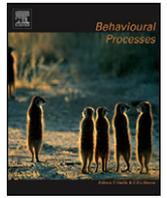




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Preface

SQAB 2008: More than the usual suspects

This volume is a special issue representing some of the best research presented at the 31st Annual Meeting of the Society for the Quantitative Analyses of Behavior (SQAB), which took place in Chicago, IL, May 22–24 of 2008. The continuing growth in poster submissions encouraged us to add a new poster session that occurred during our opening reception and registration. The increase in number of posters probably reflects the enthusiastic discussions during the poster sessions and the opportunity to submit manuscripts for this SQAB special issue in a new category of short communications, which began with SQAB 2006 and published in 2007. These shorter articles undergo the same peer-review process as full-length papers and succinctly describe important and highly original research that may have considerable impact on our field.

This SQAB special issue contains 5 full-length articles from invited speakers and 24 short communications representing some of the most exciting and original research in our field from around the world. The ‘usual suspects’ are here: Many of the articles derive from core SQAB research areas such as choice, response strength, and timing; but there are some surprises too, including articles which demonstrate the applicability of quantitative analyses to diverse topics such as spatial navigation, state-dependent valuation, and wildlife conservation, to name a few. There are also several theoretical contributions, underscoring the continuing importance of conceptual analysis in our discipline. We have created brief summaries of each article and attempted to group them into the following categories.

1. Choice and response strength

The article by Donald Blough describes two experiments which compare choice and latency measures in a conditional discrimination. In both experiments, the location of a correct response (left/right) depended whether blue or green stimuli had been presented. In different phases of training, response bias was manipulated by either varying the probability that a blue or green stimulus was presented, or by varying the probability that a correct response produced reinforcement. Results showed that for choice responding, measures of response bias were equivalent for both manipulations. However, for response latencies, manipulation of reinforcement but not signal probability produced bias. Thus, there was a clear dissociation between instrumental and Pavlovian contingencies: response bias was determined by the relative reinforcement probability associated with the two responses, whereas latency bias was determined by the relative reinforcement probability associated with the two stimuli. This beautiful result should, as one reviewer put it, ‘start a snowball of research in this area’.

Baum and Davison propose a dynamic model for choice based on results from experiments in which pigeons are exposed to many different reinforcer ratios within the same session. Unlike previous linear-operator models which compute the strength of individual responses which are then combined to yield choice (e.g., [Grace, 2002](#); [Mazur, 1992](#)), Baum and Davison’s model calculates response allocation directly. The model contains two parameters which determine the asymptotic response allocation and rate of acquisition. They show that manipulations of changeover delay and overall reinforcement rate were reflected in variation of the parameters corresponding to asymptotic response allocation and rate of acquisition, respectively. Baum and Davison suggest that their model accords with a molar view and has the potential to account for matching behavior.

A paper by Kyonka and Grace continues their exploration of rapid acquisition of choice and timing in concurrent chains procedures ([Kyonka, 2008](#); [Kyonka and Grace, 2007, 2008](#)). Their primary goal was to determine what effects initial-link duration has on preference for the shorter terminal-link delay to reinforcement and on measures of temporal control. Although previous research ([Christensen and Grace, 2008](#)) predicted a bitonic relationship between response allocation and initial-link duration, this experiment found preference for the shorter terminal-link delay was a monotonically decreasing function of initial-link duration.

In a related article Christensen and Grace examine whether the terminal-link effect in concurrent-chains schedules (i.e., increasing preference for the preferred terminal link when both terminal links are increased proportionally) occurs in a rapid-acquisition procedure with different pairs of terminal-link delays arranged daily. The data show that the terminal-link effect is obtained in such a procedure and that the dynamic decision model of [Grace and McLean \(2006\)](#) accounts for the data well. Interestingly, although the linear-operator based decision model and existing static theories of concurrent-chains performance differ in many respects, the way that the decision model accounts for the terminal-link effect is conceptually similar to Delay Reduction Theory. Both theories suggest that choice is determined by a comparison of the options relative to a comparator based on both initial- and terminal-link durations.

Maguire, Rodewald, Hughes, and Pitts examine the effects of d-amphetamine on pigeons’ sensitivity to relative reinforcement amount with concurrent-schedules in which reinforcer amount varied unpredictably between two ratios daily. Across subjects, at least one dose of d-amphetamine decreased sensitivity to relative reinforcement amount without affecting overall response rates or bias. Combined with previous work from this group, the results suggest that stimulants may decrease sensitivity to both reinforcement

amount and delay. The results could be important for understanding discrepancies in the literature on the effects of stimulants on self-control choice. Decreases in sensitivity to both reinforcement amount and delay might produce opposing effects on choices between smaller-sooner and larger-later reinforcers. The outcome of any given experiment might depend upon how other procedural variables (i.e., conditioned reinforcers during delays) impact which sensitivity parameter is affected more.

The experiment reported by Lie, Harper, and Hunt represents an extension to humans of the rapid-acquisition concurrent schedule procedure. Relative reinforcement rate was varied across components in a single session. As is often found with non-humans, sensitivity to relative reinforcement rate increased as a function of successive reinforcers, and preference pulses occurred following reinforcer deliveries. Although the authors note several potential improvements for future similar work with humans, the procedure appears to be a first step toward a procedure for studying the dynamics of human choice in a manner consistent with recent work with non-humans.

According to behavioral momentum theory, preference and resistance to change should be correlated because both are measures of response strength (Nevin and Grace, 2000). Jimenez-Gomez, Podlesnik, and Shahan test whether this prediction holds when initial-link duration is manipulated in the concurrent-chains procedure. In their experiment, rats responded in a concurrent chains in which the initial links were either short (VI 20 s) or long (VI 100 s) in different conditions. The terminal links were VI 12 s and VI 48 s schedules of nose-poke reinforcement. After baseline training, resistance to change of terminal-link responding was assessed in each condition by delivering response-independent food during the initial links. Results showed that preference for the VI 12 s was stronger when the initial links were short, consistent with previous studies (e.g., Christensen and Grace, 2008; Fantino, 1969). However, relative resistance to change for the VI 12 s was greater when the initial links were long. This result is contrary to the prediction of behavioral momentum theory and warrants further study.

Brown and Cleaveland describe an experiment designed to compare two theories of choice behavior. Scalar Expectancy Theory (SET) assumes that concurrent VI VI choice is controlled by an expectation of time until food delivery. Alternatively, Cleaveland's Active Time model assumes that the time since the most recent choice (the last response) controls the momentary probability of switching out of a particular schedule. This comparison is interesting because both models make use of a Markov chain analysis that describes behavior in terms of states and transition probabilities between states. Using multiple concurrent variable interval schedules, they observed that the active time model accurately fit individual subject data, whereas this version of SET did not.

An intriguing paper by Monteiro and Machado explores the patterns of behavior observed in extinction following exposure to periodic reinforcement schedules (fixed interval and peak procedures) contrasted with variable interval schedules. Behavior in extinction may help us better characterize what animals learn under periodic reinforcement. Periodic pause-peck oscillations during extinction, detected in cumulative records and Fourier analyses, were observed following fixed interval and peak interval procedures, but not after variable interval procedures. Experience with extinction (in the form of a long period of extinction, multiple sessions of extinction, or multiple non-reinforced trials) enhanced the cyclical behavior in extinction tests. The period of oscillations depended upon the periodicity of food presentation, yet similar average interfood intervals without periodicity (the variable interval schedules) did not produce such oscillations. These results are important because the processes responsible for these oscillations are likely related to the processes assumed by current theories of timing. Two seemingly unrelated phenomena –

response oscillations in the peak procedure and performance in extinction following FI training – may be intimately related.

2. Time matters

A series of papers examine various roles of time on behavior: reinforcement delay, models of interval timing, psychometric functions, temporal bisection tasks, the peak procedure, and delay discounting.

Thomas, Hughes, and Pitts examine whether the effects of d-amphetamine on responding of pigeons maintained by delayed reinforcement depend upon the presence or absence of delay-correlated stimuli. The previous literature on the effects of stimulants on responding maintained by delayed reinforcement has been mixed. Although moderate doses of d-amphetamine reduced the impact of delayed reinforcers, there were no differences in the signaled and unsignaled conditions. Thus, the experiment raises questions about stimulant-induced enhancements in conditioned reinforcement as a source of discrepancies in the literature. The experiment suggests that additional work will be required to isolate the variables governing whether stimulants increase or decrease sensitivity to the effects of reinforcement delay.

Ortega, Lopez, and Church studied performance on humans on a temporal bisection task. Their participants learned to respond 'short' and 'long' to durations of 200 ms and 800 ms, respectively, and then were tested with intermediate durations. The key question was whether the psychophysical functions would differ depending on stimulus modality (visual or auditory) and intermittency (steady or intermittent). They found that durations of visual steady stimuli were classified as shorter and more variable than auditory stimuli, and that the durations of visual intermittent (i.e., flickering) stimuli were classified as longer than auditory stimuli. Ortega et al. suggest that the speed of an internal clock might be mediated by modality and perceptual features of the stimuli.

Linlin Yi asks the question identified in her title, "Do rats represent time logarithmically or linearly?" Scalar timing theory is probably the best known linear timing model, in which subjective time is a linear function of physical time and standard deviation increases proportionately with the mean. Alternatively, subjective time may be a logarithmic function of physical time, and variability on the log scale is a constant. Rats were tested on a temporal bisection procedure and data were analyzed with signal detection theory producing zROC curves. Log timing fit the zROC curves much better than linear timing, indicating that the subjective scale of time is logarithmic with constant variability.

The study by Maia and Machado uses a temporal bisection task (a version of symbolic matching to sample) to ask whether the representations of time intervals in a temporal discrimination task are based on both their absolute and relative durations, as claimed by Zentall et al. (2004). Most models of timing, such as SET, BeT, and LeT, assume that absolute durations control choice. Control by relative durations would involve relational learning, which cannot be studied in the standard temporal bisection task. Therefore, Maia and Machado use a double bisection task designed to assess the contribution of relational learning on the psychometric function that describes choice proportions as a function of stimulus duration. Because they observed no evidence of relational learning, the authors explore the differences between this study and that of Zentall et al. (2004) to account for the differences in results.

In related work, Oliveira and Machado extend their previous work with a double bisection timing procedure to show that timing of the duration of a stimulus depends upon the temporal context in which it was trained, a finding that is inconsistent with Scalar Expectancy Theory (SET) but consistent with Learning to Time (LeT). The experiment presented here examines the generality of the con-

text effect using a procedure in which comparison stimuli in the discrimination task are present during the temporal samples, and a different ratio between the durations of the pairs of temporal samples is used. In addition to confirming the basic context effect consistent with LeT, the experiment produced additional data consistent with neither theory, and thus, might be useful for further development of timing theories.

Fox, Hand, and Reilly asked whether performance of two rat strains, the Spontaneously Hypertensive Rat (SHR) and Wistar-Kyoto (WKY) rats, differ on the peak procedure. The SHR has been proposed as an animal model of attention-deficit hyperactivity disorder (ADHD), and so any differences between SHR and WKY on the peak procedure might indicate a core timing deficit related to ADHD. They found that peak response rate occurred earlier for SHR when responses were sorted into 4-s bins, but not when parameters from a Gaussian model were compared. Although the Gaussian model had been used successfully in prior studies, there was evidence that its predictions deviated systematically from the data, even though the variance accounted for was high. These results provide some evidence that SHR may show timing behavior suggestive of impulsivity, but caution against the uncritical use of model fitting.

A study by McKerchar et al. evaluates the fits of four established models of delay discounting to data provided by human subjects who chose between immediate and delayed hypothetical monetary rewards. Two were one-parameter models (a simple exponential model and Mazur's 1987 hyperbola), and two were two-parameter models (Green and Myerson's 2004 hyperboloid and Rachlin's 2006 hyperbola in which delay is raised to a power). Because the exponents of both two-parameter models were less than 1.0 at the group level, McKerchar et al. argue that more than one parameter is needed to describe delay discounting in humans. As we increasingly observe in our field, both models accounted for over 99% of the variance of the group data. This finding again invites consideration of the rationale for model selection, the central issue discussed in the prefaces of the SQAB special issues in 2006 and 2008.

Robles, Vargas, Bejarano, and Vargas describe an experiment in which college students completed two series of questions between hypothetical amounts of money that were available either immediately or after a delay. The only difference between the two series was whether the immediate rewards were presented in an ascending or descending series. Robles et al. found that the degree to which the delayed rewards were discounted was significantly greater with the ascending series. Because the reward amounts were smaller in the ascending series, this result may have been related to the magnitude effect, in which the rate of delay discounting varies inversely with reward amount. Robles et al.'s results contribute to a growing body of evidence that procedural and contextual variables can influence delay discounting, which is important given the increasing attention that delay discounting is receiving as an individual difference variable (see Green and Myerson, 2004, for review).

3. Stimulus control

Can an organism's response serve as a time marker as effectively as an external stimulus? Caetano and Church report an experiment which addresses this question. One group of rats was trained to head poke for food reinforcement on a DRL 20-s schedule. An individual yoking procedure was used, such that when a rat in the first group made a head-entry response to the food cup, a 0.5 s light stimulus was presented to a rat in a second group. Caetano and Church found that although overall response rates were higher in the second group, analysis of normalized data showed that temporal control was equivalent for the two groups. These results

suggest that responses and stimuli can serve equally well as time markers.

Arantes and Berg show that an errorless discrimination training procedure is considerably more successful than trial and error learning at generating intermodal transfer of stimulus control from visual to auditory stimuli in pigeons. This result is important because most studies of the transfer of stimulus control using an errorless discrimination procedure have only examined transfer across stimuli within the same modality (i.e., typically visual).

4. Spatial navigation and behavioral ecology

An invited paper by Hamilton, Johnson, Redhead, and Verney compares spatial navigation in rats in the Morris water maze to that of humans in computerized, virtual Morris water task. Rats prefer to navigate in the direction of a goal in the environment (directional responding) rather than to the precise location of the goal (place navigation). The central issue of this paper is how directional responding and place navigation are influenced by room and apparatus cues. They demonstrate that humans, like rats, perform directional responses when cues from the apparatus are present, whereas place navigation predominates when apparatus cues are eliminated. Furthermore, when an eye-tracking system measured gaze location in the virtual environment dynamically as humans navigated from a start point to the goal, they observed two distinct navigation patterns: participants looked primarily at room cues during the early segment of each trial, but focused primarily on the apparatus as the trial progressed. These distinctive patterns indicate that room and apparatus cues may control distinct, sequential components of navigation to a goal.

Aw, Holbrook, de Perera, and Kacelnik examine how the deprivation state of fish at the time of learning about two equally reinforced options affects preferences for those options when given a choice. Consistent with findings with wide range of species across taxa, fish preferred an option previously experienced in a greater state of deprivation, regardless of their state of deprivation at the time of the choice. The authors conclude that such state-dependent valuation is widespread across animals and review evidence that different species accomplish such learning via different mechanisms. They further suggest that species likely evolve toward state-dependent valuation because it is generally advantageous, even though it may sometimes lead to paradoxical choices.

The article by Alligood, Wheaton, Daneault, Carlson, and Savage provide two types of diversity to this SQAB special issue, and both types are especially valuable. Disney's Animal Kingdom is involved in the recovery plan for the endangered Key Largo woodrat, where they maintain and propagate the species. Breeding these woodrats in captivity is a challenge because they display intense aggression toward conspecifics and have small litter sizes, resulting in low reproduction rates. A major goal is to develop behavioral techniques to predict whether two woodrats, when paired together, will copulate rather than display aggression. This prediction must occur early enough to allow the managers to separate the animals if aggression appears likely. The second type of diversity provided in this article is the type of data analysis used: a pattern of diverse behaviors (categorical variables) is used to predict the type of behavior (also categorical) most likely to occur. Thus, the authors develop a model of categorical variables, rather than the quantitative ones found throughout this special issue. They successfully use logistic regression to demonstrate the degree to which repeated observations of behaviors could be used to predict subsequent binary categories, such as the presence or absence of copulation and aggression. This type of sequential analysis is a powerful, but underappreciated, technique that should be used more often by SQAB members because of its wide applicability in behavioral prediction.

5. Associative learning

Witnauer and Miller report three experiments which compare overexpectation and extinction in associative learning. Whether overexpectation (in which control by a target cue is disrupted by pairing it with another well-established signal) and extinction are determined by a common process is an important question. For example, theoretical accounts of associative learning such as the Rescorla-Wagner model propose that the discrepancy between the associative value of the conditioned stimuli present on a trial and the asymptotic strength supportable by the US is a key factor in conditioning. According to these models, overexpectation and extinction should be fundamentally similar. However, Witnauer and Miller show that manipulations such as posttraining context exposure and overtraining have differential effects on overexpectation and extinction, suggesting that they are not determined by a common process.

Two experiments reported in the paper by Luque, Morís, Cobos, and López examine retroactive interference between cues resulting from training the relation between one cue and an outcome ($A \rightarrow O1$) and then another cue and the same outcome ($B \rightarrow O1$). The authors argue that such interference in previous work might have resulted from instructions and tasks that fit some familiar causal scheme in various types of game scenarios. Contrary to this suggestion, Luque et al. found interference in a task suggesting only arbitrary relationships between events. Thus, it appears unlikely that interference between cues with a shared outcome in previous research results from framing the tasks in terms of causal scenarios.

6. Response structures

Johnson, Pesek, and Newland explore the structure of responding engendered by high-rate percentile schedules in two mouse strains that differ in levels of spontaneous locomotor activity. Shull et al. (2001) argued that bout-initiation rate is influenced by motivational variables, whereas within-bout response rate is affected by the type of response device and variables that influence motor function. Johnson et al. manipulated the presence of a running wheel, presumed to influence bout length, bout-initiation rate, or both. In addition, they separately eliminated food restriction, a motivational variable presumed to lower overall response rate, for the two mouse strains. Log-survival analysis showed that the two mouse strains had distinct patterns of bout structure. For both strains, adding a running wheel decreased total nose pokes and bout length, but increased bout-initiation rate. Free-feeding reduced nose poking by decreasing bout-initiation rate.

7. Theoretical explanation

One of the most important challenges we face is how to choose between competing models or theories. In particular, when a theory provides an excellent fit to data, how do we know that the theory is justified? What if an off-the-shelf mathematical function with no theoretical basis and the same number of parameters provides an equivalent fit? In their article, Guilhardi and Church provide an example of a sophisticated methodology for theory testing. They argue that the acid test for a successful theory is cross validation – its ability to make predictions (i.e., generalize) beyond the original data used to estimate parameters. They present a case study in which a theoretical explanation of timing, Guilhardi et al. (2007) modular theory, is contrasted with an atheoretical function, which they call an ‘empirical explanation of behavior’. Guilhardi and Church show that although both the empirical and theoretical accounts provide equivalent descriptions of representative timing data in terms of variance accounted for, the theoretical account was also able to generalize successfully to data obtained from other procedures.

Davison and Elliffe’s contribution is a challenging and provocative analysis of the assumptions we make when fitting models to data. Using the generalized matching law as an example, they show that the assumptions of ordinary regression – normality, homoscedasticity, and that values of x are fixed with no variance – are questionable when applied to concurrent schedules. Consider homoscedasticity – the requirement that variance in y be equal for all values of y . Davison and Elliffe show that if choice responses are assumed to be binomially distributed, then log response ratios will be increasingly skewed as responding becomes more extreme, and the systematic change in variance results in underestimates of the true regression slope. Similar problems arise when fitting nonlinear models. This leads Davison and Elliffe to conclude that our customary practices of model fitting and parameter estimation may be wrong, and suggest an alternative method that can be used if the variance in choice is measured. An implication of their paper is that proper application of techniques for parameter estimation necessarily involves assumptions about the stochastic process underlying the data, that is, a model of how responses are generated. It follows that there may not be a clear distinction between the assumptions for the statistical analysis, and those of the model itself. In summary, Davison and Elliffe’s paper gives anyone with an interest in model comparison and parameter estimation much to consider.

In a short communication Francis Mechner extends his analysis of behavioral contingencies presented in the SQAB special issue last year (Mechner, 2008). The emphasis in this theoretical paper is on dynamics – behavioral contingencies that change as a function of time, of the individual’s own behavior, or of the behavior of other parties interacting with them. This analysis is important because it shows that the behavioral contingencies involving seemingly unrelated activities, in this case locomotion and reading aloud, may actually be nearly indistinguishable. Mechner explores the implications of this similarity and makes parallels to other seemingly unrelated behavioral phenomena.

McDowell and Popa review Stephen Wolfram’s *A New Kind of Science* and explore its implications for behavior analysis. The Wolfram book is a manifesto for a new scientific program. According to Wolfram, all complexity arises from the operation of simple computational rules, which can be modelled by cellular automata. He proposes that by exploring these automata empirically, representations of all the phenomena in universe can be found. McDowell and Popa take up his challenge for the behavior of organisms, and find that simple cellular automata can indeed generate some complex outcomes, such as the hyperbolic relation between response and reinforcement rate predicted by Herrnstein’s equation. Whether it will initiate a revolution in behavioral science remains to be seen, but McDowell and Popa provide an accessible summary of the major points of Wolfram’s program, and useful resources for interested readers to learn more about this intriguing new approach.

The summaries above represent the wide diversity leading us to describe this SQAB special issue as ‘more than the usual suspects.’ The core research areas are strongly represented, and we also see quantitative analyses applied to wildlife conservation, state-dependent valuation, and spatial navigation. The theoretical articles continue to underscore the importance of conceptual analysis in our discipline. This increasing breadth of topics shows the applicability of SQAB’s quantitative methodology to substantive problems in a variety of areas – a strong indication of reproductive success in our field.

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