Increasing Sidman Avoidance Behaviour: An Animal Model

By Lisa Hunter

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Abstract

Avoidance is behaviour that prevents or postpones the occurrence of an aversive stimulus; whereas, escape is behaviour that terminates an aversive stimulus. There are two types of avoidance, both of which prevent an aversive stimulus from occurring. Standard avoidance involves a warning stimulus that predicts an aversive stimulus, reinforced by the termination of the warning stimulus. Alternatively, Sidman or free-operant avoidance does not include a warning stimulus and it is unknown what the exact reinforcing properties are that maintain it. Previous research has found that *Betta splendens* (Siamese fighting fish) may not engage in Sidman avoidance whereas other fish species including *Carassius auratus* (goldfish) do. The present study looked at whether *Betta splendens* could be taught Sidman avoidance when water disturbance is the aversive stimulus, by prompting the fish to emit the avoidance response of crossing over between the two sides of an experimental tank in 30second intervals, and reinforcing the behaviour with a mirror. Results showed an increase in the frequency of independent (i.e., unprompted) crossovers between the sides of the experimental tank resulting in avoidance of water disturbance, an aversive stimulus for these fish. The increase in responding was maintained for one of the three subjects when reinforcement was removed, suggesting that this species can learn Sidman avoidance.

Key words: Sidman avoidance, reinforcement, learned helplessness, Betta splendens

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Introduction

Avoidance is behaviour that prevents or postpones an aversive stimulus. There are two types of avoidance: avoidance with an extereoceptive warning stimulus referred to as standard avoidance, and avoidance without an extereoceptive warning stimulus referred to as Sidman or free-operant avoidance (Sidman, 1953). Standard avoidance is reinforced by the termination of a warning stimulus (Martin & Pear, 2015; Pear, 2016). Although it is not known what reinforces Sidman avoidance, one might be tempted to suggest it is reinforced by the absence of the aversive stimulus. However, it is unclear how the nonoccurrence of an event can be a reinforcer.

Research investigating avoidance in rats has indicated that it is not learned by all animals. While almost all subjects readily learn standard avoidance, many do not learn Sidman avoidance (Dr. Michael Perone, Dept. of Psychology, West Virginia University – personal communication).

Sidman avoidance has been observed with at least one species of fish. Behrend and Bitterman (1963) assessed Sidman avoidance in three experiments with *Carassius auratus* or goldfish, using shock as the aversive stimulus. In Experiment 1, there were two groups, a control group and a test or experimental group. Subjects in the test group were placed in a shuttle box with two compartments. If the subject did not cross to the other compartment within 20 seconds it would be shocked. To avoid the shock, the subject had to swim through an opening to the other compartment. To continually avoid the shock, the subject needed to repeatedly cross between the compartments within 20-second intervals. The control group was not in the same apparatus as the experimental group. They were in what is called a “yoked control design”: the control subjects received shocks at the same time the fish they were yoked to did but could not avoid or postpone them. The results of this study showed that at least some goldfish learned avoidance when crossing over resulted in postponed shock. The results were presented in terms of group means and so it was not clear whether all goldfish learned avoidance. The control group showed little change over sessions. In Experiments 2 and 3, Behrend and Bitterman added a warning stimulus (a light) that was presented 5 seconds before the shock was administered. The results were that crossing over decreased in the first 15 seconds but increased within the final 5 seconds of the interval in which the warning stimulus was presented. Exclusive of the warning stimulus, rate of crossovers was not substantially different from baseline. These results are comparable to those of rats (Sidman, 1962).

By contrast, results of Sidman avoidance with *Betta splendens* (Siamese fighting fish) have been inconclusive or negative (Hurtado-Parrado, 2015; Otis & Cerf, 1963). This raises the question of whether *Betta splendens* respond the same way to avoidance conditioning as goldfish. Otis and Cerf (1963) compared standard avoidance responses across these two species. The study involved an experimental tank that required the subject to follow a moving light within the tank. A shock would be delivered if the fish did not cross over within 15 seconds of the presentation of the moving light . The predetermined criteria were five successive conditioned avoidance responses to cross to the compartment with the activated light before the 15 seconds elapsed resulting in shock. Otis and Cerf (1963) hypothesized that *Betta splendens* would learn avoidance at a higher frequency than the goldfish due to the aggressive nature of *Betta splendens*. The results did not support this hypothesis. The goldfish showed significantly more conditioned avoidance responses than the *Betta splendens.* Of the 12 goldfish, 10 met the criterion as compared to only 4 of the 12 *Betta splendens*. These results suggest that *Betta splendens* are inferior to goldfish in conditioned avoidance learning. Otis and Cerf suggested that this might be due to the inherent characteristics of the species since goldfish are bottom feeders while *Betta splendens* are surface swimmers. The presence of the light in the tank may have been more salient to the goldfish since bottom feeders swim at the bottom of bodies of water where it is dark and therefore light is less accessible and is novel. This may have resulted in rapid learning.

Although some *Betta splendens* may learn Sidman avoidance when shock is the aversive stimulus, results in our lab indicate that they do not when water disturbance is the aversive stimulus.

Pavlovian Conditioning

Pavlovian conditioning, also known as classical conditioning, is a learning process that involves pairings of a stimulus – called a *conditioned stimulus* – with another stimulus – called an *unconditioned stimulus*. This results in the conditioned stimulus producing a response similar to that produced by an unconditioned stimulus. Pavlov demonstrated this process by conditioning the response of a salivating dog by pairing a previously neutral stimulus, such as a ringing bell, with meat powder (Martin & Pear, 2015; Pear, 2016). The meat powder was the unconditioned stimulus that produced the unconditioned response of salivating. When paired multiple times, the bell became a conditioned stimulus, producing salivation without the meat powder present. Pavlovian conditioning is commonly related to the learning process of standard avoidance behaviour. Rescorla (1968) and others have hypothesized that in standard avoidance conditioning, the warning stimulus presented immediately before the aversive stimulus, is a fear-eliciting stimulus; however, in Sidman avoidance there is no warning stimulus. Nonetheless, it has been hypothesized that there are some Pavlovian mechanisms involved in Sidman avoidance (Rescorla, 1968). More specifically, there might be reinforcing properties involved in the prevention or postponement of aversive stimuli similar to the way in which the removal of a warning stimulus decreases fear.

Research by Shindman (1968) looking at standard and Sidman avoidance compared how long it would take for rats to be effectively extinguished of Sidman avoidance behaviours with and without an added warning stimulus. For the rats to avoid a shock, they had to press a lever. In the warning stimulus procedure, a white noise preceded the occurrence of shock. Once the rats had met a pre-specified criteria, researchers began extinguishing the behaviour by removing the occurrence of the shock. In the warning stimulus procedure, the white noise still occurred; however, the shock was not administered. Extinction was defined as zero responses in a 15-minute block. It was reported that in less than one 4-hour session, extinction of responding occurred for both groups. Avoidance was maintained longer for rats in the warning stimulus extinction condition compared to the rats that did not have a warning stimulus. This study suggests that maintenance of standard avoidance may be stronger than Sidman avoidance.

Prompting Strategies

Prompting procedures have been utilized in previous research to facilitate learning. Research has been conducted with humans examining most-to-least prompting strategies to encourage errorless learning (Libby, Weiss, Bancroft, & Ahearn, 2008). Most-to-least prompting is described as administering the most intrusive prompt first in order to ensure the individual responds correctly. This is followed by a less intrusive prompt such as a gesture, verbal cue, or weaker physical prompt. This method of prompting promotes errorless learning; namely, the individual cannot learn the incorrect response because most-to-least prompting ensures they will not make an error. Most studies of prompting strategies have been done with discrete trial teaching, which is a common method used in early intervention programs for children with autism. Libby et al., (2008) compared most-to-least versus least-to-most prompting strategies to teach children with autism to build with Lego. The authors found that while both strategies were successful, most-to-least strategies resulted in fewer errors during teaching producing quicker learning. Additionally, Morse and Schuster (2004) reviewed the literature on simultaneous prompting and amalgamated a total of 74 articles that examined prompting strategies. Errorless learning prompting strategies also known as most-to-least prompting were found to either generate learning or produce correct responding for most of the studies, typically during one-to-one teaching or small group teaching. Specifically, 89% of participants in the meta-analysis achieved criterion to master a target skill. Moreover, the skills taught using discrete trial training and chaining were maintained and generalized across most cases. These results suggest errorless learning may be relevant to teaching Sidman avoidance. For example, one of the important factors of errorless learning is that it eliminates the possibility of old, perhaps incorrect, learning patterns that may inhibit correct responding. Eliminating these incorrect patterns using these prompting strategies ultimately increases the chance of success of target behaviour in the future since a history of learning errors is avoided.

Learned Helplessness

An important reason for evaluating avoidance behaviour is its relationship to learned helplessness which may result in a subject not learning to avoid an aversive stimulus. Learned helplessness is defined as a loss of motivation and detrimental emotional changes that lead to impairments in learning (Manrique, Molero, Candido, & Gallo, 2004.). To induce learned helplessness, researchers have created experiments where an animal cannot escape an aversive stimulus or must complete a task that is too challenging for the animal. Research with young rats has found that learned helplessness can lead to impairments in learning abilities later in life

(Manrique et al., 2004). Most research examining Sidman avoidance and learned helplessness has used shock as an aversive stimulus with various species of animals such as dogs and rats (Seligman & Beagly. 1976). When examining Sidman avoidance, it is crucial to be cautious of the number of sessions conducted with the subjects to reduce the possibility of producing learned helplessness.

Purpose

Studying avoidance with *Betta splendens* may have practical importance, working as a model for how clinicians may help establish avoidance behaviour in their clients when warranted such as refraining from "talking to strangers, hugging people they don't know, and touching stove top elements"; or conversely, to decrease harmful avoidance such as obsessive compulsive tendencies like excessive hand washing. The importance of examining these strategies to teach avoidance to *Betta splendens* can lead to further information about how to teach humans Sidman avoidance. Baron and Perone (2001) suggested that the lack of empirical information about avoidance is problematic because such information could be helpful on the individual and societal level. Specifically, it could be relevant to overeating, alcohol abuse, gambling, and pollution. For example, learning about avoidance is important for treating anxiety in people as well as teaching individuals with disabilities to avoid possible dangerous situations. Learning more about Sidman avoidance and whether it can be taught (as opposed to simply being learned due to exposure to a Sidman avoidance schedule) could lead to further research on learned helplessness and decreasing future learning impairments caused by it.

Thus the present research project examined whether specific prompting and reinforcement sequences could produce Sidman avoidance responding in *Betta splendens* using water disturbance, rather than shock as the aversive stimulus. To the best of my knowledge, no teaching strategies have previously been examined to teach Sidman avoidance in *Betta splendens*. It is important to examine teaching *Betta splendens* Sidman avoidance since research indicates that they may not learn it naturally like other species of animals do, at least when water disturbance rather than shock is used as the aversive stimulus (Hurtado-Parrado, 2015; Otis & Cerf, 1963).

Method

Subjects

Three male *Betta splendens* served in this study. Males were chosen for their high level of aggression and their availability. A fourth *Betta splendens* was discontinued due to a health condition that impaired him from participating; therefore, the study had three completed subjects. It is common in this type research to have relatively small numbers of subjects because the method requires that a large number of detailed observations be made on each subject (see Kazdin, 2011; McReyonolds & Kearns, 1983; Sidman, 1960).

Apparatus

An experimental fish tank 33L (41x41x20cm) separated in the middle by a plastic partition was filled with 18L of water (see figure 1). There was a 2.5 cm wide gap in the partition large enough for a fish to swim across to each side of the tank. The tank also consisted of a compartment that was inaccessible to the subjects that contained the water pumps responsible for water disturbances. Water disturbances were created by two AquaClear 50® water pumps that produced a water flow of approximately 3600ml per minute.

A computer-automated system designed by J. Pear and colleagues, tracked how many times subjects crossed the midline. The water in both the experimental and home tanks were dechlorinated due to chlorine's harmful effects on fish. The water was stored in water bins that were cleaned once a month to prevent excess bacteria growth. After each session, the water in the experimental tank was emptied using a Shop-Vac® and dried with paper towels to minimize the transfer of bacteria between subjects.

Materials

The subjects were housed in a separate room approximately 50 m away from the experimental room. Transfer of the subjects included removal from the home tank using a five sided plastic container with the subjects then being placed on a weighted trolley to minimize vibrations of the trolley and further disturbance to the fish. A plastic cover was placed over the container to keep the fish from jumping out and to avoid stress and water disturbance. The identical procedure was employed for the return of the subject. The five sided plastic container was cleaned with a mixture of a bacteria-killing agent called Percept™ to eliminate the transfer of bacteria from subject to subject. The bacteria-killing agent mixture was composed of 1:16 parts Percept™ to water with 1:40 parts Oxivir™ to water. The Percept™-Oxivir mixture was well rinsed from the five sided plastic container prior to capturing a fish with it. The animal facility manger was responsible for monitoring the health and feeding of the subjects. To run the research sessions, one to two research assistants were involved to carry out procedures along with myself, the principle investigator. I implemented the procedures and the research assistants were responsible for collecting the data. The procedure for data collection will be explained later.

Procedure

All sessions were 20 minutes in length. The study consisted of 4 conditions. The first condition, called Baseline 1, examined whether the subject engaged in Sidman avoidance without special training. The second and third conditions, called Phases 1 and 2, were two intervention conditions. The fourth condition was a return to baseline, labeled Baseline 2.

Baseline 1 involved presentations of water disturbances in the form of 10-second periods of water flows produced by water-pump activations on each side of the experimental tank. The fish was on a Sidman avoidance schedule for water disturbances with a flow-flow interval of 30 seconds and a response-flow interval of 30 seconds. When the subject had been on one side of the tank continuously for 30 seconds, the water pump on that side produced a 10-second steady water flow. Previous research has shown that steady water flow is aversive to *Betta splendens*, possibly because their natural habitat is a still water environment where water disturbance is correlated with the presence of a predator (Hurtado-Parrado, 2015). To escape the water flow, subjects could swim to the other side of the divided tank, which terminated the water flow. I tracked the number of crossovers subjects made as escape responses while the pump was active as well as crossovers made prior to pump activation, which would prevent the aversive stimulus from occurring. If the subject swam across the midline in less than 30 seconds (the response-flow interval) after the previous water flow or response, the pumps were not activated. The number of crossovers made prior to the next scheduled pump activation indicated whether the subject showed avoidance. The tracking system automatically recorded the total time and frequency that the pumps were activated on each side as well as the response rates (i.e., rate of crossovers) during the baseline conditions. In order to minimize any learning impairments that may arise due to learned helplessness, only as many sessions as were necessary to determine stability of responding were conducted during Baseline 1. Therefore, once 3-5 stable data points (i.e. limited variability between data points) occurred the subject was moved to Phase 1.

During Phase 1, subjects experienced a specific prompting sequence to cross over at 30-second intervals. Specifically, each subject was gently guided across the midline between the two sides of the experimental tank by using a 10 x 10 cm plastic panel or barrier. Subjects were not physically pushed with the barrier; instead, they were blocked from swimming in an opposing direction from the divider gap. Once a subject had crossed the midline, it immediately received reinforcement consisting of 15 seconds of access to a mirror placed in the tank. Reinforcement was administered on a fixed ratio (FR) 1 or continuous reinforcement schedule; i.e. reinforcement was provided after each crossover response, whether prompted or independent. The length of time required to prompt subjects before they crossed over was recorded to compare prompting times between subjects. A 30-second inter-trial interval then took place where the subject was not prompted, but could receive reinforcement if it crossed over to the other side of the tank. This length of time was chosen to be consistent with the previously mentioned procedure in the avoidance condition, where the pumps activated when the subject stayed on one side of the tank for 30 seconds. The pumps were not activated in the intervention conditions, i.e. Phases 1 and 2. The interval schedules would have been affected and less controlled if the tracking/pump activations had occurred during the intervention conditions since the mirror and research assistant's hands would have interfered with the accuracy of the tracking system.

Research has shown that the sight of its mirror image – which elicits aggression – is reinforcing to *Betta splendens* (Bols & Hogan, 1979). This can be seen by the darkening of colour on their body, gill erection (which makes the fish's head look bigger), and the fish swimming up and down alongside the mirror (Meliska, Meliska, & Peeke 1980). Some fish will even attack their image by swimming into the mirror making biting movements. To collect data on whether the fish noticed the reinforcer, I recorded whether the fish showed gill erection following the presentation of the mirror. This information was useful in determining the strength of the reinforcer. The mirror was submerged into the tank immediately after the subject crossed from one side of the tank to the other and was placed directly in front of the subject for 15 seconds, then removed. The next 30-second interval then started and the prompting and reinforcement sequence was administered. If the subject independently crossed over the midline, the principle investigator or research assistant immediately provided mirror reinforcement for 15 seconds. A research assistant tracked the duration and frequency of prompts and reinforcement, independent responses of the fish, and flaring by using an application on an iPod called ABC Data Pro (see Appendix A). The application was chosen for its multi button functions that allowed collection of multiple target behaviours. This phase continued until a stable number of independent responses occurred.

Phase 2 involved continuing the aforementioned prompting and reinforcement sequence. However, the schedule of reinforcement was changed to a variable ratio (VR) 2. That is, on average the subject was reinforced after two responses, varying between one, two, and three responses. The Phase 2 condition was added due to results found from the pilot study. In the pilot study, there was only one intervention phase, with each response reinforced along with reinforcer assessments of three different reinforcers (see Appendix B for pilot study data). Once stable independent responses occurred, prompting and reinforcement were completely removed and the same condition as in the original baseline (Baseline 1) was administered (Baseline 2). It was found that the independent responses immediately decreased to baseline levels, indicating there was no maintenance of the behaviour change after the intervention (see Appendix C for pilot study data). Therefore, I added Phase 2 to the current study, to administer reinforcement on a VR schedule to increase the probability of maintaining the crossover behaviour. Research has shown that a VR schedule of reinforcement maintains behaviour longer than a fixed-ratio schedule (FR) of reinforcement (De Luca & Holborn, 1992).

The final phase of the study, Baseline 2, involved removing both prompting and reinforcement to return to the baseline condition once subjects appeared to have consistently demonstrated stable avoidance behaviour. During this condition, the number of crossovers in a 20-minute trial were recorded to see whether the intervention phases resulted in an increase in avoidance behaviour, whether the behaviours were maintained, and (if they were not maintained) the rate of extinction.

Inter-observer Agreement and Procedural Integrity

All research assistants, experimenters, and observers completed the fish ethics online course before participating in any lab activities. After completion of the course, the research assistants followed a standard training procedure involving 5 observations of sessions followed by 5 sessions where they carried out the procedures while being observed by a supervisor, usually myself. During this training, assistants learned proper handling of the subjects and how to accurately collect data on the behaviours of the subjects, so that all phases were identical across research assistants. All fish behaviours were operationally defined to promote both procedural integrity (PI) and inter-observer agreement (IOA). Prompting time was defined as the time between the initial entrance of the divider into the water and the commencement of the removal of the divider once the fish crossed over to the other side. Reinforcer time was defined as the time between the initial submersion of a mirror into the tank and the removal of the mirror. Flares were defined as gill erections where the fish extend their gills from the body at any visual degree larger than their neutral state. An independent response was recorded when more than half of the fish's body has passed through the divider in the tank. Prompted responses were recorded as prompted, but were still reinforced. To promote consistency in the observations, the observers were periodically asked to tell the principal investigator to operationalize each particular behaviour she was recording. This controlled for observer drift, which can occur over time if observers begin to modify the definition of the target behaviours they are tracking (Kazdin, 2011). Data were collected using the ABC Data Pro mentioned above (see Appendix A). The two observers collected PI data on the research assistant administering the intervention, as well as completing IOA data on the behaviour of the fish. The observers tracked the behaviours of the experimenters to monitor PI. Two experimenter behaviours were recorded. One experimenter behaviour that was recorded was prompting. The observer pushed a button on the ABC Data Pro when the research assistant began prompting the subject and pushed the same button when the prompting had stopped. The other experimenter behaviour that was recorded was reinforcement. The observer pushed a button when the experimenter began reinforcing the fish and when she finished. No feedback was given to the experimenter or research assistants regarding PI unless further training was needed.

For IOA, two behaviours of the fish were monitored. One of these was whether the subject independently crossed over from one side of the tank to the other. The observers pushed a button labeled "independent" if the fish crossed the tank independently; otherwise the observer pushed "prompt" if the fish crossed over after being prompted. Finally, observers tracked whether or not the fish flared at the sight of the mirror. Flaring was defined as a gill erection where the gills of the fish extend from its body.

Multiple individuals were trained to carry out all procedures to reduce possible observer expectancies that could impair the accuracy of the data collection. A third of the sessions had two observers for data collection for the purpose of IOA. Each session was video recorded in case two observers were not present and to minimize observer reactivity, which is when being observed may change the observer's reliability (Kazdin, 2011). To ensure independence in data collection, the observers stood at opposite ends of the tank. The tracking of multiple behaviours controlled for observers knowing which buttons were being pushed throughout the observations. Due to both the nature of the intervention and the setup of the tank, it was not possible for observers to be on opposite sides of the room or to use a one-way mirror. The data were analyzed by myself who did not collect data to avoid bias but was in charge of running the procedures. IOA and PI was calculated as agreement scores, by dividing the number of agreements by the number of agreements plus disagreements then multiplying the result by 100 to obtain a percentage (Kazdin, 2011). IOA for frequency of independent crossovers was 97.25%. This is considered strong agreement; agreements above 80% are considered acceptable (Harris &Lahey, 1978; Iwata, DeLeon & Roscoe, 2013). IOA for whether the fish flared or not was 93%. PI for prompting the subject was 86%, the average agreement for prompting was 100%; however there was one session with only an agreement of 66%. This could be attributed to an instance of poor PI or observer drift. Finally, the PI for reinforcing the subject was 99%. Overall, the IOA and PI for this project was strong.

To ensure integrity of the tracking system, the system was tested before each session by using a dummy fish, which was simply a black bolt on a stick. The purpose of this was to test if any errors in tracking were present, and to ascertain whether the pumps activated following 30 seconds of the dummy fish being on one side of the tank. To guarantee that the system was tracking properly, I also watched each session and recorded avoidances manually. Due to tracking errors because of the size and colour of the subjects, manually collected data was used for avoidances. The system had no problem keeping track of time spent on each side of the tank. To account for any residual water flow, avoidances were considered after three or more seconds following the cessation of water activation; otherwise these were considered escapes. The tank was cleaned once a month using the same cleaning agent referred to earlier to help maintain the integrity of the computer automated system.

Results

The data were plotted in a graphing program and were analyzed through visual inspection. Visual inspection is a very common way to evaluate data in single-case subject research designs; this is different from the standard statistical analysis used in between-groups research designs (Kazdin, 2011). Visual inspection is conducted by examining graphs following the process of describing, predicting, and testing the data. This means that I describe the data in each session so that I can predict what the phase would continue to look like if no changes were made to the condition. Then, I test the intervention by comparing the data points to the baseline or previous conditions and within the phase. When conducting visual analysis, I looked to satisfy five different criteria: (1) changes in the means, (2) changes in levels of performance, (3) trends, (4) latency of behaviour change, and (5) overlapping data points between the phases (Kazdin, 2011). When examining means, I looked for whether the averages (rate, or number on the measure) across phases remained the same, decreased, or increased. Changes in level refer to shifts of responding from the end of one phase to the beginning of the next phase. For example, was there a change in performance when the intervention was removed? When I look at the data only within a phase of the study, I am looking for trends. “Trends” refers to slopes whether negative, positive, or flat. Latency of behaviour change refers to the amount of time it takes for changes in the behaviour to occur between baseline and intervention. The overlapping data points criterion specifies that there should be limited or zero number of data points that overlap between phases (Kazdin, 2011). To the extent that inspection fails to meet these criteria, either the results are unclear or the intervention was ineffective. Conversely, if all these criteria are met, it is considered likely that the intervention was effective.

Figure 2 illustrates the results for Fish 1. Note that during Phase 1 and Phase 2 independent crossovers increased to higher levels relative to Baseline 1 and continued to increase or remain high during Phase 2 (see Table 1 for the means from each condition per subject). This was demonstrated by the changes in means and levels of data points between the phases. When reinforcement was removed in Baseline 2, levels of responding decreased below that of the intervention phases; however, the means of responding maintained above those of Baseline 1. This suggests that not only did learning occur but also avoidance of the aversive stimulus occurred. There were nonoverlapping data points between Baseline 1 and Phase 1, with a few overlapping points when the intervention was removed between Phase 1 and Baseline 2, which also indicates the behaviour was maintained. A short latency of behaviour change occurred between Baseline 1 and Phase 1, suggesting that the change in responding was due to the intervention. There was no trend in Baseline 1, whereas in Phase 1 there is a positive slope; in Phase 2 there is no detectable positive or negative slope; and in Baseline 2 there was a slight downward trend. Consequently, it appears that the intervention was successful at increasing independent crossovers, with some level of maintaining the behaviour after the intervention was removed. Fish 1 flared on average 0.2% of the time when the mirror was present during intervention. Finally, the duration of time used to prompt the fish to swim to the other side of the tank gradually decreased after a few sessions (see figure 3).

Figure 4 illustrates the results for Fish 2. A change in the means and levels was demonstrated with each condition change. The mean rate of responding increased from Baseline 1 to Phase 1, with a gradual increase in level of performance from the end of Baseline 1 to the end of Phase 1. Rate of responding increased between Phase 1and Phase 2, suggesting the VR schedule in Phase 2 was the more powerful intervention at increasing independent crossovers. With the introduction of Phase 2, no latency of behaviour change was observed. The subject's responding increased, ranging from 31-46 responses compared to Phase 1 with 7-29 responses per session. When the subject was returned to baseline during Baseline 2, the data showed a downward trend until the responding leveled out near the initial baseline levels. There are a few overlapping data points between Phase 1 and Baseline 2 demonstrating extinction of the behaviour once the reinforcement was removed, this could also be considered a transition state prior to the behaviour stabilizing. Thus, for this fish, the intervention phases increased independent crossovers; however, the behaviour was not maintained when the intervention was removed. Fish 2 flared on average 88% of the time when the mirror was present during intervention. The duration of time used to prompt the fish to swim to the other side of the tank gradually decreased throughout the sessions (see figure 5).

Figure 6 shows the results for Fish 3. Note that the changes in the means from Baseline 1 to Phase 1 were large, there was also a small change of mean rate of responding from Phase 1 to Phase 2 (refer to table 1 for means per condition). This suggests that the VR 2 schedule of reinforcement increased responding to higher levels than did the intervention in Phase 1 alone. When looking at the levels between phases, there was a clear difference when the interventions (i.e., Phase 1 and Phase 2) were implemented compared to when they were not (i.e., Baseline 1 and Baseline 2). A short latency in the change in responding was found from Baseline 1 to Phase 1 and from Phase 2 to Baseline 2, which indicates that the changes in responding were due to the interventions. The trend in both baseline conditions were flat, whereas in Phase 1 there was a positive slope and responding in Phase 2 was variable but remained high. Finally, nonoverlapping data points were found when comparing Baseline 1 and Baseline 2 to the intervention conditions in Phase 1 and Phase 2. Thus, Fish 3 showed clear increases in responding when the intervention was introduced, but once the intervention was removed, responding returned to baseline levels. This indicates that the behaviour of crossing over was not maintained once reinforcement was removed. Fish 3 flared on average 94% of the time when the mirror was present during intervention. The duration of prompts displayed a downward trend, then increased in time, presenting a slight upward trend (see figure 7). However the duration of the prompts needed were relatively short in time, ranging between 0-23 seconds.

Discussion

I hypothesized that with prompting and reinforcement sequences the frequency of independent crossovers in the experimental tank would increase from initial baseline levels, thus demonstrating that *Betta splendens* can learn Sidman avoidance. What I found was that the interventions were successful in producing an increase in crossing over between the two sides of the tank during the interventions (Phase 1 and Phase 2). However, when the interventions were removed and the activation of the aversive stimulus (i.e., the implementation of the water disturbance) was reintroduced for two of the fish (Fish 2 and Fish 3), the crossover behaviour was not maintained. This suggests that avoidance was not learned in Fish 2 and Fish 3's particular cases. That being said, for one participant (Fish 1) the avoidance responses were maintained above initial baseline responses of Baseline 1, which suggests this subject did in fact demonstrate an increase in Sidman avoidance. For Fish 2, there was a steady decrease in responding that returned to baseline levels after five sessions.

In summary, the major findings from this study were as follows. First, for each fish the intervention phases (Phase 1 and Phase 2) increased the rates of responding (i.e., independent crossovers) compared to both baseline conditions. This is important because it suggests that the interventions were responsible for the changes in behaviour. It also replicates previous research showing that *Betta splendens* can learn simple tasks (i.e., in the present study, crossing over between two sides of a tank in 30s intervals) by implementation of reinforcement schedules using a mirror as a reinforcer. Second, since there was an increase in frequency of crossovers after the administration of the mirror, the fish's mirror image can be considered a strong reinforcer (as has been found in previous studies). The mirror image elicited an aggressive response from Fish 2 and Fish 3 almost every time the mirror was presented, suggesting that aggression-eliciting stimuli can serve as reinforcers. Fish 1 rarely made an aggressive response to the mirror, regardless the frequency of independent crossovers were high. Consequently, crossover behaviour maintained above initial baseline levels only for Fish 1. This makes me question whether maintenance did not occur in Fish 2 and Fish 3 because their aggressive responsiveness towards the mirror impeded their learning. Third, the crossover behaviours were strengthened by reinforcement after prompting the fish closer to the target behaviour to swim to the other side of the tank. The frequency and duration of prompts decreased from initial sessions. Therefore, demonstrating that the prompting procedure was effective in teaching the fish to cross to the other side of the tank. Fourth, Sidman avoidance was not demonstrated during the initial baseline, suggesting *Betta splendens* do not engage in Sidman avoidance in response to water disturbances without an intervention to develop that behaviour. Finally, for one of the subjects, levels of responding (i.e., crossovers) remained above initial baseline levels once the intervention was removed. This is the most important result since it suggests that some level of avoidance of the water disturbance occurred. This suggests that Sidman avoidance can be taught with prompting and reinforcement.

The present study demonstrated that learning was exhibited in the intervention conditions, which shows that *Betta splendens* can learn as a result of prompting and reinforcement schedules. This is consistent with previous literature that examined the use of mirrors as a reinforcer to modify the behaviour of *Betta splendens* (Bols & Hogan, 1979). This study used two schedules of reinforcement: In Phase 1 an FR 1 where the subject was reinforced after each crossover response; and in Phase 2 a VR 2 schedule, where the fish was reinforced on average after two responses but which response would be reinforced was unpredictable. The VR schedule was added to the study after a pilot study suggested that the independent crossovers were not maintained after reinforcement was removed (see Appendix C). The results of the VR 2 showed increased means of responding compared to the FR 1 specifically for Fish 2. These results are consistent with research that suggests that VR schedules of reinforcement increase behaviour more than FR schedules (De Luca & Holborn, 1992). Research suggests this occurs because the subject cannot predict the next chance for reinforcement, therefore engaging in the behaviour more frequently. In addition, a higher rate of responding is predicted when the ratio: of reinforcement is larger, such as VR20 would produce higher rates of responding than a VR3 (Cooper et al., 2007). This may have been the case in this study, the frequency of independent crossovers increased in Phase 2 with a VR2 schedule of reinforcement., compared to Phase 1 which administered reinforcement on a FR1 schedule, which required less responses to encounter the reinforcement. As for maintaining the crossover behaviours once the Phase 2 was removed, for one subject (Fish 2) the behaviour was initially above baseline levels after Phase 2 but slowly decreased to levels of Baseline 1 after five sessions. For another subject (Fish 3) responding decreased more rapidly to the baseline level. However, for another subject (Fish 1) the behaviour maintained stable with levels of responding above initial baseline levels. Thus, for one fish the interventions may have produced Sidman avoidance.

Strengths

A strength of this study includes its addition to the literature that has previously shown that mirrors can act as reinforcers for *Betta splendens*. The study also found that habituation of the mirror did not occur throughout the course of the intervention. This was observed by stable increases in responding during intervention phases. This is consistent with previous research that found that habituation of the mirror occurs at a very slow pace (Clayton & Hinde, 1968). Clayton and Hinde (1968) found that even after 10 days of various schedules of interaction with the mirror, the aggressive response of *Betta splendens* weakened over time but never ceased altogether. The intensity of aggressive responses did recover a short time after the removal of the mirror.

The results of this study during baseline conditions were consistent with those of Hurtado (2015) that suggested that *Betta splendens* do not learn Sidman avoidance without teaching when water disturbance is the aversive stimulus. Subjects needed external procedures from the interventions consisting of contrived reinforcement to learn avoidance. This is confirmed by the maintenance of the crossover behaviours when the intervention was first removed for Fish 2, which suggests that some *Betta splendens* may be able to learn avoidance when water disturbance is the aversive stimulus. However, further research needs to be done since two of the fish crossovers did not maintain.

Limitations

It is commonly suggested to have three phases in an ABA reversal design in single-subject case designs, therefore suggesting a baseline condition between the intervention phases

(Kazdin, 2011). I chose not to add more sets to the design since the purpose of the study was to teach avoidance, therefore examining if the behaviours would continue post intervention instead of removing them. Generally, the results illustrate that the intervention (i.e., Phase 1 and Phase 2) was responsible for the increases in behaviour for the study with stronger responding in intervention phases compared to baseline. The reason for adding another set of intervention and baseline conditions would be to examine whether the behaviour increased again once the intervention was introduced and extinguish when the intervention was removed.

The research sessions occurred four times a week and the start time for each session varied by day of the week due to scheduling constraints (i.e., every Monday at 5:00 pm, and every Tuesday at 11:30am) and remained consistent throughout the entire length of the study. To decrease variability it would have been ideal to conduct sessions everyday at the same time each day. A possible extraneous variable could have been the time when the subject was fed. To minimize this variable, two sessions were held in the morning right after feeding time and the other two sessions were held in the late afternoon, and these were alternated. Thus, making any variability in the data readily observable; however, the data do not suggest the variation in time of feeding relative to session time affected responding.

Another limitation was the health of the fish. Fish 2 developed fin rot and it was advised by the veterinarian to cease sessions until the fish was deemed healthy (on hold session seven- see figure 3). In this case, the subject was given antibiotics (Erythromycin) for two weeks until he recovered. It does not appear that the increased time between sessions impacted the data significantly (i.e., no decreases of responding during intervention).

Future studies

For future studies the strengthening of maintenance of the independent responses should be examined. A possible way to increase maintenance could include additional phases of VR schedules. Research suggests that the larger the ratio of responding to reinforcement, the higher the responding within limits, as the ratio increases there is a point at which responding begins to decrease, this is dependent on multiple variables such as, the response and the behaviour being reinforced (Cooper et al., 2007). Therefore, adding a VR 3 and VR 4 could increase responding and teach the consequence of a less frequent reinforcement, which may increase the maintenance of the crossovers.

Another future study could look at other possible aversive stimuli to better examine Sidman avoidance. Previous research with fish used shock as an aversive stimulus (Brehend & Bitterman, 1963). What other aversive stimuli could be contrived in an experimental tank to assess avoidance? This is something that could be further looked at.

Finally, the results of this study are most relevant to the species – *Betta splendens* – used in the study. Therefore, the following questions arise: Would these prompting and reinforcement procedures be effective for other species? These are research questions that can be further investigated.

Conclusion

Being able to study behaviour in a controlled basic research setting can help us better understand ways to implement strategies in applied settings in future research. The results of this study provide an animal model for studying Sidman avoidance which, dependent on the aversive stimulus used may not be possible to conduct with humans for safety or ethical reasons. The results of the study suggest that reinforcement can be used to teach appropriate behaviours to avoid dangerous stimuli. This could be beneficial for teaching humans to avoid dangerous situations or understand mechanism to stop unhealthy avoidance behaviours such as obsessive compulsive tendencies and absenteeism.

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Tables

Table 1.

Means of frequency of independent crossovers throughout the four conditions: Baseline 1, Phase 1, Phase 2, Baseline2

Subjects	Baseline 1	Phase 1	Phase 2	Baseline 2
Fish 1	2	37.67	50.75	19.55
Fish 2	3.67	21.14	40.60	6.90
Fish 3	8	46.67	56.60	10.25

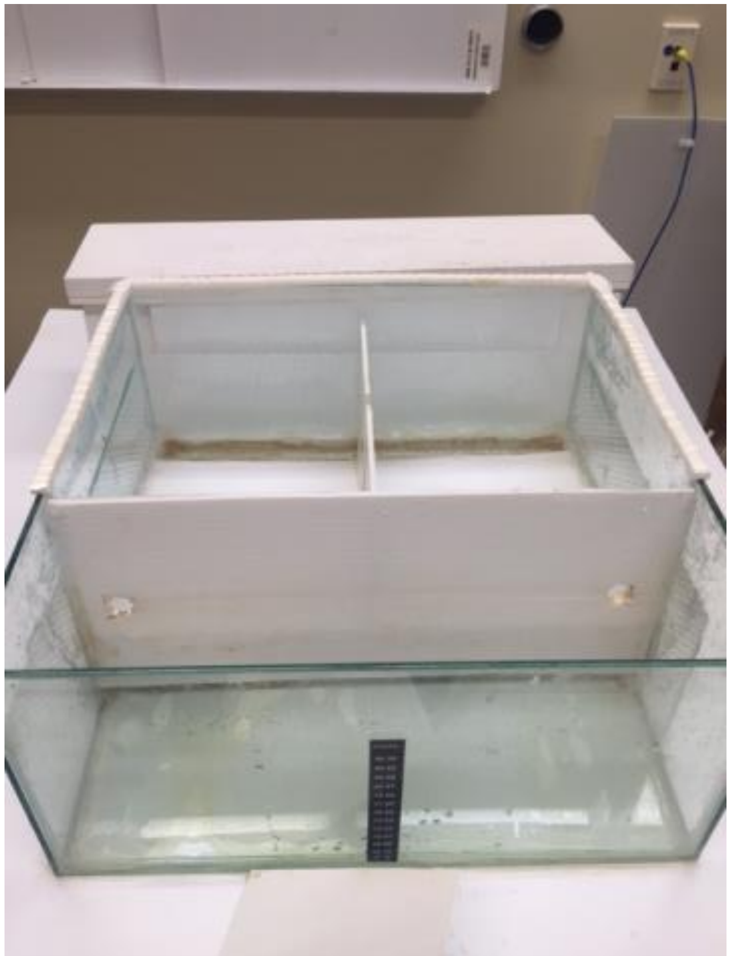


Figure 1. Image of empty experimental fish tank 33L (41x41x20cm) separated in the middle by a plastic partition.

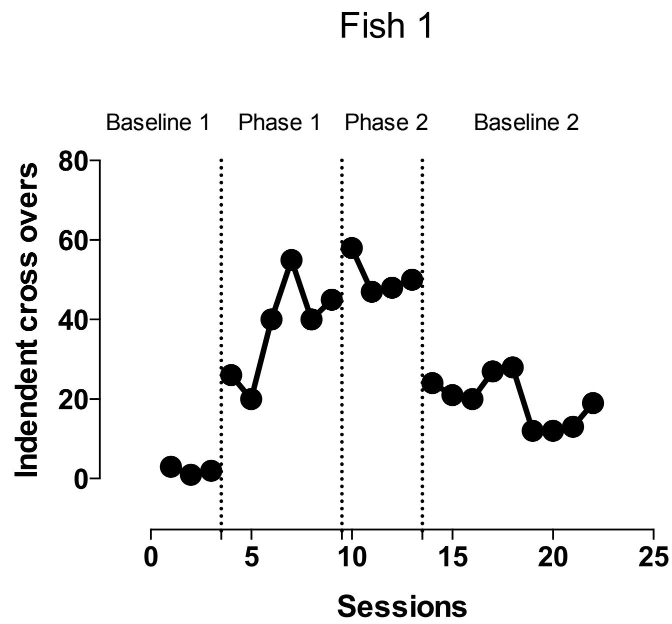


Figure 2. Frequency of independent crossovers between sides of the experimental tank during Baseline 1, Phase1, Phase2, and Baseline 2 for Fish 1.

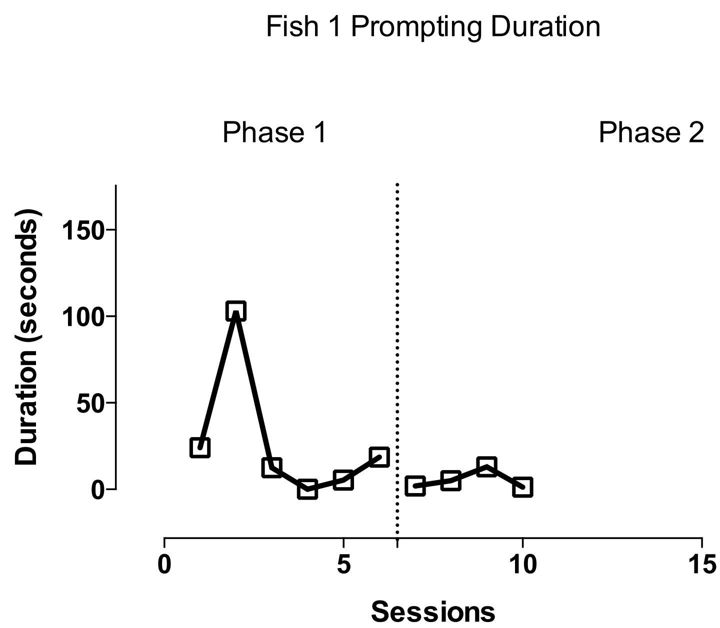


Figure 3. Duration of prompts in seconds during Phase 1 and Phase 2 to prompt Fish 1 to crossover between the sides of the tank.

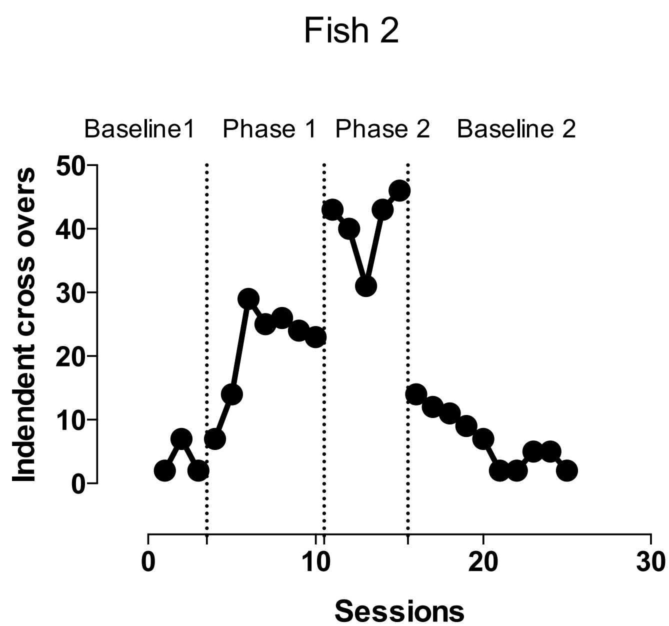


Figure 4. Frequency of independent crossovers between sides of the experimental tank during baseline, Phase1, Phase2 and return to baseline for Fish 2.

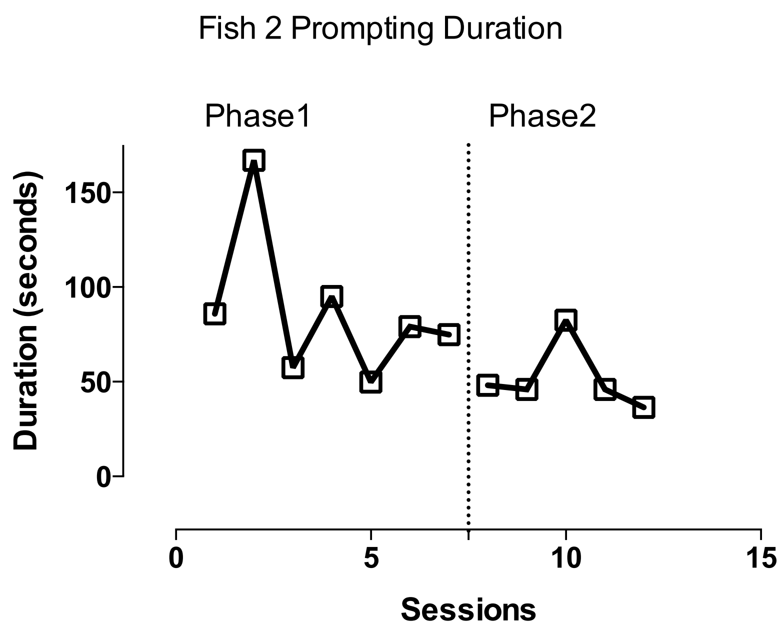


Figure 5. Duration of prompts in seconds during Phase 1 and Phase 2 to prompt Fish 2 to crossover between the sides of the tank.

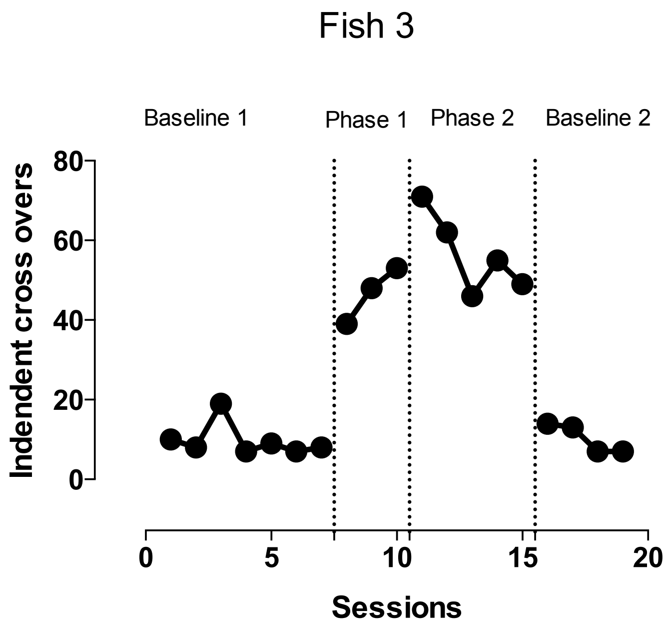


Figure 6. *Frequency of independent crossovers between sides of the experimental tank during baseline, Phase1, Phase2 and return to baseline for Fish 3.*

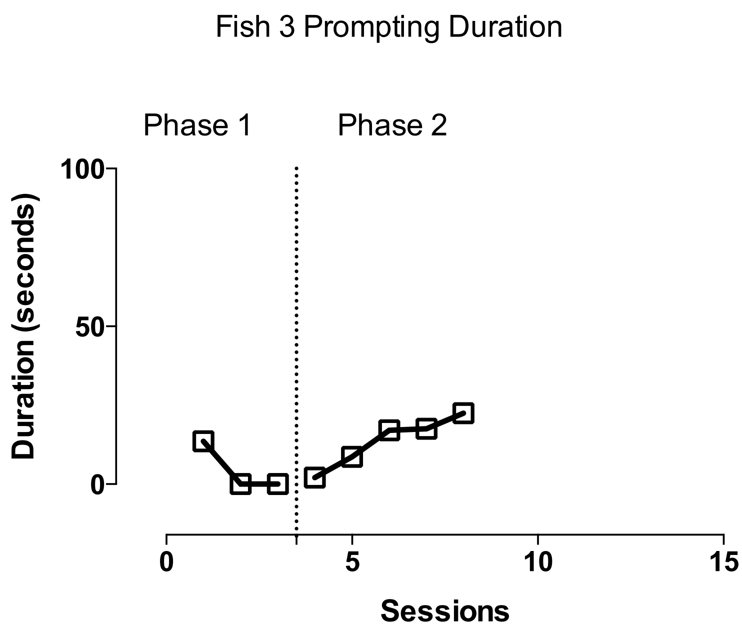


Figure 7. Duration of prompts in seconds during Phase 1 and Phase 2 to prompt Fish 3 to crossover between the sides of the tank.

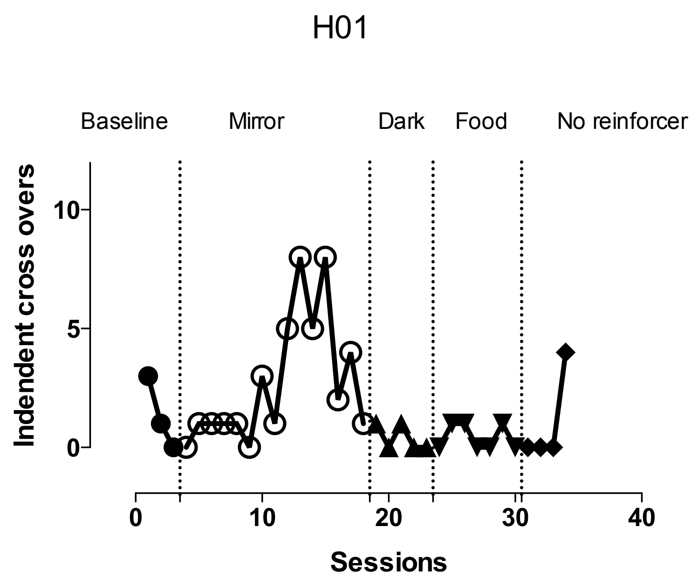
Appendix A

ABC data pro template for data collection

ABC data pro application buttons-template used to collect data on the behaviour of the subject and the behaviour of the investigator.

Appendix B

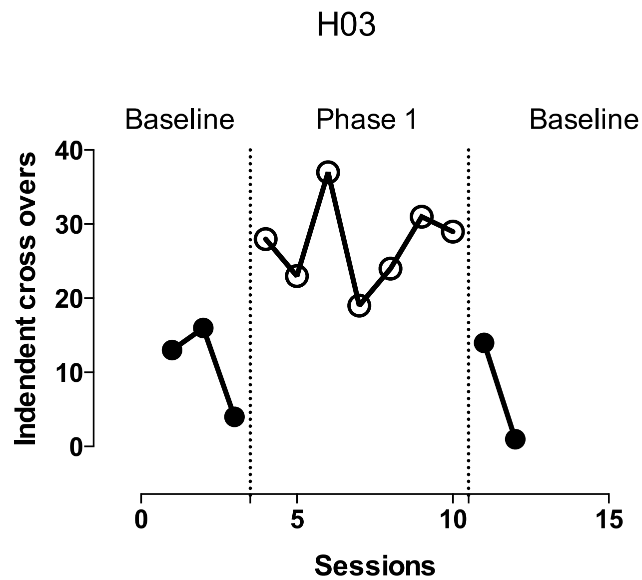
Pilot data figure for subject H01



Pilot data: Frequency of independent crossovers between sides of the experimental tank during baseline, Phase1 with a mirror, darkness, food, and a condition where no reinforcer was administered after crossovers. The results of H01 from the pilot study demonstrated no increase in independent responses compared to baseline. Therefore, other potential reinforcers were examined. These other potential reinforcers were edibles and darkness. H01's daily food was replaced with food received during sessions. However, neither food nor darkness was effective as a reinforcer for this subject.

Appendix C

Pilot data for subject H03



Pilot data: Frequency of independent crossovers between sides of the experimental tank during baseline, Phase 1, return to baseline for H03.