SQAB 2007 at a Glance

Thursday Evening, May 24
Randle A & B

5:00-8:00+ Registration and Cash Bar

Friday Morning, May 25
Randle A & B

7:00	***Registration, Coffee and Pastries***
8:30	Randolph Grace (President's Introduction)
8:45	Ralph Miller & Daniel Wheeler
9:20	Bernard Balleine
9:55	***Coffee Break (20 min)***
10:15	Matthew Bell
10:50	Timothy Shahan & Christopher Podlesnik
11:25	Daniel Cerruti
12:00	***Lunch Break (12:00-1:30)***

Friday Afternoon, May 25
Randle A & B

1:30	Geoffrey White
2:05	Armando Machado
2:40	Kimberly Kirkpatrick & Anna Wilkinson
3:15	***Coffee Break (15 min)***
3:30	Carlos Aparicio
4:05	James MacDonall
4:40	Michael Commons & Alexander Pekker
5:30	***Business Meeting***
6:30	***Poster Session / Cash Bar*** until 9:00 pm

Saturday Morning, May 26
Randle A & B

7:00	***Registration, Coffee and Pastries***
8:15	Thomas Zentall & Rebecca Singer
8:50	John Wixted, Laura Mickes & Peter Wais
9:25	***Coffee Break (20 min)***
9:45	Francis Mechner
10:20	Peter Killeen
11:00	***End of SQAB -Beginning of ABA***

Saturday Afternoon, May 26
Randle A & B

SQAB-Invited Preeminent Tutorials
From Basics to Contemporary Paradigms

1:00	James MacDonall - *Getting Started in Quantitative Analyses of Behavior*
2:00	Peter Killeen - *The Law of Affect*
3:00	Robert Cook - *Stimulus Control*
4:00	Peter Balsam - *Time, Uncertainty, and Anticipation*

SQAB

Society for the Quantitative Analyses of Behavior

SQAB

The *Society for the Quantitative Analyses of Behavior*, SQAB, was founded in 1978 by J. A. Nevin and M. L. Commons to present symposia and publish material which bring a quantitative analysis to bear on the understanding of behavior. This can be defined as the development and use of mathematical formulations to characterize one or more dimensions of a data set, derive predictions to be compared with data, and generate novel data analyses.This International Society holds its annual meeting in conjunction with the *Association for Behavior Analysis International*, ABA.

You can retrieve more information pertaining to SQAB, as well as abstracts of papers, from our web site *http://sqab.psychology.org*

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Notes

7:00-8:30 Registration, Coffee and Pastries

8:30-8:45 Welcome to SQAB 2007: President's Introduction

Randolph C. Grace
University of Canterbury (New Zealand)

8:45-9:20 Interactions Between Competing Stimuli: Confirmation of Some Surprising Predictions of the SOCR Model of Pavlovian Responding (a Mathematical Implementation of the Extended Comparator Hypothesis)

Ralph R. Miller & Daniel S. Wheeler
SUNY-Binghamton and Johns Hopkins University (USA)

The comparator hypothesis is a model of Pavlovian responding that posits simple non-competitive learning based on contiguity and uses a retrieval rule (rather than competition during training) to account for many Pavlovian phenomena. SOCR is a mathematical implementation of the comparator hypothesis that allows us to generate precise predictions, some of which are highly counterintuitive concerning select situations in which a target cue (CS) has more than one companion (competing) stimulus during training. Although each competing stimulus alone (a punctate cue or the training context) attenuates responding to the target, multiple competing cues presented together also compete with each other, leading to the surprising prediction that two competing stimuli should sometimes attenuate responding to the target cue less than either competing stimulus alone. Simulations will be contrasted with data from situations designed to concatenate pairs of response-attenuating treatments such as overshadowing, trial massing, degraded contingency, latent inhibition, partial reinforcement, US preexposure, long CSs, and overtraining. SOCR is further tested by posttraining manipulations that deactivate the consequences of one of the normally response-attenuating treatments. These manipulations are found to allow the expression of the other response-attenuating treatment as anticipated by SOCR. The empirical point is that two response attenuating treatments do not always summate. The theoretical point is that there is merit to attending to rules for retrieval and response generation.

9:20-9:55 Goal-Directed and Habitual Instrumental Actions

Bernard Balleine
University of California, Los Angeles (USA)

Behavioural analyses have found evidence of two distinct learning processes underlying the acquisition of actions that are instrumental to gaining access to rewarding events. The first of these is a goal-directed process that encodes the association between an action and its outcome. The second process encodes sensory-motor associations and mediates the acquisition of habitual actions. In addition to their distinct associative structure, these aspects of behavioral control appear to be sensitive to distinct feedback processes associated with reward on the one hand and reinforcement on the other. Various theories describing both transitions and interactions between these two learning processes have been advanced and these will be described in the context of recent research suggesting that the neural bases of the goal-directed and habitual learning processes involve parallel cortico–basal ganglia–cortical circuits coursing through dorsomedial and dorsolateral regions of the striatum, respectively.

9:55-10:15 Coffee Break

Equation 1: Recognize this equation?

$$\log\left(\frac{B_1}{B_2}\right) = a \cdot \log\left(\frac{R_1}{R_2}\right) + \log c$$

(Answer on p.32)

10:15-10:50 Signal Effects and Resistance to Change

Matthew C. Bell
Santa Clara University (USA)

Behavioral momentum theory is ambiguous about the role of signals in controlling responding in chain schedules. One possibility is that signals function as conditioned reinforcers for responding to earlier links of a chain schedule. Across a series of three studies, I evaluated effects of a signaled delay on resistance to change using pigeons responding to a multiple schedule of reinforcement. The first set of experiments evaluated resistance to change when a signal stimulus was present and when it was absent. The absence of the signal consistently reduced resistance to change for the pre-signal stimulus. Probe preference tests showed preference for the signal stimulus. Together, the results are consistent with the hypothesis that the signal functions as a conditioned reinforcer. An alternative explanation is that the effect was due to a generalization decrement. To test this hypothesis, a second experiment was conducted to evaluate the conditioned reinforcement and generalization decrement hypotheses. Preliminary results providing support for the hypothesis that the signal is functioning as a conditioned reinforcer. The final set of experiments evaluated the effect of adding an unsignaled delay between stimuli in a chain (rather than at the end of a chain). Equal resistance to change occurred, suggesting that the unsignaled delays between the initial link and the terminal link do not affect resistance to change. One possible explanation is that disruption procedures affect S-S relationships differently than S-R relationships.

10:50-11:25 Quantitative Analyses of Observing and Attending

Timothy A. Shahan & Christopher A. Podlesnik
Utah State University (USA)

We will present experiments examining whether simple models of the allocation and persistence of operant behavior are applicable to attending. In one series of experiments, observing responses of pigeons were used as an analog of attending. Maintenance of observing is typically attributed to the conditioned reinforcing properties of a food-correlated stimulus (i.e., S+), so these experiments also may inform our understanding of conditioned reinforcement. Rates and allocations of observing were governed by rates of food or S+ delivery in a manner consistent with the matching law. Resistance to change of observing was well described by behavioral momentum theory when only rates of primary reinforcement in the context were considered. However, frequency or value of S+ presentations did not affect resistance to change. This finding calls into question the response-strengthening properties of conditioned "reinforcers" and suggests that the persistence of attending to stimuli is governed by primary reinforcers in the context, rather than by conditioned reinforcing effects of the stimuli. In a second series of experiments, the applicability of the matching law to the allocation of attending to the elements of compound stimuli was examined using a divided-attention task. Performance was well described by the generalized matching law, and sensitivity to relative reinforcement varied with the duration of compound-sample stimuli. We suggest that the sensitivity and bias terms of the generalized matching law may provide measures of stimulus-driven and goal-driven control of divided attention. Further application of theories of operant behavior to the allocation and persistence of attention may provide insights into what is often referred to as goal-directed, voluntary, endogenous, or top-down control of attention.

11:25 - 12:00 Timing Versus Conditioned Reinforcement as Determinants of Choice in Concurrent-Chain Schedules

Daniel T. Cerutti, J. Jozefowiez, & J. E. R. Staddon
Duke University (USA)

It is difficult to find a situation where a timing theory and standard molar choice theories of conditioned reinforcement make clearly different predictions. In timing theory, response latencies in the initial-links of a concurrent schedule are determined by the overall delays to food signaled by initial-link onset (time-to-reinforcement); not the delay to conditioned reinforcement. A crucial experiment to decide between timing and conditioned reinforcement involves comparing (1) choices in which responses lead to the same /non-differential/ stimulus signaling different reinforcement schedules, versus (2) choices in which response lead to /differential/ stimuli signaling differentially signaled reinforcement schedules (e.g., McDevitt & Williams, 2001). We have conducted a series of such experiments with pigeons finding that initial-link latency varies with time-to-reinforcement in the case of differential stimuli in terminal links, but not in the case of non-differential stimuli. These findings suggest that a mixture of timing and conditioned reinforcement determine responses in the initial-links of concurrent schedules. However, we believe that our findings and those of others show that terminal-link signals function in an /assignment-of-credit role/ in which initial- and terminal-link signals combine to provide a signal for time-to-reinforcement.

12:00 - 1:30 Lunch Break

Equation 2: Recognize this equation?

$$AICc = n \cdot \log_e \frac{RSS}{n} + 2K\left(\frac{n}{n-K-1}\right)$$

(Answer on p.32)

1:30 - 2:05 Diffusion in Time Predicts Rate of Forgetting

Geoffrey White
University of Otago (New Zealand)

In the model for remembering described by White and Wixted (JEAB, 1999), discriminability is predicted by the extent of overlap of distributions relating the likelihood of reinforcers for alternative choices to stimulus value. The forgetting function is predicted by the rate at which the standard deviation of the distributions increases as a function of time since occurrence of the to-be-remembered event (diffusion). The relation between diffusion and time determines the form of the forgetting function. Data from a delayed matching-to-sample procedure are presented in an attempt to quantify the optimal relation.

2:05 - 2:40 Numerosity Differentiation in the Pigeon: Problems, Data, and Models

Armando Machado
University of Minho (Portugal)

I identify three problems with the standard model of numerosity discrimination in animals (i.e., Meck and Church's adaptation of Scalar Expectancy Theory) when the model is applied to the following situation: In order to receive a reward, a pigeon must peck the left key a minimum of k times and then switch to the right key (Mechner's Fixed Consecutive Number with parameter k, or FCN k). The first problem is that because of directional selection the model predicts increasingly longer run lengths on the left key, which is contrary to fact. The second problem is that the model does not account for the animal's relative inefficiency in collecting the rewards (mean run length is close to k and therefore a significant proportion of available rewards is not collected). The third problem is the model's failure to explain how the animal detects a decrease in the reinforcement criterion k. I present a new model of numerosity discrimination that solves these problems and contrast the model with new data.

2:40 - 3:15 Visually-Guided Capture of Moving Objects by Pigeons: Effects of Disappearance and Occlusion

Kimberly Kirkpatrick & Anna Wilkinson
University of York (UK)

Four experiments examined the ability of pigeons to track moving objects on a touch screen monitor. In Experiment 1, three birds were presented with a small round object that could appear from multiple locations along the four sides of the monitor and moved directly to the opposite side of the screen, or on some trials made an abrupt turn of 90 degrees at a random point in the path. An analysis of the turn trials indicated that the initial motion played a strong role in predicting post-turn search behavior. In Experiments 2a and 2b, test trials were administered during which the object disappeared at a random point for either 1.2 cm or 3.6 cm of the total path, after which it reappeared and either continued in a straight line or turned 90 degrees. The performance on disappearance trials was highly similar on both straight and turn trials, indicating that the disappearance did not reset search behavior after the turn. Experiment 3 examined the effect of partial occlusion in which the object disappeared behind a 1.2 x 1.2 cm square. Here, the effect of the prior motion on responding after a turn was reduced by the occluder. The combined results suggest that the effect of prior motion on post-turn behavior is due to a perseveration of particular motor patterns rather than a visual after-effect.

3:15 - 3:30 Coffee Break

3:30 - 4:05 Dynamics of Choice: Studies with Rats

Carlos F. Aparicio
University of Guadalajara-CEAA (Mexico)

Recent research with pigeons has examined the effects of behavioral adjustment of the range of within-session changes in the reinforcer ratio available from two alternatives. Regularity in the local effects of individual reinforcers on choice behavior emerged from such manipulation. The present studies manipulated the reinforcing environment of the choice situation to assess the generality of this finding with rats. Environment A arranged seven non-signaled reinforcer ratios to occur within the same session in two levers, each ratio provided 10 reinforcers and ended with a 1-minute blackout. In Environment B, every day a different reinforcer ratio was arranged in the levers, each ratio provided 70 reinforcers, and none of the seven reinforcer ratios operated for two consecutive days. In Environment C, the same reinforcer ratio remained in the levers for 15 consecutive days providing 70 reinforcers per session, after which, a different reinforcer ratio was randomly selected for the next 15 sessions. For several sessions, three groups of eight rats each responded to those environments in different order (group-1 A-B-C, group-2 B-C-A, and group-3 C-B-A). In all cases, the response ratios adjusted to changes in the reinforcer ratios. But environment dependent effects on sensitivity to reinforcement (the parameter s) were observed.

4:05 - 4:40 Earning Magnitudes of Reinforcers Influences Choice

James MacDonall
Fordham University (USA)

According to the at-the-alternative model of concurrent choice subjects choose to respond at one alternative or to switch from that alternative; thus, concurrent choice is made up of two sets of these choices. Each choice is controlled by the reinforcers *earned* per-visit for staying at the alternative and for switching from the alternative (MacDonall 2000, MacDonall, Goodell & Juliano, 2006). The present experiment extends this model to choices between earning different magnitudes of reinforcers. Previous research showed that the ratio of obtaining reinforcers was not a *necessary* condition for changing preference (preference changed when the reinforcer ratio was unchanged) and not a *sufficient* condition for changing preference (the reinforcer ratio changed but preference did not change). The purpose of the following experiment was to see if changing the ratio of the magnitudes of reinforcers obtained at the alternatives were necessary and sufficient conditions for changing preference. Six rats were trained on a two-lever concurrent random-interval schedule with the reinforcer delivered following a response for: Staying at the left lever, switching from the left lever, staying at the right lever and switching from the right lever. Across conditions the magnitudes of the reinforcers for these four responses varied. Preference changed when the ratio of the reinforcer magnitudes was constant – that is, changing the ratio of the reinforcer magnitudes was not necessary for changing preference. For some rats, preference was unchanged when the ratio of reinforcer magnitudes changed – that is, the ratio of reinforcer magnitudes was not sufficient to change preference. Overall, the generalized matching law did not adequately describe the response preferences but did adequately describe the time preferences. An equation based on the at-the-alternative model adequately described each rat's response and time preferences and these descriptions were better than those provided by the generalized matching law.

4:40 - 5:15 Additive Discounting Models of Reinforcement

Michael Lamport Commons & Alexander Pekker
Harvard Medical School & University of Texas (USA)

This paper presents the development of two models on additive discounting models of reinforcement that follow Fantino's original work. These are Commons and Woodford's Linear Noise Model (1982) and Mazur's Hyperbolic value addition (2001). Here the models are compared both historically and in the present. These models are quite related. How do they differ? After tracing the history of these models, a series expansion of them is performed to see how far out the terms begin to differ and in what form. Which instances in which one model does better than the others is described.

5:30-6:15 Business Meeting

Equation 3: Recognize it?

$$P(A) = \sum_{\omega_j \in A} P(\omega_j)$$

(Answer on p. 32)

6:30-9:00 Poster Session/Cash Bar
Located in Randle A & B

SQAB Books Available at Conference Prices

A limited number of remaining volumes from **The Quantitative Analyses of Behavior** series will be available at the SQAB meeting registration desk for discounted purchase.

SQAB thanks the Association for Behavior Analysis (ABA) International for generous support that helped to make this meeting possible, and encourages SQAB participants to take advantage of the ABA convention that begins immediately following the SQAB program. The ABA program includes many presentations on experimental and applied behavior science. A separate registration fee and badge are required to attend the ABA meeting.

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Effects of Frequently-Changing Food Ratios with Changing Food Rates

Michael Davison & William M. Baum
The University of Auckland (New Zealand) & University of California, Davis (USA)

A series of experiments reported by Davison, Baum, and others have investigated many aspects of performance on concurrent variable-interval schedules that change frequently across components within sessions. They kept the overall food rate the same across components, but the original paper using this procedure (Belke & Heyman, 1994), which was focused on Herrnstein's hyperbola, did not do this: They kept one of the concurrent schedules constant, and varied the other across components. In the present research we used the Belke-Heyman variant, with 4 different constant-VI schedules, and analysed the data using the procedures we developed, and added a new analysis. Most notably, preference pulses were larger on the alternative that changed between components than on the unchanged schedule, and preference pulses occurring across food continuations were additive, the increment increasing according to a negatively-accelerated curve. This latter finding critically informs the quantitative modelling of preference pulses.

Comparison of Bird vs. Human Performance in Category Learning Tasks

Mark E. Berg & Randolph C. Grace
University of Canterbury (New Zealand)

Five humans completed a category-learning task in which they had to make one of two responses to Gabor stimuli (i.e. sine wave gratings modulated by a circular gaussian filter) that were presented on a computer display. The stimuli varied in terms of frequency and orientation (cf. Maddox & Ashby, 2003), and participants were required to attend to both dimensions in order to achieve high accuracy. Two conditions were included in which the orientation varied over a relatively wide (90 degrees) or narrow (10 degrees) range. Subjects were counterbalanced for both key location and condition order and completed two sessions for each condition. For all subjects, higher accuracy was achieved in the wide range condition. This experiment is the first of its kind using Gabor images in a within subjects design comparing narrow and wide range orientation conditions in a multi-dimensional task. Performance was different from the results of pigeons in a similar task.

Examining Preference for Variable Response Topography in Pigeons

Eric A. Thrailkill
Arizona State University (USA)

When given a choice between obtaining food by pecking one response key and obtaining the same amount of food by pecking either one of two keys, pigeons prefer to the latter over the former. This is known as the preference for "freedom of choice" (or PFC; Catania, 1975, 1980). The purpose this research is to (a) replicate the PFC effect, and (b) determine whether this preference is dependent on the association of food with instrumental responses of variable topography. First, we replicated the PFC procedure using a standard three-key operant chamber, and a touch-screen mounted in a modified pigeon chamber. Second, pigeons were provided with a choice between having one key in a fixed position, and having one key in a variable location as test of a preference for variability in response topographies associated to food. The versatility of the touch-screen allows a direct measurement of pigeon's preference for variable response topographies.

Category Perception, Category Propagation, and Equivalence for the Natural Communication Signals of Songbirds

Ronald Weisman, Laurie L. Bloomfield, Tara M. Farrell, Marc T. Avey, & Christopher B. Sturdy
University of Alberta & Queen's University (Canada)

The most important perception is not that two things are different but rather that they are similar. The authors summarize progress in research on how songbirds (oscines) categorize acoustic communication from conspecifics (other members the same species). Category perception for the learned songs and calls of oscines are well described by three rules: The exemplars of different vocal categories are more easily discriminable one from another than exemplars of the same vocal category. Vocal categorization transfers to novel exemplars of the same categories. Vocal communication is the conjoint adaptation of production and perception, so that the biacoustic features and auditory perception of note types and larger units such as songs and calls determine their categorization. The authors contrast studies of visual and acoustic category perception in birds. They conclude that interpretation of studies of visual category perception in birds is problematic because the photographic images presented are constructed for human not avian eyes. In contrast, the acoustic reproduction of avian communication is effective in eliciting the same responses as communication produced by the birds themselves. Studies of the natural communication signals of birds offer an opportunity to provide direct explanations of category perception.

Equation 4: Recognize this?

$$P(k) = \frac{n!}{k!(n-k)!} p^k q^{n-k}$$

(Answer on p. 32)

Equation 5: Recognize this?

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-(x-m)^2/2\sigma^2}$$

(Answer on p. 32)

Delay Discounting of Appetitive and Aversive Stimuli: Analysis of Mathematical Models

Fábio Leyser Gonçalves & Maria Teresa Araujo Silva
Universidade Presbiteriana Mackenzie & Universidade de São Paulo (Brazil)

Choices between immediate and delayed appetitive stimuli have been studied trough mathematical models. Few studies have investigated the situation involving delayed and immediate aversive stimuli. The aim of this research was to evaluate some of these models when the aversive scenarios are presented. Participants were 36 volunteers, undergraduate students, aged 18 to 28, both sexes. A titration procedure was used in which participants choose between a fixed delayed value of R$1,000.00 (1 week to 25 years) and a variable immediate value that could range from R$1.00 to R$1,000.00 in either a gain situation (appetitive-APT) or a payment situation (aversive-AVS). For each delay and in each situation an indifference point representing the immediate value of the delayed value was calculated. The analysis of the mathematical models revealed that two hyperbolical with exponent models described also the data in APT. For the AVS situation the models found in the literature failed to describe the data obtained. An alternative model has been proposed in which the aversive value of the delay is modulated by two parameters and added to the Hyperbolic-Exponential model. Such model was effective in describing the data obtained in the AVS situation and could be generalized to the APT situation.

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Parameters of Delay Discounting Assessment: Number of Trials

Elias Robles & Perla A. Vargas
Arizona State University & University of Arkansas for Medical Sciences (USA)

Previous studies have shown that procedural variants in estimating delay discounting (DD) may lead to within-subjects differences in behavior and estimated degree of DD. In this study, participants (n = 35) were assessed with two computerized DD tasks where the delayed reward was a hypothetical $1000, and 8 delays and 30 immediate hypothetical cash values were compared. In one assessment (*Full-Length*), all 240 trials were presented in either ascending or descending order, regardless of the subjects' choices. In the other assessment (*Abbreviated*), once a subject had shown indifference between the immediate and delayed rewards for a given delay value, the remaining trials for that delay value were omitted. RESULTS: Estimated degree of DD, as area under the curve, did not differ (t (34) = -.78, p = .43) between assessment methods. In addition, a significant correlation (R^2= .44, n= 35, p < .0001) in estimated degree of DD was found. Reaction times (RT) varied systematically, with a higher probability of longer RT around the indifference point trial. Scores on the visual analog scales "very easy-very difficult" and "boring-interesting" revealed no differences between the methods. Finally, the Abbreviated method led to 66% less trials per subject on the average, considerably reducing the total duration of the assessment session.

Equation 6: Recognize it?

$$R = \left[l\, n\left(m\, e^{1/r} + b \right) \right]^{-1}$$

(Answer on p. 32)

Pitch Contrast in the Perception of the Meter of Auditory Polyrhythms

Nigel O. Lay & Mark Hedrick
University of Tennessee (USA)

Rhythmic sequences were presented monaurally through headphones to each [human] participant, who tapped the meter on a pressure-sensitive key. The taps were recorded as MIDI (Musical Instrument Digital Interface) events in a music production software program. Six polyrhythmic organizations were used: 2x5, 2x7, 3x5, 2x3x7, 2x5x7 and 3x4x5. The first frequency condition was a no-contrast condition in which all pulses in the polyrhythms were at musical note C4. The second was a low-contrast condition which, in the case of the two-part polyrhythms, consisted of one pulse train being presented at C4 while the other was presented at G4. Each pulse train was presented at each frequency. In the case of the three-part polyrhythms, two pulse trains were presented at C4 while the third was presented at G4, and the frequency arrangement was reversed, so that two pulse trains were presented at G4 while the third was presented at C4. In both arrangements each pulse train served as the contrastor. The third frequency condition was a high-contrast condition in which the musical notes used were C4 and G6. The conditions were the same as in the low-contrast group. There were 54 arrangements in all. Results suggest that S's tend to prefer contrasting-pitch and slower pulse trains.

Real-Time Computer-Based Temporal Discounting in College Students

Makenzie D. Williams, Heidi L. Eyre, Jade C. Hill, M. Gaus Alam, Kayla Ogura, & Andrew Sanders
Jacksonville State University (USA)

Behavioral researchers have found that temporal discounting data are best represented by a hyperbolic curve rather than an exponential curve. This indicates that organisms usually prefer smaller-sooner payoffs to larger-later payoffs. The purpose of this study was to conduct a computer-based assessment of real-time temporal discounting in undergraduate students. The computer program presented students with the opportunity to earn extra credit through a series of choices. Students had the choice of receiving a minimum amount of extra credit immediately (smaller-sooner) or successively larger amounts of extra credit for increasing lengths of time (larger-later). Based on student choice, the computer would go blank for the length of time chosen followed by the awarding of extra credit. This program was composed of 10 trials with the length of time for the larger-later payoffs becoming progressively larger. Results will focus on which type of curve best represents the data and how students' tendencies to engage in temporal discounting correlates with their course performance.

Evidence for Retrospective and Prospective Spatial Coding by Pigeons May Result from Faulty Assumptions

Cassandra Gipson, Kelly DiGian, & Thomas Zentall
University of Kentucky (USA)

In a radial maze task, when a delay is interpolated at different points in the trial (over trials), rats show evidence of both retrospective and prospective memory (Cook, Brown, & Riley, 1985). This effect has been replicated in pigeons but it relies on the assumption that subtracting control-trial errors from delay-trial errors results in errors solely attributable to the delay. In the present research, this assumption was avoided by including a binary choice involving one already visited and one not yet visited alternative following each point of delay interpolation and also pigeons were prevented from selecting the order of the stimuli chosen. We found that relative to control trial accuracy, on delay trials there was a constant error rate attributable to the delay (i.e., there was a general memory loss attributable to the delay). Thus, the findings from earlier research may have resulted from inappropriate assumptions.

Equation 7: Recognize it?

$$V = \sum_{i=1}^{n} P_i \left(\frac{A}{\left(1 + K \cdot D_i\right)} \right)$$

(Answer on p. 32)

Equation 8: Recognize it?

$$\frac{T_1}{T_1 + T_2} = \frac{R_1}{R_1 + R_2}$$

(Answer on p. 32)

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Quantity:

_____ **Paul Andronis**
Evolution (1999)

_____ **Peter Balsam**
Pavlovian Conditioning (2000)

_____ Associators, Accumulators, and Cartographers (2000)

_____ Time, Uncertainty, and Anticipation (2007)

_____ **William M. Baum**
Choice (1998)

_____ **Marc Branch**
Behavioral Pharmacology (2000)

_____ **Gordon Burghardt**
Evolution, Behavioral Variation, and Plasticity (2000)

_____ **José E. Burgos**
Neural-Network Modeling in Conditioning Research (2006)

_____ **A. Charles Catania**
Creating Artificial Behavior: A Tutorial on Modeling (2006)

_____ **Daniel Cerutti**
Temporal Regulation of Choice (2005)

_____ **Russell Church**
Simulation of Quantitative Models of Behavior (2005)

_____ **Robert Cook**
Stimulus Control (2007)

_____ **Michael Davison**
What Reinforcers Do to Behaviour (2001)

_____ **John Donahoe**
Neural Networks (1999)

(continued on next page)

3:00-3:50 Stimulus Control

Robert Cook
Tufts University (USA)

Chair: Thomas Zentall
University of Kentucky (USA)

Stimulus control is one of the essential features of behavior, as animals learn to differentially behave to specific stimuli in a remarkably wide variety of settings. This important capacity allows animals to adaptively organize their behavior to both present and future situations. This tutorial will provide an overview of this topic, its fundamental methods, established principles and mechanisms, and outstanding problems and issues. These themes will be illustrated in part by new advances in the study of object perception, the relationship between stimulus-specific and relationally-controlled modes of behavior, and the organization of behavior over time.

4:00-4:50 Time, Uncertainty and Anticipation

Peter D. Balsam
Bernard College & Columbia University (USA)

Chair: Ralph Miller
SUNY-Binghamton (USA)

Even in the simplest of conditioning procedures animals learn about temporal relationships between events, sometimes over long delays. The encoding of temporal information seems to be automatic and occurs from the very start of learning. The temporal information affects how long it takes for conditioned responses to emerge and the form and timing of the learned behavior. Formal information theory applied to temporal signals provides an accurate description of the speed with which anticipation develops. The sense of time may even be the scaffolding on which experience is encoded.

SQAB thanks the Association for Behavior Analysis (ABA) International for generous support that helped to make this meeting possible, and encourages SQAB participants to take advantage of the ABA convention that begins immediately following the SQAB program. The ABA program includes many presentations on experimental and applied behavior science. A separate registration fee and badge are required to attend the ABA meeting.

The **Developmental Behavior Analysis SIG (DEV**) invites you to attend the following invited talks in the ABA program:

Tutorial: Parallels in Processes of Avian and Human Vocal Learning
Michael H. Goldstein (*Cornell University*) Sunday 10:00 AM - 10:50 AM in Douglas B

Interbehavioral Psychology in Service to Behavior Analysis
Linda J. Parrott Hayes (*University of Nevada, Reno*) Monday 11:00 AM - 11:50 AM in Douglas C

Evolutionary Theory is the Proper Framework for Behavior Analysis
William M. Baum (*University of California, Davis*) Monday 2:30 PM - 3:20 PM in Douglas C

Hyperbolic Discounting: Stochasticity or Rate Computation? Experiments with European starlings (*Sturnus vulgaris*)

Justine Aw & Alex Kacelnik
University of Oxford (UK)

Hyperbolic discounting is often attributed to a misperception of probability of loss, but can alternatively occur if subjects compute the value of sources of reward according to the ratio of gain over time between choice and outcome in each option. While the former view assumes that animals fail to some extent to learn actual probabilities, the alternative predicts preferences directly from experimental parameters. We tested starlings' preferences between a fixed option and variable option which delivered either of two outcomes. We systematically varied the probability of the more desirable of the two variable outcomes (the larger of two possible amounts or shorter of two possible delays). Starlings adjusted their choices to the programmed probabilities exhibiting preferences quantitatively consistent with the rate hypothesis. We suggest that the stochastic hypothesis for hyperbolic discounting in animals should be abandoned and that hyperbolic discounting results from an adaptation to cope with repeated, rather than one-shot choices. As an adaptive explanation for the maximization of the ratio of mean reward to mean choice-reward interval we refer to credit attribution: animals assign value to each option according to the experienced outcomes, disregarding components of the cycle common to all alternatives, such as the inter-trial interval.

Artificial Neural Networks That Learn Under Non-Optimal CS-US Intervals

José E. Burgos
University of Guadalajara – CEIC (Mexico)

When a conditioned stimulus (CS) is paired with an unconditioned stimulus (US) using a non-optimal (too-long or too-short) CS-US or interstimulus interval (ISI), conditioned responding (CR) is severely reduced. This reduction is typically explained as a learning deficit. This paper presents simulations that favor a different explanation: Non-optimal ISIs produce a performance deficit. The simulations were based on a neural-network model whose learning function takes into account the role of hippocampal and dopaminergic systems in conditioning. A network first received 200 CS-US pairings with a non-optimally long ISI, which produced low CR. Then the network received 200 CS-US pairings with an optimal ISI. This treatment produced faster acquisition than that observed in another network which received only 200 CS-US pairings with the optimal ISI. Comparable results were observed with a non-optimally short ISI. The mechanism is the same one that accounts for faster reacquisition after extinction in the present model. In a layered network, weights in deeper layers are protected against the reducing effect of nonreinforced segments of the CS.

Equation 9: Recognize it?

$$\frac{B_L}{B_R} = b\left(\frac{R_L}{R_R}\right)^{a_1}\left[\left(\frac{1/D_L}{1/D_R}\right)^{a_2}\left(\frac{X_L}{X_R}\right)^{a_x}\right]^{(T_t/T_i)}$$

(Answer on p. 32)

Effects of Varying Stimulus Disparity and Relative Punisher Ratio on Human Signal Detection

Celia Lie & Brent Alsop
Victoria University of Wellington & University of Otago (New Zealand)

McCarthy and Davison (1984) identified two different response bias functions using a signal-detection procedure with pigeons. When stimulus disparity was varied with constant, controlled reinforcer ratios, isobias functions were found. However, when stimulus disparity was varied using uncontrolled reinforcer ratios, alloiobias functions were found. Johnstone and Alsop (2000) systematically replicated this finding using human participants. The present study investigated bias functions from human participants when constant, controlled punisher ratios were arranged at different levels of stimulus disparity. We found that participants were biased away from the alternative associated with the higher rate of punishment, and data was better described by isobias functions than alloiobias functions. This provides further evidence that punishers have similar, but opposite, effects to reinforcers in detection procedures.

Habituation Dynamics of Tap-Elicited Swimming in the Zebrafish, *Danio rerio*

D. T. Cerutti, Z. Bencan, J. Jozefowiez, & E. D. Levin
Duke University (USA)

The zebrafish shows a vigorous burst of swimming in response to a sharp tap. We studied habituation of the tap-elicited swim with emphasis on the effect of stimulus rate, dishabituation, and recovery from habituation. Habituation of swim bursts shows properties similar to those found with other species; however, parametric studies of swim burst recovery indicate two processes contributing to habituation: a fast acting process that decays in 4-5 minutes; and a slower time-lagged process that decays in many hours.

Computational Model of Selection by Consequences: Cumulative Records and Log Survivor Plots

Saule Kulubekova & J. J McDowell
Emory University (USA)

The poster presents the details of responding of the computational model of selection by consequences proposed by McDowell (JEAB, 81(3): 297–317). The model has an evolving repertoire of behaviors which continuously undergoes selection, reproduction, and mutation over many generations and is based on the computational approach, which is non-deterministic and rules-based. The model consistently showed a hyperbolic relationship between response and reinforcement rates, described by the quantitative law of effect. The current project focuses on the molecular patterns and examines the details of responding using cumulative records and log survivor plots.

The Society is committed to simplifying the transition to quantitative analyses for both researchers and students. To this end, the Society sponsors a set of tutorials, *From Basic to Contemporary Paradigms*, given by preeminent researchers/teachers in the field. Inexpensive videotapes and DVDs of these tutorials for classroom use are available (see pages 37-40).

1:00-1:50 Getting Started in Quantitative Analyses of Behavior

James MacDonall
Fordham University (USA)

Chair: Alliston Reid
Wofford College (USA)

The purpose of this tutorial is to help those who are interested in attempting quantitative analyses. As an organizing theme I will use my experiences to provide some suggestions for how to get started. Included will be suggestions for organizing data using several common computer programs for data analyses, and for avoiding some of the pitfalls that await the unwary. While there will be something for everyone, I am going to focus on providing guidance to those not already engaged in quantitative analyses.

2:00-2:50 The Law of Affect

Peter Killeen
Arizona State University (USA)

Chair: Mark Branch
University of Florida (USA)

Skinner divorced the Law of Effect from Thorndike's satisfiers, and remarried it to a change in the frequency of the response being reinforced; the Operant Canon holds that reinforcers need not be pleasurable. But why then was our ability to be pleasured selected for over our evolutionary history? Is it in fact generally to our evolutionary advantage to increase the frequency of responses that are reinforced? Thorndike operationally defined satisfiers as a state of affairs that an animal does nothing to avoid, often doing things to attain and preserve. This tutorial urges us to replace Skinner's version of the law with Thorndike's; it reinterprets common experimental and applied methods and analyses in Thorndike's terms; it invites us to take pleasure in taking pleasure back into our analyses, and to savor the possibilities of this old fashioned revolution in our analyses.

9:45 - 10:20

A Language for the Formal Description of Complex Behavioral Contingencies

Francis Mechner
The Mechner Foundation (USA)

A language is presented, with its specialized vocabulary and syntax, for analyzing and diagramming any system of behavioral contingencies, including intricate ones encountered in the fields of law, business, economics, public affairs, sociology, and education.

- A → , read as, "If act A occurs, then consequence C." The agent of the A is indicated by a pre-subscript (e.g., $_{a}$A, $_{bc}$A).
- T →, read as "When time T (or vT) terminates, then consequence C."
- Any contingency represented by a horizontal arrow is terminated when it is cut by a vertical arrow originating from another A or T.
- Presubscripts of C indicate the party(ies) that perceive a C, and the notation C^{a+} *or* C^{ab-} indicates the C's valence for each party.
- Arrows are labeled according to party(ies) that are aware of the denoted contingency.
- Additional notational devices indicate probabilities, magnitudes, estimations, or misperceptions by the various parties.

This language's ability to express the myriad nuances of meaning needed to provide the required generality and reach is illustrated by its application to examples like fraud, betting, blackmail, various games, theft, setting traps, contracts, elections, global warming, racing, competition, mutual deterrence, feuding, bargaining, deception, loan transactions, insurance, personal tipping, vigilance, sexual overtures, decision making, mistaken identity, etc.

A process is described for applying this contingency analysis system to practical problems in areas like those listed above. First, the user, responding to prompts, registers all the relevant known information about the situation to be analyzed. Software then converts this information into virtual multi-dimensional behavioral contingency structures, and models the way these would play out, using a data base consisting of relevant knowledge from the field of behavior analysis. Finally, the result can be fine-tuned or modified by iteratively revisiting the information that was entered.

10:20 - 10:55

Foundations of Science [Check Your Favorite]: □ Contingency □ Complexity □ Causality □ Codability

Peter Killeen
Arizona State University (USA)

Skinner and Sidman redirected us from the testing of hypotheses to the creation of orderly data, from the experimental analysis of behavior to its experimental synthesis. Theory was recovered with the various laws of matching and timing, and with other ad hoc covers for otherwise undisciplined fiddling with keys and levers. Transcendence of such random-access word/symbol/number/animal rearrangements requires rethinking foundations. I review five models of science. *Contingency* treats all variables as random: Our task to reduce their variance. *Complexity* sees order emerge from the permutations of simple entities with simple rules of engagement: Our task to identify them. *Causality*—Aristotle's fourfold way—treats the efficient (S^d), final (S^R), material (neural) and formal (models) becauses as orthogonal dimensions of knowing: Our task to characterize and inter-relate them. *Codability*—Mach's *Science as Shorthand*—reduces contingent complexity to glosses: Our task to write them. *Consilience* subsumes these characterizations by use of tools such as Rissanen's Minimum Description Length to maximize the mutual information in the theory/data relation. The implications of Consilience for everyday practice are explored.

Evaluating the Mathematical Principles of Reinforcement: Contextual Cues Affect the Parameters of Killeen's (1994) Model

Pablo Covarrubias & Carlos F. Aparicio
University of Guadalajara (Mexico)

According to the Mathematical Principles of Reinforcement (MPR), the parameter of specific activation (*a*) represents the motivational state of the organism which is sensitive to the quality of the reinforcer and contextual conditioning, and the parameter of response time (δ) is sensitive to motor requirements of responding. The present study assessed the generality of those parameters with rats responding to progressive ratio (PR) schedules of reinforcement. To affect *a*, we manipulate the quality of reinforcers (food vs. saccharine) and the context of reinforcement (signaled vs. non-signaled reinforcer). The value of δ was affected by increasing the ratio requirement (PR1 vs. PR3). Results showed that the rats completed more ratios and reached higher response peaks for saccharine reinforcers than for food reinforcers. But these dependent variables reached the highest values when either food or saccharine was signaled (contextual conditioning). The parameters of MPR, however, did not change in systematic way as a function of these manipulations

Effects of Haloperidol on Progressive Ratio Performance

Pablo Covarrubias & Carlos F. Aparicio
University of Guadalajara (Mexico)

The idea that dopamine (DA) regulates motivational and motor aspects of instrumental behavior is widely discussed in the field of neurosciences. Recent studies suggest that DA also affects the role of stimuli present in the context of reinforcement. To explore these possibilities, the parameters of activation (*a*) and response time (δ), in Killeen's (1994) model, were used to estimate the effects of haloperidol on the rats motivation for food and motor components of lever-pressing, respectively. Progressive ratio (PR) schedules of reinforcement were used to manipulate the type of reinforcer, the size of the ratio, and the context of reinforcement. With steady state performance, four doses of haloperidol (0.5, 0.10, 0.15, 0.20 mg/kg) were assessed (ip) over a twelve-day period. Results showed that the number of completed ratios and the peak of the response decreased as a function of increasing dose of haloperidol, but the parameters of activation (*a*) and response time (δ) did not reflect those changes in systematic way.

Equation 10: Recognize this?

$$\frac{B_1}{B_2} = b\left(\frac{r_{i1}}{r_{i2}}\right)^{a_i}\left(\frac{V_{t1} - a_t V_i}{V_{t2} - a_t V_i}\right)$$

(Answer on p. 32)

Assessing Sensitivity to Within-Session Variation of Reinforcer Frequency in Conditional Discrimination

Ryan D. Ward & Amy L. Odum
Utah State University (USA)

A procedure for examining sensitivity to within-session variations in reinforcer frequency was developed. Four pigeons responded on a multiple schedule of matching-to-sample components in which the ratio of reinforcers for correct S_1 and S_2 responses was varied across components within session. Initially, 5 components, each arranging a different reinforcer-frequency ratio (from 1:9 to 9:1), alternated randomly within a session. Under this procedure, sensitivity to variations in reinforcer frequency was low (<.20). Sensitivity failed to improve after extended exposure to this condition, and under a condition in which 3 reinforcer-frequency ratios were varied within session. In a later condition, 3 reinforcer frequency ratios were varied within session, but the reinforcer- frequency ratio in effect was differentially signaled within each component. Under this procedure, values of sensitivity were similar to those traditionally obtained when reinforcer-frequency ratios are varied across conditions (.61). Trial-by-trial analyses of steady state performance showed that response bias and sensitivity generally reached their terminal values early in a component and maintained these levels through the remainder of the component.

Patients with Schizophrenia Demonstrate Altered Neural Activation Associated with Temporal Difference Errors in a Classical Conditioning Paradigm

Julie Schweitzer, James Waltz, Emma Jane Rose, Betty Jo Salmeron, Kimberly Warren, James Gold, Thomas Ross, Pradeep Kurup, Yihong Yang, Samuel McClure, & Elliot Stein
University of California, Davis; University of Maryland School of Medicine; National Institute on Drug Abuse; & Princeton University (USA)

It is now recognized that schizophrenia is associated with impaired learning and reward processing. Altered brain dopamine systems may underlie the impaired learning in schizophrenia. We predicted that patients with schizophrenia would produce attenuated brain activation to temporal difference errors (TDEs), particularly in the basal ganglia, a major dopamine target area. TDEs occur when there is a mismatch between an expected and actual outcome and are hypothesized to underlie learning. A positive TDE occurs when an outcome is better than expected and a negative TDE when the outcome is worse than expected. A classical conditioning task (McClure et al., 2003) combined with fMRI tested for TDEs in patients with schizophrenia (n=9) and controls (n=9). Subjects learned a juice squirt would occur exactly 6 sec after the presentation of a yellow light during training. "Catch trials" were intermixed among standard trials during fMRI acquisition with juice delivery occurring 10-13 sec after the light stimulus, rather than at the expected 6 sec after the light, serving as negative TDEs. Unexpected juice delivery 4-7 sec later served as a positive TDE. Patients demonstrated reduced brain activation in multiple areas, associated with the unexpected delivery of the juice reward, including bilateral putamen and inferior frontal cortex, and left insula and claustrum in comparison to controls. These results suggest schizophrenia is associated with altered TDEs and may contribute to learning deficits found in the disorder.

7:00-8:15 Registration, Coffee, Pastries

8:15-8:50 A Discrete-Trial Contrast Effect and Its Implications for 'Cognitive Dissonance' Theory

Thomas R. Zentall & Rebecca A. Singer
University of Kentucky (USA)

Humans often value reinforcers more when they follow more effortful or more aversive (i.e., less preferred) events. For example, college students rate groups more favorably when the initiation requirements to join the group are more aversive (Aronson & Mills, 1959). Although this effect has been attributed to the *justification of effort*, a form of *cognitive dissonance* in which the discomfort that comes from the inconsistency between one's beliefs (avoid aversive events) and one's behavior (going through the initiation), we have found that pigeons show a similar effect. For this reason, we have proposed an alternative account, based on contrast, in which prior aversive events are contrasted with the reinforcers that follow. According to this theory, the greater the contrast between the aversive event and the reinforcer, the greater the value of the reinforcer that follows. In a series of studies we have found such contrast effects with differential prior effort (differential response requirement), differential delay, and the absence of food (in the context of food on other trials). We have also distinguished this effect from delay reduction (signals that reduce the delay to reinforcement are preferred over those that do not; Fantino & Abarca, 1985) by holding constant delay reduction and showing that a pigeon's preference for an initial event is negatively correlated with its preference for the conditioned reinforcer that follows.

8:50-9:25 Signal-Detection Theory: A Comparison of the Direct Rating Method vs. ROC Analysis

John Wixted, Laura Mickes, & Peter Wais
University of California, San Diego (USA)

Signal-Detection Theory applies to many situations in which there are two states of the world (e.g., an item was seen earlier in the session or not) and the subject's decision about an item is based on a continuously distributed, unidimensional psychological variable (e.g., memory strength). The psychological variable of interest cannot be directly measured, and that fact, coupled with detailed assumptions about the way in which that variable is distributed (e.g., according to a Gaussian distribution) -- assumptions that can only be tested using esoteric techniques like ROC analysis -- renders the entire approach too theoretical for some. We investigated the basic assumptions of signal-detection theory more directly in the context of a recognition memory experiment by asking subjects to simply rate the memory strengths of targets and lures using a 20-point strength scale. In virtually every respect, the results from this direct method replicate what one finds using less direct ROC method.

9:25 - 9:45 Coffee Break

I would like to express the Society's appreciation to each of the presenters, our advertisers, and to the following journals and societies:

The Behavior Analyst
Behavior Analyst Today
The Psychonomic Society
Behavioural Processes

Alliston Reid
(Program Chair)

Answers to "Recognize the Equation?"

1. The generalized matching law expressed as a linear function
2. The second-order Akaike information criterion in units of information
3. The additivity of the probabilities of independent events
4. The binomial distribution
5. Density function of a normal distribution with mean *m* and variance σ^2
6. McDowell & Kessel's (1979) linear system theory's rate equation
7. Mazur's (1989) hyperbolic decay model
8. Time allocation version of Herrnstein's (1961) matching law
9. Grace's (1994) contextual choice model
10. Mazur's (2001) hyperbolic value-added model
11. Definition of a Markov chain
12. Kagel, Battalio, & Green's (1995) utility function, assuming constant elasticity of substitution
13. Staddon's (1979) minimum-distance model, assuming the free-operant level of responding is zero
14. Coupling coefficient for VI schedules in Killeen's (1994) Mathematical Principles of Reinforcement
15. Simplest form of Delay Reduction Theory (Fantino, 1969)
16. Behavioral momentum theory (Nevin & Grace, 2000)
17. Davison & Jenkins (1985) contingency-discriminability model
18. The diffusion rule in Reid & Staddon's (1998) route-finder model
19. Killeen's (1998) First Principle of Reinforcement
20. Rescorla & Wagner (1972) model
21. Staddon & Zanutto's (1998) cascaded-integrator feeding model
22. McDowell, Bass, & Kessel's (1993) linear system's theory

Of course, lots of other interesting equations could have been included.
After all, this is the Society for the Quantitative Analyses of Behavior!

Summation and Subtraction of Associative Strength with Visual Three-Element Compound Stimuli and Autoshaping in Pigeons

Bertram O. Ploog & Zane Ferguson
College of Staten Island & City University of New York (USA)

An autoshaping paradigm with superimposed response contingencies was employed in an attempt to assess stimulus summation and subtraction in pigeons. During training, the response requirements and the probability of food delivery were adjusted such that towards the end of training 12 of 48 trials ended in food delivery, the same proportion as under testing. Visual stimuli (outlines of squares of three sizes and colors — A, B, C) were used that could be presented separately or in any combination of two or three stimuli. Twelve pigeons (summation groups) were trained with either A, B, and C or with AB, BC, and CA, and tested with ABC. Additional twelve pigeons (subtraction groups) received training with ABC but were tested with A, B, and C or with AB, BC, and CA. Each of these groups of six pigeons was further subdivided into training and testing with stimulus elements that were presented either in a concentric or in a dispersed manner (distributed over the area of the key). Summation did not occur in any of the pigeons. Subtraction occurred in six birds (concentric arrangement). The results were analyzed according to two models (Pearce, 1987, and Rescorla & Wagner, 1972).

Equation 11: Recognize it?

$$P(X_{n+1} \in A \mid X_n = x_n, \ldots, X_o = x_o) = P(X_{n+1} \in A \mid X_n = x_n)$$

(Answer on p. 32)

The Effect of Two Extinction Procedures and Amount of Reinforcement on Resistance to Change

Alana E. Dulaney & Matthew C. Bell
Santa Clara University (USA)

This study is a systematic replication of an experiment conducted by Nevin (1974) that examined the effects of amount of reinforcement on key-pecking response rates and resistance to change in pigeons. The present study used a two-component multiple schedule. Each component presented reinforcement on a variable-interval 3-min schedule. One component presented 2-s of access to reinforcement and the other 8-s. Components were 10 min and were separated by 60-s blackouts. Extinction (in one condition the hopper and hopper light were not presented; in a second, the hopper and hopper light were activated but access to food was blocked) followed baseline training. Baseline response rates were significantly higher during the 8-s component. In addition, the 8-s component was more resistant to extinction compared to the 2-s component. The extinction procedure that included the hopper stimuli resulted in slower extinction compared to the more typical extinction condition. Amount of reinforcement affected both response rate and resistance to change as did the type of extinction procedure. Interestingly, however, the type of extinction procedure did not interact with amount effects.

The Three-Term Contingency, Learning, Working Memory, and Fluid Intelligence: A Replication and Extension of Williams and Pearlberg (2006)

Elaine Tamez, Joel Myerson, & Sandra Hale
Washington University (USA)

Based on early findings showing low correlations between intelligence test scores and learning on laboratory tasks, psychologists typically have dismissed the role of learning in intelligence. In 2006, however, B. A. Williams developed a verbal learning task inspired by three-term reinforcement contingencies and reported unexpectedly high correlations between this task and the Ravens Progressive Matrices (Williams & Pearlberg, 2006). The present study replicated this finding: Performance on the three-term learning task explained more than one-fourth of the variance in Ravens scores. Adding verbal working memory, measured using Engle's Operation Span task, did not improve prediction. Notably, this was not due to a lack of correlation between verbal working memory and Ravens. Rather, it occurred because most of the variance captured by verbal working memory was already accounted for by the three-term learning task. In contrast, when spatial memory spans were added to the regression model, approximately one-third of the variance was explained. Taken together with the findings of Williams and Pearlberg, the present results provide strong evidence for the role of learning in performance on intelligence tests.

What do these models have in common?

$$U = V_c C^m + V_d D^m$$

Equation 12

$$C = a(R - R_o)^w + b \cdot X^W$$

Equation 13

(Answer on p. 32)

Relations Between the Development of Pause, Response Rate, and Locomotion Under a Fixed-Interval Schedule of Reinforcement

Brian D. Kangas & Marc N. Branch
University of Florida (USA)

Six pigeons engaged in key pecking under a fixed-interval 3-min schedule of food presentation. The experiment was conducted in a modified operant-conditioning chamber with the floor divided into 6 equal-area panels mounted on microswitches to detect locomotion. Each pigeon was studied for 200 daily sessions with 15 intervals per session (3000 total food presentations). Analyses included examination of changes over sessions of mean pause in key pecking at the beginning of each interval, key-pecking rate, and locomotion. Relationships among the measures were assessed. In addition, locomotion (indexed by rate of floor-panel activation) during and after the pause was assessed separately, with results indicating that most subjects initially had a higher rate of locomotion during the pause. That difference, however, diminished across sessions.

A Method of Presenting 3D Objects as Stimuli in Discrimination Training

Renee Railton, T. Mary Foster, Bill Temple, & Catherine Sumpter
University of Waikato (New Zealand)

Artificial stimuli (e.g., pictures, slides, video or computer generated images) are often used as substitutes for real animals or objects in the study of animal perception. However, there is relatively little research addressing the issue of whether animals can or do interpret such two dimensional stimuli as the three-dimensional objects they represent and the results of this research are equivocal and often contradictory. One problem with undertaking such research is the difficulty of presenting real three-dimensional objects to the animals. This poster will describe equipment designed for this purpose and outline the methodology used to assess two dimensional/three dimensional equivalence for hens. The equipment allowed the presentation of small real objects (or their photographs) to the hens. Its use will be illustrated by data from a series of experiments in which hens learned discriminations between two objects (or between photographs of the objects), and then were tested to see if the discriminations generalized to the photographs of these objects (or to the objects). Some of the methodological problems encountered will be addressed.

Equation 22: Recognize it?

$$B(t) = \int_0^t G(t - t')R(t')\ d\ t'$$

(Answer on p. 32)

The Relation Between Concurrent Schedule Preference and Fixed Ratio Performance with Differing Food Durations

Amber Grant, Aimee Harris, William Temple, Catherine Sumpter, T. Mary Foster, & Amy Tannahill
University of Waikato (New Zealand)

Six hens' preferences between 3s versus 3s, 2s versus 8s, and 2s versus 12 s durations of access to wheat were measured using a concurrent schedules procedure. Their performances under increasing fixed-ratio schedules were then examined. The concurrent schedule preferences ranked the 12s reinforcer as most preferred, followed by the 8s reinforcer, and then the 2s reinforcer. However, when the FR schedules were small the hens responded fastest for the smallest reinforcer duration and slowest for the largest. This result would be expected if the hens were responding to attain approximately equal total amounts of food per unit time under the differing magazine duration conditions. Presentation of the data in terms of weight of food gain per session against the FR value suggests this was the case.

Social Discounting and Ultimatum Games

Bryan A. Jones, Brady A. Wilbanks, & Howard Rachlin
Stony Brook University (USA)

In ultimatum games one player (A) decides what portion of resources to offer to a second player (B). B must then accept the offer or reject it; a rejection ensures each player receives nothing. In experiment 1, participants acted as (A) and were asked to decide how much of an amount of hypothetical money to offer a person (B) at a given social distance. Half of the participants were tested with an ultimatum game in which B could reject the offered money. If the offer was rejected, neither player would receive anything. The other half were tested with a dictator game and told only that they could split the money with B. Participants offered more money in the ultimatum game than in the dictator game and offered a smaller portion of the overall amount of money when the magnitude of money available was greater. A hyperbolic social discounting function (Jones & Rachlin, 2006) predicted the amount of money offered as social distance increased. In experiment 2, participants acted as the receiver (B) in the ultimatum game. Participants accepted smaller offers from people at close social distances and required larger offers from people at greater social distances.

Exchange-Schedule Effects on Risky Choice in a Token-Reinforcement Paradigm

Carla H. Lagorio & Timothy D. Hackenberg
University of Florida (USA)

In a risky-choice paradigm, pigeons were given the choice between a mixed-time and a fixed (adjusting) alternative. The elements in the mixed-time schedule were systematically manipulated across conditions. In one phase of the experiment (immediate consumption), each chosen delay terminated with the presentation of a token (stimulus lamp arrayed above the response keys) that was immediately exchanged for access to grain. A second phase (delayed consumption) was identical to the first except that either 5 or 11 tokens were required before an exchange opportunity. In the immediate-consumption phase, there was strong preference for the mixed-time (variable) alternative, or risk sensitivity. Moreover, preferences were ordered with respect to the smallest element in the mixed-time distribution, consistent with predictions of a hyperbolic discounting model. In the delayed-consumption phase, behavior was less sensitive to delay and choice patterns varied systematically across blocks of cycles leading up to the exchange period. Responses for the mixed-time were most likely on the trial immediately preceding the exchange period, a result similar to prior research on token-based self-control choices. Choice latencies were longer in the early cycles of an exchange ratio, consistent with prior research on extended chained schedules.

Equation 21: Recognize it?

$$V_S = \sum_{i=1}^{N} w_i V_i$$

(Answer on p. 32)

Effects of Break Location on the Operation of the Internal Clock

Marina Menez & Florente López
Universidad Nacional Autónoma de México (Mexico)

According to the internal clock metaphor of timing models, the clock works like a stopwatch: It can be started, reset or stopped. To analyze these properties, the effects of breaks on stimulus signaling time are observed. Previous research has shown that the break location in peak trials determines how the clock operates. Early breaks in the first half of the peak trials stop the internal clock, whereas late breaks reset it. In order to test the generality of the stop-reset location hypothesis, we increased the number of programmed breaks in a peak trial and their location. Long breaks were introduced in the first half, middle and second half of the peak trial, in two groups of rats. Breaks in the first half and middle of the peak trial displaced the peak time, as predicted by stop-reset location hypothesis. Breaks in the second half of the peak trial did not change the operation mode of the internal clock, although it did affect response rate. Introduction of breaks in late location produced response rate decays and recoveries similar to those observed in early location break. The results are discussed in the context of current timing theories and the possibility of simultaneous timing.

Equation 14: Recognize it?

$$\xi = \frac{\rho \cdot \lambda \cdot B}{\lambda \cdot B + R}$$

(Answer on p. 32)

Independence of Reinforcer Rate and Magnitude: The Matching Law and Choice in Transition

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The present research investigates whether the independent effects of rate and magnitude as determiners of value observed in steady-state research also apply to choice in transition. Pigeons responded in a concurrent-schedules procedure in which relative reinforcer rate and magnitude changed unpredictably across sessions according to independent random series. Programmed relative reinforcement rates were 2:1 and 1:2 and on each trial the reinforced alternative was selected by a probability gate. Relative reinforcer magnitudes were 2 s to 4 s and 4 s to 2 s. Pigeons' response allocation tended to change early in sessions but stabilize by the end of sessions. Multiple regression analyses showed that with little training, pigeons' response allocation at the end of sessions was determined primarily by relative rate and magnitude from the current session. Although there were individual differences in sensitivity to rate and magnitude, their interaction was not significant for any subject. Overall, results support the concatenated generalized matching law's assumptions of independence and additivity.

Effects of Temporary Availability of Reinforcers Under Concurrent Schedules of Reinforcement

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Studies of responding under concurrent schedules are generally limited to contingencies where reinforcers, once available, remain available indefinitely or until collected. We studied temporary availability of reinforcers (analogous to limited hold) as a parameter, with pigeons choosing among three keys. Pecks to *any* of the keys fired the three random-number generators that controlled reinforcer availability, one for each key. When a random-number generator indicated reinforcer "set up," a peck to that key produced grain. However, once set up, reinforcers had some probability of being removed before the key was pecked. We systematically explored how probability of reinforcer removal affected response distributions and structures. The first of two main effects was that the payoff matrix of the concurrent schedule was affected as probability of removal increased, this in turn, resulting in increased preferences for the richer alternatives. The second was that the structure of responding was changed so as to reduce the rate of switching among operanda. Because reinforcers are never held indefinitely in natural environments, the inclusion of a "temporary availability" variable is a face-valid way of simulating the disappearance of food (whether by decay or collection by a competing organism), and also contributes to a theoretical understanding of the structure of responses under concurrent schedules.

A Real-time Procedure for the Study of Human Choice

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We demonstrate a novel computerized procedure for studying choices by human participants under concurrent schedules of reinforcement. Presented on a computer screen is a circle divided into pie-shaped subdivisions. A choice consists of the movement of the cursor from the center of the circle into one of the subdivisions. The program allows for specification of any number of different subdivisions (i.e., choice alternatives), probabilities of reinforcement, amounts of reinforcement, and reinforcement decays (see below). Reinforcers are programmed probabilistically, with an individual random number generator associated with each of the choice alternatives. Responses to *any* of the alternatives causes firing of all of the random number generators, thus creating a contingency analogous to concurrent variable-interval schedules. Reinforcers are indicated by appearance of an on-screen button randomly placed within the subdivision. Clicking the button generates a display of some number of points. The point value of each reinforcer can be parametrically varied. Point-values can also be degraded such that, after a reinforcer sets up on a given alternative, each subsequent response to any other alternative causes the reinforcer in questions to diminish in value. This degrade is similar to a limited hold contingency. The program can be run from a pre-written script, with changes in parameter values occurring after a fixed number of reinforcers or responses. Alternatively, the program allows for modification of the contingencies in real time from a different computer, with changes based on participant performances. Analysis of ongoing responses is continuously updated and shown on the controlling computer's screen in graphic form. Using this procedure, we demonstrate rapid changes in human choice as a function of reinforcer proportion and reinforcer degradation.

Screening for Memory Mutants with Matching and Timing Tasks

Efstathios B. Papachristos, Fuat Balci, Charles R. Gallistel, Melitta Schachner, & Gleb P. Shumyatsky
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Many different mechanisms mediate the extraction of information from experience, the carrying of it forward in time by a memory mechanism, its retrieval from memory, and its expression in observed behavior. Ideally, a behavioral screen for genetic alterations affecting the memory mechanism itself would be sensitive to malfunction only in it. Most memory screens measure the rapidity of learning and/or the asymptotic level of performance. The wide range of molecular defects that are said to affect memory, suggest that the measures commonly used are sensitive to malfunction in the ancillary mechanisms alluded to above, not the mechanism whose sole and specific function is to carry the information forward in time. Thus, a desirable feature of a behavioral screen for malfunction in the memory mechanism is a measure that undeniably depends on information gleaned from past experience but is NOT affected by many genetic manipulations that have large effects on the commonly used measures of learned performance (e.g, swim latency in the water maze or amount of freezing in response to shock-cue and/or context). We show that measures of matching and timed switching in NCAM-, 24-OH- and GRPR- knockout mice meet this criterion.

Effects of Session Spacing and Number of Sessions on Spontaneous Recovery

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What causes an extinguished response to spontaneously recover with time has been puzzling learning theorists since Pavlov. Devenport's Temporal Weighting Rule provides a satisfactory account that emphasizes the importance of relative recency of the two contradictory experiences (acquisition and extinction). We propose that in addition to recency, the duration of each experience may also be important, because longer observations of a repeated event allow stronger inferences to be made about its temporal stationarity (stability). Our preliminary data show that, contrary to our prediction, increasing the acquisition regime by spacing the sessions, does not affect spontaneous recovery. However, increasing the number of acquisition sessions while keeping overall trial number and context exposure constant positively does so. The results suggest that the number of sessions (as distinct from the number of trials) may be an important parameter of learning.

Equation 20: Recognize it?

$$\Delta V = \alpha \cdot \beta \left(\lambda - V_{Sum} \right)$$

(Answer on p. 32)

Pigeons' Discounting of Delayed and Probabilistic Food Rewards.

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Discounting of delayed and probabilistic food rewards was studied using adjusting-amount procedures. In one condition, pigeons chose between an adjusting number of food pellets contingent on a single key peck and an alternative in which 20 pellets were contingent upon completion of a variable-ratio (VR) schedule; 5 VR values were studied. In a second condition, pigeons chose between an adjusting number of pellets available immediately and 20 pellets received after a delay; 6 delays were studied. To compare discounting in the two conditions, indifference points (adjusting amounts approximately equivalent in value to the fixed amount) from the delayed-reward condition were plotted as a function of time until receipt of the delayed reward and indifference points from the probabilistic-reward condition were plotted as a function of the harmonic mean of times until completion of each VR value. For each subject, data from both conditions were well described by a single hyperbolic discounting function. These results support Rachlin et al.'s (1991) hypothesis that the discounting of probabilistic rewards is controlled by the average time until a win.

Errorless Transfer from a Visual to an Auditory Modality

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In an extension of errorless learning, a procedure developed by Terrace (1963), pigeons were exposed to an intermodal transfer from a visual discrimination to a sound discrimination. The experiment was divided into four phases. During the first 10 sessions, pigeons were progressively trained in a successive discrimination between red (S+) and green (S-) keys. In the next 5 sessions, a low tone was presented with the S+ and a high tone was presented with the S-, followed by a gradual decrease of the intensities of the red and green lights. Then, pigeons received low-high discrimination training until they satisfied a criterion of four successive sessions without an error. Finally, pigeons were returned to the red-green discrimination. Results were compared with a control group that was trained directly on the low-high tone discrimination.

Effects of Stimulus Dynamics on Temporal Discrimination

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The purpose of the present study was to observe the functional relationship between stimulus dynamics and stimulus duration discrimination in humans. Participants performed a bisection task requiring the judgment of the duration of a stimulus (a sphere) that rotated on its y-axis at various rates. In Experiment 1, temporal discrimination was observed under four rotation speeds (88.9, 44.4, 22.2, and 0˚/s). Participants' duration judgments were longer the faster the sphere was rotated. In Experiment 2, this effect was shown to be context dependent (e.g., the judged duration of a 44.4˚/s stimulus depended on whether it was accompanied by mostly slower or faster speeds). In Experiment 3, the original effect was replicated across a much wider range of rotation speeds (711.1 - 2.7˚/s). In general, stimulus dynamics had a systematic effect on temporal discrimination - the faster a sphere rotated, the longer its judged duration. These results are described using a quantitative model that includes a change measure and compared to the predictions of pacemaker models.

Performance of Spontaneously Hypertensive Rats in a Peak-Interval Procedure with Gaps

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The purpose of the present experiment was to evaluate time production in Spontaneously Hypertensive Rats (SHR) and Wistar Kyoto Rats (WKY). In the first phase of the experiment, rats were exposed to a Peak Interval procedure; in which fixed-interval 30 sec trials were alternated with nonreinforced and extended (peak) trials. After 60 sessions, responses during peak trials were fitted with a Gaussian distribution to estimate the expected time of reinforcement. The results showed no difference in the peak time between the strains, but a smaller Weber fraction in SHR than in WKY. In the second phase of the experiment, a gap procedure was introduced; in 40% of the peak trials the stimuli associated with the fixed interval and peak trials was turned off for 9 sec. There were two types of break trials: early, starting at second 6; and late, starting at second 15. Each rat was exposed to 12 sessions with each type of break. In both conditions, break trials produced time shifts that were longer than those expected if the clock had stopped during the break but shorter that if the clock had reset, and no significant differences between the strains were found. As it has been postulated that attention is related to the performance in the gap procedure, the present results suggest that this process is not affected in SHR, and question its validity as an animal model of attention deficit.

A Decision Model for Concurrent Chains: From Acquisition to Steady State

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Grace and McLean (2006) proposed a decision model for acquisition of preference in concurrent chains when terminal-link schedules change unpredictably across sessions. The model uses a linear-operator rule to describe changes in performance within sessions, and assumes that terminal-link delays are judged against a criterion. We propose an extension of their model which can describe both learning across sessions and changes in the criterion. We derive equations for steady-state performance, and show that the extended decision model can predict the well-known effects of initial- and terminal-link duration on choice in concurrent chains. The extended decision model is then fitted to several archival concurrent-chains data sets and compared against the leading models for behavioral choice, including the contextual choice model (Grace, 1994) and the hyperbolic value-added model (Mazur, 2001). The results from our archival analyses suggest that the extended decision model is a successful contender for describing molar choice in concurrent chains.

Equation 15: Recognize it?

$$\frac{B_L}{B_R} = \frac{T - t_L}{T - t_R}$$

(Answer on p. 32)

Effects of Amphetamine and Methamphetamine on Interval Timing Tested with Temporal Discrimination of Concurrent Fixed-Interval Schedules

Fuat Balci, Efstathios B. Papachristos, Charles R. Gallistel, Brian Allen, Jacqueline M. Gibson, Bryan Kapustinski, & Daniela Brunner
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Dopamine is claimed to have a central role in interval timing by affecting the speed of the internal clock. This claim is derived from observations of leftward and rightward shifts in indices of central tendency of temporally controlled responses. Although most of the research demonstrated a leftward shift under increased levels of dopamine suggesting increased clock speed, more recent findings demonstrated a rightward or no shift in temporally controlled responses under same pharmacological conditions. These differences are likely to be due to algorithms used to determine different aspects of temporally controlled responses in peak procedure. These measures were further shown to be affected by overall response-rates. We tested the effects of amphetamine and methamphetamine under a new temporal discrimination paradigm, which, unlike the peak procedure, has a clear unit of analysis and its measures are not response-rate dependent. Also, this work constitutes the first attempt to test the effect of psychostimulants under concurrent fixed-interval schedules and thus would serve to determine the generalizability of previous findings gathered from the peak procedure.

Equation 16: Recognize it?

$$\log \frac{B_x}{B_o} = \frac{-x}{(r_s / r_a)^b}$$

(Answer on p. 32)

Estimating Herrnstein's r_e: The Effects of Home Cage Housing and an Alternative Manipulandum

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Recent investigations, including those in our lab, have suggested that housing rats in different types of home cage (hanging wire v. polycarbonate tub w/bedding) can exert subtle effects on operant behavior. One possible mechanism for such effects is the relative reinforcement level associated with the different living environments, the polycarbonate tub being the cage style associated with greater overall levels of reinforcement. To investigate this possibility, we generated variable-interval response rate functions within sessions and modeled them using Herrnstein's hyperbola under three conditions. In the first condition, the rats were housed in polycarbonate tubs. In the second condition, the rats remained housed in polycarbonate tubs but a marble was placed in the operant chamber with them during their daily sessions. In the third condition, the rats were housed in hanging wire cages. This arrangement allowed a test of whether putative changes in reinforcement rate occurring outside the operant chamber can affect estimates of r_e, which would challenge the traditional interpretation of r_e as the concurrent rate of reinforcement for all responses other than the instrumental response. Results supported the traditional interpretation of r_e: systematic changes were apparent in 3 out of 5 subjects when a marble was introduced into the operant chamber but in only 1 out of 5 subjects when wire cage housing was instituted.

Assessing the Influence of Delay on Risk

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In a reanalysis of Yi, de la Piedad, and Bickel (2006), the relative influence of delay on risky gains was assessed. Using a common discounting procedure, indifference points were obtained from twenty-seven college students for hypothetical money gains that were probabilistic, delayed, or both. As expected, participants became more risk averse as delay increased. Based on data from delayed gains and probabilistic gains, projected indifference points for the combined conditions were calculated assuming additive effects of risk and delay. Comparison of projected and obtained indifference points indicated a interaction of risk, delay, and magnitude. Though delay increased risk aversion overall, the relative influence of risk decreased as delay increased. However, the influence of risk was exaggerated for high-risk, short-delay outcomes. Using an indifference point procedure, the present study validates previous research examining decision-making under risk, further allowing for quantification of the relationship between risk and delay.

Successive Approximations and Variability in Shaping

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During shaping, variability in responding is produced when previously reinforced responses are placed on extinction. As variability increases, movement is reinforced. A computerized shaping algorithm, using a forward stepsize (FSS) to reinforce movement closer to a target response and a backstep rate (BSR) to relax the criterion to avoid extinction, is used in the present study to study shaping parameters. The present study uses FSS values = 1, 20, or 40 pixels (p), and BSC values = 0, 10 p/5 non-reinforced responses. All participants were exposed to: (a) a no-shape baseline; (b) either FSS held constant, or varying between two of the values; and (c) the BSS held constant, or varying between two of the values. Using target hits, variability, and distance from target as dependent measures, it is expected that a small FSS with a moderate BSR will result in relatively optimal shaping.

Discrimination and Memory in Temporal Sequences in Pigeons

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Seven pigeons were trained in a delayed conditional discrimination task, where the sample stimulus consisted of four possible sequences of durations; each sequence could be short or long and was composed by two light modalities (steady-flicker). Once the discrimination criterion was met, the effect of a retention interval was assessed (where all the lights of the experimental spaces remained off). The location of the retention interval was varied in two conditions. In one, it was inserted between the components that formed the sequence (Retention Interval Between Components, RIBC), in the other it was located at the end of it (Retention Interval at the End of Sequences, RIES).The intertrial intervals and the retention intervals were signaled by different stimuli: the general lights of the box and the keylights off respectively. The discrimination indexes were symmetric for the long and short sequences in both conditions, the RIES and the RIBC. These results are discussed in terms of an information processing model for tasks of temporal estimation.

Effects of the Outcome Delivery Pattern on Selective Reinstatement of Instrumental Responding

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Two experiments examined the effects of temporal pattern pellet delivery on reinstatement of instrumental responding; in addition, the experiments sought to show that reinstatement was outcome-specific by using two different responses each associated to one of two different outcomes (i.e. purine or sucrose pellets). The experiments consisted of three phases. In the first phase rats received two daily sessions where left or right-lever pressing were reinforced, using one of the two possible outcomes under a variable interval (VI) 60s schedule. During the second phase both responses were extinguished in one daily session for five days. Finally, during testing one of the outcomes used in the first phase was presented under a variable time (VT) 60s schedule (Experiment 1 and 2) or massed in a sort time (Experiment 2). The results showed selective-outcome reinstatement only when the outcome was presented on a VT 60s schedule.

Temporal Estimations and Visual Flicker Frequencies

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Proposals of both Scalar Expectancy Theory (SET) and the Treisman et al. (1990) model are based on an internal clock; however, the first assumes that the clock emits pulses and the latter is based on oscillators. There is evidence showing that visual or auditory flickers accelerate the internal clock, however the models predict different effects of the manipulation of flicker frequencies: SET suggests that any repetitive stimuli will produce temporal overestimations due to an increase in the arousal of the clock, while Treisman's model predicts that temporal overestimations will be greater for flicker frequencies close to the oscillators' frequencies. In a bisection task, we compared the effects of 7 Hz, 14 Hz and 28 Hz visual flicker frequencies over temporal estimations during the training or during the test phase. Flickers preceded visual filled stimuli with durations within a range of 200-800 ms. Bisection points and psychophysical functions suggested that 1) Flickering in the test phase produces temporal overestimations, while a flickering in the training phase yields underestimations; 2) There were no differences in temporal biases when different flicker frequencies were presented, giving support to SET assumptions. The results also suggest flicker effects on the memory components of the SET model.

Equation 19: Recognize this?

$$\frac{d\ A}{d\ t} = -(\beta A + \alpha)A$$

(Answer on p. 32)

Effect of Retention Interval Delays on Numerical Reproduction Performance

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We performed a study examining the effect of manipulating the retention interval (RI) on pigeons' performance in a numerical reproduction task (Tan et al., submitted). In the procedure, two, four, or six keylight flashes were presented in a sample phase, and subjects had to make the same number of center-key responses during a subsequent production phase to obtain reinforcement. There was a 2 s RI between the sample and production phases in baseline; this was changed to 0.5 or 8 s in different conditions. Results showed an overall increase in average response number when RIs were changed from the 2s baseline to either 0.5 s or 8 s, the vertical shift being much greater in the latter condition. This effect is contrary to previous research, which has found "choose-small" effects following longer delays relative to baseline (e.g. Santi & Hope, 2001). Additionally, plots of the coefficients of variation, which decreased as a function of flash number in baseline, were approximately constant when RIs were changed. These findings are discussed in terms of a prototype response-class model proposed by Tan et al (submitted).

A Likelihood Ratio Comparison of Quantitative Models of Discriminated Operant Behavior

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The Davison-Tustin (1978) and Alsop-Davison (1991) models of conditional discrimination performance were compared using the likelihood ratio statistic (Glover & Dixon, 2004). The likelihood ratio statistic is an index of the relative descriptive accuracy of two competing models. Differences in the number of free parameters were corrected using the Bayesian information criterion. Each model was fit to individual subject data from several published studies. Within- and between-model comparisons were conducted on restricted and full parameter versions of each model. In the full parameter versions of each model, all parameters were allowed to vary freely, whereas in the restricted parameter versions the parameters were constrained to take on the same values. Results of within-model comparisons show that in the majority of cases, the restricted model was the more likely model. Results of between-model comparisons show that overall the Davison-Tustin model was the more likely model.

Equation 17: Recognize this?

$$\frac{B_L}{B_R} = c\left(\frac{d_r R_L + R_R}{d_r R_R + R_L}\right)$$

(Answer on p. 32)

Comparing the Generalized Matching Law and Contingency Discriminability Model as Accounts of Concurrent Schedule Performance

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A major controversy in the experimental analysis of behavior has been whether the Generalized Matching Law (GML; Baum, 1974, 1979) or the Contingency Discriminability Model (CDM; Davison & Jenkins, 1985) provides a better model of response and time allocation under concurrent variable interval (VI) schedules of reinforcement. In order to test the two models, a meta-analysis of residual data from 34 studies, contributing over 1000 data points for each of response and time allocation in concurrent VI schedules, was performed. Multiple regression analyses were used to identify any systematic polynomial trends amongst the residual data of the GML and the CDM. Overall, results suggest that the GML may perform better than the CDM when describing data from studies that use a two-key procedure, while the CDM may perform better than the GML when describing data from studies that use a changeover-key procedure.

Spatiotemporal Distribution of Behavior Across Concurrent Pavlovian, Simple and Conditional Discriminations in Open Field

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The temporal (head-poking, lever-pressing, and accuracy) and the spatial (direction, preference, variability, and effort) distributions of the behavior of rats across non-contingent (NC), contingent (C) and conditional-contingent (CC) water delivery were analyzed. Repetitive 60 s-long multiple t^D - t^Δ schedules were available at three panels of a 92 cm x 92 cm enclosure. A fourth response alternative was always correlated with extinction. For different rats NC water was concurrently or successively delivered across dispensers. Contingent water was produced by the first response within t^D in either of two levers, while in the CC phase the water-correlated lever was randomly pre-selected and differentially signalled. A strong bias for a particular panel was observed for each rat, while little or no activity at the extinction panel was recorded. Concurrent NC water produced the highest temporal indexes. Variability and effort decreased with increases in the temporal indexes, but increased with the complexity of the schedules. Preference was partially correlated with temporal indexes, but direction was uncorrelated. Results are discussed in relation to experiments on choice and stimulus control, highlighting the behavioral history effects and the spatial dimension of behavior.

Equation 18: Recognize this?

$$\Delta V_i = (\alpha / N_i) \sum_{i=1}^{N} \kappa_j (V_j - V_i)$$

(Answer on p. 32)

Effects of DAMGO and DSLET in Rats Trained to Discriminate 22 from 2 Hours Food Deprivation

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We tested the effects opioids on rats' discrimination between 22 and 2 hour food deprivation. Following acquisition, rats were placed under 2 hour deprivation conditions and injected in the hypothalamus (PVN) with either saline, the mu-agonist DAMGO, the delta-agonist DSLET, or the non-opioid neuropeptide Y (NPY). At doses previously demonstrated to increase eating when food was freely available, DAMGO and DSLET did not induce discriminative stimulus effects similar to 22 hours food deprivation. Previously we determined NPY-induced discriminative stimulus effects were similar to those of 22 hours food deprivation. The opioid antagonist naltrexone did not reduce the discriminative stimulus effects of either 22 hour deprivation or NPY. The findings are consistent with the hypothesis that mu- and delta-agonists increase food intake by increasing meal duration and that NPY administered into the PVN appears to increase food intake by producing discriminative stimuli similar to 22 hours food deprivation and initiating eating.

Delay Discounting of Various Commodities by Cocaine-Dependent Outpatients: Comparison of Two Equations and Associated Measures of Discounting

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Traditionally, delay-discounting findings have been described and quantified using a parameter estimate of discounting (k) derived from a simple hyperbola. Recently, researchers have increasingly used a more complex hyperbolic-like model and area under the curve to describe and quantify their observations. In the present study, we directly compared these approaches in the delay discounting of various commodities (money, cocaine, cigarettes, and health) by cocaine-dependent outpatients. Although the more complex hyperbolic-like model accounted for more variance than the simple hyperbola, both equations adequately described the data. According to Akaike's Information Criterion, the simple hyperbola was the preferred model for the discounting of money and cigarettes, whereas the more complex hyperbolic-like equation was the preferred model for the discounting of cocaine and health. K values derived from the simple hyperbola indicated that health was discounted significantly less than money, cocaine, and cigarettes, and cigarettes were discounted significantly more than money. Area under the curve measures indicated similar differences in discounting across commodities. Finally, area under the curve and k were highly correlated. Overall, there was a general concordance of results among the common methods of analyzing discounting data. The occasional discrepancies that were observed are illustrated and discussed.