Experimental Analysis of Human Behavior Bulletin

Volume 8 **Winter 1990** **Number 2**

EAHB SIG
Department of Psychology
University of North Carolina at Wilmington
601 South College Road
Wilmington, North Carolina 28403-3297

THE EXPERIMENTAL ANALYSIS OF HUMAN BEHAVIOR BULLETIN

The EAHB Bulletin is published twice yearly, in the Spring and Fall, by the Experimental Analysis of Human Behavior Special Interest Group (EAHB SIG), a group organized under the auspices of the Association for Behavior Analysis (ABA). Articles in the Bulletin represent the views of the authors. They are not intended to represent the approved policies of the SIG or ABA, or the opinions of the membership of the SIG or ABA. The inside back cover has information about joining the SIG and contributing to the Bulletin. Publication costs are paid by the dues of the SIG members and by the Department of Psychology of the University of North Carolina at Wilmington.

Editors: Carol Pilgrim and Mark Galizio, University of North Carolina at Wilmington

Editorial Assistants: Martha Jo Clemmons and Lydia R. Woodard

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ANNOUNCEMENTS !!!

STUDENT PAPER CONTEST

The purpose of the contest is to foster student thinking and scholarly writing in the area of the experimental analysis of human behavior. Graduate student papers should be sent to Barbara Wanchisen, Department of Psychology, Baldwin-Wallace College, Berea, OH 44017. Submissions from undergraduates should be sent to Anna D. Hatten, Department of Psychology, Averett College, Danville, VA 24541. Interested students should consult the above individuals for further information concerning specific requirements of the paper competition or consult Vol. 7, no 2 of the EAHB Bulletin.

NEW NETWORK

A Behavior Analysis/Human Factors Network has been established under the auspices of the Cambridge Center for Behavioral Studies to foster mutual interests of these two domains of research and application in human performance. If you are interested in participating and receiving the Network's Newsletter (with no financial obligation), please send your name and address to the undersigned. You are urged to invite others with similar interests to do the same.

M. McIlvaine Parsons, Essex Corporation, 333 N. Fairfax St., Alexandria, VA 22314 (703-548-4500), or
Cambridge Center for Behavioral Studies, 11 Waterhouse Street, Cambridge, MA 02138.

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Arbitrary Stimulus Relations and Delayed Identity Matching to Complex Samples

Robert Stromer and Harry A. Mackay
Eunice Kennedy Shriver Center and Northeastern University

Delayed matching-to-sample procedures are often used to examine how stimulus variables may affect the accuracy of matching performance (e.g., Baron & Menich, 1985; D'Amato & Salmon, 1984; Riley, 1984). In one such procedure, the samples are complex, multi-element stimuli and the comparison stimuli are the elements that make up the samples. Figure 1 illustrates a set of identity trial types like those used to study monkeys' matching performance (e.g., Cox & D'Amato, 1982). For example, the samples for training trials might consist of a color and a form superimposed on one another (red/circle and green/square). A response to the sample removes that stimulus and initiates a delay period with all keys blank (not shown in Figure 1). Either colors or forms then appear as comparison stimuli. The subject is reinforced following selection of the comparison that is identical to the color or to the form element of the preceding sample. In studies with monkeys and pigeons, performance on such delayed matching trials has been compared to that on other trial types. For example, a frequent finding is that matching accuracy is notably worse on trials with two-element samples than on trials with single-element samples. Such outcomes have been important to researchers who study the attentional processes of nonhumans (see reviews by D'Amato & Salmon, 1984; Riley, 1984).

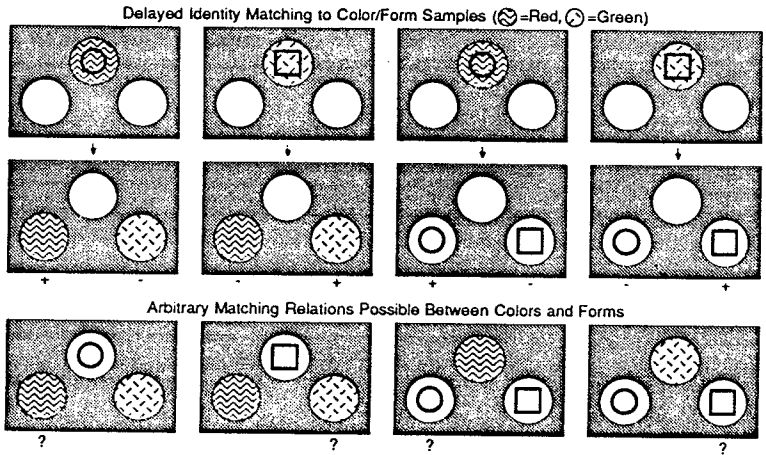

Figure 1. Top and middle rows of panels depict delayed identity matching training trials. The sample stimuli are color/form arrays (top). After a delay interval in which all keys are blank (not shown), either colors or forms are displayed as comparison stimuli (middle). Selections of the color or the form comparisons that match a sample element are reinforced (+) and incorrect selections are not reinforced (-). Lower panels illustrate the arbitrary relations among colors and forms that may arise as a function of the delayed matching training.

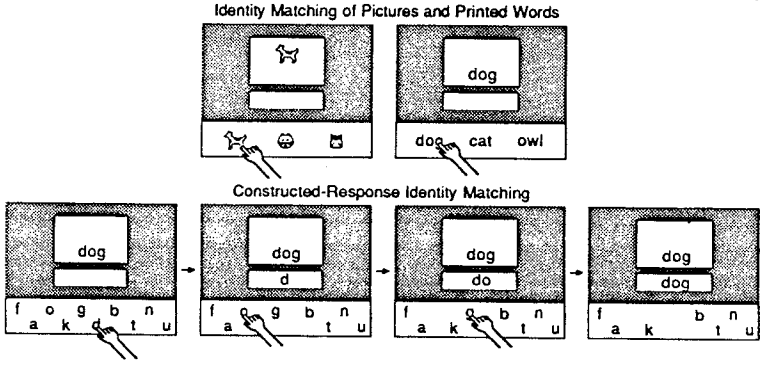

Figure 2. Top panels show identity matching trials that involve pictures and printed words. Lower panels show a constructed-response identity matching trial: Touching the letters remove them from the choice below and place them in the construction area above. In this example, successive touches to the letters **d**, **o**, and **g** would produce reinforcement.

Delayed identity matching of element comparisons to complex samples is interesting from a stimulus control perspective because the procedure may promote joint control of comparison selection by each sample element. As illustrated in Figure 1, there is nothing about the sample stimulus or the delay interval that is discriminative for which of the comparison sets will occur. Correct performance is possible only if a subject discriminates both the color and the form elements of the sample stimulus. If such joint stimulus control develops, however, one can examine whether the elements may have become related to each other during training. The lower panels in Figure 1 illustrate the arbitrary matching-to-sample trials that provide the empirical test for this possibility. For example, the performance of matching colors to forms, or vice versa, may occur without explicit training because previous training had required the matching of either of these stimuli (as comparisons) to samples that consisted of both. The available data suggest that nonhumans may have difficulty in acquiring joint control by both sample elements and, hence, with any task involving relations among the elements. Humans, however, may be readily capable of such performances.

This paper describes a delayed matching procedure like that in the preceding example. However, the baseline used in our current studies is more complex than that in the animal experiments and the subjects have been learning disabled and mentally retarded individuals. Rather than colors and forms, the stimuli have been pictures and printed words, and the outcome performances include constructed-response matching to picture samples (Dube, McDonald, McIlvane, & MacKay, submitted), a form of anagram spelling (Mackay, 1985; Mackay & Sidman, 1984). Figure 2 represents computer displays of some of the prerequisite skills for our delayed matching procedure. The upper panels show standard identity matching trials. The lower panels show a typical trial of constructed-response identity matching. The sample is the printed word **dog** and the subject is required to "construct" the word by selecting the letters **d**, **o**, and **g** in succession from the choice pool at the bottom of the display. A touch to the letter **d** moves it from the choice pool to the center of the construction area above the choice pool. Subsequent touches to the **o** and **g** complete the word **dog** in the construction area and terminate the trial. The particular printed word displayed in the sample area and the positions of letters in the choice pool vary unsystematically from trial to trial. With some of our subjects, construction of words up to six letters in length has been established by trial-and-error teaching methods. Other subjects have been taught with a program that gradually adds letter elements to the sample and letters to the choice pool (Dube et al., submitted).

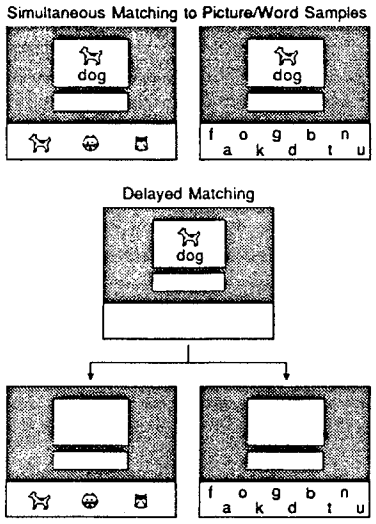

Figure 3. Top panels exemplify simultaneous matching trials with picture/printed-word samples. The comparison stimuli are either pictures or letters. Touching the picture that is identical to a sample element or constructing the appropriate printed word are reinforced. Lower panels show the same displays as delayed matching trials. Samples disappear after being touched. Delayed selection of the picture that matches the sample or delayed construction of the word produce reinforcement.

Figure 3 illustrates the essential baseline trials that involve complex sample stimuli. The top of Figure 3 shows simultaneous matching trials in which pictures and printed words appear as sample stimuli and either pictures or a pool of letters as comparison stimuli. These trials require the subject to discriminate the picture from the word in the sample array. However, whether the picture or the word is relevant on a given trial depends on the comparison display. Note that because the sample stimuli remain present throughout each simultaneous matching trial, these trials do not require joint control by both the picture and the printed word sample stimuli. In contrast, such joint control is required when the same displays are

used in the delayed matching procedure illustrated in Figure 3. Here, a response to the sample removes the sample stimuli and produces the picture comparisons or the choice pool of letters. Just as in the earlier example with colors and forms, correct performance on such trials is possible only if both the picture and the printed word have been discriminated.

In our teaching sequence, the delayed matching trials are introduced only after accurate simultaneous matching performance has been obtained. An accurate delayed matching baseline then permits assessment of whether the picture and word elements of each sample are related to one another. Critical tests of this potential outcome are depicted in Figure 4. The top panels illustrate simultaneous arbitrary matching of picture and printed-word stimuli. The lower panel exemplifies trials in which words must be constructed in response to picture samples. Here the sample is a picture of a **dog** and the subject is asked to touch the letters **d**, **o**, and **g** in the choice pool without the benefit of having the word **dog** in the sample.

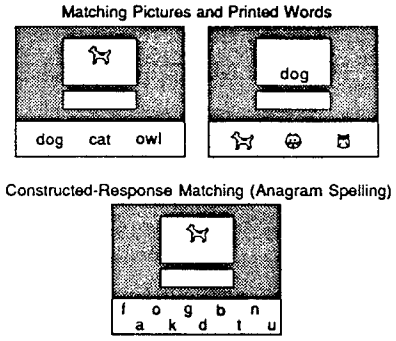

Figure 4. Top panels depict trials that assess simultaneous picture/printed word matching. Lower panels show a constructed-response matching trial or anagram spelling to pictures.

The foregoing training and testing procedures have produced positive results. Subjects have acquired the arbitrary matching performances with picture and printed word stimuli, and the constructed-response performance. Positive results have also been obtained with subjects whose outcome tests involve delayed matching trials, rather than the simultaneous matching trials shown in Figure 4. The matching of pictures and printed words represents a rudimentary form of reading comprehension; construction of words in response to pictures constitutes anagram spelling.

These training outcomes have been extended via the use of trials in which the same pictures are presented in combination with different words as the sample stimuli. For example, the picture of a dog has been paired with the new printed words **canine** and **pisces** in separate trials. The outcome tests have shown that the subjects are then capable of spelling each of these words in response to the picture alone. Of critical importance has been the additional finding that arbitrary relations emerge among the printed words (e.g., the subjects matched **dog** to **canine**, **pisces** to **dog**, and **canine** to **pisces**), thus suggesting the formation of equivalence relations among pictures and printed words. Such results extend recent studies of arbitrary matching to complex samples with normally capable adults (Stromer & Stromer, 1990, in press).

Our work with the delayed identity procedure has also shown that the appearance of anagram spelling to pictures is related to improvements in spelling the same words in response to dictated-word samples. This finding replicates and extends previous studies of the relations among various spelling performances in the context of stimulus equivalence (Mackay, 1985; Mackay & Sidman, 1984; Stromer, in press). One of our prime reasons for developing reliable procedures to teach anagram-spelling is to study the relationship of spelling to the formation of equivalence classes and to reading. The emergence of reading as a by-product of spelling instruction is relevant to the issue of how speaking and writing repertoires may be related to one another (cf. Skinner, 1957). So far, our work supports the observations of Ehri and Wilce (1987) that children's reading may improve following spelling instruction. In contrast, attempts to establish spelling performances by teaching reading supports Lee and Pegler's (1982) finding that reading instruction does not necessarily enhance spelling.

Finally, we should mention that anagram spelling to picture samples may be taught with other methods. The delayed matching baseline described here requires a complex entry repertoire, the preconditions for which are unknown. The critical teaching stage involves transferring control of word construction from printed words to the pictures. With some subjects this transfer has been accomplished by combining pictures and printed words as samples and gradually fading out the printed words (Dube et al., submitted). The delayed matching procedure described in this report, however, may be an expedient way to establish new arbitrary performances that include anagram spelling. Delayed identity matching

procedures may also be used to study the variables that may affect the formation of conditional relations among the elements of complex sample stimuli (cf. Stromer & Stromer, in press).

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Author Notes

This research was supported by the National Institute of Child Health and Human Development (Grants HD04147 and HD25995) and the Massachusetts Department of Mental Retardation (Contract No. 3404-8403-306). Correspondence can be addressed to **Robert Stromer**, Behavior Analysis Department, E. K. Shriver Center, 200 Trapelo Road, Waltham, MA 02254.

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Laboratory Description: Human Behavioral Pharmacology at the University of Vermont

R. J. DeGrandpre, C. R. Rush, W. K. Bickel, S. T. Higgins, and J. R. Hughes
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The Human Behavioral Pharmacology Laboratory (HBPL) is a research unit of the Department of Psychiatry, University of Vermont College of Medicine. The unit was established in 1986 and presently consists of three Principal Investigators (JRH, WKB, STH), three postdoctoral fellows, two graduate students, three research nurses, and several research assistants. Major sources of funding are grants from the National Institute on Drug Abuse (NIDA), National Institute on Alcohol Abuse and Alcoholism (NIAAA), and the National Heart, Lung and Blood Institute (NHLB) as well as grants from pharmaceutical companies.

Research Agenda

Research at HBPL uses principles of the experimental analysis of behavior to determine the environmental, pharmacological, and biological factors that influence the behavioral effects of drugs of abuse. Our research spans several classes of drugs, studied separately or in combination; e.g., alcohol, amphetamines, benzodiazepines, cannabinoids, caffeine, cocaine, nicotine, and opioids. Research is divided between basic human laboratory research that focuses on behavioral rather than physiological or biochemical outcomes and clinical research that focuses on the behavioral and pharmacological aspects of drug abuse treatment.

Facilities

The main HBPL facility of 6,000 sq. ft. is located adjacent to the University of Vermont in the city of Burlington. This facility was recently renovated for basic laboratory research in drug self-administration, drug discrimination, and the direct effects of drugs. Laboratories are controlled by networked microcomputers with Mackintosh and IBM computers used for word processing, graphics, and data analysis. Two additional sites exist. The Treatment Research Center (TRC) is a facility for testing new behavioral treatments for cocaine dependence and new pharmacological and behavioral treatments for opioid dependence. The Clinical Research Center of the Medical Center Hospital of Vermont (which is not maintained by HBPL) is used for studies requiring more medical supervision.

Major Areas of Research

Drug Self-Administration

Behavioral Economics of Drug Self-Administration (WKB): We are applying behavioral economics to nicotine self-administration to test the utility of consumer demand theory in the study of drug abuse. Subjects are placed in a laboratory setting (cubicle) for approximately three hours and one or more characteristics of the economic environment are manipulated. Examples of variables that we have manipulated thus far include: a) reinforcer magnitude and response requirement, b) substitutes and complements, and c) price and income manipulations. This line of research appears promising and has led to a paper series titled the "Behavioral economics of drug self-administration." At the present time, the first two articles in this series are in press (see below), one is under review, and several are soon to be submitted.

Reinforcing effects of caffeine (JRH): We are studying caffeine as a reinforcer via a series of studies using a drug self-administration procedure in which caffeine is administered via coffee or cola. Subjects are placed in double-blind concurrent access schedules in which one of the beverages contains caffeine. Reinforcement is inferred from the relative rates of self-administration. Our first study showed caffeine served as a reliable reinforcer in some subjects (Hughes, Higgins, Bickel, Hunt, Fenwick, & Gulliver, 1990).

Drug Discrimination (WKB)

Drug discrimination is used in humans and nonhumans to study the discriminative stimulus effects of psychoactive drugs. Responding is maintained via monetary reinforcers that are contingent upon correct discrimination between different drugs, different doses of drugs, and/or drugs and placebo. Currently at the HBPL laboratory two human DD studies are being

conducted; one is a caffeine DD study and the other employs drugs from the benzodiazepine class. These studies assess the relationship between discriminative stimulus effects of drugs and self reports in humans and test for generalization gradients across novel doses and novel drugs.

Direct Effects of Drugs on Behavior and Physiology

Learning and Performance (WKB & STH): The effects of a variety of drugs are assessed using repeated acquisition and performance of behavioral sequences. This procedure allows a within-subject analysis of drug effects on both the acquisition of novel response sequences and the performance of a previously learned response sequence. In many instances the two outcomes are affected differently by drugs. For example, alcohol, barbiturates, and benzodiazipines typically disrupt the acquisition of novel response sequences at doses that have little effect on performance, although responding in both conditions is often disrupted by higher doses. Stimulants (caffeine, cocaine, and d-amphetamine), buspirone, and delta-9 THC generally do not disrupt learning or performance. One recently completed study examined the effects of alcohol and caffeine, alone and in combination, using this procedure. Overall, drug effects observed with humans using this procedure are concordant with data from nonhuman laboratories.

Social Interaction (STH): Commonly abused drugs typically increase social interaction. Yet, few empirical studies exist which examine the effects of drugs on the control exerted by social reinforcers. We use a two-choice concurrent schedule where normal volunteers choose between interacting with a same-sex partner or engaging in monologue speech to earn money. d-Amphetamine increases choice for social versus monetary reinforcement in this setting. Preliminary results indicate that secobarbital similarly increases choice for social versus monetary reinforcement. Studies comparing the effects of diazepam and secobarbital using this paradigm are currently ongoing.

Stimulant-alcohol combinations (STH): Recent studies have focused on the cardiac effects of stimulant-alcohol combinations. When combined, the behavioral and cardiac effects of stimulants (cocaine and d-amphetamine) and alcohol are greater than when the compounds are administered alone. Interestingly, when caffeine and alcohol are combined the cardiac effects are less than when the drugs are taken alone. The combined use of some stimulants (e.g., cocaine) and alcohol may increase the risks of cardiac toxicity beyond that observed when the drugs are taken alone.

Summary: Our work on the direct effects of drugs contributes to the field of behavioral pharmacology in that it demonstrates: 1) the generality of behavioral principles across species, 2) the utility of several procedures and analyses in the experimental analysis of behavior (e.g., behavioral economics, concurrent schedules, drug self-administration, and the repeated acquisition and performance procedure), 3) the importance of environmental factors in modulating drug effects on human behavior (e.g., alternate reinforcers, instructions).

Clinical Research

Treatment of Cocaine Abuse (STH): We are currently involved in a 5 year project assessing the efficacy of behavioral interventions for treating cocaine dependence. In a series of studies behavioral interventions involving community reinforcement of abstinence and basic contingency-management are being evaluated relative to standard alcohol and drug counseling. Preliminary data are promising, with the behavioral treatment achieving levels of cocaine abstinence beyond those currently reported in the literature. An experimental analysis of the efficacy of different components of the behavioral intervention will comprise subsequent studies.

Treatment of Opioid Abuse (WKB): We are presently embarking on a 5 year program to study the clinical pharmacology of opioid abuse and dependence. A series of 10 studies will examine the clinical pharmacology of buprenorphine -- a promising new opioid treatment agent. Specifically, we will be examining three aspects of buprenorphine pharmacology. First, we will examine how individuals maintained on methadone (the existing replacement-treatment) can be transferred to buprenorphine without any withdrawal discomfort. Second, we will examine buprenorphine's heroin blocking effects. Third, we will examine the feasibility of a combination buprenorphine-naltrexone product. In the course of this grant, the first outpatient pharmacotherapy clinic for opioid dependence will be established in the state of Vermont.

Treatment of Nicotine Dependence (JRH): We have completed several studies examining the behavioral concomitants of cessation of nicotine. Also, we have tested nicotine, replacement therapies (nicotine gum and patch) as treatments. We have noted that these treatments appear to be effective when given with behavior therapy but not when given without behavior therapy.

Comparative Behavioral Pharmacology of Panic Patients vs Normal Controls (WKB): We are investigating differences between normal and panic-attack patients in their sensitivity to diazepam (an anti-anxiety or anxiolytic agent). One especially interesting behavioral test in this analysis is the suppressed responding test in which the effects of diazepam on a suppressed baseline will be evaluated. Studies with nonhumans have demonstrated that anxiolytics, unlike drugs from other classes, increase punished responding at doses that have no effect on unpunished responding.

Training

The HBLP has recently been awarded a NIDA Institutional Research Training Program (Director: WKB). This program will support up to three pre- and postdoctoral fellowships and three summer medical student internships. These positions provide the unique opportunity to conduct funded research on basic and applied issues in human behavioral pharmacology using state of the art techniques and therapies. For pre-doctoral students, HBPL is one of only two established national training sites for human behavioral pharmacology. Individuals who might be interested in pre- or post-doctoral fellowships at HBPL in the experimental analysis of behavior, behavioral pharmacology or the clinical treatment of drug abuse, are encouraged to contact one of the Primary Investigators at the address below.

For more information about HBPL, contact any of the Principal Investigators at HBPL, Department of Psychiatry, University of Vermont, 38 Fletcher Place - Human Behavioral Pharmacology Lab, Burlington, VT 05401.

Recent Publications at HBPL

Bickel, W. K., DeGrandpre, R. J., Higgins, S. T., & Hughes, J. R. (1990). Behavioral economics of drug self-administration. I. Functional equivalence of response requirement and drug dose. Life Sciences.

Bickel, W. K., DeGrandpre, R. J., Higgins, S. T., & Hughes, J. R. (in press). Behavioral economics of drug self-administration. II. Unit-price analysis of cigarette smoking. Journal of the Experimental Analysis of Behavior.

Bickel, W. K., Higgins, S. T., & Hughes, J. R. (in press). The reported acquisition and performance of response sequences: Behavioral and pharmacological analysis of selective drug effects. Journal of the Experimental Analysis of Behavior.

Higgins, S. T., Bickel, W. K., Hughes, J. R., Lynn, M., Capeless, M. A., & Fenwick, J. (in press). Effects of intranasal cocaine on learning, performance and physiology. Psychopharmacology.

Higgins, S. T., Preston, K. L., Cone, E. J., Henningfield, J. E., & Jaffe, J. H. (in press). Behavioral, physiological and hormonal effects of a naloxone challenge following acute morphine pretreatment. Journal of Pharmacology and Experimental Therapeutics.

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Proceedings of the 1990 EAHB SIG Group Poster Session

The SIG's seventh annual group poster session was held at the Association for Behavior Analysis Convention in Nashville. Richard DeGrandpre (University of Vermont) served as chair.

The following posters were among those presented. To encourage correspondence, the name of a contact person is included at the end of each abstract.

2-Dimensional Stimulus Equivalence

Michael Alspaugh

In previous studies of visual equivalence class formation, matching was based on only one stimulus dimension (e.g., form). The present study investigated class formation using stimuli with two relevant dimensions (form and color).

Four subjects learned conditional discriminations between three three-member sets of uniquely-colored arbitrary figures. Conventional and specialized B-C and C-B probes, which separated the two dimensions, were used to assess equivalence. Three subjects formed equivalence classes which included both dimensions. Subject 4, however, responded incorrectly to almost all probes.

When an equivalence class, A1, B1, C1, is formed by two-dimensional (form/color) stimuli, there are at least six class members: A1 (form), A1 (color), B1 (form), B1 (color), C1 (form), and C1 (color); and possibly 9: A1 (form and color), B1 (form and color), and C1 (form and color).

Contact: Michael Alspaugh, 5454 S. Shore Drive, #835, Chicago, IL 60615

Effects of Amount, Delay, and Rate of Reinforcement in Human Self Control

Stephen R. Flora & William B. Pavlik
University of Georgia

Choice responding in adult humans as a function of amount-of, delay-to-, and rate-of reinforcement was examined in six experiments. In contrast to previous results reported with humans responding on a computer for points, subjects frequently chose the small-immediate reinforcer if its relative rate-of reinforcement was high. Choice for either large-delayed reinforcement, i.e., self control, or small-immediate reinforcement, i.e., impulsiveness, was most dependent on the relative rates-of reinforcement. Amounts-of and delays-to reinforcement which produced impulsive choice in Experiments 1 and 2, produced self-control choice in Experiment 3 when a postreinforcer delay was added to impulsive choice trials. Amounts-of and delays-to reinforcement which produced impulsive choice in Experiment 5 with a variable-interval 1.5-s schedule of choice responses produced self-control choice with a variable-interval 30-s schedule. Postreinforcer delays and different variable-interval values alter only the molar variable, reinforcement rate, not the molecular variables, amount-of and delay-to reinforcement. Matching equations comprised of only the molecular variables, amount and delay, do not account for these results. When rate-of reinforcement is equal for both alternatives (Experiment 4), or when the absolute difference in amount between alternatives is large (Experiment 6), amount-of reinforcement tended to control choice more so than delay-to reinforcement. When the length of the experimental session is determined by the number of choices made rather than by a set amount of time, impulsive behavior may produce a rate-of reinforcement that is greater than the rate produced by self-control behavior, but results in less total reinforcement and thus may be maladaptive.

Contact: S. R. Flora, Psychology Department, Fort Hays State University, Hays, KS 67601

The Effects of Two Error-Correction Procedures Upon the Acquisition of Human Sequential Ordering

Gerard R. Gaydos, Samuel M. Deitz,
Laura D. Fredrick, & David L. Myers
Georgia State University

Two experiments were conducted to examine the effects of two error correction procedures--correct position and correct stimulus--on the acquisition of human sequential ordering performance. Given three sets of seven abstract stimuli on a multiple schedule, subjects figured out and mastered a predetermined sequence for each set. After selecting a stimulus in the wrong order, subjects were exposed to one of the error correction procedures. In the correct position error correction procedure, the correct position for the selected stimulus was highlighted. In the correct stimulus error correction procedure, the stimulus that should have been selected in that position was highlighted. One experiment compared these correction procedures when the stimuli were presented in a new order on each trial while the other experiment compared them when the stimuli were presented in the same order on each trial that followed a trial with an error and in a new order on each trial that followed a trial with no errors. Results indicate that the correct stimulus error correction procedure consistently resulted in a higher percentage of correct responses, fewer trials to acquisition, and fewer trials to mastery.

Contact: Gerry Gaydos, Ed. Found., G. S. U., Atlanta, GA 30303

Reinforcement of Music Note-Labeling

Debbie S. Hanson
AIDSTECH/Family Health International

Key pressing responses were recorded for human subjects during a music note-labeling task. Three subjects were presented with a single, computer-generated note on a treble staff. Correct responses consisted of pressing the 'f' key, incorrect responses consisted of pressing any other key, and reinforcement was in the form of paired points and sounds, points only, or sound only. Experimental procedures consisted of alternating between reinforcement contingent upon correct responding and a control condition involving a DRO procedure in which reinforcement was contingent upon incorrect responding. Two of the subjects demonstrated differential responding under the reinforcement contingencies, while the responding of the other subject failed to show a stable increase in responding. The results indicated that the points were an effective reinforcer and could be instrumental for musical learning. The sound, however, appeared to have possibly functioned as an aversive environmental noise rather than as a reinforcer.

Contact: Debbie S. Hanson, AIDSTECH/Family Health International, P. O. Box 13950, Research Triangle Park, NC 27709

Stimulus Classes Established by Sample-and-S- Conditional Discrimination Performances

Cammarie Johnson
The New England Center for Autism and Northeastern University

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In a two-choice conditional discrimination task, it is impossible to tell whether the discrimination is under Sample-and-S+ or Sample and-S- control as both responding to the S+ and responding away from the S- would be observed as the same response: touching the S+ stimulus. This research examined the tests for emergent conditional discrimination performances within a two-choice, matach-to-sample paradigm which biased toward Sample-and-S- control. In all symmetry tests (BA, CB, and DC) the subject demonstrated performances consistent with either Sample-and-S+ or Sample-and-S- control. In the three-term transitivity tests (AC and BD), the subject demonstrated performances consistent with Sample-and-S- control. In six of seven three-term equivalence tests (CA and DB), the subject demonstrated performances consistent with Sample-and-S- control. Four-term transitivity and equivalence test performances were consistent with either Sample-and-S+ or Sample-and-S- control. The results from the tests and a subsequent naming probe suggest three findings: (1) three-term transitivity and/or three-term equivalence tests demonstrate whether the conditional discriminations were learned under Sample-and-S+ or Sample-and-S- control, (2) in this experiment, the baseline conditional discriminations were learned under Sample-and-S- control, and (3) with the Sample-and-S- conditional discrimination learning, two four-member classes were established (A1 B2 C1 D2 and A2 B1 C2 D1).

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Trial and Error vs. Component Training in Arbitrary Matching

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Three moderately retarded adolescent or adult subjects were exposed to a set of two training sessions each weekday. One two-choice arbitrary matching problem was presented under trial-and-error conditions and the other under a component training procedure. The latter began by establishing the comparison discrimination and it's rapid reversal. Then, the successive discrimination between the sample stimuli was established through differential naming. Finally, the same sample was presented in blocks of consecutive trials (sample naming was maintained). Block size decreased across sessions until sample presentation was randomized (as in trial-and-error training). Two subjects initially acquired arbitrary matching only with component training; both eventually learned rapidly under trail-and-error conditions. A third subject, still participating, has not consistently learned under either condition.

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Delayed Sample Presentation in MTS: Some Possible Advantages for Teaching Individuals with Developmental Limitations

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Matching-to-sample (MTS) procedures have been used for studying a wide range of topics in human and nonhuman behavior. Past research has led to the widespread use of what we may call "sample-first" MTS procedures. In such procedures, the sample stimulus is displayed first to start each trial. The comparison stimulus display then follows, typically after the subjects makes an "observing" response to the sample. In this methodological note, we will discuss the possible advantages of reversing the typical sequence, that is, presenting the comparison stimuli first and then the sample.

Before proceeding, we will first consider the major rationale for "sample-first" procedures. MTS performances have traditionally been analyzed in terms of chains of stimuli and responses: the subject's response to the sample results in events that in turn set the occasion for a response to a given comparison stimulus. These analyses seem particularly apt when nonhuman subjects are studied (e.g., Cumming & Berryman, 1965; McIntire, Cleary, & Thompson, 1987). Recent work in EAHB, however, suggests that human MTS performance may not be fully or even appropriately described by the traditional chaining accounts. Results from studies of stimulus equivalence and related topics, for example, seem more appropriately analyzed in terms of stimulus-stimulus relations (cf. Sidman, 1986). Within this analytical framework, the rationale for sample-first MTS methods appears less compelling. What follows will develop a rationale for presenting sample and comparison stimuli in a different sequence under some circumstances.

Studies with both human and nonhuman subjects have taught us that stimulus control of comparison selections in MTS may derive from features of the comparison display alone rather than from the sample stimulus differences intended by the experimenter. Although the subject may always initiate a MTS trial by touching the sample, that behavior does not necessarily engender reliable sample control. It seems obvious that the subject could make this "observing response" without actually observing the distinctive features that differentiate the current sample from other samples. If so, the subject is likely to respond on the basis of feature(s) of the comparison display alone -- stimulus control that is irrelevant and undesirable from the standpoint of the experimenter. Specific stimulus or position biases are well-known examples.

When stimulus control by a single irrelevant feature of the comparison display predominates, such control may not be difficult to identify. In the case of a position bias, for example, one merely notes that the subject tends to select comparisons in a particular position, regardless of what sample is present. Sometimes the analysis is not so easy, however. Our recent studies have shown us that MTS procedures may produce baselines in which demonstration of control by the desired sample-comparison relations is mixed with evidence of undesired control by irrelevant features of the comparison display (cf. Sidman, 1969, 1980). These findings are central to the main concern of this note, because we have found that reversing the usual order of sample and comparison presentation may be a useful technique for decreasing the frequency of control by the comparison display alone (e.g., McIlvane & Stoddard, 1981). As an illustration, we will describe some recent efforts to establish generalized identity MTS baselines in individuals who are severely mentally retarded. Subjects were two young women, JMG and LMT, aged 18 and 20 years, respectively. Their age-equivalent scores on the Peabody Picture Vocabulary Test were 4-1 and 2-2 (years-months), respectively.

The subjects were exposed to a visual-visual identity MTS procedure. Stimuli were two different line drawings presented on "keys" that appeared on the screen of a computer-based testing apparatus (Dube & McIlvane, 1989). Different pictures were used in every session.

In Condition A, a sample-first procedure was employed. Every trial began when a sample stimulus was displayed on a key in the center of the screen. After a touch to the sample, comparison stimuli were displayed on any two of four outer keys. One of the comparison stimuli was physically identical to the sample; its selection was followed by the removal of all stimuli, a token reinforcer, and a 1.5 s intertrial interval (ITI). The

other comparison stimulus was physically different from the sample; its selection was followed only by removal of the stimuli and the ITI.

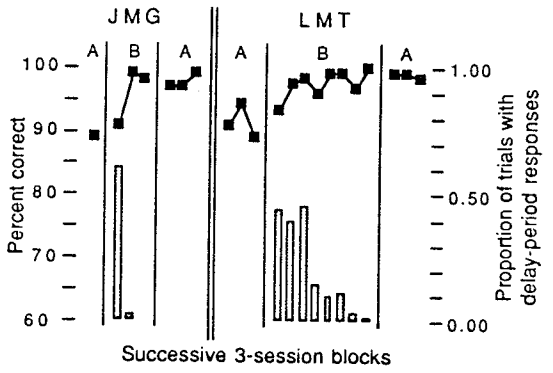

Figure 1: Left ordinate and filled squares: Accuracy scores (percent correct) of subjects JMG and LMT with samples-first (A) and delayed-sample (B) MTS procedures. Right ordinate and histograms: Proportion of trials on which subjects responded to the comparison display prior to the sample presentation.

The filled squares in Figure 1 show performance in successive blocks of three sessions each; blocks typically consisted of 144 trials. The subject's Condition A accuracy scores were good but variable. Individual session scores ranged from 85% to 92% for JMG and from 75% to 100% for LMT. MTS baselines like this -- good but short of perfection -- are often observed with developmentally limited subjects. They stand in marked contrast to the virtually perfect performances that are customary with more capable human subjects like college students. On encountering accurate but imperfect performances like the ones we obtained, one is led to ask two questions. First, why do errors continue given that the otherwise high accuracy scores show that the subject understands what to do? Second, what can be done to reduce these errors?

Addressing the first question, one might point out the subjects' developmental limitations, perhaps asserting that unreliable performance must be expected in this population. If so, prospects for improving performance would not seem very good. Experience tells us, however, that unreliable performance is not inevitable with developmentally limited individuals. For example, we recently reported an extensive methodological study of discrimination learning in people with profound intellectual handicaps (McIlvane, Kledaras, Dube, & Stoddard, 1989). That work demonstrated that persistently inaccurate discrimination resulted when teaching contingencies inadvertently maintained stimulus control that was not consistent with the performances that we sought to teach. When the contingencies were refined, virtually errorless performance often proved attainable. The major refinement was to arrange the contingencies such that irrelevant stimulus control was less likely to be reinforced. In broad overview, the approach was to begin each discrimination trial by displaying irrelevant stimuli that might control unwanted responding. The relevant stimuli were displayed only after responding to the irrelevant ones had abated.

Applied to MTS, this general approach is implemented by initially displaying the comparison stimuli alone, without a sample. Any responses that occur to this display are obviously controlled by stimuli irrelevant to MTS performance; the sample is not present. The sample is presented after a brief delay period during which no responses have been made to the comparison display. This delayed-sample procedure was applied in an effort to improve our severely retarded subjects' MTS baselines (Condition B). The comparison stimuli were displayed first, and no sample appeared on the center key for a least 3 s. The sample was presented only if there was no response to the comparisons for the 3 s delay period. Thus, any such responses delayed the sample presentation for an additional 3 s.

The histograms in Figure 1 show the proportion of trials on which the subjects responded at least once in the delay period, prior to the sample presentation. In the initial Condition B sessions, both subjects displayed substantial delay-period responding, thus revealing stimulus control by the comparison display alone that might potentially compete with the desired control by the samples. In subsequent Condition B sessions, however, responding during the delay period declined, abruptly for JMG and more gradually for LMT. Such responding eventually ceased for both subjects. The variable(s) responsible for the between-subject difference in the persistence of delay-period responding is (are) not clear. Likely candidates include the functional level of the subjects (LMT was much less capable) or the length of the Condition A baseline (nine sessions for LMT vs. three for JMG).

For both subjects, declining delay-period responding was accompanied by increasing MTS accuracy scores. Further, high accuracy was maintained when we reinstated the Condition A procedures. Maintaining accuracy with these

procedures was important because there are circumstances under which the sample-first procedure must be used (e.g., delayed MTS). However, maintained accuracy also raises the possibility that the improvement observed in Condition B would have occurred even if the delayed-sample procedure had not been implemented, that is, if training had merely continued with the Condition A procedures. A formal comparison of the sample-first and delayed-sample methods is thus necessary to ascertain empirically whether one tends to encourage higher accuracy scores than the other.

Logically, however, the delayed-sample method seems to offer some possible teaching advantages. The method may ultimately prove to be a good one for ferreting out and decreasing the frequency of competing control by the comparison display alone. If the comparison display tends to control behavior other than waiting for the sample, that behavior can occur during the delay period. Because delay-period responses are never reinforced, the future probability of stimulus control that does not involve the sample should be reduced. Decreasing the probability of such irrelevant control, therefore, might be expected to make sample stimulus control increasingly more likely.

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Author Notes

This research was supported by NICHD grants HD22218 and HD 25995 and by the Department of Mental Retardation of the Commonwealth of Massachusetts (Contract 3403-8403-306). W. J. McIlvane, L. T. Stoddard, and W. V. Dube are also affiliated with Northeastern University. Joanne Kledaras is also affiliated with the Learning Center for the Multiply Handicapped. We thank Anne Kupfer and the staff of the Learning Center for their cooperation in the conduct of this research. We also thank Gina Green for helpful comments on the paper. Correspondence may be addressed to **W. J. McIlvane**, Behavior Analysis Division, E. K. Shriver Center, 200 Trapelo Rd., Waltham, MA, 02254.

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