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SELF-CONTROL WITH RUNNING REINFORCEMENT

By

Jennifer Lynn Brinegar

M.A., University of Montana, Missoula, Montana, 2006
B.A., University of Arkansas, Fayetteville, Arkansas, 2002

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Approved by:

Dr. David A. Strobel, Dean
Graduate School

Dr. Allen Szalda-Petree, Chair
Psychology

Dr. Nabil Haddad
Psychology

Dr. Wendy Shields
Psychology

Dr. Stuart Hall
Psychology

Dr. Jerry Smith
Biomedical and Pharmaceutical Sciences

Self-Control Choices Using Running Reinforcement

Chair: Allen D. Szalda-Petree, Ph.D.

Rats were given a choice between two amounts of a run-reward after responding on one of two equidistant levers. Responding on one lever resulted in the delivery of a smaller, immediate access to a running wheel (Impulsive) while responding on the other lever resulted in the delivery of larger but delayed access to a running wheel (Self-control). A variable inter-trial-interval was used to control the session duration regardless of the distribution of choices made by the subject. The results demonstrate that the use of a wheel-running reinforcer results in a significant self-control choice bias. This suggests that the use of a wheel-running reinforcer can be used alongside food and water reinforcers without having to undergo caloric deprivation. This study demonstrates that the use of a running reinforcer may be a potentially powerful motivator in choice studies among rats.

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Self-Control Choices Using Running Reinforcement

Self-control is traditionally defined as the choice of a larger but delayed reinforcer (LL) over a smaller and immediately available reinforcer (SS) while the opposite choice has been defined as impulsivity (Ainslie, 1974; Logue, 1981; Rachlin & Green, 1972). Results from choice studies in humans have shown a bias toward the self-control (LL) option (Forzano & Logue, 1994; Logue, 1998; Logue, Forzano, & Tobin, 1992; Mischel, Ebbesen, & Zeiss, 1972; Millar & Navarick, 1984; Mischel, Shoda, & Rodriguez, 1989). Results from choice studies using pigeons suggest a greater bias toward the impulsive choice (SS) option (Ainslie, 1974; Chelonis, King, Logue, & Tobin, 1994; Grosch & Neuringer, 1981; Logue, Rodriguez, Pena-Correal, & Mauro, 1984; Logue, Chavarro, Rachlin, & Reeder, 1988; Mazur, 1994; Mazur & Logue, 1978; Rachlin & Green, 1972).

It has also been demonstrated that the condition of the environment (i.e. the delay to stimulus, delay to response, and/or magnitude of reward across conditions) can play a role in choice. Such studies have revealed shifts in choice biases as the result of variability in delay to reinforcement (Chelonis, et al., 1994), increased effort requirements (Chelonis, Logue, Sheehy & Mao, 1998), reinforcer value (Grosch & Neuringer, 1981), precommitment (Ainslie, 1974; Rachlin & Green, 1972) and fading (Logue, 1981; Logue, et al., 1984; Mazur & Logue, 1978). It follows then that with respect to self-control studies, the manner in which the stimulus and response options are presented might be affecting choice behaviors.

A key peck response has been used in the majority of self-control studies using pigeons as subjects. Chelonis and Logue (1996) suggest that the typical key pecking

response itself might be influencing the choice bias observed due to an autoshaped responding to a lit key and the proprioceptive similarity between that response and eating. To address these issues, Chelonis and Logue compared sensitivities to reinforcer delay and amount for key pecking and treadle pressing, finding no significant differences. Thus, the sensitivities observed in key pecking can be generalized to treadle pressing, eliminating the possibility of autoshaping and proprioceptive similarity as influential of choice. Further considering response, it can be suggested that the response mode resembles one that would exist in the animals' natural ecological system. In other terms, the response in question might actually be acting as an evolutionarily-developed stimulus itself.

A behavior systems approach states that behaviors are governed by organized systems that allow the animal to adapt as it responds to dynamic aspects of the environment (Timberlake, 1993). Such a behavior-process approach lends itself to the examination of motivational state differences in responding across as well as within species. Timberlake discusses how the variations of behaviors involved in the feeding process in an animal's natural environment might be influenced by response modality in a laboratory setting. This suggests that some response types resemble different classes of behavior and that using a response that resembles those respective classes may in turn yield different results. For example, with pigeons, it is common to employ a key peck response. Such a response resembles a naturally-occurring behavior like pecking at food, a terminal mode in the class of feeding behavior of pigeons. For rats, the use of a running wheel as a response would resemble a naturally-occurring behavior like seeking food, a general search motivational mode. If motivation is influenced by these modes of

behavior, the response used in a lab might be influencing sensitivity to the reward size or delay based on the evolutionary preparedness for that animal. For behaviors as associated with feeding, Timberlake (1994) describes three functional classifications: general search, focal search, and consummatory behaviors. These behaviors can be thought of in a functionally chronological fashion, with the first two existing as more initial and the third as more terminal acquisition events. Given such a system, terminal key pecking and lever pressing would represent focal search behaviors. Thus, the majority of behavioral responses examined in self-control studies would be classified as belonging to the focal search motivational mode.

While the bulk of the animal literature on self-control relies on pigeons as subjects, the limited number of self-control studies using rats also show a general SS choice bias (Boehme, Blakely, & Poling, 1986; Chelonis, et al., 1998; Eisenberger, Weier, Masterson, & Theis, 1989; Green & Estle, 2003; Kanraek & Collier, 1973; Tobin, Chelonis, & Logue, 1993; Tobin & Logue, 1994; Flora & Workman, 1995; van Haaren, van Hest, & van de Poll, 1988). Similar to the reliance on the key peck response with pigeons, the majority of self-control studies with rats have used a lever or bar press response. An obvious choice for response comparison would be the use of a running response, due to the vast research base regarding the relationship between running and reward magnitude and delay to reinforcement manipulations. Boehme, et al. (1986) examined self-control in rats using a maze choice apparatus; a response which is potentially more representative of a general search mode. In one condition, rats chose between two 40 cm runways that led to either a SS reward or a LL reward. Consistent with the majority of rat studies, a strong preference for the SS option was observed.

However, due to the use of a constant inter-trial-interval (20 sec), the results are difficult to interpret. First, the overall frequency of reinforcement for the SS option would be greater than the self-control option. Second, an exclusive choice of the SS option would result in shorter session durations and, in most procedures, a shorter delay to daily food supplements, suggesting that either manipulation of delay or magnitude of reward may have influenced choice made.

Another response more representative of a general search mode was examined by Szalda-Petree, Craft, Wheeler, Martin, and Velkey (2003) using a modified choice box connecting two Wahman running wheels. In this study, rats were required to make a choice by running on one of two wheels presented simultaneously. Running on either wheel resulted in the choice of either a SS or LL reward, similar to those studies relying solely on lever or bar-presses. Using the wheels in place of the typical, more terminal responses, the results demonstrated a significant self-control bias as evidenced by a greater number of LL choices than predicted by chance. In a follow-up experiment, the Szalda-Petree lab (2004) used an adjusting delay procedure to determine the indifference point for delay and reward amounts' influence on choice. Using the running wheel response, rats chose between a constant option (2 pellets reward /0.1 sec delay) and a variable option (6 pellets reward/Adjusting delay). Trials were presented in blocks of four, consisting of two forced choice trials followed by two free choice trials. The delay associated with the large reward was increased with consistent choice of the large reward option, decreased with consistent choice of the small reward option, and remained the same with inconsistent choice. Results showed choice indifference at an average large

reward delay of 24.41 seconds. Thus, just as in the previous experiment, reward amount was a larger factor in the determination of choice than delay.

A follow up study by the Szalda-Petree lab (2005) was conducted to examine potential interference due to of the layout of the experimental chamber. Since a modified choice box was required to connect tunnels to the choice-wheels, possible artifacts might have influenced the immediate availability of the SS option. The 2005 study removed the wheels and replaced them with the more terminal lever-press response. It was anticipated that this study would yield a SS bias, lending evidence that the wheel-running response was tapping into some different motivational state, thereby influencing choice. The follow up lever press experiment retained the tunnels, other apparatus, and method from the former 2003 study, changing only the response modality. After comparing the mean number of LL choices using the leverpress response to the 2003 wheel-running response, no significant difference in the number of LL choices was shown. Since the results between these studies bear no significant difference, this suggests that some artifact of the experimental chamber was in fact influencing choice.

Since no significant difference was shown, the similar results in the 2003 and 2005 Szalda-Petree studies are consistent with findings by Chelonis and Logue (1996) showing that in pigeons, the use of a key peck and a treadle press response produced similar levels of SS bias. It can then be concluded that in pigeons, choice bias using key pecking as a response modality can generalize to treadle pressing. The comparison of these two response types in rats demonstrate this response generalization to an even greater degree because of the greater separation between running and the terminal response and treadle pressing and the terminal response. Thus, while a behavioral

systems analysis is useful in classification of behavior modes, it appears that the factors affecting choice bias (delay to reward and reward amount) observed under these circumstances are similar across a number of modes of responding.

A potential limitation of these studies is that in the process of making the wheel-running response temporally comparable to the lever pressing response it is possible that the amount of running involved was not sufficient to evoke the general search response modality. Thus, it is possible that the wheel-running in these experiments did not successfully accessed the construct “general search mode”, as is suggested of running that occurs in the wild. An alternative approach to engage the rat in a general search mode response would involve using running as the reinforcer rather than as the response modality. The current study will implement a running reinforcer to set the general search mode motivational state and examine self-control choice behavior using such a reward.

Numerous studies have shown that a wheel-running reinforcer can effectively maintain operant behaviors in rats and mice (Belke, 1996, 1997; Belke & Heyman, 1994; Collier & Hirsch, 1971; Iversen, 1993, 1998; Kagan & Berkun, 1954; Mazur, 1975; Premack, 1962; Premack, Schaeffer, & Hundt, 1964; Tierney, Smith, & Gannon, 1983; Timberlake & Allison, 1974), suggesting that the reinforcing effects of wheel-running can be examined alongside food and water reinforcers. The consideration of this alternative reinforcement holds promise in the study of self-control since food or water deprivation in the animal would be unnecessary. The further recognition that choice between SS and LL in specific situations may potentially reflects each species' specific biological system of responding in a given situation (Collier, 1981; Green & Estle, 2003) is also noteworthy. That is to say the choice bias observed for a given species may be the

result of both a specific evolutionary history and situational variables such as response type, reinforcer type, and deprivation level.

Customary food and water reinforcers require manipulation in the form of deprivation in order to elicit an effective response from the animals. But reinforcers free of such caloric deprivation have been established by using access to a running wheel as the primary reinforcement. By initially allowing free-access to a wheel and then gradually reducing that access-time, deprivation similar to those that rely on food and water reinforcers can be implemented with running as the primary reinforcer. Using rats as subjects, access to running wheels can also reinforce other behaviors such as eating, licking, or lever-pressing (Collier & Hirsch, 1971; Kagan & Berkun, 1954; Pierce, Epling, & Boer, 1986; Premack, 1962, 1965; Premack, Schaffer, & Hundt, 1964; Timberlake & Allison, 1974; Timberlake & Wozny, 1979). Since wheel-running reinforcement has been established as a technique to study various theories regarding behavior regulation and reinforcement processes (see Mazur, 1975; Tierney, Smith, & Gannon, 1983; Timberlake & Wozny, 1979) it is logical to use a wheel-running reinforcer for a self-control study.

This experiment assesses choice bias in a self-control choice paradigm using a lever-press response and a running reinforcer. It is hypothesized that the use of a wheel-running reinforcer will yield a choice bias resulting in greater self-controlled choices than predicted by chance. This study also lends itself to the further examination of running as an adequate reinforcer in choice studies and suggests that responding patterns are similar to those using more traditional reinforcers.

Method

Subjects

Twelve, female, Sprague-Dawley rats served as subjects. One rat was eliminated following the training phase because of a failure to learn the lever press/wheel-run contingency. Female rats have been shown by Belke and Christie-Fougere (2006) and Iversen (1993) to run at higher rates than do male rats, possibly finding wheel-running as a more effective reinforcer. It has been further shown by Belke and Christie-Fougere (2006) that the female rats do not require a sucrose solution reinforcer or food deprivation to elicit a lever-press response. All subjects were approximately 90 days old at the beginning of the experiment and had an average weight of 282.20 grams. They were allowed ad-lib food and water access in the home cages at all times. The rats were housed in groups of three in polycarbonate cages (480 mm x 270 mm x 220 mm).

Apparatus

Four sound-attenuated cabinets each housed one running-wheel (Lafayette tethered wheel, model number 80860). The wheels required 0.20 N of force to turn. Two lever presses (Lafayette retractable lever, model number ENV-112CM) were mounted in the plexiglass wall 3 1/2 cm above the lowest point of the running wheel and 15 cm off the midline of the running wheel. Above each lever a 24-volt bayonet light was mounted for use as the discriminative stimuli. A lever-press was recorded after a 3 mm depression of the lever with a force of 0.20 N. Two solenoid-operated brakes were mounted on opposite sides of the running wheel. When operated, a rubber tip attached to the metal shaft of each solenoid contacted the outer rim of the running wheel bringing it to a stop. Wheel rotations were measured by a reflective sensor (model number OPB704W)

detecting movement by emitting an infrared beam and recording any breaks in the beam (a maximum of 6 beam breaks per wheel rotation).

Procedure

Subjects received initial training to establish running reinforcer control similar to that used by Iversen (1993, 1998) and Belke (2004). The first phase consisted of ten 60-minute sessions of unrestricted access to running wheel. After these sessions, a brake-habituation phase was implemented for ten sessions in which the running wheel was braked for 10-seconds then released for one minute of free-access for a period of 60-minutes. The brake habituation phase was immediately followed by a gradually decreasing availability of free running access. Establishing reinforcer control, these secondary sessions involved locking the braking the running wheel for 5-minutes periods separated by 1-minute periods with free access to running for a period of 60-minutes. The free access period was then reduced to 30-seconds, 15-seconds, 10-seconds, and 9-seconds. Reinforcer control was considered established when running occurred in all the available access periods and within 1 or 2 seconds after the release of the brakes.

Finally, the opportunity to run for 60 seconds was made contingent upon a single lever press of the retractable lever. Though Iversen's 1993 study showed that the initial low frequency of lever-pressing was sufficient to bring the subject in contact with the contingency and no shaping was necessary, some shaping by manually reinforcing the approach of the levers (by releasing the brakes) was necessary for this experiment. Thus, a lever press caused the lever to retract and the brake to release. The wheel was then free to turn for 60-seconds. After the 60 second free access period the brake was applied and

the retractable lever extended. The session terminated when 30 reinforcers were delivered.

When the subjects were reliably pressing the levers and running on the wheel during free access times, the experiment began. Each daily session consisted of six forced-choice trials intermittent among 30 free-choice trials. During the forced-choice trials, one lever was retracted, leaving only the alternate lever available for responding. A single lever press resulted in the initiation of the delay period, immediate retraction of that lever, and the subsequent release of the brakes after the delay period elapsed. The alternate lever press was made available on the next consecutive trial. Forced-choice trials were presented in pairs evenly spaced throughout the session (trials 1 & 2, 13 & 14, 25 & 26), so that two forced choice trials preceded a block of 10 free choice trials. The reward amount/delay conditions were pseudo-randomly assigned to the levers to control for a possible position bias, such that no lever was associated with a given schedule for more than two consecutive sessions. The signal light above each lever was counterbalanced across subjects such that an illuminated lamp indicated the large/delayed option for half the subjects and the smaller/immediate option for the remaining subjects.

Free-choice trials consisted of concurrent availability of both levers for responding. A particular schedule was chosen when a lever was pressed. When a choice was made both levers were retracted and the delay period associated with the lever chosen was initiated. Upon completion of the delay period, the running wheel was released for the reinforcer access period associated with the selected lever.

A variable inter-trial-interval was used for all trials to control for the session duration regardless of the distribution of choices made by the subject (Szalda-Petree,

Craft, Martin, & Deditus-Island, 2004, Tobin, Chelonis, Ackerman, & May, 1996). The trial-onset to trial-onset period was restricted to a total of 60 seconds. The specific inter-trial-interval for a given trial was defined as 60 sec minus the choice latency minus the response latency minus the delay period associated with the choice. If the latency to choose a lever plus the delay period was greater than or equal to 60 sec, the next trial began immediately after wheel availability commenced. Data collected for each trial consisted of lever/choice, latency to choice, and distance run. Sessions continued until stable choices were obtained, with stability defined as no upward or downward trend in choice across five consecutive sessions.

Results

The number of LL choices, mean LL choice distance run, mean SS choice distance run, and total mean distance run were averaged across the last five sessions for each subject (see table 1). A one-sample t -test conducted on the mean number of LL choices ($M = 19.47$, $SEM = 0.61$) revealed a significant self-control bias ($t(10) = 7.34$, $p < .01$, $d = 2.21$). Correlations between the number of LL choices and the mean run performed to determine whether the reward amount is predictive of LL choice bias, Pearson-correlations showed no significant relationship between the number of LL choices and total distance run, distance run for LL choice trials, or distance run for SS choice trials (see table 2). Correlations between LL choices and weights were performed to determine whether weight was predictive of LL choice bias, Pearson-correlations showed no significant relationship between weight and number of LL choices total distance run, distance run for LL choice trials, or distance run for SS choice trials (see table 3).

The pattern of responding seen in the current experiment resembles that of more traditional studies relying on food or water reinforcers (see figure 1). This bitonic pattern of increased initial responding and decreased rates of responding toward the end of a given trial has been studied in great depth (Bizo, Bogdanov, & Killeen 1998; Cannon & McSweeney, 1995; Killeen, 1994; Killeen, 1995; Killeen, 1997; Killeen & Amsel, 1987; Killeen, Hanson, & Osborne 1978; McSweeney, 1992; McSweeney, Roll, & Weatherly, 1994; McSweeney, Weatherly, Roll, Swindell, 1995; McSweeney, Weatherly, & Roll, 1995). The running responses for LL choice trials in this study follow the same pattern, despite their short duration.

Table 1

Average Measurements

ID	Weight	LL Choices	Mean LL Distance Run	Mean SS Distance Run	Mean Total Distance Run
RR01	277.20	21.60	151.58	12.21	163.78
RR02	298.80	21.80	140.95	24.53	165.48
RR04	278.20	22.00	318.16	38.44	356.59
RR05	271.60	20.80	228.21	43.70	271.92
RR06	303.20	16.60	230.01	57.30	287.31
RR07	289.20	18.00	138.22	10.35	148.57
RR08	267.2	16.60	345.75	41.37	387.13
RR09	266.4	18.80	259.96	31.35	291.31
RR10	301.6	18.20	253.64	64.49	318.12
RR11	292.4	19.00	215.24	40.92	256.16
RR12	258.4	20.80	280.51	43.63	324.14

Table 2

Pearson Product Choice Correlations (N = 11)

	<u>LL Choices</u>
<u>Total Distance Run</u>	-0.279 ($p = .46$)
<u>Mean LL Distance Run</u>	-0.234 ($p = .488$)
<u>Mean SS Distance Run</u>	-0.370 ($p = .263$)

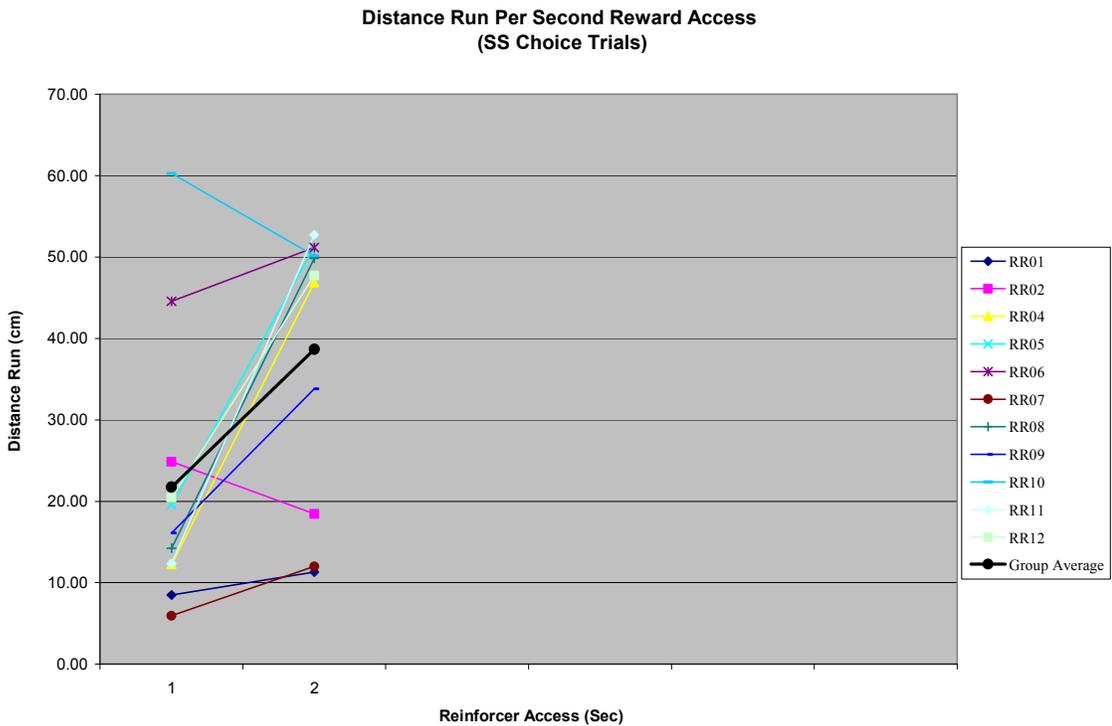
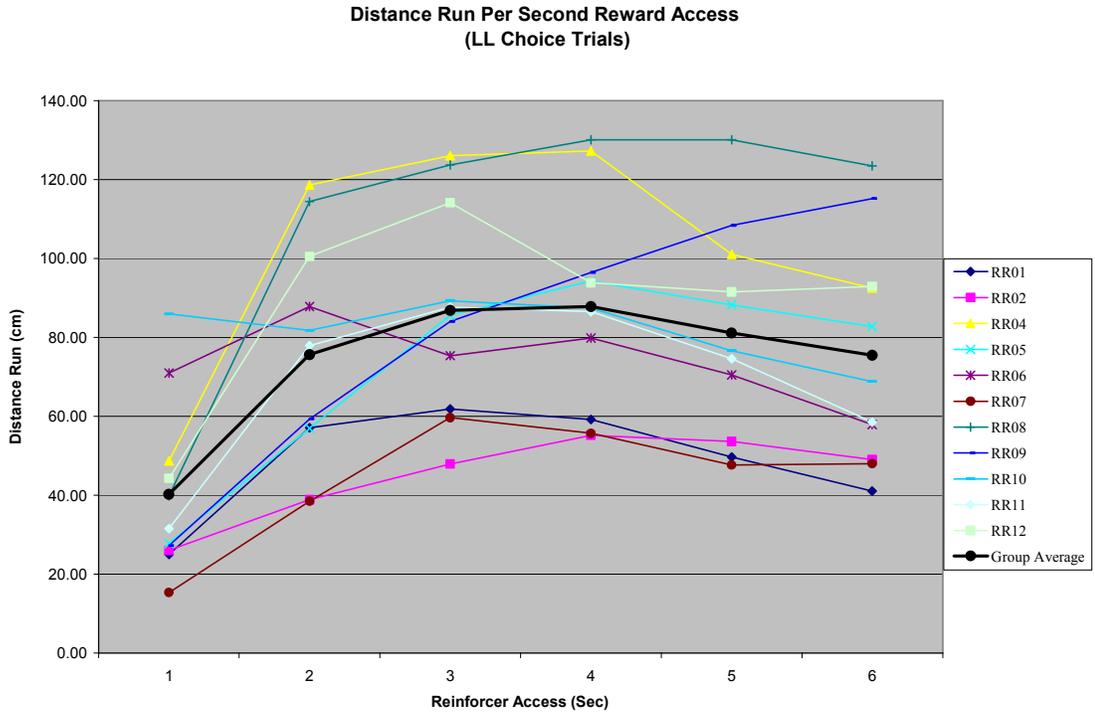
Table 3

Pearson Product Weight Correlations (N = 11)

	<u>Weights</u>
<u>LL Choices</u>	-0.235 ($p = .487$)
<u>Total Distance Run</u>	-0.371 ($p = .262$)
<u>Mean LL Distance Run</u>	-0.478 ($p = .137$)
<u>Mean SS Distance Run</u>	.198 ($p = .559$)

Figure 1

Distance Run Rate Pattern



Discussion

The results from the present experiment demonstrate that in addition to eliciting LL choice biases, running can serve as an adequate reinforcer to elicit motivation to respond in rats. While studies relying on rats as subjects have often used running as the primary dependent measure (see Aparicio & Baum, 1997; Belke, 1996; Belke & Dunlop, 1998; Belke, Pierce, & Duncan, 2006; Beneke, Schulte, Vander, & Jerry, 1995; Dixon, Ackert, & Eckel, 2003; Eikelboom & Lattanzio, 2003; Lattanzio & Eikelboom, 2003; Nakao & Sakata, 2006;), its use as the reinforcer is less common (see Belke, 1997; Belke & Heyman, 1994; Collier & Hirsch, 1971; Iversen, 1993, 1998; Kagan & Berkun, 1954; Mazur, 1975; Premack, 1962; Premack, Schaeffer, & Hundt, 1964; Tierney, Smith, & Gannon, 1983; Timberlake & Allison, 1974).

Using a running reinforcer allows for the comparison of various systems and subsystems described by Timberlake (1993) who argued that behaviors are governed by organized systems that allow the animal to adapt responding to dynamic aspects of the environment. The choice between the SS and LL options in laboratory situations, such as in the current experiment, potentially reflects species' specific biological system of responding in that given situation (Collier, 1981; Green & Estle, 2003). That is, the choice bias observed in the present experiment may be the result of both a specific evolutionary history and situational variables.

By classifying an animal's feeding behaviors into systems and subsystems, qualitatively different reinforcers can also be examined to better understand motivational states' influence on choice behaviors. Since the majority of reinforcers examined in self-control studies would be classified as belonging to the lattermost stages of acquisition

behavior, a running reinforcer represents an entirely different subsystem within the feeding paradigm. In the current study, this resulted in the subjects' responding for a 'general search mode reward' that yielded a LL choice preference when compared to rewards that represent the actual consummatory event. Sensitivity to environmental factors within the lab as influential of choice can be readily observed. Shifts in choice bias can be seen as the result of variability in delay to reinforcement (Chelonis, et al., 1994), increased effort requirements (Chelonis, Logue, Sheehy & Mao, 1998), reinforcer value (Grosch & Neuringer, 1981), precommitment (Ainslie, 1974; Rachlin & Green, 1972) and fading (Logue, 1981; Logue, et al., 1984; Mazur & Logue, 1978). With this in mind it behooves us to acknowledge the role of the laboratory environment with respect the animal's natural systems of behavior. Differences in responding due to qualitatively different reinforcers is addressed by the behavioral systems approach nicely.

Among humans, thought to be highly self-controlled over the age of 5 (Logue, Forzano, & Ackerman, 1996), a difference in LL choice bias was observed when the reward was food versus non-food reinforcers in adult females (Forzano & Logue, 1994). In this study, the subjects responded with a lesser LL choice bias for the food reward and a greater LL bias for a point-exchangeable reward. Consider the positions of a food reward on the continuum of feeding behavior. According to a behavior approach, it would lie much closer to a terminal place than a non-food reward lying much closer to an initial place. Thus, when considering food versus non-food rewards in the feeding behavior systems, greater impulsivity would be expected for the food reward. This response difference can also be seen in food versus money reinforcers (Hyten, Field, Madden, Greenspoon, & Mistr, 1991); again, such a difference in responding is expected

since a monetary reward (subsequently leading to the attainment of food) would lie in a much more initial place of the behavioral continuum. Among children, a disparity in responding for the same reward can be seen when visibility is a factor. For a visible versus non-visible food reward, children showed LL choice bias to a lesser degree when reinforcer was readily visible (Mischel & Ebbesen, 1970; Forzano, Szuba, & Figurilli, 2003). As with food versus a money scenario, a visible food reward would lie on the latter end of the feeding behavior spectrum, and its more immediate choice over a non-visible item would be expected.

In more traditional rat and pigeon studies, the difference in responding patterns for food versus water have been clearly shown (Hull, 1977; Jenkins & Moore, 1973; Peterson, Ackil, Frommer, & Hearst, 1972; Petry & Heyman, 1994). While these reinforcement types have satisfied a primary need in the animal, their respective different effects on responding can again be acknowledged by the behavior systems approach since the need for water appears to be more immediate and mandatory in a natural setting. With regard to self-control choice studies, the types of reinforcement used have also traditionally relied upon reinforcement that meet the organism's primary needs. In the aforementioned studies, food was the primary reinforcer being delivered upon the conclusion of a choice made. The use of a reinforcer meeting a biological need (such as water or food) is by far more common than not. In fact, few studies address choice behavior made for other types of reinforcement (short of drugs, which has been argued as more of a primary reinforcer). To date, no self-control choice study employing rats as subjects have attempted to examine choice bias in which the reinforcement was a non-

primary reinforcement. Thus, the use of a running reward in rats is unique and can be examined alongside other non-primary rewards across species.

Results from the current study support the hypothesis that when using a running reinforcer, a higher level of self-control can be seen in female Spague-dawley rats. By classifying behaviors using a systems approach, we can more fully consider motivation as effectively influencing choice. Through the implementation of differential reinforcements, each resembling different behaviors on the feeding continuum, potentially different motivational states can be examined in the lab. Regarding self control studies, this holds promise for research as to the capability of different levels of self-control depending on the reinforcement used.

The limitations of the current study are twofold. First, the majority of self-control choice research relies on male rats as subjects. The present study used female rats due to the literature which showed that females more readily respond to the opportunity to run than do males (Belke & Christie-Fougere, 2006; Iversen, 1993). While there is no evidence to suggest females demonstrate a significantly different choice bias compared to males a comparison study with males as subjects should be conducted. The present study attempts to address one of the differences between male and female rats by determining whether the weight predicts choice, but correlations showed that weight was not predictive of either choice or distance run. Second, subjects in the present study were not food deprived. It remains that the undeprived caloric state might have effectively influenced choice. This experiment replicated Iversen's 1993 study relying on initially higher-running opportunities during training that were then stepped down to elicit a state of run-deprivation in the animals. While this might yield motivation to respond similar to

that of initially ad-lib fed, then food-deprived animals, it does not rule out the role of unrestricted diet on performance in this group of animals.

Comparing these results to those of the former Szalda-Petree lab studies which relied upon deprived male rats and food reinforcers subsequently makes the current results less clear. This study should be replicated with both female and male rats in deprived and undeprived food states to more fully examine the effects of the running reinforcer on choice behavior. Since deprivation state can elicit differences in responding (Belke, 2004; Clark, 1958; Cotton, 1953; Mechner, 1962; Shull, 2004), the consideration of sated animals in this study must be examined alongside deprived animals to gauge the actual effect of running as a reward. Future studies should examine the use of a running reinforcer among food-deprived animals to assess any potential motivational state change due not to the reinforcement type, but to the deprivation level in the animal. With future study, the effects of diet as influencing choice-response could be ruled out. The use of both deprived and sated males would also reveal any differences due to gender, making these results more universally applicable to the area of choice when using rats as subjects.

These results hold promise for a relatively unused reinforcement in the field of choice. Since motivation to respond is necessary for any study, the examination of various motivational states on choice behaviors could greatly enrich and add to the literature. Incorporating type of reinforcement as a factor within the systems of feeding behavior, a more comprehensive analysis of the animal's evolutionary history can be considered alongside situational variables.

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