Fixed-ratio Behaviour of Lake Sturgeons (*Acipenser fulvescens*): Darkness as a Reinforcer

B. Cook & J. Pear

Department of Psychology, University of Manitoba

Introduction

- Lake Sturgeons are large, non-teleost, freshwater fish native to North America. Other extant non-teleost fish include sharks, bowfin fishes, and gars (Peterson, Vecsei, & Jennings, 2007).
- Lake sturgeons primarily inhabit the bottom of rivers and lakes suggesting that their exposure to light is limited and thus may prefer darkness.
- Maximino et al. (2007) found that four out of five teleost species of fish preferred darkness over light which offers support for selecting darkness as a reinforcer.
- Cook, Fonti, La Fleur, Martin, Martsynkevych, Summers, and Pear (2018) found in one naïve lake sturgeon that darkness was a reinforcer and that therefore there was preliminary evidence to suggest that lake sturgeons are capable of learning via operant conditioning.

We designed an operant conditioning experiment to expand on Cook et al.'s findings regarding lake sturgeons' ability to learn and further examine darkness as a reinforcer for lake sturgeons. The present research aimed to expand the literature on lake sturgeon operant behaviour by applying a fixed-ratio schedule of reinforcement.

Figure 1. Juvenile lake sturgeon (Acipenser fulvescens).

Methods

Three experimentally naïve juvenile lake sturgeons (arbitrarily named Cheese, Mac, and Big) were obtained from the University of Manitoba Department of Biological Sciences courtesy of Dr. G. Anderson. Outside of experimental sessions the subjects were maintained by trained animal care personnel in a 45-gallon tank with other lake sturgeons. Water flowed continuously to provide the subjects with fresh water and the temperature was maintained at 16°C ±1°C.

Experimental sessions were conducted in a square experimental tank (ET) with four identical target areas located in each corner of the ET. Each target area consisted of an arc of a circle with a radius of 100 mm. The target behavior was the subject entering a target area with any portion of its body; this was also referred to as a response. Lighting of the apparatus was automated by a computer to turn on when a session was initiated, turn off after a specified duration of session time, and turn off when a response occurred in the subject's reinforced target area during phases where darkness was used for reinforcement. Data was collected by visual observation and video-tracking software. The reliability of visual observation was confirmed by IOA among observers and a Pearson correlation (r) was used to compare visual observation data to automatically recorded computer data. One 30-minute session per day was conducted at approximately the same time each day 4 to 7 days a week.

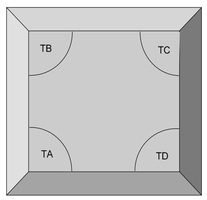

Figure 2. Schematic of top-down view of experimental tank (ET) with target areas.

The experiment consisted of several phases (see Table 1):

- NFB (no-feedback baseline) phase was used to observe each subject's normal behaviour within the ET.
- DSB (discriminative stimulus (S^D) baseline) phase introduced the prospective S^D, a Canadian one-dollar coin (aka a loonie) to the target area that would be reinforced. The DSB phase was used as a control to determine whether the subject showed a prior preference for the S^D.
- RFSB (response-feedback stimulus baseline) phase introduced the RFS and was used as a control to determine whether the subject showed a prior preference for the RFS (a metal bat hitting a ball sound).
- FR n (fixed-ratio n). This phase introduced darkness on a FR schedule, in addition to the S^D and RFS. Over sessions n was gradually increased to 4. The RFS was used to indicate a response and the S^D was used to indicate the reinforced target area to the subjects.

Table 1. Summary of Experimental Procedure.

a) Cheese (January 21 to February 2 2019)

Baseline	
No Feedback Baseline (NFB) Sessions 1-12	Cheese terminated due to poor health

b) Mac (January 21 – May 7 2019)

Baseline				Experimental Manipulation		
No Feedback Baseline (NFB) Sessions 1-9	Discriminative Stimulus Baseline (DSB) Sessions 10-14	Response feedback stimulus baseline (RFSB) Sessions 15-28	Second Discriminative Stimulus Baseline (DSB2) Sessions 29-43	Fixed-ratio reinforcement schedule (FR1) Sessions 44-58	FR 2 Sessions 59-67	Mac terminated due to poor health

*Sessions 68 to 72 (May 1 to May 7) were excluded from analysis as behaviour was unusual which was likely related to Mac's decline in health.

c) Big (February 11 2019 to May 17 2019)

Baseline			Experimental Manipulation	
No Feedback Baseline (NFB) Sessions 1-7	Discriminative Stimulus Baseline (DSB) Sessions 8-19	Response feedback stimulus baseline (RFSB) Sessions 20-26	Fixed-ratio reinforcement schedule (FR1) Sessions 27-43	FR 2, FR 3, FR 4 Sessions 44-51, 52-59, 60-67 respectively

Results

Baseline Phases

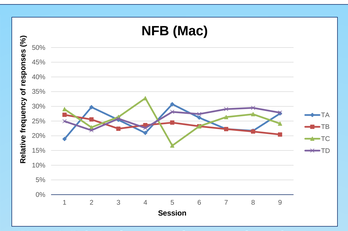

Figure 3. Relative frequency of responses for each target area during the NFB phase for Mac.

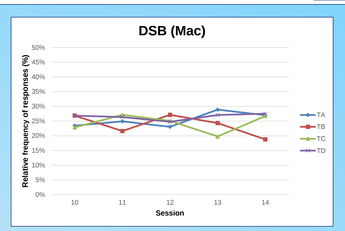

Figure 4. Relative frequency of responses for each target area during the DSB phase for Mac. S^D located in TB.

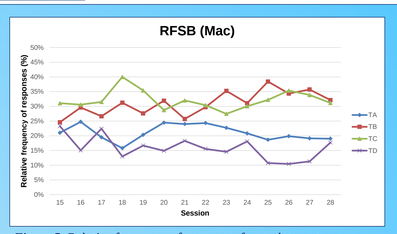

Figure 5. Relative frequency of responses for each target area during the RFSB phase for Mac. S^D located in TB and RFS occurred with each response to TB. Note the increased distribution of relative responding in TB and TC.

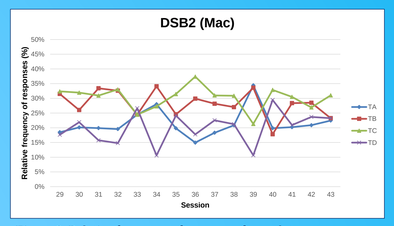

Figure 6. Relative frequency of responses for each target area during the DSB2 phase for Mac. S^D located in TB with no RFS occurring. Note that in terms of relative frequency of responding Mac had returned to the behaviour of the previous DSB phase (see Figure 4).

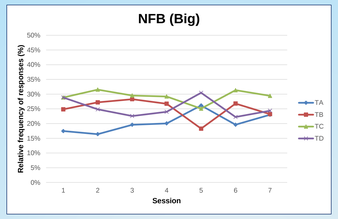

Figure 7. Relative frequency of responses for each target area during the NFB phase for Big.

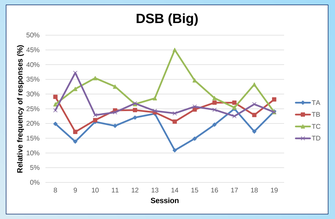

Figure 8. Relative frequency of responses for each target area during the DSB phase for Big. S^D present in TA.

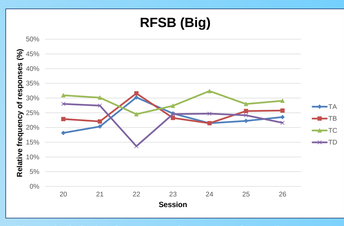

Figure 9. Relative frequency of responses for each target area during the RFSB phase for Big. S^D present in TA and RFS occurred with each response to TA.

Results Summary for Baseline Phases

Mac:

- NFB and DSB phases occurred as expected. No preference for any target area was observed.
- During the RFSB Mac demonstrated a preference for TB (the prospective reinforced target area) and TC.

Big:

- NFB, DSB, and RSFB phases all occurred as expected as Big demonstrated no preference towards TA (the prospective reinforced target area).

Fixed-ratio (FR n) Phase

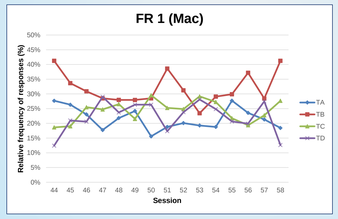

Figure 10. Relative frequency of responses for each target area during FR 1 for Mac. S^D still present in TB, RFS and darkness occurred with every response to TB.

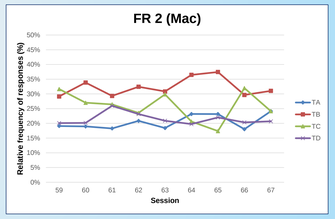

Figure 11. Relative frequency of responses for each target area during FR 2 for Mac. S^D still present in TB and the RFS occurred with each response, but darkness occurred when two responses were made.

Results Summary for FR n Phase

Mac:

- During both FR 1 and 2 Mac responded to TB the most frequently relative to the non-reinforced target areas.
- Although Mac showed a preference for TB, along with TC, during RFSB, the preference for TB was clearly accentuated while the preference for TC was reduced or eliminated during FR 1 and FR 2.

Big:

- During the FR n phase Big demonstrated a clear preference for the reinforced target area (TA). During FR 1 clear deviations between TA and the other three target areas can be seen (see Figure 12).
- During FR 2, 3, and 4 (see Figures 13, 14, and 15) the deviations between the four target areas decreased as the FR ratio increased. This likely occurred because Big maintained a clockwise swim pattern around the interior perimeter of the ET. Regardless, TA was the most frequently responded to target area across all FR n subphases.

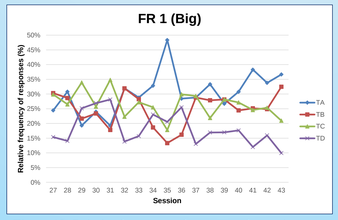

Figure 12. Relative frequency of responses for each target area during FR 1 for Big. S^D present in TA where darkness and RFS occurred with each response to TA.

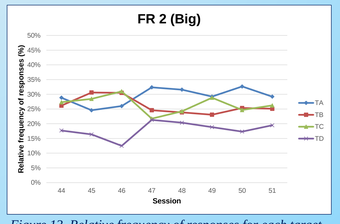

Figure 13. Relative frequency of responses for each target area during FR 2 for Big. S^D present in TA where RFS occurred with each response and darkness occurred every second response to TA.

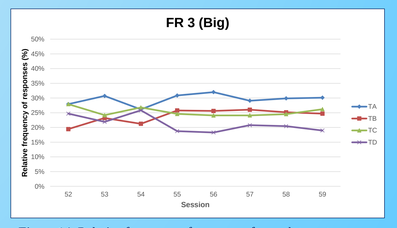

Figure 14. Relative frequency of responses for each target area during FR 3 for Big. S^D present in TA where RFS occurred with each response and darkness occurred every third response to TA.

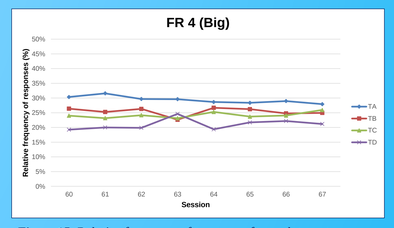

Figure 15. Relative frequency of responses for each target area during FR 4 for Big. S^D present in TA where RFS occurred with each response and darkness occurred every fourth response to TA.

Discussion

In this experiment there were several observations made about lake sturgeons learning:

- The results confirm previous studies indicating that darkness is a reinforcer for lake sturgeons.
- Darkness is a strong enough reinforcer to maintain responding on an FR n schedule up to at least n=4.
- The results appear to extend traditional operant conditioning findings to a species and reinforcer rarely studied if at all.
- Relative to more traditional reinforcers, such as food, darkness appears to be a relatively weak reinforcer.
- Future studies might also look at other schedules, such as variable ratio .
- Future studies might also examine whether typical operant conditioning results can be obtained using other types of target responses in contrast to swimming into or through a corner of the test tank.

References

Cook, B., Fonti, E., Martin, S., La Fleur, B., Martsynkevych, S., Summers, J. and Pear, J. (2018) Operant Conditioning of a Lake Sturgeon (Acipenser fulvescens). Poster presented at the 13th annual Manitoba Association for Behaviour Analysis Conference, University of Manitoba, October 25, 2018.

Maximino, C., de Brito, T. M., de Moraes, F. D., de Oliveira, F. V. C., Taccolini, I. B., Pereira, P. M., … Gouveia Jr., A. (2007). A Comparative Analysis of the Preference for Dark Environments in Five Teleosts. International Journal of Comparative Psychology, 20(4), 351–367. Retrieved from http://uml.idm.oclc.org/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=a9h&AN=37168575&site=ehost-live

Peterson, D. L., Vecsei, P., & Jennings, C. A. (2007). Ecology and biology of the lake sturgeon: A synthesis of current knowledge of a threatened North American Acipenseridae. Reviews in Fish Biology and Fisheries, 17, 59-76. doi:10.1007/s11160-006-9018-6