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SELF-CONTROL IN RHESUS MACAQUES (*MACACA MULATTA*): CONTROLLING FOR DIFFERENTIAL STIMULUS EXPOSURE[1]

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Summary.—Previous research on self-control using macaques (*Macaca fascicularis*) showed these animals have a strong bias for a delayed, larger reinforcer (Self-control) over an immediate, smaller reinforcer (Impulsive). Typical studies of self-control have used a discrete trials methodology with a secondary discriminative stimulus during the delay periods. This results in a greater exposure to the stimulus representing the self-controlled option and may account for some of the early exclusive preference for self-control observed. The present experiment examined self-control bias in three rhesus macaques (*Macaca mulatta*) while controlling for differential durations of stimulus exposure. Subjects were presented stimuli via a computer monitor and made choices by touching the stimulus at which point both stimuli were removed for the delay periods. All three subjects displayed a nearly exclusive bias for the delayed, larger reinforcer (self-control). These results are consistent with previous studies, despite the variations in methodology and species.

Self-control is defined as the choice of a larger but delayed reinforcer over a smaller and immediately available reinforcer while the opposite has been defined as impulsive (Rachlin & Green, 1972; Ainslie, 1974; Logue, 1998). A relatively wide literature exists on various factors that influence self-controlled and impulsive choice in humans (Mischel, Ebbesen, & Zeiss, 1972; Millar & Navarick, 1984; Mischel, Shoda, & Rodriguez, 1989; Logue, Forzano, & Tobin, 1992; Forzano & Logue, 1994; Logue, 1998) and pigeons (Rachlin & Green, 1972; Ainslie, 1974; Mazur & Logue, 1978; Grosch & Neuringer, 1981; Logue, Rodriquez, Pena-Correal, & Mauro, 1984; Chelonis, King, Logue, & Tobin, 1994; Mazur, 1994). Overall, results from studies using human subjects have indicated general bias towards self-control. This self-control bias signifies that choice is largely controlled by the relative magnitude of the reward. In contrast, pigeons have a strong impulsive bias, signifying that choice is controlled by the relative delay to reward. While the literature investigating self-control in other nonhuman animal species is limited, e.g., squirrel monkeys, long-tailed macaques, pigeons, rats, those reported tend to show an impulsive choice bias similar to that observed with

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pigeons (Rachlin & Green, 1972; Mazur & Logue, 1978; Grosch & Neuringer, 1981; Mazur, 1994; Tobin & Logue, 1994).

While the examination of self-control using pigeons as subjects has been fruitful, the study of self-control in mammalian species, particularly primates, would be instructive for two major reasons. First, these studies may provide evidence on the generality of the pigeon model. Second, mammals, specifically primates, may provide a better model for understanding self-control and impulsivity in humans due to the neurological and phylogenetic similarity (Tobin, Logue, Chelonis, Ackerman, & May, 1996).

To this end, Tobin, *et al.* (1996) investigated self-control in Long-tailed macaques (*Macaca fascicularis*). The study examined self-control bias in two long-tailed macaques using a discrete trials procedure with sweetened water as the reinforcer, a directional push rod response, and red or green stimulus lights arranged laterally on opposite sides of the push rod. Additionally, a 60-sec. trial-onset to trial-onset interval was imposed to maintain a constant overall reinforcer frequency and consequently the session duration. Both subjects demonstrated a pronounced self-control bias. This result is at odds with results from studies using pigeons (Rachlin & Green, 1972; Ainslie, 1974; Mazur & Logue, 1978; Grosch & Neuringer, 1981; Logue, *et al.*, 1984; Chelonis, *et al.*, 1994; Mazur, 1994), squirrel monkeys (Anderson, Awazu, & Fujita, 2000), and rats (Kanraek & Collier, 1973; Ito & Asaki, 1982; Van Haaren, Van Hest, & Van de Poll, 1988; Chelonis, Logue, Sheehy, & Mao, 1998) but is largely consistent with studies using human subjects (Logue, *et al.*, 1992; Forzano & Logue, 1994; Logue, 1998).

A procedural component in typical discrete trial examinations of self-control includes a differential duration of exposure to the discriminative stimuli (S^D) associated with the choices. Operationally, once a choice is made, both primary S^Ds are extinguished and a secondary S^D for the selected option is illuminated until the reinforcer is delivered. Thus, subjects have a greater exposure to the S^D, through the secondary S^D, associated with the self-control option compared to the impulsive option. In studies finding an impulsive bias, the differential stimulus exposure is not problematic and can be discarded as a possible confound because the choice bias is associated with shorter stimulus exposure.

In the case of Tobin, *et al.* (1996), the S^Ds were extinguished for both options after a choice was made and the main houselight (white) was replaced with a houselight the same color as the S^D selected and remained illuminated for the duration of the delay associated with the choice. Such a difference in exposure to either stimuli, even in a secondary fashion, may account for a small portion of the nearly exclusive self-control bias observed.

The purpose of the present experiment is twofold. First, the present methodology controls for the potential S^D exposure confound due to the differential delays associated with the choice options. Given the possibility of discrimination problems, without the use of differential exposures, a stimulus touch response system was used to maximize discrimination. Thus, it is hypothesized that, with equal S^D exposure, the number of self-control choices will not deviate from chance performance. Second, given that Tobin, *et al.* (1996) tested only two subjects, the present study increased the overall sample of macaque monkeys tested and provides a preliminary assessment of the generality of the results.

METHOD

Subjects

Three male rhesus macaques (*Macaca mulatta*), ranging in age from 7.5 to 10 years, served as subjects. All subjects were experienced with video tasks, using both joystick and touchscreen response systems, involving simple and serial conditional discriminations. The subjects were continuously pair-housed except for the duration of the daily sessions during which an opaque divider was used to separate subjects in their home cage. Water was continuously available during the daily sessions.

Apparatus

The subject's home cage (61 cm × 92 cm × 61 cm) served as the testing chamber with a testing cart attached via lock-down cables to the front of the home cage. The cart contained a 14 in. SVGA computer monitor, touchscreen overlay (EZSCREEN), and feeder. The monitor was placed approximately 15 cm from the face of the cage with the feeder cup centered beneath the monitor. A PC computer was used to present all stimuli and record responses and latencies. Stimuli were presented along the horizontal midline of the display and 3 cm to the left or right of the vertical midline of the display.

Procedure

The experiment consisted of two phases in which choice bias was assessed for a large, delayed reinforcer (six pieces of cereal, delayed 6 sec.) versus a smaller, immediate reinforcer (two pieces of cereal, delayed 0.1 sec.). For both phases, a daily session consisted of six forced-choice trials and 30 free-choice trials. During the forced-choice trials only one stimulus was presented. A touch response on the stimulus resulted in the immediate removal of the stimulus followed by the delay period and subsequent reward amount associated with the stimulus. The alternative stimulus was presented on the next consecutive trial. Forced-choice trials were presented in pairs evenly spaced throughout the session (Trials 1 & 2, 13 & 14, 25 & 26). The order of presentation for the stimuli on the forced trials was randomly assigned for each pair of presentations.

Free-choice trials consisted of a simultaneous presentation of both stimuli with a touch response resulting in the immediate removal of both stimuli and the start of the delay period associated with the stimulus chosen. Upon completion of the delay period, the reward amount associated with the stimulus was delivered. Choice was recorded for each trial, and each phase continued until there was no upward or downward monotonic trend in choices across three consecutive sessions.

A variable intertrial interval was used for all trials to control for the session duration regardless of the distribution of choices made by the subject (see Tobin, *et al.*, 1996). The trial-onset to trial-onset period was set at 60 sec. The specific intertrial interval for a given trial was defined as 60 sec. minus the latency to make a stimulus response minus the delay period associated with the choice. If the latency to make a stimulus response plus the delay period was greater than or equal to 60 sec., the next trial began immediately after the delivery of the reward.

For Phase 1, a red triangle was associated with the long delay and large reward option (self-control) and a green triangle with the short delay and small reward option (impulsive). Phase 2, the reversal phase, was conducted immediately after the completion of Phase 1 and was conducted to assess possible color preference effects on choice bias. Phase 2 was identical to Phase 1 with the exception that the red triangle was associated with the short delay and small reward and the green triangle with the long delay and large reward option. The stimuli, in both phases, were pseudorandomly assigned to the left or right screen position such that neither stimulus was presented in the same screen position for more than two consecutive trials.

Results and Discussion

The number of self-control choices across the last three sessions for each phase was averaged for each subject; see Table 1. During Phase 1, Subjects Abe and Bob reached choice stability at 180 trials, while Vern reached choice stability at 252 trials. All subjects reached choice stability for Phase 2 at 540 trials. A one-sample t test conducted on the mean number of self-control choices for Phase 1 indicated a significant bias for the long delay and large reward compared to chance performance ($t_2=25.35$, $p<.005$, $d=14.63$). The same analysis conducted on the reversal phase also showed a significant bias for the long delay and large reward ($t_2=21.36$, $p<.005$, $d=12.35$), even though the mean number of self-control choices for each subject was slightly lower.

The results of the present experiment clearly show a strong self-control bias for all three subjects. In fact, the bias for the self-control option is nearly exclusive for each subject. These results are consistent, in both direction and magnitude of effect, with those obtained by Tobin, *et al.* (1996), despite methodological variances and species differences.

TABLE 1
MEAN NUMBER OF SELF-CONTROL CHOICES (30 TRIALS TOTAL) AVERAGED ACROSS FINAL THREE SESSIONS OF EACH PHASE

	Phase 1			Phase 2 (Reversal)		
	M	%	*SEM*	*M*	%	*SEM*
Abe	29.67	.99	0.33	29.00	.97	0.00
Vern	28.00	.93	0.58	27.00	.90	1.15
Bob	29.67	.99	0.33	28.67	.96	0.67
M	29.11	.97	0.56	28.22	.94	0.62

The present methodology assessed the influence of differential duration of exposure for the choice options. The results indicate that the magnitude of the self-control bias observed by Tobin, *et al.* (1996) is not the result of the differential duration of exposure used in their experiment. However, the mean proportion of self-control choices in the present experiment is slightly lower ($M=.955$, $SEM=.02$) compared to that observed by Tobin, *et al.* ($M=.985$, $SEM=.005$). This difference may be due to the use of equivalent durations of exposure. Due to the small sample size for both experiments, an equally likely explanation is that the difference is due to the general variability across subjects, e.g., the actual variability across monkeys will become more apparent as the number of monkeys tested increases. In either case, high self-control bias was observed which is more consistent with the results from investigations using human subjects compared to those using nonhuman subjects (rats, pigeons, long-tailed macaques, and squirrel monkeys).

The present findings are interesting in that they address the robustness of the high self-control obtained in terms of variations in procedural details and species examined. The implications of these results lie in the evolutionary connection between human and nonhuman primates, given that both human and nonhuman primates show similar self-control bias, with respect to their ability to delay reinforcement. Thus, statements regarding causative agents like environment or learning do not provide a comprehensive explanation of this behavior. Unlike the primates, other comparative species, e.g., rats, and to a lesser degree pigeons, do not show the same self-control bias under the varying methodologies used. These findings contribute to the modest connection between human and nonhuman primates in simple choice decisions.

Studies should continue to investigate the generality of the results from self-control studies in terms of possible species and subspecies differences. In addition, it would be instructive to investigate, in detail, any possible effects due to specific procedural variances inherent when modifying methodologies for different species.

REFERENCES

AINSLIE, G. (1974) Impulse control in pigeons. *Journal of the Experimental Analysis of Behavior*, 21, 485-489.

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: Animal Behavior Processes*, 26, 87-97.

CHELONIS, J. J., KING, G., LOGUE, A. W., & TOBIN, H. (1994) The effect of variable delays on self-control. *Journal of the Experimental Analysis of Behavior*, 62, 33-43.

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.

FORZANO, L. B., & LOGUE, A. W. (1994) Self-control in adult humans: comparison of qualitatively different reinforcers. *Learning and Motivation*, 25, 65-82.

GROSCH, J., & NEURINGER, A. (1981) Self-control in pigeons under the Mischel paradigm. *Journal of the Experimental Analysis of Behavior*, 35, 3-21.

ITO, M., & ASAKI, K. (1982) Choice behavior of rats in a concurrent chains schedule: amount and delay of reinforcement. *Journal of the Experimental Analysis of Behavior*, 37, 383-392.

KANRAEK, R. B., & COLLIER, G. (1973) Effort as a determinant of choice in rats. *Journal of Comparative and Physiological Psychology*, 84, 332-338.

LOGUE, A. W. (1998) Laboratory research on self-control: applications to administration. *Review of General Psychology*, 2, 221-238.

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., RODRIQUEZ, M. L., PENA-CORREAL, T. E., & MAURO, B. C. (1984) Choice in a self-control paradigm: quantification of experienced-based differences. *Journal of the Experimental Analysis of Behavior*, 41, 53-67.

MAZUR, J. E. (1994) Effects of intertrial reinforcers on self-control choice. *Journal of the 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 the 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 of gratification. *Journal of Personality and Social Psychology*, 21, 204-218.

MISCHEL, W., SHODA, Y., & RODRIGUEZ, M. L. (1989) Delay of 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.

TOBIN, H., & LOGUE, A. W. (1994) Self-control across species. *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, 167-174.

VAN HAAREN, F., VAN HEST, A., & VAN DE POLL, N. E. (1988) Self-control in male and female rats. *Journal of the Experimental Analysis of Behavior*, 49, 201-211.

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