

## 1. Effects of Increased Serotonin on A $\beta$ production in BACE-1 KO Alzheimer's Disease Model Mice

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Alzheimer's disease (AD), a progressive neurodegenerative disorder, is characterized by neuronal death as well as the accumulation of amyloid beta plaque (A $\beta$ ) and microtubule tau tangles. This disease has behavioral symptoms such as extreme cognitive decline, an inability to create new memories, mood swings, depression, and hallucinations. There is evidence that serotonin may be linked to AD through the cleavage process of the amyloid precursor protein (APP). APP can be cleaved by two enzymes,  $\beta$ - or  $\alpha$ -secretase, with cleavage by  $\beta$ -secretase creating A $\beta$  and cleavage by  $\alpha$ -secretase creating neuroprotective fragments. Serotonin is thought to activate a tyrosine kinase cascade, which then activates  $\alpha$ -secretase. In this study, BACE1 AD Model Mice were split into three groups. The two treatment groups received 10 mg/kg/day, via drinking water, of either fluoxetine- a selective serotonin reuptake inhibitor- or 5-hydroxytryptophan. The mice in the control group received tap water, exclusively. The mice were evaluated on the Morris water maze and the radial arm maze for 11 and 8 weeks, respectively. A histology protocol was then used to determine if there were any visible differences in neuronal death and A $\beta$  plaque accumulation between groups. No substantial changes were observed for the Morris water maze or the radial arm maze. The data did indicate, however, that there were trends that suggested the treatment groups were continuing to learn, while the control group showed no such pattern. Silver staining demonstrated that while there appeared to be differences in the number of degenerative neurons, A $\beta$  plaque aggregates were inconsistent and difficult to quantify. This experiment suggests that serotonin is involved in the pathology of Alzheimer's disease.

## 2. Delay Discounting of Token Rewards with Pigeons

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Delay discounting is the process by which a reward loses value due to the time until its receipt. Results from several studies indicate that this process is widely present among a lot of species (i. e. humans, rats, pigeons, etc.) but with differences such as a steeper devaluation of a reward with nonhuman subjects and the magnitude effect that is only observed in humans (steeper discounting of smaller magnitudes and less discounting of bigger magnitudes). Nevertheless, the procedures with humans and nonhumans subjects have methodological differences that may account for the differences in the results. In such cases, token systems may be a useful tool to make the procedures more similar. The objective of the present study was to evaluate delay discounting in pigeons using exchangeable food-tokens as reward. Pigeons were exposed to an adjustable magnitude procedure with two alternatives. One

alternative delivered five delayed tokens and the other delivered an immediate adjustable number of tokens. After a reward was delivered, each token were exchanged for 1.5 seconds of food access. Delay discounting functions were established for each pigeon across a range of five delays (0s, 1s, 2s, 4s, and 8s). The results show that pigeons discount token rewards as function of the delay of its receipt and the value of the token decreases rapidly at shorter delays and more gradually at longer delays. Also this pattern of results is relatively consistent among the subjects. Methodological issues are discussed as a function of the results obtained.

### **3. Effects of High Effort Training on Effort-Based Impulsive Choice**

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Because impulsive decision-making is correlated with many maladaptive tendencies, researchers have increasingly studied methods for reducing impulsive choice; i.e., increasing choices of larger, more-delayed rewards. A second type of impulsive choice involves selecting a smaller, less-effortful reward over a larger, more-effortful one. Little nonhuman research has examined experimental methods for reducing effort-based impulsive choice. Within the realm of delay-based impulsive choice, extended exposure to reinforcer delays has proven effective in reducing impulsive choices in rats. The current research takes a similar tack by evaluating whether reductions in effort-based impulsivity can be achieved by providing rats with extended exposure to a reinforcement contingency requiring a large number of responses (i.e. exposure to “high effort”). Male rats were randomly assigned to one of two groups: 1) high-effort training (fixed-ratio 50) or 2) low-effort training (fixed-ratio 1). Following 120 sessions of training, both groups completed three tests of impulsive choice in the following order: effort-based, delay-based, effort-based. The primary aim of this experiment was to evaluate if high-effort training produces short- and longer-term increases in preference for larger, more-effortful rewards. A secondary goal was to assess whether high-effort training increases preference for larger, more-delayed rewards. Preliminary findings will be presented; however, data collection is ongoing.

### **4. Be(e) Positive! Probing *Melipona Quadrifasciata* for Select and Reject Controlling Relations after Simple Discrimination Learning**

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In simple and conditional discriminations, responding may be controlled primarily by the positive stimulus (select-control relation) or by the negative stimulus (reject-control relation). We trained *Melipona quadrifasciata* on a simple discrimination task (S+ vs. S-; e.g., blue vs. yellow) and then tested for stimulus control with two types of probe trials, S+ vs. Snovel (Select-control probes) and S- vs. Snovel (Reject-control probes). On Select probes, the bees always preferred S+ to Snovel. On Reject probes, results were mixed. Depending on the colors used in training and testing, bees responded to both S- and Snovel, and even preferred S- to Snovel. The data suggest no control by the negative function of the S- and support the Select-stimulus control hypothesis of responding.

## **5. Interrelations Between Co-substance Use and Temporal Discounting in Undergraduate Students: Implications for the Reinforcer Pathologies Model of Addiction**

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While recreational cannabis use is becoming increasingly prevalent in the United States it has received relatively little attention within behavioral economics. Toward this end, an examination of the behavioral risk factors is timely. The reinforcer pathologies model of addiction proposes that behavioral addictions are largely a function of two behavioral economic constructs: operant demand and delay discounting. These constructs manifest as behavioral markers of addiction in the form of excessive demand for a reinforcer and strong preference for immediate access and consumption of this reinforcer in spite of suboptimal long-term outcomes. The first aim of the present investigation was to identify the degree to which discounting (money and alcohol) and demand for hypothetical alcohol differ between drinkers who don't use cannabis and co-users (i.e., individuals who use both) in a college sample. As our second aim we examined the relation between discounting (money, alcohol, and cannabis) in co-users as well as demand for hypothetical alcohol and cannabis. Regression analyses suggest co-users have significantly higher demand for alcohol, demonstrate steeper delay discounting of alcoholic drinks, and are at greater risk for alcohol use disorder than individuals who drink yet don't use cannabis. Within the co-using group, cannabis Omax (peak expenditure) was positively associated with alcohol Intensity (drinks consumed when priced at \$0.00) as well as alcohol Omax. Moreover, steeper monetary discounting ( $\ln k$ ) and greater alcohol Intensity were associated with greater cannabis Intensity. These results integrate well within the reinforcer pathologies model of addiction and add to literature on co-substance use in the college population.

## **6. Evaluation of Local Behavior Dependence in Continuous and Discontinuous Environments**

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The research presents data on the local moment-to-moment changes in behavior across three interreinforcement interval (IRI) distributions of a variable interval (VI) schedule. The IRI distributions vary from a Fleshler-Hoffman (typically featureless responding) to a narrow rectangular distribution (typically FI-like break-and-run responding). The obtained behavior in continuous environments is assessed and the patterns produced by each reinforcer distribution is noted in IRT by IRI dot plots. These patterns are compared to the obtained patterns under the same VI schedule distributions during a discontinuous exposure procedure (mixed VI extinction) to assess whether brief exposure to the contingencies is enough to control responding. Finally, behavior during the extinction component between the VI exposure periods in the discontinuous procedure was analyzed to determine the schedule control produced by each distribution following the offset of reinforcement availability and preceding reinforcer availability.

## 7. Do Pigeons Book Ahead for Lunch?

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Five pigeons could get food on FR 25 if they pecked a second (“booking”) key before commencing the FR; if they did not, they got blackout. They booked on about 60% the trials. They did much better (89%) when pecking the booking key changed the key color on the FR key. In two other conditions, in which they could book food by pecking at any place in the FR sequence, they almost always pecked the booking key before commencing the FR, and again providing an FR key-color change resulted in more trials with food (78% vs. 92%). As in research on commitment and self-control, pigeons prefer to commit earlier rather than later, though models of self-control cannot work with these data.

## 8. Examining the Intersection Between Resurgence and Variability Following Discontinuation of Reinforcement for Previously Reinforced Responding

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Using a touchscreen interface, this study assessed (1) the extent to which operant responding tracks contingency changes, (2) whether extinguishing a recently reinforced response results in either an increase in a previously reinforced response or generates a general increase in variability, and (3) the extent to which greater resurgence and/or variability is observed following longer training. University students were randomly assigned to one of four groups. The first two groups were exposed to a single 6-min (group 1) or 8-min (group 2) session in which they could swipe an animated 3D soccer ball any direction/angle. The session started with a 1-min (group 1) or 3-min (group 2) period (phase 1) during which reinforcer delivery was presented upon every target determined by the first swipe direction. This was followed by a 3-min period (phase 2), during which reinforcer delivery was presented upon every

alternative swipe, 180-degrees from the target-swipe direction. Reinforcer delivery was discontinued during the last 2-min period (phase 3) with no exteroceptive stimulus change accompanying the phase change. Target-swipe direction resurged during phase 3 and an increase in swiping variability was observed across both sets of participants. Two control groups will be added to assess simple extinction (exposure to phases 1 and 3 only) and extinction of alternative responding without a history of reinforcement for target responding (exposure to phases 2 and 3 only). This procedure offers methods to assess a continuum of variability during conditions producing relapse in human participants.

## **9. Withdrawn**

## **10. The Effects of the Ratio of Smaller-Sooner and Larger-Later Delays in an Impulsive Choice Task**

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All other things being equal, shorter smaller-sooner (SS) delays increase preference for the SS option over the larger-later (LL) option (e.g., Mazur & Biondi, 2009) in impulsive choice tasks. In the present study, rats were separated into two groups that varied the absolute delay values, but kept the LL:SS delay ratios constant. In one group the rats chose between 1 pellet after 5-s (SS option) and 2 pellets after 5, 7.5, 15, 30, and 60-s delays (LL option, delays increased across 5-session blocks). In the other group the SS option offered 1 pellet after 10-s and the LL option offered 2 pellets after 10, 15, 30, 60 and 120-s. When the data were evaluated, matched by the LL:SS delay ratios (i.e., 1, 1.5, 3, 6, & 12), the 5-s SS delay group made more LL choices compared to the 10-s SS delay group. However, when assessing choices at the common absolute LL delays (15, 30, 60-s), the 5-s SS group made fewer LL choices, consistent with prior research. The results indicate that the characterization of impulsivity requires attention to how the task is conceptualized. The common delay comparison suggest that the rats are most sensitive to the SS delay value, the delay ratio comparison suggests that the rats are more sensitive to the LL delay value. Implications for theories of impulsive choice are discussed.

## **11. Coordinated Social Behavior Under Fixed- and Variable-Interval Schedules**

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The present study was designed to contrast effects of Fixed- and Variable-Interval schedules (FI and VI, respectively) on patterns of coordinated behavior in pairs of rats. Five pairs are working under several conditions of Individual and Coordinated FI and VI schedules both maintained at equal interval duration (25 s). Each of those conditions was separated by a

stability criterion. Rats worked side-by-side regardless of condition, but each schedule specified a different response criterion for reinforcement. In Individual schedules, reinforcers were programmed to follow rat's independent lever pressing. In Coordinated schedules, reinforcers followed only occurrences of coordinated behavior. Coordinated responding was defined as two lever presses, one of each rat, occurring within short time intervals of each other. The time interval used to define coordinated responding is currently under investigation within each coordinated schedules. Coordinated temporal requirements will have durations of 200, 500, and 800 ms. Comparisons of Individual and Coordinated (with 500 ms) shows that (1) rate and proportion of coordinated responding were generally higher in Coordinated schedules than in Individual schedules, (2) these measures do not differ between schedules types (i.e., FI and VI). Preliminary results of the 200 ms condition shows similar effects as those of the 500 ms condition.

## **12. Effects of Opportunity Costs on Delay Discounting for Hypothetical Money and Food**

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Opportunity cost (OC) refers to the cost of something in terms of the cost foregone by not choosing the other mutually exclusive alternative. Prior studies suggest people tend to wait for larger, delayed monetary rewards over smaller, more immediate ones when there is little to no OC. Conversely, they tend to prefer smaller, sooner outcomes when there is high OC. The present study attempted to replicate and extend the Johnson et al. (2015)'s OC study with a four within-subjects condition design for both money and food delay discounting (DD). Participants (N=226) were randomly assigned to either a money or food DD condition. Each participant completed the DD task under four hypothetical framing conditions differing in OC, specifically, the availability of reinforcement during delays. For the "free" condition, people were free to leave their computer without returning and engage in any behavior during the delays. For the "wait" condition, people remained at their computer during the delay without access to alternative sources of reinforcement. The other two conditions were "return" (freedom to pursue other activities but participants must return after a specified time) and "browse" (participants could browse the internet while waiting at computer for entire delay). Results revealed that participants discounted money significantly less in the "free" condition compared to the other three OC conditions. For food, DD results in the free condition were similar to money, but only trended towards significance. Overall, framing the larger, later reward in a DD task in terms of OC appears to influence responding for monetary outcomes, replicating previous research. Food outcomes, though promising, require additional research to account for limitations of the current study.

## **13. Delay Discounting and Obesity-Related Demographic Information Differ Between Food Insecure and Food Secure Women**

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Food insecurity, which is defined as inconsistent access to nutritious foods that meet dietary needs, has been linked to delay discounting for money, a behavioral measure of impulsivity. The purpose of the present study was to examine the difference in delay discounting for money and food outcomes in food insecure and food secure women. Ninety-two women were recruited from a community sample and completed delay discounting tasks for money and food, food security measures, and measures of demographic and health-related variables. Results revealed that food insecure women demonstrated significantly higher rates of delay discounting for both money and food compared to food secure women, and differed on several demographic variables, such as income, marital status, and intellectual functioning in the present sample. These results suggest that food insecure women are relatively more impulsive for money and food.

#### **14. Measuring Transfer of Stimulus Control: Pigeons Acquiring Behavioral Skills**

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Transfer of stimulus control is an essential feature of many acquisition procedures, such as in errorless learning, fading, acquired stimulus equivalence, treatments for prompt dependence, and skill learning. Learning new behavioral skills often involves the transfer of stimulus control from discriminative stimuli present during early training to new endogenous cues that gain stimulus control with extended practice, often leading to skill autonomy. Four studies examined how behavioral skills may become autonomous by developing reliable practice cues when the originally predictive cues were modified or eliminated. As exteroceptive cues were degraded and eliminated over four successive phases using multiple schedules, pigeons solved the discrimination problem by transferring stimulus control to other available exteroceptive and endogenous cues. By measuring and comparing conditional discriminations in signaled vs. unsignaled components, we quantified the degree of stimulus control and measured changes in discriminative control across sessions. The final phase eliminated all discriminative stimuli. Pigeons achieved autonomy by ingeniously developing a new behavioral skill that could always yield reinforcement, but not via the transfer of stimulus control observed in Phases 1-3. Transfer of stimulus control to other available exteroceptive and endogenous cues is one process that may lead to skill autonomy, but it's not the only one.

#### **15. Abstinence from Cocaine Impairs Behavioral Inhibition and Alters Neural Activity in the Prelimbic Cortex**

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Individuals with a history of cocaine use have impaired behavioral inhibition. However, few studies have investigated the changes in neural activity associated with this impairment. Therefore, we assessed neural activity in the prelimbic cortex (PrL) and nucleus accumbens (NAc) core, two regions implicated in behavioral inhibition, during a behavioral inhibition task in animals with and without a history of cocaine self-administration. Rats ( $n=20$ ) were trained on a task in which they had to wait for the presentation of a light cue before pressing a lever to receive a reward (1 sucrose pellet). Responses that occurred before the cue appeared were not rewarded and were considered 'behaviorally disinhibited'. Following training, we recorded electrophysiological activity (single-unit and local field potential, LFP) during the task. Then, animals underwent two weeks of self-administration for either cocaine (1 mg/kg/inf) or water/saline for 6 hr/day for 14 days. Subsequently, on days 4-6 of abstinence from self-administration, we reassessed behavioral inhibition and electrophysiological activity. We found that behavioral inhibition was significantly decreased in animals with a history of cocaine compared to control rats. Additionally, these animals had altered neural activity in the PrL, but not NAc core, during the task. Specifically, both naïve and water/saline rats exhibited a brief inhibition in mean PrL neural activity immediately before pressing the lever. This brief inhibition was abolished in rats with a history of cocaine. Similarly, compared to controls, rats with a history of cocaine had heightened PrL 10 Hz oscillatory activity immediately following extension of the lever into the chamber. Furthermore, the degree to which rats shifted their neural activity (single-unit or oscillatory LFP) correlated with the degree with which they decreased behavioral inhibition. In total, these data suggest that the PrL, but not the NAc core, tracks impaired behavioral inhibition in animals with a history of cocaine.

## **16. When a Stay is a Switch: Discriminative Control of Response Chunks Determines Preference During Concurrent VI VI Schedules**

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A consistent issue for models of choice involves a determination of response units. Switches, stays, bouts, response sequences – all have been proposed as the appropriate unit upon which reinforcement contingencies act. Of course, all of these units are, in a sense, "correct." Not only do environmental contingencies guide responding by assigning "value" to stimuli, but they also shape what constitutes a response. In other literatures this latter process has been termed "response chunking." Here we present evidence that changeover delays (CODs) create response chunks and that the discriminative control of these units contributes to observed preference during concurrent variable-interval (VI) VI schedules of reinforcement. Two experiments were conducted with pigeons. Both utilized multiple VI 30-s VI 60-s, VI 30-s VI 60-s schedules, and one of the VI 30-s schedules was further paired with a 2.5" changeover delay (COD). After training, unreinforced probes were conducted that paired the two stimuli associated with the VI 30-s schedules. In both experiments, during training, birds showed a preference for the VI 30-s schedule over the VI 60-s schedule. This preference was more extreme for the schedule pair in which a COD was programmed with the VI 30-s schedule. Further, an analysis of molecular response patterns found that the application of a COD led to



discrete bursts of rapid responding when birds first switched into the VI 30-s schedule. This burst was not observed at the VI 30-s schedule in which no COD was assigned. Finally, during probes we observed a preference for the VI 30-s stimulus associated with a COD, but only when our probes maintained discriminative control of response bursts. Without this discriminative control, preference mirrored the local reinforcement rates observed during training.

## **17. An Excel Add-in to Teach and Learn Statistical Models**

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I present a free Excel add-in that defines a large number of functions useful to teach and learn stochastic models and statistics. The add-in includes a full set of probability related functions (to generate random numbers, compute densities, cumulative distributions, and quantiles), functions to generate permutations and combinations (useful to teach the topic), functions to sample and shuffle vectors (useful for bootstrap analyses and permutations tests), as well as an engine to simulate simple models and collect data from the simulations. I will illustrate its use with examples

## **18. Resurgence Controlled by Different Stimulus: a Within-Session Assessment**

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When a resurgence procedure is arranged within the same experimental session, some experiments have consistently observed resurgence over multiple sessions. However, as resurgence is observed across sessions, such effect tends to decrease. Using a within-sessions resurgence procedure, in the present set of experiments different stimulus were presented in each of the phases. Using such an arrangement could control for changes in resurgence, as subjects are exposed to multiple test sessions across conditions. In Experiment 1, four rats were exposed to 30 sessions of each of the following stimulus conditions: ABA, ABC, ABB, AAB, AAA, where each letter represents the changes of stimuli within session. Whereas in Experiment 2, stimulus conditions changed every day for each rat. Greater resurgence was observed when rats were exposed to an ABA stimulus condition, in contrast to the rest of the conditions. Likewise, resurgence was scarcely observed for some rats under the ABB and AAA stimulus conditions. For all rats of Experiment 1, resurgence was mostly observed during some of the first sessions; whereas, for rats in Experiment 2, resurgence was repeatedly observed, and no differences were observed between the first and final sessions. These results provide some evidence for the effectiveness of a within session resurgence procedure, thus reducing the amount of time required to assess resurgence. Likewise, it extends previous results using this procedure to conditions where behavior is also controlled

by different stimuli. However, certain limitations should be considered. For instance, during the first sessions, target-responding did not decreased to near-zero responses when this was placed under extinction, limiting the magnitude of resurgence. Since under resurgence procedures target-responding is extinguished before testing, future research should also control for this variable before testing.

## **19. Monkey See Computer Do: Simulation of Dynamic Behavior via the Evolutionary Theory of Behavior Dynamics**

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The Evolutionary Theory of Behavioral Dynamics (ETBD) is a computational instantiation of selection by consequences that allows the generation of simulated behavioral output in environments with known reinforcement schedules. This study extends the theory to examine its predictions within an environment with dynamic, random, concurrent, interval reinforcement schedules with unsignaled transitions between schedules. The results were compared with behavioral data from rhesus monkeys (n=2; Corrado, Sugrue, Seung, and Newsome, 2005) that were placed in a similar environment. Three different levels of analysis were used in this study: a macro-level which analyzes all of the behavioral data together; a transition-level analysis that focuses on the behaviors immediately following an unsignaled transition; and a local-level analysis which compares moment to moment changes of behavior and reinforcement. At the macro-level, the generalized matching law (GLM; Baum, 1974) fit the data from the virtual organisms animated by the ETBD well and returned parameters comparable to those from GML fits to rhesus monkeys' data. At the transition level, virtual organisms adapted more quickly at the unsignaled transitions between schedules than the rhesus monkeys. At the local level, the dynamic responses of virtual organism behavior to changes in reinforcement were comparable to the responses of rhesus monkeys in the distribution of correlations between sets of local behavior and reinforcer proportions. In addition, virtual organism showed similar local proportion dynamics including local overmatching and undermatching that are not evident on more aggregated behavioral data. These results provide strong support for the ETBD account of dynamic behavior.

## **20. Human Preferences for Sequences of Hypothetical Monetary Outcomes: Effects of Amount and Time**

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When human choice is studied in the laboratory, the outcomes associated with the choices are typically isolated, discrete events. However, many of the choices we make outside the laboratory result in a sequence of outcomes—multiple events distributed over time. The

purpose of our study was to evaluate preferences for sequences of hypothetical monetary outcomes. Participants chose between one of three sequences that varied in how the amount changed within each sequence: increasing, decreasing, or constant monetary amounts. In a 3 x 4 design, we manipulated both the total amount of the reward (\$100, \$5000, and \$500,000) and the duration of the reward sequence (1 year, 4, years, 8 years, and 20 years). Across all choice trials, participants overwhelmingly preferred the decreasing or constant sequence to the increasing sequence. Furthermore, this preference did not vary as a function of the monetary amount of the sequence or its duration. Overall, these results are counter to the predictions of a “preference for improvement” (Loewenstein & Prelec, 1993), and are only partially consistent with the predictions of curvilinear discounting.

## **21. Effects of Acute and Chronic Stress on Prospective Interval Timing in Rats**

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Sustained activation of an animals’ defensive systems may compromise physiological, neural, behavioral, and cognitive functions. Previous studies have suggested that many of the brain structures implicated in estimating interval duration, including the striatum, hippocampus, and prefrontal cortex, are also sensitive to chronic stress. The current study tests the sensitivity of various components of the pacemaker-accumulator model of interval timing to acute stress and chronic variable stress. Adult male and female rats were trained on a response-initiated prospective switch-timing task. Following stable performance, half of the rats were exposed to a 21-day chronic variable stress procedure, involving two stressors a day, while also undergoing the switch-timing task. For half of the stressed rats, chronic stress and switch-timing training was discontinued for 14 days, and then only switch-timing training resumed for 14 days, in order to test overcompensation effects following recovery from stress. Data collected thus far suggests that acute stress (on the first day of chronic variable stress) lengthens both temporal judgements and latency to initiate switch-timing trials, but that this effect attenuates as stress continues.

## **22. Timing and Impulsive Choice in the CNTNAP2 Knockout Rat Model**

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The CNTNAP2 gene has been implicated in several neuropsychological disorders, such as autism spectrum disorder (ASD) and schizophrenia. The CNTNAP2 knockout (KO) rat model, rats without the CNTNAP2 gene, exhibits deficits in social interaction and increases in both repetitive and anxiety-like behaviors. However, choice and timing behaviors that may underlie several neuropsychological disorders have not been investigated. The current study

investigated timing and delay discounting in the CNTNAP2 KO rat model compared to Sprague-Dawley control rats. Results suggest possible reductions in timing precision and increased impulsivity in the CNTNAP2 KO model. In particular, the reductions in timing precision were consistent with similar findings previously reported in humans diagnosed with ASD. These findings are promising for understanding the role that the CNTNAP2 gene may play in certain neuropsychological disorders, and for developing targeted therapies.

### **23. Choices in Situations of Time-Based Diminishing Returns: Effects of Methylphenidate on "Impulsive" Behavior**

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Effects of methylphenidate on choice in situations of time-based diminishing returns were examined. Four racing homer pigeons were given a choice between a fixed-interval (FI) 60-s and a progressive interval (PI) 5-s schedule. Each selection of the PI raised the interval by 5 s for the following choice (i.e., continued choice of the PI resulted in diminishing returns); each selection of the FI reset the PI back to 0 s. The pigeons could control overall rate of reinforcement based on when they switched from the PI to the FI. Switching prior to the point at which the PI equaled the FI (i.e., switching to the FI when it was longer than the PI) could be considered a “self-controlled” choice because it increased overall reinforcement rate; whereas, switching points closer to equality could be considered an “impulsive” choice, because it provided more immediate reinforcement, but reduced overall reinforcement rate. Once median switch points were stable across sessions, acute doses of methylphenidate (0.3-17.0 mg/kg) were administered before selected sessions. For three pigeons, methylphenidate dose-dependently increased switch points either closer to or, at the higher doses, past the point of equality. For one pigeon, lower doses of methylphenidate decreased the median switch point, and higher doses increased switch point. These results are consistent with those from studies showing that methylphenidate’s effects on impulsive choice may relate to a drug-induced increase in perseverative responding

### **24. Real Contingencies in Effort Discounting by Overweight Adolescents: Using a Video Game**

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This study aimed to compare the effort discounting degree between healthy weight and overweight adolescents, through the presentation of real contingencies. The overweight group consisted of 41 adolescents (i.e., BMI  $\geq 19$ ), and the control group consisted of 30 students. Participants that met the criteria for tobacco, alcohol, and drugs were excluded from the study. A mixed factorial design was used. The first step consisted of presenting

instructions and the list of rewards (i.e., trophies and medals). After an individual effort requirement test was conducted to identify the mean of press keyboard participant was able to do. Later, forced trials were presented. A magnitude and effort assessment was performed, as well. During choice trials, participants had to choose between a small and effortless option or a large and effortful alternative, using the adjusting amount procedure. If participants choose the easy option, they had to press on the keyboard once, and after that, the small reward was delivered. On the other hand, if they choose the effortful alternative, they had to press a specific effort required to meet the criteria to get the large reward. The results suggest that there are no differences between groups, considering the Area under the Curve values. The adjustment was higher with the hyperboloid model than the hyperbola; although that adjustment was moderate (i.e.,  $R^2 > 0.50 < 0.80$ ). The difference between  $R^2$  values with both models was significant ( $p < 0.05$ ). The results should suggest that pressing keyboard like effort does not represent a significant effort for those participants. Some settings are necessary to increase the effort required and observe a steep discounting degree, also considering another type of reward more relative to the population of interest. Unlike delay discounting, we didn't found significant differences in effort discounting degree between groups.

## **25. Effects of Non-Contingent Shocks on Self-Control Behavior and Preference Reversal in Wistar Rats**

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We explored the effect of non-contingent aversive stimulation on self-control behavior and preference reversal. Sixteen rats chose between a smaller-sooner (SS) and a larger-later (LL) reinforcer. Eight rats received concurrently noncontingent 0.5-s shocks of 0.25mA in a 60-s random time schedule throughout all experiment. During the first phase, SS = 2 pellets after a 0.5-s delay and LL = 4 pellets after a 6-s delay. Rats slightly preferred LL at the start of this phase. Except three non-shocked subjects, rats increased their LL preference across sessions, with shocked rats showing an overall higher increase. In phase 2, delays were added systematically only in the LL option until each animal showed a steady SS preference (same number of pellets). The amount of time added until rats showed SS preference varied across subjects (6 to 36 s), but shocked and no shocked rats did not differ. In phase 3, systematic increases in SS and LL of 5-s, 15-s, and 25-s were implemented to reverse the rats' preference from the SS option to the LL option. Subjects exposed to shocks showed greater preference for the LL option across all the delays. Our findings overall are not aligned with the previously-reported increase of impulsive behavior under contingent and noncontingent aversive stimulation. For example, humans exposed to aversive noise and immersion of hands in cold water increased their impulsive behavior (Flora et al., 1993, 2003). Pigeons exposed to a choice procedure with commitment, and blackout contingent on the SS response, frequently chose

the commitment alternative and then defected from commitment by choosing the punished SS reward (when they could have obtained this reward without punishment; Green & Rachlin, 1996). Lastly, noncontingent aversive tone disrupted fixed-interval responding of rats, increasing unnecessary responding (Reed, 2011). The fact that none of the previous studies implemented shock as the aversive stimulus calls for systematic replications.

## **26. Interoceptive Drug Conditioning: Sex Matters in the Extent of the Discrimination Between Nicotine and Bupropion**

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Bupropion is a norepinephrine-dopamine reuptake inhibitor (NDRI) and a nicotinic acetylcholine receptor (nAChR) antagonist. Bupropion, also known by its trade name Zyban®, is one of the FDA approved non-nicotine pharmacotherapies. Bupropion has been found to have interoceptive stimulus effects in male and female Sprague-Dawley rats. In our earlier work, 20 mg/kg bupropion (IP) fully substituted for the training dose of nicotine (0.4 mg/kg, SC); 10mg/kg bupropion partially substituted for the nicotine stimulus. For the first time, the present study explored whether a drug versus drug discrimination could be acquired using the drug discriminated goal-tracking task. Specifically, we examined whether rats were able to discriminate between nicotine and either the 10 or 20 mg/kg doses of bupropion. We also examined whether acquisition would differ between the sexes. Male and female Sprague-Dawley rats were assigned to one of three groups: NIC-SAL (n=20), NIC-BUP10 (n=20) or NIC-BUP20 (n=17). For all groups, nicotine was always administered on positive days. That is, rats, in a 20-min session, had 4-sec access to sucrose 36 times on a VT 25-sec schedule. On Saline, Bup10, or Bup20, days sucrose presentations were withheld (i.e., negative days). Our primary dependent measure was rate of dipper entries before the first sucrose presentation on positive days or equivalent time on negative days. The discrimination was acquired by all three groups. Females in the NIC-BUP10 group exhibited a discrimination of smaller magnitude relative to the other groups. However, females in the NIC-BUP20 displayed a robust discrimination between nicotine and BUP20. Lastly, for males in the NIC-BUP20 showed greater variability on positive days. Follow-up work is examining the potential differences in the nicotine or bupropion dose-effect curve.

## **27. Defecting During the Delay: Delay Maintenance in Rats**

Jeremy M. Haynes<sup>1</sup>, Charles C. J. Frye<sup>1</sup>, Annie Galizio<sup>1</sup>, Ryan J. Becker<sup>1</sup>, D. M. Perez<sup>1</sup>, Amy L. Odum<sup>1</sup>

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In intertemporal choice tasks with non-human animals, subjects are presented with the choice between a smaller, more immediate outcome (e.g., 50 µL of a sucrose solution delivered immediately) and a larger, delayed outcome (e.g., 150 µL of a sucrose solution delivered after

8 seconds). These tasks have been widely used as a measure of impulsive choice in non-human animals; however, prior research with humans and non-human animals suggests that the initial preference for an outcome may not be stable during the delay to its receipt. For example, on Monday an individual may decide to withhold spending money on snacks throughout the week to save for an expensive dinner on Friday night. While the individual is waiting for this delayed outcome, they have the opportunity to buy snacks at any point during the week if their initial preference changes and the expensive delayed dinner is no longer preferred over the snacks available now. Current intertemporal choice tasks for non-human animals force their subjects to endure the delay to the larger outcome; therefore, these tasks cannot measure changes in preference for the larger outcome during the delay to its receipt. We were interested in whether rats, choosing between small-immediate and large-delayed amounts of sucrose, would maintain their preference for the larger sucrose throughout the delay. To measure whether preference was maintained throughout the delay, we used an intertemporal choice task that included an available defection response. Thus, after choosing the larger-delayed sucrose, subjects could make a response to receive the smaller sucrose immediately, while at the same time forgoing receipt of the larger sucrose. Our results indicate that rats can maintain their preference for the larger sucrose throughout the delay to its receipt, suggesting that current intertemporal choice tasks may be appropriate measures of preference during the delay to an outcome.

## **28. Numerosity Discrimination: Can Pigeons Report Uncertainty?**

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We studied the ability of pigeons to monitor uncertainty (i.e., the chances of success or failure) and respond accordingly in a number-discrimination task. After producing a numerosity (10, 11, 13, 15, 20, 23, 26, or 30) by pecking a central key, pigeons had to classify it as “Small” (up to 15) or “Large” (at least 20) by choosing one of the two colored side keys. Correct responses were reinforced whereas incorrect responses were immediately followed by the inter-trial interval. The psychometric function showed that the proportion of “Large” choices was close to zero for small numerosities (i.e., 10 and 11) after which it increased reaching one for the larger numerosity (30). Intermediate numerosities were more difficult to discriminate. The point of subjective equality was close to the geometric mean (17.5). We then introduced a third option, the escape key, designed to avoid choosing when uncertainty was high. By pecking that key, pigeons could increase the numerosity previously produced and choose one of the options, “Small” or “Large”, at any time. For instance, after producing 15 pecks pigeons could peck the escape key 10 more times completing a total of 25 pecks and then choose the “Large” option and be reinforced. Pigeons did not use this third option spontaneously. After two sessions training them to peck the escape key, we modified the procedure. When pigeons chose the escape key, the two other options become unavailable and they had to peck the remaining key N times for reinforcement. The value of N was increased to a different number, depending on the bird. Our goal was to increase the cost of escaping such that birds restricted the use of this key to uncertainty trials. Most pigeons did

choose the escape key and this choice appeared modulated by the number of pecks produced previously. Yet, the pattern was not uniform across birds.

## **29. A Proposal of a Little but Significant Adjustment of the Rate Maximization Model**

Laurent Avila-Chauvet<sup>1</sup>, Óscar Garcia -Leal<sup>1</sup>, Alejandro Segura<sup>1</sup>

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In social foraging situations, a member of a group can either search for new feed sources (i.e., behaving as a producer) or join to a source previously discovered by some other member of the group (i.e., behaving as a scrounger). The Rate Maximization Model (RMM) prescribes the optimal ratio between producers and scroungers to reach an Evolutionary Stable Strategy, and allow to make some predictions about the number of production responses expected across a foraging episode: 1) As group size increases, the proportion of scrounger responses will also increase; 2) it will also increase as the amount of food in feed sources is higher. We develop a task analogue to a foraging-situation with human participants. We ran a between-subjects experiment, with four groups each one composed by twenty undergraduate students. For two groups, 4 participants conformed the foraging group, one of them was a real participant, while the other 3 participants were simulated. For two more groups, 8 participants conformed the foraging group, one real and 7 simulated. Each one of the two different group size was exposed to food sources that delivered 5 or 15 food items when they were foraged. The ratio between producers and scroungers was reasonably well-predicted by the RMM when the number of subjects and the amount of food potentially available in the foraging situation was manipulated but, more importantly, when the effect of the number of subjects in the RMM was mathematically modulated, the RMM's predictions improved and were closer to our data. We discussed the relevance of this change in the RMM's equation to predicting foraging behavior.

## **30. The Role of Prior Delay Exposure on Intertemporal Choice Preference in Rats**

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<sup>1</sup> Central Michigan University

We developed a quantitative model describing the role of prior experience with delayed reinforcement on preference in rats using an intertemporal choice procedure. Preference was evaluated for 1 vs 3 food pellets when the delay for the 3-pellet option was varied in an initially ascending and subsequently descending series (e.g., 0, 1, 3, 6, 12, 24, 24, 12, 6, 3, 1, 0 s). Choice trials began with the illumination of stimulus lights above the left and right levers. A lever press delivered either one pellet immediately or three pellets following a non-resetting delay signaled by a flashing stimulus light above the selected lever (lever-outcome contingencies were counterbalanced across rats). A compensating 45-s intertrial interval separated each trial. In Experiment 1 data from Fox, Hand and Reilly (2008; comparing



impulsive choice in Spontaneously Hypertensive rats or SHR, an animal model of ADHD, with the control Wistar-Kyoto or WKY) strain were re-analyzed. In Experiment 2, the effects of radiation-induced brain injury on preference was evaluated in Wistar rats. In Experiment 3 Sprague-Dawley rats experienced three exposures to the ascending and descending sequences. In all three experiments, preference universally shifted to the immediate pellet as the delay was increased. Furthermore, preference for the three-pellet alternative was greater in the ascending than in the descending sequence. The difference between the ascending and descending sequence was greater for the SHRs (Experiment 1), irradiated Wistar rats (Experiment 2), and during the first exposure to the delay sequence (Experiment 3). Prior delay exposure influences intertemporal choice and should be accounted for in studies that assess choice using non-steady-state designs. A quantitative model was developed that incorporates a weighted moving average of the prior delays experienced into a hyperbolic discounting model in order to describe both the rate of discounting and the sensitivity to changing delay contingencies.

### **31. Behavioral Economic Demand Elasticity Significantly Predicts Blood Nicotine Across Reduced-Nicotine Cigarettes: A Preliminary Analysis**

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The FDA recently released an Advanced Notices of Proposed Rulemaking for reducing nicotine in combustible cigarettes. Several recent reports have described relations between reduced nicotine cigarettes and their behavioral economic demand measures. However, no research has directly evaluated whether behavioral economic measures are associated with the absorption of nicotine in an individual's blood after consuming combustible cigarettes that differ in nicotine concentration.

Twenty-six participants have so far completed the current double-blind, within-subject design protocol. During each of six laboratory sessions, participants smoke one of the following cigarettes: usual brand or SPECTRUM investigational cigarette differing in nicotine content (15.8, 5.2, 2.4, 1.4, 0.4 mg/g). After smoking, participants complete several assessments including a behavioral economic purchase task. Throughout each laboratory session, blood is drawn and blood nicotine concentration is measured. Linear mixed-effect models were used to examine the interaction of two primary behavioral economic measures (alpha [i.e., price sensitivity] and intensity [i.e., consumption at unrestricted cost]) and cigarette type on changes in blood nicotine. A significant interaction between alpha and cigarette type was observed on changes in blood nicotine ( $F[5, 129.88] = 3.40, p = .006$ ). That is, alpha was negatively associated with changes in blood nicotine among the higher concentrations, including the participant's usual brand cigarette, but not the lower concentrations. No significant effect of demand intensity predicting changes in blood nicotine was observed ( $F[1, 134.79] = 0.22, p = .64$ ). We discuss how the current findings shed insight

on the utility of behavioral economic measures in understanding the abuse liability of novel products, such as reduced-nicotine cigarettes, and how such measures may be valuable in prospectively estimating the impact of nicotine reductions in combustible cigarettes.

### **32. Mitigating Renewal of Pediatric Feeding Problems**

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Feeding problems are common in children diagnosed with Autism Spectrum Disorder. Although behavioral treatments are effective at reducing feeding problem behaviors in the clinic, they can return when caregivers implement treatment at home. This study evaluated multiple techniques for mitigating the renewal of feeding problem behavior, namely multiple-context training and treatment cues. A functional analysis was conducted to determine the variable maintaining food-refusal behaviors – in all cases, behavior was maintained by negative reinforcement in the form of escape. During the first condition, caregivers fed their child in the clinic (Context A). Next, a therapist provided treatment of the feeding problem behavior to increase quick acceptances and decrease inappropriate mealtime behavior (Context B). Once mastery criteria were met, trained caregivers implemented the intervention in Context A. This will be followed by multiple-context training to mitigate renewal of problem behavior, and then a return to context A. For both participants there was an increase in quick acceptance and a decrease in inappropriate mealtime behavior to clinically significant levels during treatment in Context B. Thus far, return to Context A shows an increase in inappropriate mealtime behaviors and a brief decrease in quick acceptances across sessions with and without the treatment cue.

### **33. Concurrent and Single-Alternative Progressive Ratio Schedules in Rats**

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<sup>1</sup> University of Nevada

Progressive Ratio (PR) schedules are commonly used to measure the value of a reinforcer. Under a properly arranged PR schedule, a subject will eventually stop responding once the ratio requirement becomes too large. This breakpoint is typically assumed to happen sooner (at a lower ratio) for lower-valued reinforcers. In Experiment I, six rats were exposed to progressive ratio schedules for reinforcers that varied – across conditions – in the number of sucrose pellets per ratio completion. Very little difference was seen in breakpoints across reinforcer magnitudes. This could be because increases in reinforcer amount also produced decreases in motivation. In Experiment II, a concurrent progressive ratio schedule was used, with a one-pellet reinforcer on one alternative and a five-pellet reinforcer on the other alternative. Substantially more responding was obtained on the five-pellet lever. However, under nicotine administration, this difference was lessened in a dose-dependent manner.

These results are consistent with previous studies showing that nicotine increases the magnitude of smaller reinforcers relative to large. These results also suggest advantages of concurrent progressive ratio schedules over single-alternative schedules when measuring reinforcer value.

#### **34. Molar Analysis of Active Patterns in Human Relational-Behaviour: Beyond Contemplative Responses in a Transposition-Based Task**

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The purpose of the study was to analyze the functional role of active patterns in relational behavior in humans. The participants were five children, 9 to 11 years-old. A modified transposition task (size) that required active behavioral patterns to form two relational pairs of stimuli, according to two pairs of sample stimuli that indicated the current relationship (greater or lesser than) trial to trial, was used. A molar analysis of behavioral patterns was performed focusing on the variation of response patterns (variety of sequences used and exceeding movements), their directionality (choice of relevant stimuli) and their relationship with the conformation of compounds that fulfilled the relationship indicated by the sample compounds. The data suggest that variation and directionality were associated with the establishment of relational behavior. The relevance of the active patterns in relational behavior and their omission in the dominant perspectives of this research field are discussed.

#### **35. Quantitative Analysis of Discriminability and Bias during Conditional Discriminations with Changes in Sample and Comparison Disparity**

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This study used Davison and Tustin's (1978) framework to quantify errors due to stimulus or location biases (log b) and discriminability (log d) during a matching-to-sample task in children diagnosed with ASD. The task was displayed on a touchscreen device in which touching a sample stimulus at the beginning of each trial resulted in the appearance of two comparison stimuli. Accurate matches produced reinforcement comprised of verbal praise, onscreen visual feedback, and delivery of a preferred edible. In two experiments, we manipulated task difficulty by altering the disparity between sample stimuli (Experiment 1) or comparison stimuli (Experiment 2). Both experiments yielded similar results – decreases in disparity reduced discriminability (log d) across all participants with unsystematic effects on stimulus or location biases (log b). This study demonstrates the use of this framework for categorizing error patterns in a clinically relevant population of children diagnosed with

ASD. Future research aims to develop these methods clinically to (1) assess preacademic skill deficits linked with error patterns and (2) base antecedent- and consequence-based interventions on error patterns for more precise and effective elimination of errors during teaching.

### **36. Poor Stimulus Control in Multiple Frequency-Dependent Schedules of Reinforcement in Pigeons**

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<sup>1</sup>Utah State University

Variability may be an operant dimension of behavior, controlled by its consequences and discriminative stimuli. Data in support of this position show that animals can discriminate between contingencies which demand variability and those that merely permit it. However, variability exists along a continuum, and this hypothesis predicts that the degree of behavioral variability should come under discriminative control within-session. The present experiment tested this prediction with eight pigeons naïve to frequency-dependent schedules of reinforcement. All pigeons responded on a multiple lag 1 lag 8 schedule of reinforcement throughout the experiment. Lag  $n$  schedules deliver food when the animal emits a response which has not occurred in the last  $n$  trials. We imposed several discriminative stimulus reversals to test discrimination between the two variability schedules and found that pigeons behaved similarly across the components. We then yoked reinforcement rates in the lag 1 component to those obtained in the lag 8 component and found that reinforcer rate may facilitate discrimination for some birds. Our results are not clearly in line with the conception of variability as an operant dimension of behavior. Indeed, animals adjust their behavior to conform to the demands of other reinforceable response dimensions (e.g., speed, force), and one would expect such sensitivity to variability contingencies if it were an operant. Thus, based on our results it is hard to discern if variability is under operant control or is a by-product of some other process. To elucidate this issue, we propose a follow-up experiment where reinforcement is contingent upon responses falling within one of two non-overlapping ranges of acceptable variability, where each range is associated with its own discriminative stimulus. The implications for the status of variability as an operant dimension of behavior are discussed in light of our results and future expected results.

### **37. Temporal Discounting of Aversive Stimulation in Spontaneously Hypertensive Rats**

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Spontaneously hypertensive rats (a purported animal model of ADHD) have been demonstrated to show a higher degree of temporal discounting when they choose among positive reinforcers. However, to date there is no research on temporal discounting of

aversive consequences on this strain. Because of the high relevance that aversive consequences have on diverse choice situations, we were interested in complementing the study of temporal discounting by studying the sensitivity to delayed aversive stimulation in SHR. With this goal, we evaluated SHR and wistar rats as a control group, in a modification of Evenden and Ryan's procedure (1996, *Psychopharmacology*, 128(2), 161–170). Rats chose between two alternatives: a smaller food amount with no shock, and a larger-amount plus shock, whose delay was increased from 0 to 40 s within the session. Preference was measured as proportion of choice for the smaller-amount-no-shock alternative. The results indicated that the preference for this alternative diminished as a hyperbolic function of the delay to shock in the other alternative. However, the degree of temporal discounting was equivalent between strains. This result could indicate that SHRs show impulsive behavior when the consequences are positive, but not when they are aversive. Alternatively, it is possible that we evaluated the non-impulsive subpopulation of SHR rats. For distinguishing between these hypotheses, we currently are comparing the same rats in a delay discounting procedure with positive consequences.

### **38. Effects of Within-Session Progressive-Interval Schedules of Alternative Reinforcement on Resurgence**

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Both basic and applied research has shown that thinning the schedule of reinforcement for an alternative response in a differential reinforcement of alternative behavior (DRA) procedure will ultimately reduce the magnitude of resurgence when the alternative response is subsequently put on extinction. During thinning procedures themselves, however, resurgence of problem behavior is common, especially as schedules become leaner. The purpose of the present study was to begin to examine the temporal dynamics of resurgence during alternative reinforcement thinning via the use of within-session progressive-interval (PI) schedules. Subjects (N=15) were male Long-Evans rats maintained at their 80% free-feeding weights. Phase I consisted of acquisition of a target response (lever-pressing) according to a VI-30s schedule for food pellets. Phase II involved extinction of the target response while simultaneously an alternative response was made available according to a FI-10s. For the subjects in the PI group, phase III consisted of continued extinction of the target response, while the alternative reinforcement schedule was changed to a PI-10s with a step size increasing by 20% after the receipt of each reinforcer. The final phase consisted of both target and alternative response extinction. Results are consistent with both the basic and applied literature with respect to thinning the alternative response schedule in a DRA procedure. Resurgence of target responding occurred on the PI schedule as the interval durations became successively longer, but no additional resurgence occurred upon moving to extinction in the final phase. On average, rats in the PI condition began to resurge at an interval approximately 60 seconds in length. These results suggest that PI schedules may be a viable method for thinning alternative reinforcement rates in clinical settings.