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Christopher Matthew Collins
The University of Montana

SIAMESE FIGHTING FISH (BETTA SPLENDENS) SHOW SELF-CONTROL FOR

ACCESS TO A MIRROR

By

CHRISTOPHER MATTHEW COLLINS

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Approved by:

Dr. David A. Strobel, Dean
Graduate School

Dr. Allen Szalda-Petree, Chair
Psychology

Dr. Wendy Shields
Psychology

Dr. Jerry Smith
Biomedical and Pharmaceutical Sciences

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Siamese Fighting Fish (*Betta splendens*) show self-control for access to a mirror

Chairperson: Dr. Allen Szalda-Petree

Self control is defined as choosing a larger, delayed reinforcer over a smaller, more immediate reinforcer with the opposite defined as impulsivity. In general, results from self-control research involving avian and non-primate mammalian subjects have shown a strong to moderate impulsive choice bias whereas studies using adult humans and non-human primates have shown a strong self-control bias. While the non-human self-control literature is rich with studies using select avian and mammalian species, there is very little self-control literature on the choice behaviors of fish or social reward. The present experiment assessed preference in male *Betta splendens* using an immediate/2 sec mirror access option verses a 15 sec delay/15 sec mirror access option. Results revealed a statistically significant bias for the self-control choice option. The findings are discussed in terms of current theories of choice behavior and are compared to choice preferences in avian and mammalian species.

Self-control has been defined as the choice of a larger, delayed reinforcer over a smaller, but immediate, reinforcer while the opposite choice has been defined as impulsivity (Ainsle, 1974; Logue, 1981; Rachlin & Green, 1972). There is a wealth of literature about the various factors that influence impulsive and self-controlled behavior in species such as humans (Forzano & Logue, 1994; Logue, Forzano, & Tobin, 1992; Mischel, Ebbesen, & Zeiss, 1972; Millard & Navarick, 1984; Mischel, Shoda, & Rodriguez, 1989) pigeons (Ainslie, 1974; Chelonis, King, Logue, & Tobin, 1994; Grosch & Neuringer, 1981; Logue, Rodrigeuz, Pena-Correal, & Mauro, 1984; Mazur, 1994; Mazur & Logue, 1978; Rachlin & Green, 1972) and rats (Chelonis, Logue, Sheehy, & Mao, 1998; Green & Estle, 2003; Tobin & Logue, 1994). In general, self-controlled responding has been reliably observed in primates such as adult humans (Logue, King, Chavarro, & Volpe, 1990; Logue, Pena-Correal, Rodriguez, & Kabela, 1986) macaque monkeys (Szalda-Petree, Craft, Martin, & Deditius-Island, 2004; Tobin, Logue, Chelonis, Ackerman, & May, 1996), and squirrel monkeys (Anderson, Awazu, & Fujita, 2000). Non-primate species tend to show a moderate to strong impulsive bias indicating a stronger effect of delay to reward compared to reward amount (Ainslie, 1974; Chelonis, King, Logue, & Tobin, 1994; Chelonis & Logue, 1995; Chelonis, Logue, Sheehy, & Mao, 1998; Green & Estle, 2003; Grosch & Neuringer, 1981; Logue, Rodrigeuz, Pena-Correal, & Mauro, 1984; Mazur, 1994; Mazur & Logue, 1978; Rachlin & Green, 1972).

While there are many studies examining self-control and impulsivity in mammalian and avian species, little literature exists investigating self-control and impulsivity in aquatic species. The use of an aquatic model would address a different phylogenetic domain of animals and create a more comprehensive comparison of choice

behavior between species. This comparison could also advance the generalizability of various models of choice.

Siamese fighting fish (*Betta splendens*) would make an excellent model by which to study impulsivity/self-control due to the large amount of extant behavioral data collected on associative processing (Craft, 2005). *Betta splendens* represent a unique parental investment strategy relative to other species normally used in such experiments. In most avian species, including pigeons, care of the offspring is usually split evenly between the parents while in mammals the female generally has the greater investment. In *Betta splendens*, the male is solely responsible for the care of the offspring, and displays a very different parental investment strategy. In addition, because of the unique reproductive behaviors of the *Betta splendens*, it is possible to use social reinforcers as opposed to food reinforcers. Finally, use of *Betta splendens* will expand the species base for examining impulsivity/self-control behavior by including a representative from a new order.

To date, few studies have been conducted examining self-control and impulsivity in Betta. In a study conducted by Lattel and Metzger (1994), male Betta responding directed toward a 15 second mirror presentation, decreased as delay to reinforcement increased from 0 to 10 seconds to 25 seconds. This study is consistent with the operant responding observed in avian and mammalian species provided with food reinforcers. In other words, as delay increased, operant responding decreased. The results of this experiment show that the Betta are sensitive to delay to reinforcement when the reinforcement is an aggressive display. For this reason, it is possible that the Betta could show a choice bias in a self-control/impulsivity procedure by using the aggressive display

as the reinforcement. Such an experiment was conducted by Craft (2005), wherein male Betta showed a significant preference for the self-control option when presented with an aggressive display to a mirror image. This suggests that Bettas may be more sensitive to the magnitude of the reward than to the delay to reward. However, Betta in this experiment began in a start box before entering the chamber in which they made a choice, thus, experiencing a delay to choice and reinforcement which has been shown to increase self-control choices (Green & Estle, 2003; Lane, Cherek, Pietras, & Tcheremissine, 2003). The design also required the researcher to reach over the apparatus and animals in order to remove and replace the guillotine doors during the trials potentially influencing the subject's behavior.

In order to examine self-control and impulsivity in the aggressive displays of Betta, instrumental conditioning of choice behavior could be used to determine biases in choice directed toward access to a mirror image of themselves (Craft, Velkey, & Szalda-Petree, 2003). Thus, the goal of this experiment was to explore the Betta's choice between a larger, delayed social reward versus a smaller, immediately available social reward while addressing the possible confounds associated with the aforementioned experiment. It is predicted that the choice of the long-delay, large-reward option will be significantly larger than would be predicted by chance.

<p style="text-align:center">Method</p>

Subjects

The subjects (N = 13) were naïve, healthy adult male Siamese fighting fish (*Betta splendens*) obtained from a local supplier. The subjects averaged approximately 6 cm in length, and were red or blue in color.

Apparatus

The apparatus was a modified T-maze similar to the apparatus used in the experiment by Bols (1976). The T-maze consists of a goal box (20 x 5 x 11 cm) and a choice chamber (10 x 5 x 11 cm). The T-maze was submerged in a tank (65 x 45 x 15 cm; approximately 30 L). Each tank had an overhanging PVC frame that allowed the researcher to control the guillotine doors at a distance using wires from the front of the tank. Each tank consisted of a gravel floor, a temperature gauge, a submerged tank heater, an air stone, and a T-maze. All of the latency measures were recorded using digital stopwatches.

Subjects were housed in the portion of the T-maze that did not contain the mirrors and guillotine doors. The water used in the apparatus was de-chlorinated before the subjects were introduced and water temperature was regulated at 25 ℃ throughout the experiment. The subjects were fed eight Betta Bits food pellets per day, two pellets after the 8 a.m. and 12 p.m. session and four pellets after the 4 p.m. session. A 12 h : 12 h light/dark cycle was maintained throughout the course of the experiment.

Procedure

Subjects were run in two separate squads during two different phases of the experiment. That is, subjects 1 through 7 were in the first squad, which ran until completion. Subjects 8 through 13 were in the second squad, which did not begin the experiment until after the first squad had reached completion. Data for all subjects were then combined into one sample.

Each session consisted of three sets of two trials per day (8 a.m., 12 p.m., and 4 p.m.) for a total of six trials a day. The two trials per session were delivered

approximately twenty minutes apart. To limit any bias due to the researcher's presence, the subjects made choices at the end of the tank furthest away from the researcher.

To ensure that each subject had exposure to both choices, forced choice trials were used. Forced choices were established by preventing access to one of the choice options, leaving the other unimpeded. The first two days consisted of twelve forced choice trials only. During the forced choice trials, subjects were forced into either the longer, larger option or the shorter, smaller option and then the alternative option on the subsequent trial. The order of exposure to the reward options in the forced choice trials was randomized to eliminate any potential primacy or recency effects. For the remainder of the experiment, the first two trials of each day (8 a.m.) were forced choice trials. Following the 8 a.m. forced choice trials, subjects were presented with two free choice trials in the 12 p.m. session and two free choice trials in the 4 p.m. session. During the free choice trials, subjects were allowed to choose from both options.

The small, but immediately available option was defined as a delay of 0.1 seconds followed by the delivery of a two second exposure to a mirror. The larger, but delayed option was defined as a delay of fifteen seconds followed by the delivery of a fifteen second exposure to a mirror. The side for stimulus presentation was counterbalanced across subjects to eliminate any potential side bias. Thus, half of the subjects experienced the self-control option in the left goal box and the other half experienced it in the right.

At the beginning of each trial, the subject swam into the choice chamber and the chamber guillotine door was lowered into place (see figure). Once the subject was in place and the stopwatches were set, the choice door was raised, beginning the trial and the choice chamber latency measure. Once the subject swam through one of the goal

openings the choice chamber latency ended and the choice guillotine door was lowered.

The subject was then presented with the appropriate delay to and exposure to the mirror

relative to the choice made. Following the exposure to the mirror, the subject returned to

the choice chamber and remained there until the next trial began. If both trials were

completed, the subject was allowed to return to the open portion of the T-maze and swim

freely.

Figure 1.

Choice apparatus.
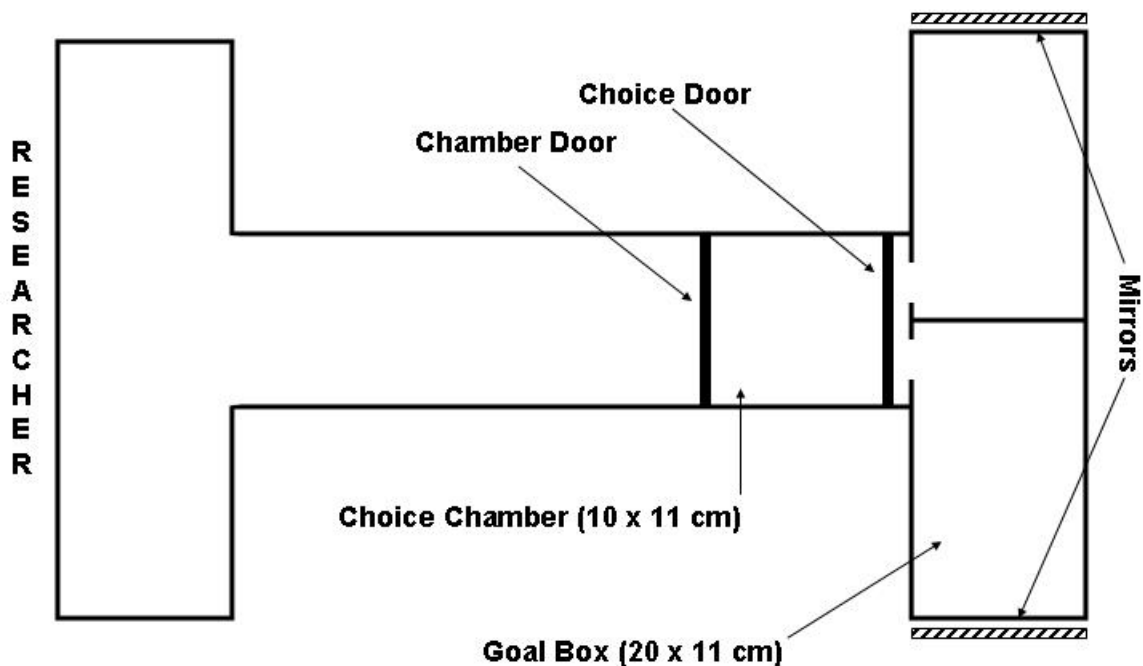
Results

The number of self-control choices was averaged across the last five days for each

subject (see Table 1). Subjects 1 through 7 (first squad) reached stability as a group at

168 trials and subjects 8 through 13 (second squad) reached stability as a group at 144

trials. A one-sample t-test conducted on the mean number of self-control choices revealed

a significant bias for the long delay/large reward option compared to chance performance

($t(12) = 3.59$, $p = .004$, d = 1.00). There was no systematic difference in the number of

self-control choices observed between the counter-balanced groups based on side of

presentation or for time of day (noon versus 4 pm. sessions).

Table 1.

Proportion of self-control (SC) choices (20 trials total) averaged across the last five days

of the experiment.

	Mean SC proportion	Standard deviation	t-test probability
Overall	0.72	0.224	.004
Counter-balance (SC side)			.88
Right (n=5)	0.71	0.261	
Left (n=8)	0.73	0.217	
Session Time (n=13)			.89
Noon Session	0.76	0.073	
4 pm. Session	0.74	0.105	

Table 2.

Latency (secs) to choice (20 trials total) averaged across the last five days of the

experiment.

	Mean latency to choice	Standard deviation
Squad 1 (n=7)		
15 sec delay/15 sec exposure option	46.10	43.94
.1 sec delay/2 sec exposure option	61.61	50.97

Squad 2 (n=6)		
15 sec delay/15 sec exposure option	51.91	49.67
.1 sec delay/2 sec exposure option	54.87	49.07

Discussion

In this experiment Siamese fighting fish (Betta splendens) exhibited a significant preference for the long-delay, large reward option. In other words, the subjects appeared to be more sensitive to the duration of the exposure to the mirror image than to the delay to the mirror exposure. These findings are unique in that previously, a bias for the self-control option was only observed in adult humans (Logue, King, Chavarro, & Volpe, 1990; Logue, Pena-Correal, Rodriguez, & Kabela, 1986) and non-human primates (Anderson, Awazu, & Fujita, 2000; Szalda-Petree, Craft, Martin, & Deditius-Island, 2004; Tobin, Logue, Chelonis, Ackerman, & May, 1996). Thus, these results are inconsistent with the findings of other non-primate animals that used food or water as reinforcement.

It has been hypothesized that the self-control preference observed in human and non-human primates and the impulsive bias in avians and non-primate mammals may be a result of general cognitive ability as measured by the encephalization quotient (Anderson, Awazu, & Fujita, 2000; Tobin, Logue, Chelonis, Ackerman, & May, 1996). Encephalization quotient refers to the ratio of brain size to body weight. This hypothesis suggests that the hitherto isolated observation of self-control in human and non-human primates is unique due to a shared phylogenetic evolutionary history. The results of the current experiment are not congruent with this hypothesis because the fish brain is quite small relative to the overall body size (Helfman, Collette, & Facey, 1997). Thus, the

encephalization quotient model appears unable to explain self-control across a wide

variety of species.

The extant literature on self-control has demonstrated that the type and quality of

the reinforcer can influence choice biases (Forzano & Logue, 1994; Grosch & Neuringer,

1981). Although adult humans show a preference for the self-control option, there tends

to be less self-control observed when the reward is a primary reinforcer such as food or

water (Forzano & Logue, 1994; Tobin & Logue, 1994). Adult humans show a greater

bias for the self-control option when the reward is not immediately consumable, such as

money or points that can be exchanged for money or food following the experiment

(Forzano & Logue, 1994; Logue, et al., 1990; Logue, et al., 1986). Human children

younger than 5 do not appear to have this bias as they tend to prefer the impulsive option

for both food (Bovino, Ackerman, & Logue, 1991; Forzano, Szuba, & Figurilli, 2003)

and secondary reinforcers, such as stickers (Logue & Chavarro, 1992). In fact, Jackson &

Hackenberg (1996) used a token reinforcement paradigm with pigeons in which the

choices were later exchangeable for access to food. Although the pigeons again displayed

a bias for the impulsive option, when the delay to exchange the tokens for food was

similar, the subjects exhibited significantly less impulsivity.

These findings suggest that the type of reinforcement used can influence self-

control choice. When the reward is immediately consumable (e.g. food or water) animals

have a greater tendency to select the smaller, immediately available option. When the

reward is delayed or a token reinforcer is used, there is a decrease in impulsivity. The use

of an exposure to a mirror reflection as the type of reinforcement is unique in regard to

previous research of self-control and choice behavior. Unlike reinforcement used in other

studies, the aggressive display of the Betta is a social reward. Like food or water, the

reinforcement is immediately available to the subjects during the experiment. However,

unlike these other rewards, the aggressive display of the male Betta has a more direct link

to reproductive success. Specifically, *Betta splendens* represent a unique parental

investment strategy wherein the males have the greater investment in the reproductive

process and the offspring. Because the males have greater investment in the offspring, it

is possible that they would exhibit greater self-control in order to attain larger reinforcers.

For example, males Betta not only must establish, but also maintain suitable territories in

which to mate. By driving away other males, the chances of reproduction increase for the

defending male. Likewise, it is believed that female Betta select mates based on the

quality of territories and nesting sites (Hogan, 1961). By displaying a choice preference

for a larger amount of exposure to a mirror, the subject or defending male may be

increasing the probability of establishing a quality territory in which to build a bubble

nest and, in turn, increasing the probability of reproductive success. Therefore, such a

choice preference could be the result of selection pressures in the male Betta's specific

evolutionary history.

More research is needed in exploring the choice behavior of aquatic species other

than Betta splendens. In particular, it could be useful to explore self-control and

impulsivity in an aquatic animal that utilizes a different parental investment stratagem

than the male Betta. One example would be guppies (*Poecilia reticulata*) in which, like

the Bettas, males occasionally put on an aggressive display and will attack other male

intruders. However, unlike the Bettas, the guppies engage in direct sexual reproduction

and, additionally, the female guppies gestate and birth the offspring (Magurran, Paxton,

Seghers, Shaw, & Carvalho, 1996). Such a model could serve to expand the literature on choice in aquatic species as well as further exploring influences of parental investment strategies on self-control and provide a more direct test of the parental investment hypothesis.

In order to make a study of aquatic species, such as this experiment with Betta, more comparable to other self-control studies behavior, one may wish to use food reinforcers similar to those done with mammals and avians. However, because Betta require such little food intake to survive, this could prove to be problematic in making the food reinforcing to the Betta. It would be interesting to examine more social types of reinforcement in mammalian and avian species to gain a comparative perspective that includes aquatic species as well.

References

Ainslie, G. (1974). Impulsive control in pigeons. *Journal of the Experimental Analysis of Behavior, 21,* 485-89.

Anderson, J. R., Awazu, S. & Fujita, K. (2000). Can squirrel monkeys (*Saimiri sciureus)* learn self-control? A study using food array selection tests and reverse-reward contingency. *Journal of Experimental Psychology, 26,* 87-97.

Bols, J. R. (1976). Display reinforcement in the Siamese Fighting Fish, *Betta splendens*: Aggressive motivation or curiosity? *Journal of Comparative and Physiological Psychology, 91,* 233-244.

Bovino, L. J., Ackerman, K., & Logue, A. W. (1991, May). *Variables related to self-control in preschool children: Age, language ability, and sensitivity to reinforcer amount and delay.* Poster presented at the meeting of the Association of Behavior Analysis, Atlanta, Georgia.

Chelonis, J. J., King, G., Logue, A. W., & Tobin, H. (1994). The effect of variable delays on self-control. *Journal of Experimental Analysis of Behavior, 62,* 33-43.

Chelonis, J. J., & Logue, A. W. (1997). Effects of reinforcer type on rats' sensitivity to variation in reinforcer amount and reinforcer delay. *Behavioral Processes, 39,* 187-203.

Chelonis, J. J., Logue, A. W., Sheehy, R., & Mao, J. (1998). Effects of response effort on self-control in rats. *Animal Learning and Behavior, 26,* 408-415.

Collier, G. H. (1981). Determinates of choice. *Nebraska symposium on motivation,* 69-127.

Craft, B. B. (2005). Aggressive Displays in *Betta splendens.* Unpublished Doctoral

Dissertation, The University of Montana.

Craft, B. B., Velkey II, A. J., & Szalda-Petree, A. D. (2003). Instrumental conditioning of

choice behavior in male Siamese fighting fish (*Betta splendens*). *Behavioural*

Processes, 63, 171-175.

Forzano, L. B., & Logue, A. W. (1994). Self-Control in adult humans: Comparison of

qalitatively different reinforcers. *Learning and Motivation, 25,* 65-82.

Forzano, L. B., Szuba, M., & Figurilli, J. M. (2003). Self-control and impulsiveness in

children: Effects of visual food cues. *Psychological Record, 53*, 161-175.

Green, L. & Estle, S. J. (2003). Preference reversals with food and water reinforcers in

rats. *Journal of the Experimental Analysis of Behavior, 79,* 233-242.

Grosch, J. & Neuringer, A. (1981). Self-Control in pigeons under the Mischel paradigm.

Journal of the Experimental Analysis of Behavior, 35, 3-21.

Helfman, G., Collette, B., & Facey, D. (1997). The diversity of fishes. Malden,

Massachusetts: Blackwell Publishing.

Hogan, J. A. (1961). Motivational aspects of instinctive behavior in *Betta splendens*.

Unpublished Doctoral Dissertation, Harvard University.

Jackson, K. & Hackenberg, T. D. (1996). Token reinforcement, choice, and self-control

in pigeons. *Journal of the Experimental Analysis of Behavior, 66,* 29-49.

Lane, S. D., Cherek, D. R., Pietras, C. J., Tcheremissine, O. V. (2003). Measurement of

delay discounting using trial-by-trial consequences. *Behavioural Processes, 64,*

287-303.

Logue, A. W. (1981). Laboratory research on self-control: Applications to administration. *Review of General Psychology, 2,* 221-238.

Logue, A. W. & Chavarro, A. (1992). Self-control and impulsiveness in preschool children. *Psychological Record, 42,* 189-204.

Logue, A. W., Forzano, L. B. & Tobin, H. (1992). Independence of reinforcer amount and delay; the generalized matching law and self-control in humans. *Learning and Motivation, 23,* 326-342.

Logue, A. W., King, G. R., Chavarro, A., & Volpe, J. S. (1990). Matching and maximizing in a self-control paradigm using human subjects. *Learning and Motivation, 21*, 340-368.

Logue, A. W. & Pena-Correal, T. E. (1984). Responding during reinforcement delay in a self-control paradigm. *Journal of Experimental Analysis of Behavior, 41,* 267-277.

Logue, A. W. & Pena-Correal, T. E., Rodriguez, M. L., & Kabela, E. (1986). Self-control in adult humans: Variation in positive reinforcer amount and delay. *Journal of the Experimental Analysis of Behavior, 46,* 159-173.

Logue, A. W., Rodriquez, M. L., Pena-Correal, T. E., & Mauro, B. C. (1984). Choice in a self-control paradigm: quantification of experienced-based differences. *Journal of Experimental Analysis of Behavior, 41,* 53-67.

Magurran, A. E., Paxton, C. G. M., Seghers, B. H., Shaw, P. W., & Carvalho, G. R. (1996). Genetic divergence, female choice and male mating success in Trinidadian guppies. *Behaviour, 133,* 503-517.

Mazur, J. E. (1994). Effects of intertrial reinforcers on self-control choice. *Journal of Experimental Analysis of Behavior, 61,* 83-96.

Mazur, J. E. & Logue, A. W. (1978). Choice in a "self-control" paradigm: effects of a fading procedure: *Journal of Experimental Analysis of Behavior, 30,* 11-17.

Millar, A. & Navarick, D. J. (1984). Self-control and choice in humans: Effects of video game playing as a positive reinforcer. *Learning and Motivation, 15,* 203-218.

Mischel, W., Ebbesen, E. B. & Zeiss, A. R. (1972). Cognitive and attentional mechanisms in delay gratification. *Journal of Personality and Social Psychology, 21,* 204-218.

Mischel, W., Shoda, Y. & Rodriguez, M. L. (1989). Delay gratification in children. *Science, 244,* 933-938.

Rachlin, H. & Green, L. (1972). Commitment, choice and self-control. *Journal of the Experimental Analysis of Behavior, 17,* 15-22.

Szalda-Petree, A. D., Craft, B. B., Martin, L. M. & Deditius-Island, H. K. (2004). Self-control in Rhesus macaques (*Macaca Mulatta*): Controlling for differential stimulus exposure. *Perceptual and Motor Skills, 98,* 141-146.

Tobin, H. & Logue, A. W. (1994). Self-control across species (Colombia livia, Homo sapiens, and Rattus norvegicus). *Journal of Comparative Psychology, 198,* 126-134.

Tobin, H., Logue, A. W., Chelonis, J. J., Ackerman, K. T., & May, J. G. (1996). Self-control in the monkey, *Macaca fascicularis. Animal Learning and Behavior, 24,* 168-174.