

Does elimination of a negative phototaxis eliminate CAR acquisition in goldfish?

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Eleven groups run under classical, instrumental, pseudoconditioning, CS-only, US-only, and time-lapse procedures, with the ITI illuminated and a color change CS, showed that true classically trained animals do not increase CAR performance with training, whereas instrumentally trained goldfish do. This is consistent with a phototactic interpretation suggested in earlier work. Additionally, the finding that CS-only and time-lapse controls show high "acquisition" rates, whereas pseudoconditioning controls do not, not only questions the use of the pseudoconditioning procedure as the sole learning control in this situation, but also questions a learning interpretation itself. Conclusions of what and how, or even if, goldfish learn in this apparatus seem premature.

Zerbolio and Wickstra (1978) have shown that, with a dark intertrial interval (ITI) and a sudden illumination onset conditioned stimulus (CS), goldfish, whether classically or instrumentally trained, acquired a conditioned avoidance response (CAR) in a shuttlebox, showing high and comparable performance levels. This finding is consistent with earlier reports (Woodard & Bitterman, 1973). But Zerbolio and Wickstra (1978) offered an alternative to Woodard and Bitterman's (1973) conclusion that all of their data could be accounted for by classical processes and without reference to instrumental processes. Specifically, with the pairing of CS and unconditioned stimulus (US) in all learning groups, goldfish develop a negative phototaxis and respond to the sudden light onset. Thus, the critical stimulus event is the negatively phototactic CS onset, not the consequences of the response in terms of omission or not of the US. The phototactic explanation has been used to explain differential conditioning due to spatial location of an illumination onset CS where, when the phototaxis was eliminated by using an illuminated ITI and a color change CS, the spatial location differences failed to materialize (Zerbolio & Wickstra, 1976; Zerbolio, 1976).

Additionally, Zerbolio and Wickstra (1978) found that, although pseudoconditioning procedures produced no CAR acquisition, additional control groups run under CS-only, US-only, and time-lapse procedures all showed significant "CAR" acquisition, which challenges the use of the pseudoconditioning paradigm as an appropriate learning control procedure for this animal (Jensen, 1961; Kimble, 1967; Rescorla, 1967).

The present study is basically a replication of the earlier Zerbolio and Wickstra (1978) work, including the same learning and control groups. In the present study, to eliminate the phototaxis effect, all subjects were run with an illuminated ITI and a color change CS (Zerbolio, 1976).

METHOD

Subjects

The subjects were 110 5-6 cm goldfish from Ozark Fisheries, housed in 30-gal aquaria upon receipt and transferred 24 h prior to use to 7.5 x 11.5 x 12.5 cm deep individual aquaria for the duration of the experiment. Fish were fed daily, and housing was well aeriated and filtered. Temperature (21.1°C) and pH (7 ± .1) were held constant throughout all procedures.

Apparatus

Subjects were run in identical 29.2 x 11.4 x 11.4 cm deep shuttle tanks, divided into two compartments by a 9-cm hurdle with 45-deg sloping sides, with photocells mounted at hurdle ends. This apparatus is essentially that described by Horner, Longo, and Bitterman (1961). The hurdle, 6.35 cm high, was covered with 2.5 cm of water, comparable to water clearance in Behrend and Bitterman (1962). Christmas tree 110-V ac lamps, mounted at the ends of the tank served as CS (blue) and provided ITI illumination (green). Color of CS and ITI illumination (green or blue) has been shown to produce no differences (Zerbolio & Wickstra, 1976). CS or ITI illumination, which occurred simultaneously at both ends as appropriate, was evenly diffused via translucent plates attached to the ends of the tank. The US, a 7.5-V ac (.66 V/cm) shock, was a single 200-msec pulse. This duration and intensity has been found to produce maximal avoidance performance (Zerbolio & Wickstra, 1975). All events were programmed and recorded via automatic circuitry.

Procedure

Eleven groups of 10 subjects each were run 5 days at 20 trials per day with a variable-interval (VI) 60-sec ITI. A trial consisted of a 10-sec period, during which subject's activity was monitored for response. If a response (or responses) occurred during the 10-sec trial period, an "avoidance" (one only) was recorded. The number of responses during the ITI was also recorded. The US, if appropriate, occurred at the end of the 10-sec period or during the ITI in the pseudoconditioning procedures. The CS, if appropriate, was a color change from green (ITI) to blue (CS) during this period. The specific procedures are detailed below.

Instrumental conditioning (IC). Two IC groups were trained: The first was a true IC procedure, where CS termination was contingent (CSc) on the subject's response; in a second, or modified, procedure, CS termination was not contingent (CSnc)

or independent of the subject's response and remained on for the full 10-sec period. In both IC groups, a response during the 10-sec period was counted as an avoidance and produced US omission for that trial.

Classical conditioning (CC). Two CC groups were trained: a true CC condition, where CS remained on for the full 10-sec trial period and was independent of the subject's response (CSnc), and a second modified procedure, where CS termination was response contingent (CSc). US presentation occurred on every trial independent of response. "Avoidances" were recorded as above.

CS only. Two CS-only groups were run: For the first group, CS termination was not response contingent (CSnc); for the second, the subject's response produced CS termination (CSc). "Avoidances" were recorded as above.

US only. The IC and CC groups had a potential 20 US presentations each day. The US-only procedure was comparable except the CS was never presented. One US-only group could produce US omission with a response in the proceeding 10-sec period (USc), whereas the second received a US following each trial period (USnc). "Avoidances" were recorded when subjects responded in the 10-sec period, as above.

Pseudoconditioning (PC). Two PC groups were run. The IC and CC groups received 40 stimuli (paired in 20 trials). The PC groups received 40 stimuli (20 CS and 20 US) in Gellerman series with a VI 30-sec ITI. CS and US were never paired. In one group, a response during the CS period produced CS termination (CSc), whereas, in the second PC group, CS termination was not contingent (CSnc) on the subject's response. "Avoidances" were recorded only in the 10-sec CS period and all subjects received 20 US presentations per day.

Time lapse. A single group of 10 subjects was monitored for 20 10-sec periods per day for "avoidance responses," with trials spaced as the CS intervals of other groups. Responses in a 10-sec "trial" period were recorded as "avoidances."

RESULTS AND DISCUSSION

The mean number of avoidances for each of the 11 groups over the 5 days of training appears in Figure 1.

A two-way repeated ANOVA found reliable differences between training procedures [$F(10,99) = 9.084$, $p < .01$], a reliable training effect [$F(4,396) = 66.668$, $p < .01$], and a significant Training by Procedure interaction [$F(40,396) = 3.853$, $p < .01$]. A partition of the interaction showed that increases in avoidance (learning?) occurred for the true IC [$F(4,396) = 36.488$, $p < .01$], modified IC [$F(4,396) = 12.183$, $p < .01$], modified CC [$F(4,396) = 24.224$, $p < .01$], CS only CSnc [$F(4,396) = 9.477$, $p < .01$], CS only CSc [$F(4,396) = 10.477$, $p < .01$], US only USc [$F(4,396) = 3.922$, $p < .01$], and time-lapse [$F(4,396) = 7.459$, $p < .01$] procedures. The noncontingent US-only procedure (USnc), the two PC groups (PC-CSc and PC-CSnc), and the true classical procedure showed no reliable increases in avoidance behavior over training [$F(4,396) = 1.738, .472, .948, \text{ and } 2.279$, respectively, $p > .05$]. Basically, the only difference in the learning groups between this study and the earlier work by Zerbolio and Wickstra (1978) is that, with the phototaxis reduced or eliminated by the use of an illuminated ITI and a color change CS as opposed to a dark ITI and a sudden onset of illumination CS, the true classical procedure

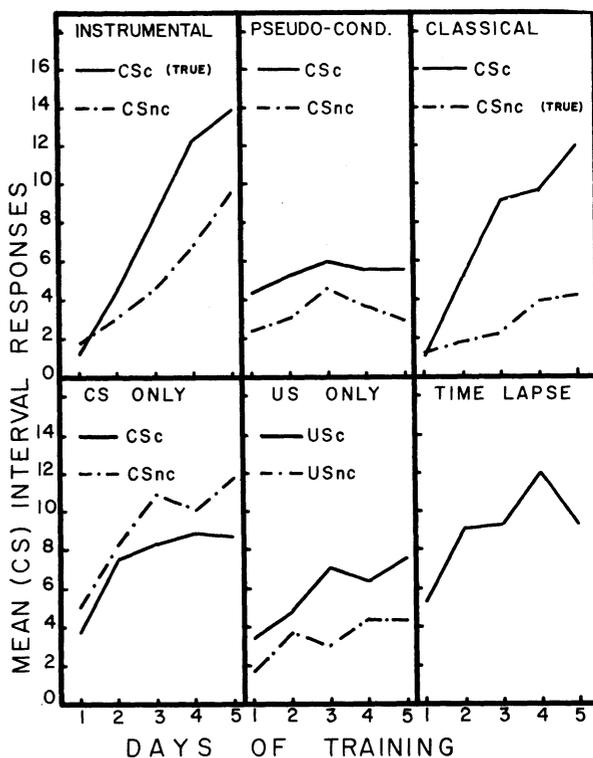


Figure 1. The mean number of trial intervals in which at least one response (avoidance or avoidance equivalent) occurred for all 11 groups. Shown are response-contingent CS termination (CSc) and noncontingent CS termination (CSnc), as well as response-contingent US omission (USc) and noncontingent US procedures (USnc). True classical (CSnc, USnc) and true instrumental (CSc, USc) procedures are indicated.

shows no statistical evidence of learning. On the other hand, the true IC, modified IC, and modified CC, where the CS and/or US is terminated or omitted by the subject's response (an instrumental procedure), show significant acquisition with training. These results are highly consistent with Zerbolio and Wickstra's (1978) suggestion that, with a dark ITI and an illumination onset CS, after the CS and US are paired, the critical stimulus event is the onset of a highly negative phototactic CS; the events that follow, namely, the omission or inclusion of the US, are of secondary importance. What is more disturbing about these data is the high activity rates shown by the additional controls. As Zerbolio and Wickstra (1978) found earlier, the pseudoconditioning groups show very low or no acquisition rate, but the additional controls suggested by Jensen (1961) clearly show an acquisition rate equivalent to and, in some cases, above that of the traditional learning procedure groups. Clearly, the pseudoconditioning procedure, or at least the explicitly unpaired PC procedure, is not an appropriate learning control for this organism (Kimble, 1967; Rescorla, 1967).

The present data pose a much more serious question. Given the unexpectedly high "acquisition" performances

shown by the CS-only and time-lapse controls, is the performance increase shown by the "learning" groups (e.g., IC true) really learning or simply a return to a high (control) base rate performance level following a suppression of response rate due to the novelty of the situation. Several studies have shown that, upon the introduction of a US, response rate is immediately suppressed but recovers with training (Scobie & Fallon, 1974; Woodard & Bitterman, 1973; Zerbolio & Wickstra, 1978). The recovery of response rate could be learning, but, with the phototaxis effect removed, it could also be simply a return to a high base rate performance level. Studies involving more training to determine asymptotic levels reached or perhaps requiring a response different than a high activity rate such as a passive avoidance response seem indicated. As far as the original question of whether goldfish learn classically or instrumentally, the present data and that shown earlier by Zerbolio and Wickstra (1978) seem to indicate that a learning conclusion, classical or instrumental, may be premature.

REFERENCES

- BEHREND, E. R., & BITTERMAN, M. E. Avoidance-conditioning in the goldfish: Exploratory studies of the US-US interval. *American Journal of Psychology*, 1962, **75**, 32-40.
- HORNER, J. L., LONGO, N., & BITTERMAN, M. E. A shuttlebox for fish and a control circuit of general applicability. *American Journal of Psychology*, 1961, **74**, 114-120.
- JENSEN, D. D. Operationism and the question "Is this behavior learned or innate?" *Behavior*, 1961, **17**, 1-8.
- KIMBLE, G. A. *Foundations of conditioning and learning*. New York: Appleton-Century-Crofts, 1967.
- RESCORLA, R. A. Pavlovian conditioning and its proper control procedures. *Psychological Review*, 1967, **74**, 71-80.
- SCOBIE, S. R., & FALLON, D. Operant and Pavlovian control of a defensive shuttle response in goldfish (*Carassius auratus*). *Journal of Comparative and Physiological Psychology*, 1974, **86**, 858-866.
- WOODARD, W. T., & BITTERMAN, M. E. Pavlovian analysis of avoidance conditioning in the goldfish (*Carassius auratus*). *Journal of Comparative and Physiological Psychology*, 1973, **82**, 123-129.
- ZERBOLIO, D. J. Spatially located visual CS effects in conditioned shuttlebox avoidance in goldfish: A phototatic explanation. *Bulletin of the Psychonomic Society*, 1976, **8**, 359-361.
- ZERBOLIO, D. J., JR., & WICKSTRA, L. L. The effect of power (US intensity by US duration) on shuttlebox avoidance acquisition in goldfish. *Bulletin of the Psychonomic Society*, 1975, **5**, 345-347.
- ZERBOLIO, D. J., & WICKSTRA, L. L. Spatially located visual CS effects in conditioned avoidance shuttle response acquisition in goldfish: Conditioned aversion or phototaxis? *Bulletin of the Psychonomic Society*, 1976, **8**, 156-158.
- ZERBOLIO, D. J., & WICKSTRA, L. L. Goldfish avoidance acquisition: Is the process classical, instrumental, or a phototaxis? *Bulletin of the Psychonomic Society*, 1978, **11**, 321-323.

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