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Are Progressive Ratio and Fixed Interval Schedules of Reinforcement Related Measures of Impulsivity?

Christine Guiterrez
University of Texas-Pan American

ARE PROGRESSIVE RATIO AND FIXED INTERVAL SCHEDULES OF REINFORCEMENT RELATED MEASURES OF IMPULSIVITY?

A Thesis

by

CHRISTINE GUTIERREZ

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COMMITTEE MEMBERS

Frederick A. Ernst, Ph.D
Chair of Committee

Cheryl Fielding, Ph. D., B.C.B.A
Committee Member

Valerie N. Neeley, M.A., B.C.B.A
Committee Member

December 2011

ABSTRACT

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The area of impulsivity is widely studied among many different professional fields. However, given the broad brush that has been used to paint the construct of impulsivity, it's apparent that there is no true agreement on a definitive definition. In the present study, a purely behavioral procedure was tested with 10 female Sprague-Dawley rats who were placed on a progressive ratio and then a fixed interval 20 s schedule of reinforcement to see if these two schedules were related measures of impulsivity. The definition of impulsivity used in this study was relative to the performance of all animals in that those that responded sooner and the most were considered impulsive. It was hypothesized that that high rates of responding in a PR schedule of reinforcement would predict high rates of responding in an FI schedule of reinforcement. This hypothesis was not supported and possible explanations and limitations are discussed.

DEDICATION

I dedicate the completion of my master's thesis to my parents, Cris and Bea Gutierrez. They have sacrificed so much to provide me with all that I have and to encourage my further education. I will forever be grateful and appreciative for their never ending love and selflessness. The completion of my masters would not have been possible without their love and support.

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I acknowledge my friend and thesis partner, Mandy Sanchez. She kept me motivated and sane during the most stressful moments in the completion of this thesis and I will forever be grateful to the times we shared and the hard work we discovered we could accomplish together.

I would also like to thank my committee members: Dr. Cheryl Fielding and Valerie N. Neeley. Their guidance and wisdom were the elements I needed most from them as my committee members. I have the upmost respect and appreciation for these two women. I feel very privileged to have had them serve on my committee.

Special thanks to my roommate, Lucy Salinas, for helping me keep things in perspective and always being there for me as a friend and confidant. Knowing we were going through the same trials and tribulations connected us in a special way that I am grateful for.

Last, but not least, I would like to thank and acknowledge my boyfriend, Darryl G. Scott Jr., for his unconditional love and patience throughout this important time in my life and for always believing in me.

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CHAPTER I

INTRODUCTION

Impulsivity is a construct that has been researched in the literature under various disciplines. Clinically, it is recognized as playing a role in various disorders including ADHD, mania, substance abuse, and personality disorders (American Psychiatric Association [*DSM-IV-TR*], 2000). Human studies of impulsivity have heavily relied on self-report measures such as the Barratt Impulsivity Scale (Barratt, 1959) and the I-7 Impulsiveness Questionnaire (Eysenck & Eysenck, 1978). In addition, there have been several studies that have employed the delayed discounting procedure in humans as a measure of impulsivity (Hyten, Madden, & Field, 1994; Schweitzer & Sulzer-Azaroff, 1998; Bickel, Odum, & Madden, 1999; Richards, Zhang, Mitchell, & De Wit, 1999).

Behavioral psychology has utilized the use of animal experiments as models for understanding impulsivity in humans. Animal models have been used for the stronger manipulations that can be attempted than with human subjects (Ainslie, 1975). The most common animal models in the study of impulsivity include delay discounting (Madden, Smith, Brewer, Pinkston, & Johnson, 2008; Monterosso & Ainslie, 1999; Winstanley, Eagle, & Robbins, 2006; Perry, Larson, German, Madden, & Carroll (2005) and differential reinforcement for low rate responding (DRL) (Monterosso & Ainslie, 1999; Pizzo, Kirkpatrick, & Blundell, 2009).

The backbone of behavioral research has unequivocally been the schedules of reinforcement (Stafford & Branch, 1998). Since their first appearance in the well recognized and abundantly cited work of Ferster and Skinner (1957), *Schedules of Reinforcement*, these schedules have been examined in both experimental and applied behavioral literature. The two schedules used in the present study include the Progressive Ratio Schedule and the Fixed-Interval Schedule. In the literature, progressive ratio schedules have been primarily used as a measure of the strength of a reinforcer (Hodos, 1961; Hodos & Kalman, 1963; Roane, 2008; Penrod, Wallace & Dyer, 2008) while the fixed-interval schedule has been used to determine the rate of responding as a measure of temporal discrimination (Shull & Brownstein, 1970; Rider & D'Angelo, 1990; Gollub, 1964; Odum & Schaal, 2000).

Impulsivity

Human behavior is inarguably complex and controlled at any moment in time by multiple interacting factors. Impulsivity is one such human characteristic that has been studied by many different disciplines including economics, sociology, social psychology, and behavioral psychology with not one definitive conclusion of what defines "impulsivity" (Ainslie, 1975). Impulsivity is an interesting construct in that it can be seen as beneficial, as when we seize a valuable opportunity that may quickly pass us by, or as detrimental, as when we make a rash decision that is later regretted (Winstanley, Eagle, & Robbins, 2006). Given that we all act impulsively from time to time, impulsivity can be seen as an element of normal behavior. However, high levels of impulsiveness are associated with maladaptive behaviors such as self-injurious behaviors, substance abuse, and violence (Monterosso &Ainslie, 1999). In addition, impulsivity is a component of several diagnoses including Obsessive Compulsive Disorder, Attention Deficit/Hyperactivity Disorder, and the number of disorders under the classification of Impulse-Control disorders Not Otherwise Specified (American Psychiatric Association [*DSM-IV-TR*], 2000).

In human studies, impulsivity has been analyzed through self-report measures/questionnaires that include the Barratt Impulsivity Scale (BIS) and Eysenck Impulsiveness scales. Both of these widely used scales introduced multiple subtypes and these subtypes differ depending on the version of the scale used. For example, the BIS-10 proposes cognitive impulsiveness, motor impulsiveness, and non-planning impulsiveness, while the BIS-11 includes attentional impulsiveness along with the motor and cognitive subtypes from version 10 (Patton, Stanford, & Barratt, 1995). Version 5 of the Eysenck Impulsiveness scale (I-5) proposes narrow impulsivity, risk taking, liveliness, and non-planning (Eysenck & Eysenck, 1977), while version 7 (I-7) proposes just two subtypes: impulsiveness and venturesomeness (Eysenk & Eysenck, 1978). Furthermore, in a review by Evenden (1999), the importance of the concept of impulsivity is explored and the fact that little unanimity exists between the different fields who have studied the concept is brought to light with a table that lists a number of different definitions for impulsivity.

In addition to personality theories that attempt to measure impulsivity, a behavioral approach commonly used with human research in the area of impulsivity includes the Delayed Discounting Model. This model is heavily based on a temporal discounting notion of impulsivity (Monterosso & Ainslie, 1999). In this procedure, the subject chooses between two rewards: a larger later reward (LL) or a sooner smaller reward (SS). Impulsivity is associated with the subject's tendency to choose the more immediate alternative (i.e. SS) even though, in the long run, this means a decrease in the total amount of rewards received (Madden & Bickel, 2010).

It has, although, been argued that it is quite difficult to observe impulsiveness in a traditional laboratory experiment using adult humans (Logue, Peña-Correal, Rodriguez, & Kabela, 1986). An explanation for this could be that research with humans has shown that the selection of delayed rewards is also related to age and verbal repertoire (Schweitzer & Sulzer-Azaroff, 1988). That is to say that the older and more verbally equipped an individual is, the better able they are to assess the situation and choose the larger and more delayed reinforcer to maximize on the total number of rewards received. In another study by Flora & Pavlik (1994), subjects made choices to acquire points that would later be exchanged for money. Manipulations of the density of the reinforcer (money per points) caused a reversal in preference from the larger later reward to the sooner smaller reward. However, the authors explain that the self-control preference condition in this experiment always resulted in less points (i.e. money) so the impulsive choice actually was more rewarding in total. This type of manipulation in order to acquire an “impulsive” behavior is questionable as to whether it can even be called “impulsive” given that it does not meet the basic criteria of an impulsive choice which is a choice that results in receiving less reinforcement overall (Hyten, Madden, & Field, 1994).

Animal models, in contrast, have more experimental control for manipulation than is posible when humans are subjects of an experiment. Several animal models have been created in an attempt to, as closely as posible, re-create the disorders/behaviors that are of interest in the human population. Animal models of impulsivity have been created for this exact purpose. Several models have been developed as a way to measure the different variations of impulsivity with the most common models being the Delayed Discounting Model and the Differential Reinforcement of Low Rates of Responding (DRL) (Monterosso & Ainslie, 1999). During a review of the literature, however, the majority of articles utilize the delayed discounting procedure.

In the classic study by Ainslie (1974), ten Carneaux pigeons were used to study impulse control. The experiment included an experiment condition and three control conditions. Fifty trials, each lasting 19 seconds, were run each day. Each pigeon served as its own control and the birds went twice from the experimental condition to each control condition and back again for a total of 12 changes over a period of 23 months. The pigeons were given a small (immediate) food reinforcer for pecking a key and a larger (delayed) reinforcer for not pecking the same key. It was found that most of the pigeons pecked the key on more than 95% of the trials but, when a different colored key that was available for pecking earlier in the session was provided and prevented the birds access to the immediate reinforcement, three of the ten subjects consistently pecked it and consequently forced themselves to wait for the larger, delayed, reward. It's important to note that the pigeons did not peck the key when it did not prevent immediate reinforcement. This study is an experimental example of psychological impulse and a learnable device to control it. The authors state that while only a few of their subjects were able to learn *control*, "the fact that such learning is possible at all argues for a theory of delayed reward that can predict change of preference as a function of elapsing time" (p.485).

In another study by Madden, Smith, Brewer, Pinkston, and Johnson (2008), delayed discounting was used to assess impulsive choice in Lewis and Fischer 344 rats. The purpose of this study was to systematically replicate a previous study that found that Lewis rats make more impulsive choices in comparison to Fischer 344 rats. The procedure used in this study involved manipulating between conditions where the study being replicated used with-in session manipulation. The study specifically examined impulsive and self-control choices in Lewis and

Fischer 344 rats when delays were held constant within sessions and manipulated between conditions after a steady-state of choice responding had occured. Ten 100-trial pretraining sessions were conducted to establish responding with 3 levers. The experimental sessions lasted for 42 trials which were broken up into seven blocks of 6 trials where each block consisted of 4 forced-choice trials followed by 2 free-choice trials. Delays to a larger later reinforcer was manipulated betwen conditions after choice was assessed as consistent. It was found that the percentage of larger later choices decreased with increasing delays in the delievery of the reinforcer and that Lewis rats were more sensitive to this reinforcer delay (i.e. responded more impulsively). This finding is consistent with the results from the study that was replicated.

Progressive Ratio

The progressive ratio schedule (PR) is not one of the original four schedules of reinforcement introduced by Ferster and Skinner in 1957 but has proven to be an important schedule in behavioral research in both experimental and applied settings. Findley (1958) originally described the progressive ratio schedule as one in which a number of responses being required in order to receive reinforcement, and in addition, that ratio would be increased from one reinforcer delievery to the next. It's important to mention that the notion of how quickly the response requirements increase is termed *step size*. For example, a PR 6 or step size of 6 means that the first reinforcer would be delievered after 6 responses, the second after 12, the third after 18, and so on. The defining characteristics of the progressive ratio schedule, therefore, are (1) a number of responses are required for reinforcement and (2) this number systematically increases with every reinforcement delivery (Stafford & Branch, 1998).

In an article by Hodos (1961), the progressive ratio schedule is examined independently (Finely's 1958 study embedded PR schedules with-in a concurrent-schedule) as a measure of reward strength as a means to overcome the limitations and aversive effects of the dominant method which involved the use of electric shock. Hodos (1961) also discusses the *break point* in the progressive ratio which is an important feature of the schedule. The break point terminates the session and reveals the largest number of responses an animal will make in order to obtain the reinforcer. A previously established period of time without a response is known as the *break point criterion* and once this is met, the breaking point for the animal can be established. This, in essence, is exactly how the strength or power of the reinforcer is determined. Therefore, the higher the break point the more powerful the reinforcer.

Sclafani & Ackroff (2003) looked at reinforcement value of a liquid (sucrose) measured by progressive ratio operant licking in the rat which is a different approach from the highly used lever pressing tasks. This study intended to discover if progressive ratio licking shows the same sensitivity to variations in reinforcement value as does progressive ratio lever pressing. In this study, two experiments were conducted in order to measure the sweet taste reward when using a progressive ratio operant licking task with rats. Food deprived rats were used in experiment 1while nondeprived rats were used in experiment 2. Both were offered sucrose to drink on a progressive ratio lick or fixed ratio lick schedules for 30 minutes each day where the sucrose solution concentration was systematically increased. In both experiements, it was found that the fixed ratio rats increased but then decreased their sucrose solution intake as concentration increased from 1% to 32% or 64%. The progressive ratio rats, in contrast, showed an almost linear relationship. This means that the more concentrated the solution was with sucrose the more licks the rats made. This study indicates that the progressive ratio operant licking is just as effective as the operant lever pressing procedure in measuring the reward value of sucrose solutions and possibly other liquid solutions in rats. An important advantage to this approach is that since licking is already a natural response for the rat, no to minimal training is required.

Today, the progressive ratio schedule is still used as the dominant procedure for determining reward strength for food substances, such as sweetened milk in rats (Hodos & Kalman, 1963) or commonly abused drugs, such as cocaine (Richardson & Roberts, 1996). In an article by Baron & Derenne (2000), they mention that progressive ratio schedules have recently been used to study motivational processes. The nature of the progressive ratio to escalate response ratios until the animal no longer responds apparently reflects the maximum effort that the animal will produce in order to receive a reinforcer (Richardson & Roberts, 1996). A recent article by Wonjnicki, Babbs, & Corwin (2010), eloquently summarized the progressive ratio schedule by stating "PR performance serves as a measurement of 'how hard the animal is willing to work' or 'how motivated the animal is'' (p. 316). This was the intent with which the progressive ratio schedule was used in the present study.

Fixed-Interval

In a fixed-interval schedule of reinforcement (FI), the first response after a fixed, predictable interval of time is followed by a reinforcing stimulus (Ferster & Skinner, p. 133). It's important to note that responses that occur before the time has passed have no effect upon the occurrence of reinforcement. One of the key, and unique, features of this schedule of reinforcement is the production of a scalloping effect (see Figure 1). This effect emerges as the organism produces an accelerated amount of responses as the *time* of reinforcement approaches and after reinforcement is received, what is known as a *post-reinforcement pause* will be observed. An everyday example of this can be observed by the behavior of most college students during a semester. Over the course of a semester, most students make relatively few visits to their library for the purposes of studying. However, there is a notable increase in the rate in the number of students' visits to the university library as the time of final examinations approaches in order to obtain the favorable outcome of a passing grade for the semester.

An important feature of the fixed interval schedule is that responses made prior to the time specification are irrelevant and have no effect on the delievery of reinforcement. That is, there is no favorable consequence for responding before the time interval but rather, these responses are inefficient in acquiring reinforcement. However, they may not be meaningless. Ferster and Skinner (1957) attributed discriminative stimulus properities to the number of responses emitted in an interval because that number (or a number close to it) may have been associated with reinforcement and, consequently, that number has taken on reinforcing properties.

In a study by Cole (2001), ten rats were exposed to lever press training using a *continuous reinforcement* schedule up to 50 responses. In a continuous reinforcement schedule, every correct response is followed by reinforcement. This schedule is commonly used as a method for teaching a new behavior to an organism. In this study, continuous reinforcement was used to teach rats to press a lever in order to obtain food. Following this procedure, pairs of rats were randomly assigned to one of the following five conditions: one pair of rats were exposed to an FI 30 s from the outset, two pairs were exposed to either DRL 20 s or FR 20 s prior to exposure to the FI 30 s, and two more pairs were exposed to both DRL 20 s and FR 20 (not in the same order) prior to exposure to the FI 30 s (p. 45). The purpose was to examine the long-term effect of high and low rates of responding histories on fixed interval responding. Results showed that fixed interval response rates were initially affected by the immediately preceding schedule but traces of these effects disappeared after 80 to 100 sessions.

The literature illustrates that the most common approach to studying impulsivity is the use of the delayed discounting model while the schedules of reinforcement have been applied in research to study a variety of different constructs and relationships. The intent of the present study was to use the schedules of reinforcement in their purest form to analyze the possibility of a relationship that would yield a measurement of impulsivity.

Purpose of Present Study

The purpose of the present study was to examine if the progressive ratio schedule and the fixed interval schedule were related measures of impulsivity in an animal model. The important element in this study was the notion that efficient responses on both schedules would be adversely affected by impulsive responding. The definition of impulsivity, as used in this study, was not specific to a set number of responses for progressive ratio or a set time for fixed interval but rather, a relative definition was elected as the best indicator of impulsiveness. This relative definition means that all ten rats were compared against each other to form a continuum of "least impulsive to most impulsive" based on how the rats responded in each given schedule. For progressive ratio, rats that responded more often than necessary to require reinforcement were noted as impulsive since their additional responses were not efficient in gaining reinforcement while rats who responded more frequently on the fixed interval schedule were characterized as impulsive since more frequent responses were wasted energy. The overall objective for this study was the notion that excessive responding in the progressive ratio schedule might correlate with level of responding in the fixed interval schedule as a measure of impulsivity. Specifically, it was hypothesized that high rates of responding in a progressive ratio schedule of reinforcement would predict high rates of responding in a fixed interval schedule of reinforcement.

CHAPTER II

METHODOLOGY

Subjects

Ten female Sprague-Dawley rats were purchased from Charles River Laboratories. One animal was removed from the study due to an error in the computer program running the schedules of reinforcement. Specifically, on Day 3 of the FI20 schedule the program was affected by a power surge that elicited a precipitous change in the schedule causing a return to the FR1 default schedule. Therefore, nine animals completed the study. Animals were housed in the Behavioral Neuroscience Laboratory, room 116, at the University of Texas - Pan American campus. Testing was carried out at constant room temperature (22±1°C) and at a 12:12 light-dark cycle (light on at 08:00 hrs). Animals were housed in standard polypropylene rat cages (10.5” x 19” x 8”). Subjects were placed on a 23-hour food deprivation schedule and given one hour access to food during the experiment sessions. The feeding schedule was arranged in this manner in order to use food as the primary reinforcer and to ensure the subjects would be highly motivated to work while deionized water was available ad libitum. Experimental procedures were performed following The University of Texas-Pan American’s Institutional Animal Care and Use Committee (IACUC) approval.

Apparatus

Five operant conditioning chambers (Med. Associates, Inc., St. Albans, VT) with interiors measuring 25 cm x 30 cm x 30 cm were situated in ventilated, noise-attenuated boxes with hinged front doors for access to the chambers. Noise attenuation was provided by a small fan situated in the rear wall of the outside box in which the chamber was located. Ambient chamber lighting was provided by a light in the back wall of the chamber. The chambers each had two operant levers for bar-press training. The right-side operant level was activated for shaping and all training in both schedules of reinforcement described below. A light above the lever was on at all times during training. A pellet dispenser at the center floor of the front wall delivered 45 mg. pellets (BioServe, Inc., Newark, N.J.) one at a time for each depression of the activated lever.

Design and Procedures

Subjects were trained under the Progressive Ratio schedule for one day during a four hour session. The Fixed Interval 20 schedule ran for 14 consecutive days with each training session lasting two hours. After the completion of data collection, ten hours were dedicated to converting the FI 20 cumulative graph into pdf files of the first 50 reinforced responses for each of the 14 days. It took an average of 5 pdfs to capture the 50^{th} reinforced response for each day. This was done for each of the 14 days across 10 subjects which yielded a total of 700 pdf files that needed to be measured. Once all pdf files were saved, the next step involved measuring the distance of length between each reinforced response and the following response (whether it was reinforced or not). Measuring was done on the computer using the Acrobat version 9's measuring tool by inches. Inches were later converted into seconds for data analysis and interpretation. It required approximately 40-hours to measure a total of 7000 individual responses by the primary author and an assistant. It's important to note that during this preparation of the data it was not discovered until very late in the process that there was missing data for subject #5. After careful investigation it was discovered that an error in the computer program caused a return to the FR1 default schedule rather than another trial of FI 20 training (this error is described under "Subjects"). It was for this reason that subject #5 was removed from the study for further analysis.

Statistical Analysis

Statistical analyses were performed using Statistica software (Statsoft, Inc., Tulsa, OK). Latencies across days were analyzed using an ANOVA with alpha at 0.05. A Pearsons product-moment correlational statistic was used to analyze the relationship between the total number of responses in the single session of progressive ratio schedule of reinforcement and total responses during the acquisition of the first fifty reinforcers during each of the fourteen sessions of fixed interval (20-sec).

CHAPTER III

RESULTS

Total responses during the progressive ratio schedule of reinforcement and the total responses during the acquisition of the first fifty reinforcers across 14 days of fixed interval (20-sec) schedule of reinforcement are presented in Table 1 for each of the nine subjects included in this study. As can be seen from this Table, there was a great deal of variability in total responses between subjects in both schedules of reinforcement. Mean total responses for the nine subjects across the 14-days of fixed interval 20 training are illustrated in Figure 2. Mean latencies of the first response following reinforcement during the fixed interval schedule of reinforcement are presented in Table 2 for all of the nine animals. Mean latencies for the group of animals was analyzed across the 14 days of training using a repeated measures ANOVA. A statistically significant repeated measures F-Ratio revealed that latencies increased across time as expected ($F = 2.71$, $df = 0, 0$, $p < 0.05$). Figure 2 illustrates the change in mean latencies for the nine animals across the 14 days of training. As can be seen in Figure 2, the shift in latencies occurs rapidly, i.e., during the first three days of training and then appears to flatten.

Total number of responses in the progressive ratio schedule of reinforcement were used to predict total number of responses during each of the 14 days of fixed interval 20 training. Fourteen Pearson product-moment correlation coefficients were employed to assess the association of total responses in the one session of progressive ratio training with each of the 14 sessions of fixed interval 20 training. The results are presented in Table 1. As can be seen from this Table, none of the correlation coefficients yielded statistical significance. However, positive coefficients were found in the first six sessions of training and negative coefficients were found in the last eight sessions of training. Figure 3 illustrates this shift in the direction of the association from early to late training.

Figure 4 reveals the consistency of differences in total responses to achieve the same number of reinforcements (in this case, approximately 50 reinforcers). As can be seen in this figure, subject 3 reveals relatively fewer responses to achieve 50 reinforcers than subject 7 in early (session #4) and late (session #14) training.

Table 1. Total responses during a single session of Progressive Ratio (PR) and fourteen sessions of Fixed Interval 20 (FI20).

		FI20													
Subject #	PR	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	137	430	319	354	357	263	368	340	787	437	478	548	486	461	553
2	1999	333	340	401	314	330	379	417	464	526	601	561	610	472	624
3	988	157	152	127	115	132	166	155	169	164	134	143	153	166	117
4	1011	229	257	325	237	248	251	257	255	296	351	279	309	246	379
6	97	339	210	230	202	203	194	234	305	256	236	305	230	306	235
7	4321	425	290	275	293	258	268	181	282	240	227	240	222	186	208
8	1035	226	186	181	233	310	334	306	280	178	246	223	198	210	206
9	2221	268	213	194	197	155	251	238	238	123	227	152	72	152	195
10	1541	308	268	311	205	228	272	293	307	244	216	156	234	295	247

Table 2. Mean latencies for the first responses following the first 50 reinforcements in 14 sessions of Fixed Interval (20-sec) schedule of reinforcement in the fixed interval (20-sec) Schedule of reinforcement.

Subject #	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	.27	.36	. 44	.48	.48	.48	.48	.51	.43	.49	.51	.52	.48	.50
2	.34	.37	.41	.50	.60	.52	.51	.46	.42	.47	.41	.33	.48	.36
3	.62	.75	.76	.80	.77	.72	.79	.80	.69	.73	.73	.79	.70	.76
4	.52	.56	.44	.61	.60	.51	.59	.74	.50	.98	.54	.53	.60	.43
6	.48	.65	.64	.59	.10	.60	.64	.52	.57	.56	.49	.66	.56	.55
7	.36	.54	.57	.54	.51	.61	.78	.63	.62	.66	.62	.67	.72	.67
8	.48	.63	.65	.53	.49	.41	.47	.56	.71	.61	.68	.66	.68	.67
9	.55	.67	.74	.69	.73	.66	.67	.70	.84	.66	.78	.00	.79	.74
10	.43	.46	.54	.60	.61	.53	.57	.51	.55	.61	.67	.64	.48	.54

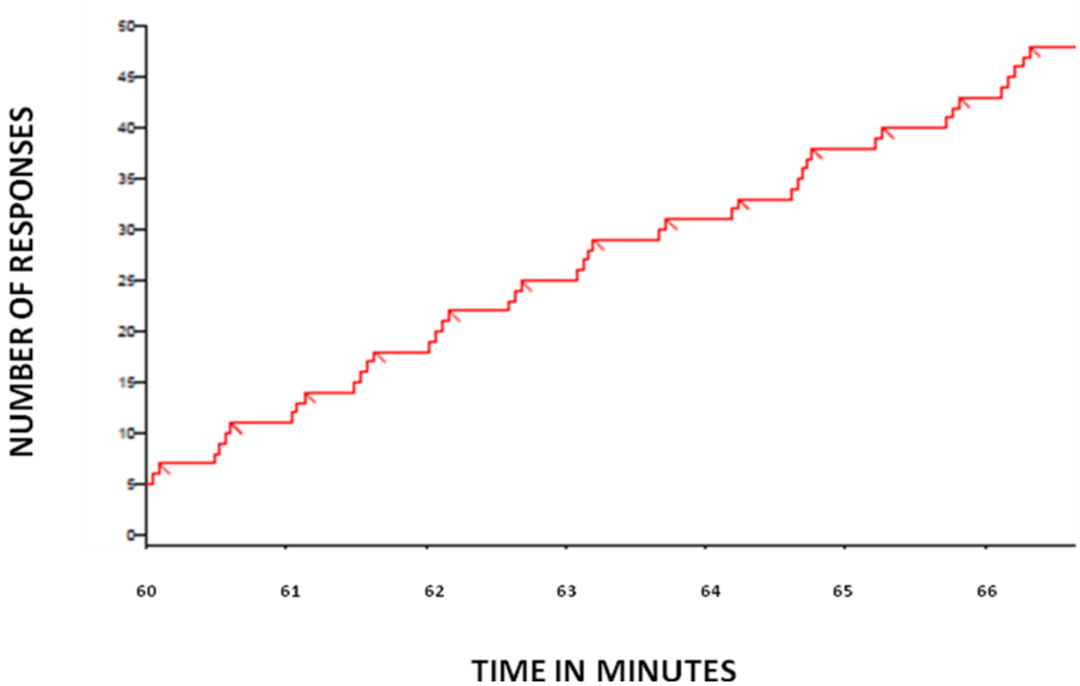

Figure 1. Cumulative response recordings of a Fixed Interval 30 second schedule of reinforcement. The tic marks indicates the time a reward (a pellet of food) was administered.

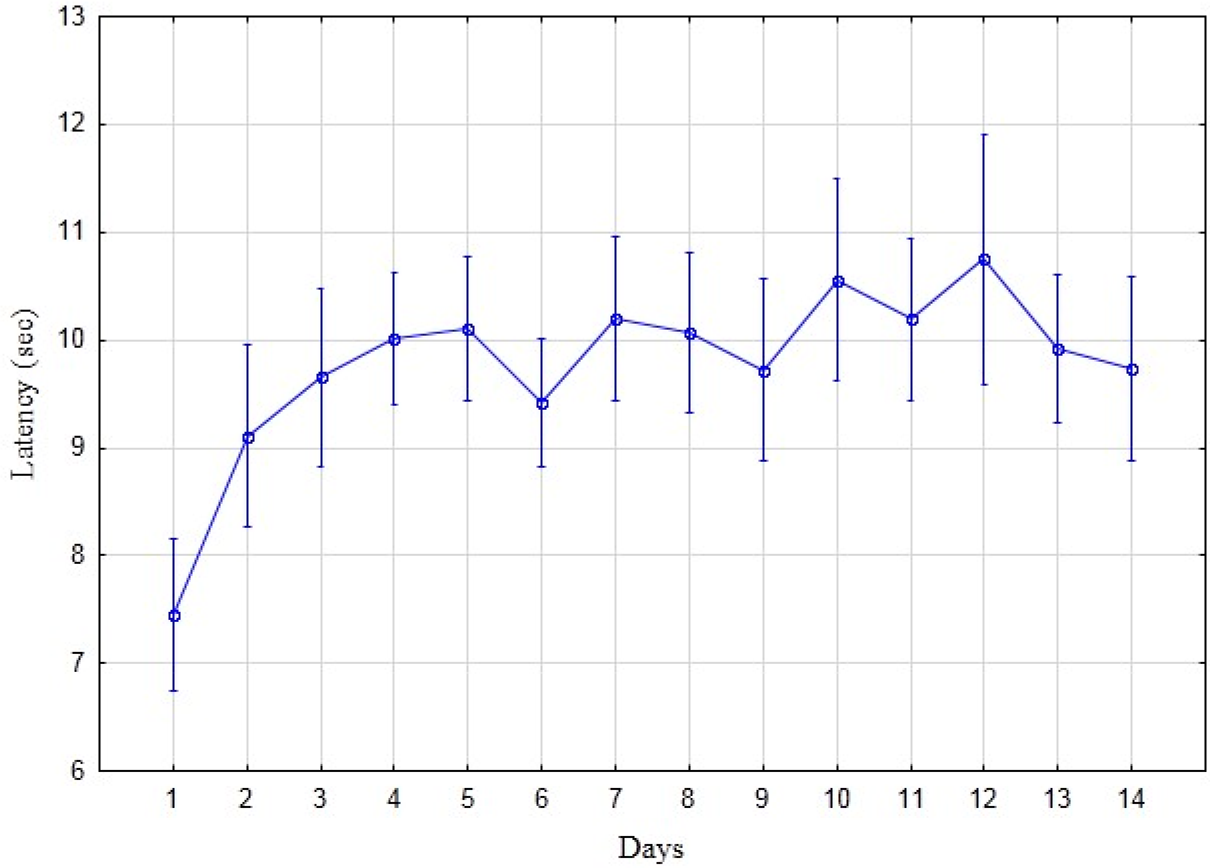

Figure 2. Mean response latencies following receipt of the first fifty reinforcements across 14 days of training on Fixed Interval (20-sec) schedule of reinforcement.

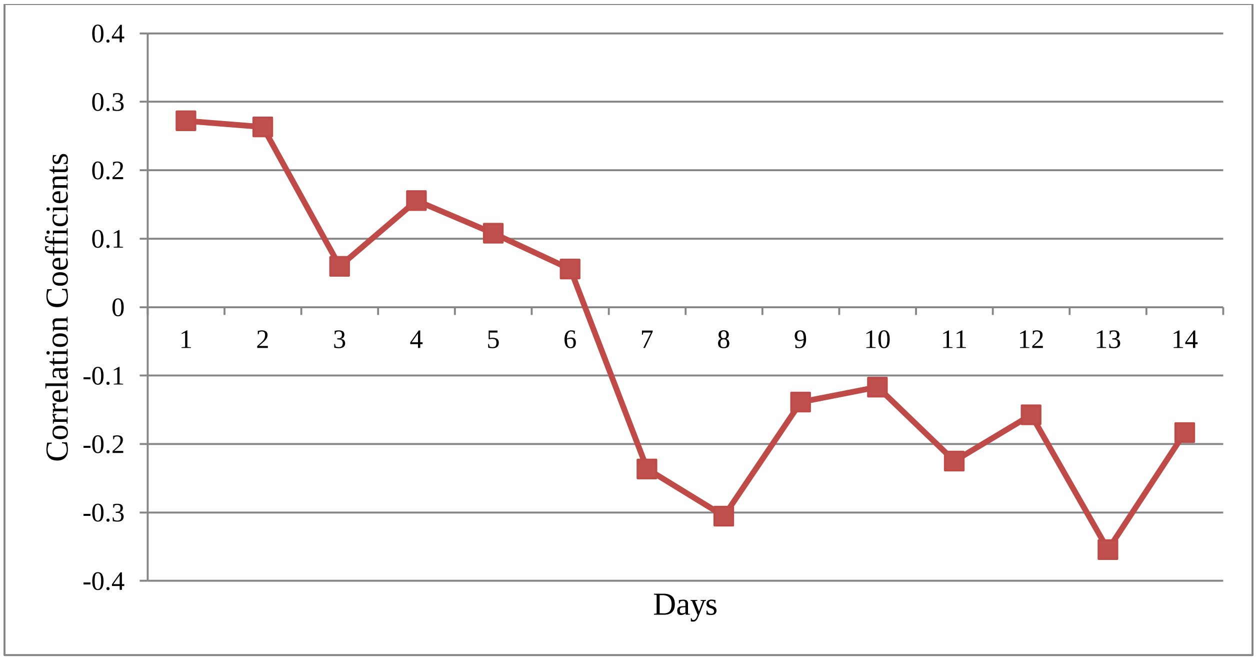

Figure 3. Correlations of total responses of one 4-hour Progressive Ratio schedule of reinforcement with total responses to achieve 50 reinforcements in 14 sessions of Fixed Interval (20-sec) schedule of reinforcement, illustrating a shift in the direction of the association from early to late training.

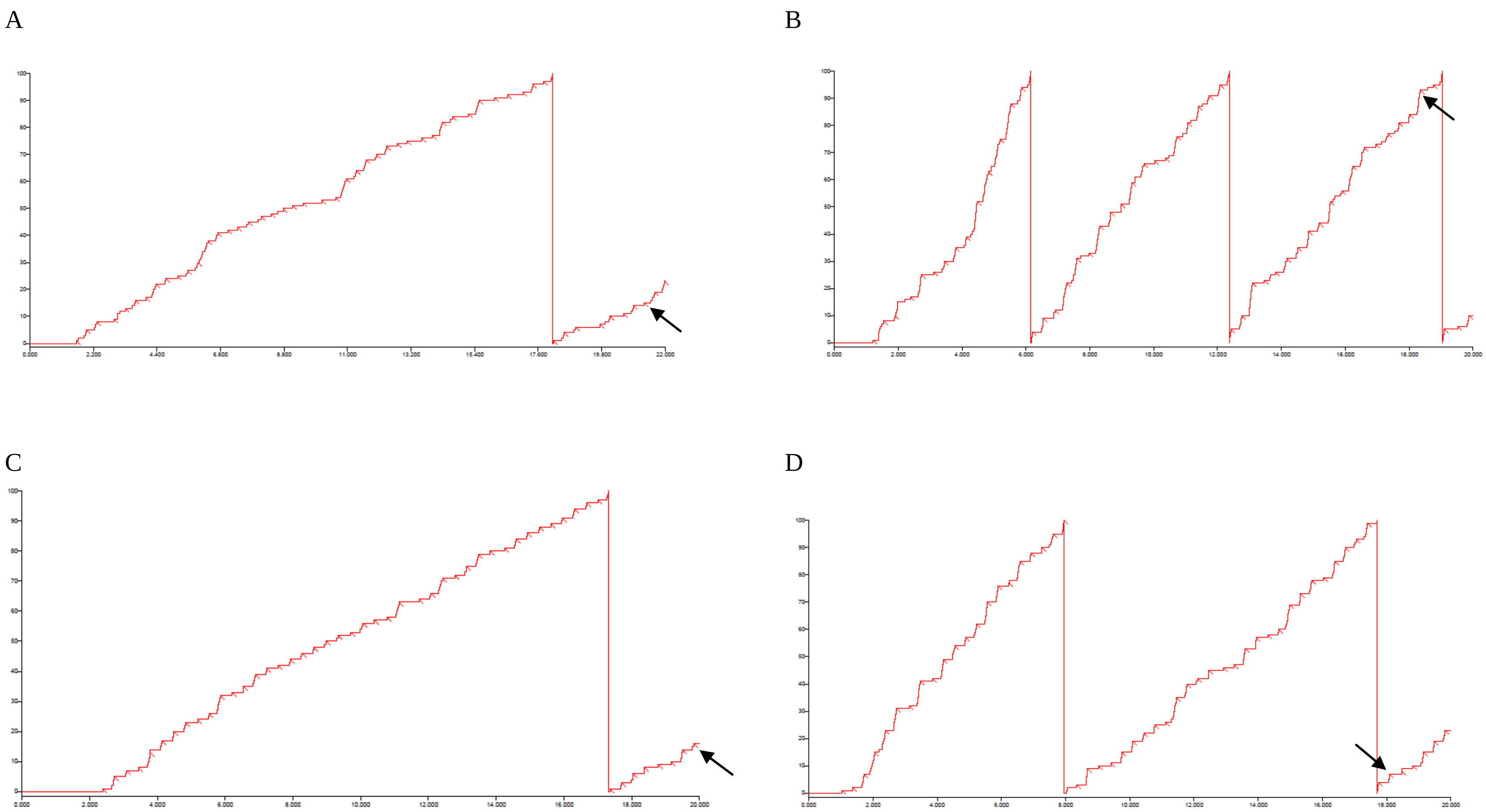

Figure 4. Four cumulative graphs of the fixed interval 20 s schedule have been arranged side by side to show difference in responding strategy in order to contrast these two subjects in early and late training A: Subject 3 in early training session #4 (115 responses yielding 50 reinforcers). B: Subject 7 in early training session #4 (289 responses yielding 50 reinforcers). C: Subject 3 in late training session #14 (114 responses yielding 50 reinforcers). D: Subject 7 in late training session #14 (204 responses yielding 50 reinforcers). Arrows indicate the point in the cumulative responses at which the 50th reinforcement was achieved.

CHAPTER IV

DISCUSSION

It is reasonable to expect that strategies in acquiring reinforcement are similar in different schedules of reinforcement. With progressive ratio schedules, one strategy is to emit a high rate of responding throughout the progressive ratio session to maximize the acquisition of reinforcement. This is not necessarily the most expedient strategy but it will produce a maximum number of reinforcers per session. Ideally, the animal would emit only the number of responses that are necessary to acquire maximal reinforcement but the complexity of this solution probably prevents this from happening in one single lengthy session. To the extent that an animal might respond more expediently, this pattern of behavior can be said to reveal good control. Conversely, an animal that simply emits very high rates of behavior achieves the same effect but with less apparent control. It is this aspect of behavior that was hypothesized to reveal impulsivity.

The same demands are made on an animal in a fixed interval schedule. Expedient responding would produce maximal reinforcement but very high rates of behavior will as well. Unlike progressive ratio schedules where the schedule of reinforcement is begun and completed in one session, fixed interval schedules are typically administered over several sessions of training. With multiple sessions of training, the complexity of mastering expediency in achieving maximal reinforcement is more probable. Moreover, animals who reveal a delayed emergence of scalloping in fixed interval schedules can be said to be revealing too many and too early responses. As with the progressive ratio schedule, I proposed that this high rate of response strategy reveals impulsivity, i.e., less control.

With this in mind, it was reasonable to hypothesize that strategies in each of these schedules of reinforcement should be similar and therefore correlated. The primary hypothesis of this thesis, therefore, was that high rates of responding in a progressive ratio schedule of reinforcement would predict high rates of responding in a fixed interval schedule of reinforcement. In order to test this hypothesis, ten subjects were run in both schedules of reinforcement so that correlation coefficients could be used to analyze the similarity of strategies during each schedule of reinforcement for the ten animals as a group. While the correlation coefficient did not yield a statistically significant finding, there was clearly an emerging trend in the data. One posible interpretation of these data is that early in training the predicitive variable of number of responses emitted in the progressive ratio schedule of reinforcement predicts a higher number of responses being emitted in the fixed interval schedule. However, later in training a higher number of responses in the progressive ratio schedule predicts a lower number of responses being emitted in the fixed interval schedule. Judging from the changing correlation that is shown in Figure 2, it may suggest that the animals that wasted responses in the progressive ratio do the same in the first half of the training in the fixed interval but those animals who responded at high rates in the progressive ratio schedule are also the same rats that during the second half of the fixed interval training are changing their strategy of high responding and now responding less to be more efficient. In other words, high responding in the progressive ratio schedule did not predict as a strategy a lot of responding in the fixed interval schedule. This possible finding further weakens any support for the original hypothesis of the study and although the finding was not statistically significant, the correlation undeniably changes from consistently positive to consistently negative at almost the exact midpoint of training. More training sessions most likely would have given better insight into the meaning of these data especially in later phases of training.

Limitations and Future Research

Limitations for this study included the number of subjects and the number of days of training for each schedule. Ideally, a much larger N would have been preferred but the budget available for purchasing subjects was unable to allow for this. In addition, keeping the rats on the progressive ratio and fixed interval schedules for longer then what was done in this study (1 day and 14 days respectively) would have been preferable for a better comprehensive study of the relationship of impulsivity between these two schedules. More training sessions would possibly have allowed enough time for the positive to negative trend observed to emerge fully and it's very possible the direction of the trend would have continued to stay negative and would have showed statistical significance and further analyses could have been explored. However, in terms of time and money this was a far stretch. In many studies that utilize the schedules of reinforcement, training can take place anywhere from 3 to 24 months but this was not feasible for the completion of this thesis.

Another major limitation for this study was the selected length of the time interval for the fixed interval schedule. Twenty seconds was selected based on the literature that used 20 and 30 second intervals but, there was a failure to appreciate the length of trainings that were used in these studies. Many studies (Shull, 1970; Shull, 1971; Cole, 2001; Williams & Royalty, 1990; LeFrancois, Chase, & Joyce, 1988; Baron, Kaufman, & Stauber, 1969) used fixed interval 30 seconds with extensive training. This was reduced to fixed interval 20 in this study in hopes that it would reduce the time it would take to see an effect. If this study should be repeated, the fixed interval length should be shortened so that the fixed interval effect will emerge sooner and more pronounced. However, it wasn't until after analysis of the data that it became evident that a shorter interval would have been more practical due to the rats being able to successfully wait an average of 10 seconds (see Figure 3). It's possible that a shorter interval might have been able to capture a relationship between the progressive ratio and fixed interval schedules in regards to impulsivity and helped to better explain the workings of this relationship.

Future research in this area should have a larger number of subjects and especially have more training sessions. Many of the studies found in the literature have 50 or more training sessions. However, for the purposes of this thesis, the year or more it would have taken to have 50 or more training sessions was not feasible and the best outcome was riding on the fourteen available days for training.

In the present study, the emerging trend between the progressive ratio and fixed interval schedules of reinforcement may indicate a possible relationship that could be an indicator of impulsivity. Future research that addresses the limitations the present study was faced with could help to determine if the simple schedules used in their purest form could be a new behavioral approach to studying the construct of impulsivity.

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BIOGRAPHICAL SKETCH

Christine Gutierrez graduated from McAllen High School in the McAllen School District with academic recognition in the year 2004. From 2004-2008 she attended the University of Texas-Pan American where she graduated from the Honors Program, Magnum Cum Laude and received a Bachelor of Arts in Psychology and Sociology. While completing her undergraduate degree, she served as President, Vice President and Secretary over two years for the National Honor Society in Psychology (Psi Chi). During her undergraduate years at UTPA, Christine was also nominated for the Excellence Award for the Social and Behavioral Science College (2004-2005) and awarded the UTPA Honors Program grant for undergraduate research (2006). Christine gained research experience in the areas of romantic relationships, body image and homosexuality and presented her research at numerous conferences locally, regionally, and nationally. Christine's research has won her both local and regional awards. In addition, Christine received the UTPA International Study Abroad Scholarship (2008). In the fall of 2009, she pursued her master's degree in Experimental Psychology, with a concentration in Applied Behavior Analysis at UTPA.

Christine currently lives in San Antonio, TX where she is working for a Pediatric Rehabilitative and Behavioral Services clinic where she provides applied behavioral services to children with Autism. All correspondence should be directed to her parents' residence at 1301 W. Heron Ct., McAllen, TX 78504.