of trials that Fathead Minnow took to reach criterion was also greater than Zebrafish. Fathead Minnow's median was 9.775 trials and the Zebrafish's was 9.15 trials to meet criterion. In addition to this the average percent of Fathead Minnow that were able to meet criterion at least once was 74% with the average percent of Zebrafish able to meet criterion being 51.25%. Also, the median percent of Fathead Minnows that successfully reached criterion at least once was 73% with Zebrafish's median percent being 55%.









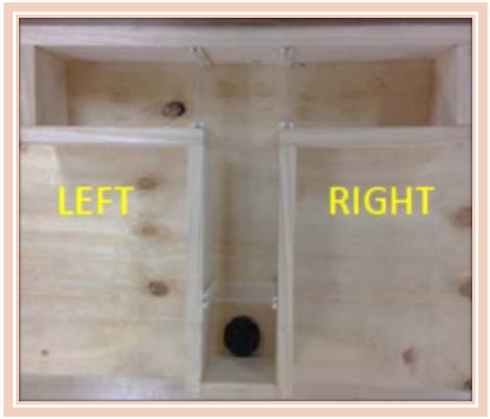


DISCUSSION

The results of the experiment answered the question that asked if fish had the ability to learn. The **results didn't support nor contradict the hypothesis** that if zebrafish and fathead minnows are punished and rewarded accordingly, then zebrafish will successfully learn the correct side for a T-maze before fathead minnows. Pointing to the comparison of the results for the relationship between the average number of trials taken for the fish to meet criterion and the fish type initially showed that Fathead Minnow took on average a greater number of trials to meet criterion compared to Zebrafish. Initially concluding that the results display that Zebrafish learn faster because they take less trials to meet the criterion of five of six successful choices, but Fathead Minnow on average were able to successfully meet criterion more often than Zebrafish. The pairing these conclusions originally showed that **Fathead Minnow reach criterion slower than Zebrafish, but Fathead Minnow have a greater chance of meeting criterion at all compared to Zebrafish**.

Where this data falls short is in the fact that it is not statistically significant due to high t-test values ($p=0.2621$ for average number of trials to meet criterion and $p=0.1938$ for the relationship between meeting criterion and type of fish). These high t-test values say that the data has too much variation within it to be able to provide a definite conclusion. Furthermore, the overlapping of the standard error bars show that the results may have experimental error.

The significance of these results is that fish can, in fact, learn and remember how to learn. Also, due to the lack of significance between intelligence and species, **fish other than Zebrafish should be considered for research projects. Increasing the types of model organism used would allow for better data because the data would be more diverse and accurate since conclusions could be drawn across the variations of fish and not secluded to one species**.



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