BRIEF REPORT

ASSESSING TRANSFER OF RESPONSE SPEED AND NODALITY VIA CONDITIONAL DISCRIMINATIONS

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What would happen if, having formed two independent sets of stimulus equivalence classes, one with a speed contingency and the other without, one member from the non-speed classes served as a positive comparison for a member of the speed classes? Would the remaining members of the non-speed classes occasion response speeds similar to those of the speed classes when tested? According to set union and intersection (Sidman, 1994), stimuli sharing membership in more than one class defined by different functions would exhibit overlapping characteristics. When sample-comparison choices between two speed and non-speed stimuli are trained, the non-speed stimulus acquires and shares overlapping response-speed characteristics with the speed stimulus, and might therefore transfer these properties to the remaining non-speed class members. What is unique about this arrangement is that transfer of the response-speed functions would have been achieved using conditional discrimination procedures exclusively.

In typical transfer-of-functions studies, upon demonstration of equivalence among class members, a new discriminative, response, or consequence function is trained to specific members of the class and then shown to transfer to the remaining class members (e.g., Barnes & Keenan, 1993; de Rose, McIlvane, Dube, Galpin, & Stoddard, 1988; Dymond & Barnes, 1994; Greenway, Dougher, & Wulfert, 1996). Besides training "a function that is independent of the shared functions that define the class" (Dougher & Markham, 1996, p. 139), many such studies employ various nonmatching-to-sample procedures to train and/or test the independent function (e.g., Barnes & Keenan, 1993; Greenway et al., 1996). A study reported by Fields, Landon-Jimenez, Buffington, and Adams (1995) in which two five-member classes were formed is illustrative. The researchers trained four new responses to a subset of equivalence class members (A1, E1, A2, and E2 stimuli) using stimulus fading procedures, before testing for response transfer. They reported the formation of two five-member equivalence classes for two participants whose accuracy performances were inverse functions of nodality on post-transfer tests.

The post-transfer nodality effect suggests, of course, that the equivalence class members were not equally related to one another with respect to the new response function. Such evidence of nonsubstitutability of equivalence class members is problematic because by virtue of their class membership they should be substitutable for one another, ipso facto, due to their common history of reinforcement (Fields et al., 1995; Sidman, 1990, 1994; Sidman, Wynne, Maguire, & Barnes, 1989; cf. Fields, Adams, & Verhave, 1993). When new stimuli join a class by training or testing (Saunders, Saunders, Kirby, & Spradlin, 1988), therefore, the new members should become equivalent to the old ones (see Sidman, 1994, p. 543). Reports of nodality effects thus are unsettling from a reinforcement contingency perspective (Catania, 1996; Schick, 1971).

Imam (2001, Experiment 2) virtually eliminated the nodality effect by presenting equal numbers of baseline trial types, for participants who formed speed and non-speed equivalence classes. If, however, a member of a speed class served as a sample for a member of a non-speed class, would the other members of the non-speed

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class exhibit response speeds similar to those of the speed class when tested? What would be the effect on nodality? The present study was designed to answer these questions.

No report of transfer of response speeds is available in the literature. Class expansions or mergers achieved by training new conditional discriminations between members of two existing equivalence classes have been reported, however (Saunders, Saunders, et al., 1988; Saunders, Wachter, & Spradlin, 1988; Sidman, Kirk, & Willson-Morris, 1985; see Green & Saunders, 1998). Sidman et al. (1985), for example, showed that training conditional discriminations with C and E stimuli from two separate three three-member classes (A, B, C, and D, E, F) resulted in six-member classes for five of eight participants (see also Saunders, Saunders, et al. 1988; Saunders, Wachter, & Spradlin, 1988). In a similar vein, if one could merge two sets of equivalence classes independently defined by sample-comparison selections with and without speed, it would forestall the need for new procedures and new functions commonly used in transfer-of-functions studies of substitutability that sometimes clutter the theoretical status of transfer of functions (for discussions see Dougher & Markham, 1994, 1996).

The present study trained and tested transfer of response speeds using only conditional discrimination tasks. A linear-series (LS) training structure typically employed in nodality tests (Imam, 2001; Saunders & Green, 1999) was used with equal numbers of baseline trial types to preclude the likelihood that the previously reported lack of nodality effect resulted from the extra FG trials presented in Imam (2001, Experiment 2). Thus, pre- and post-transfer tests should show no nodality effect.

METHOD

Subject and Apparatus

Dina was a female undergraduate of the American University of Beirut. She earned money based on hourly attendance and session performance, at a rate of LL. 4,500.00 (= U. S. $3.00) per hour and LL. 31.00 (= U. S. $0.02) per point earned regardless of feedback in a block.

A Macintosh computer controlled experimental events and collected data using MTS software (Dube & Hiris, 1997). Samples appeared at the center of the screen. Comparisons appeared randomly from trial to trial at the corners of the screen. A click on the mouse button registered responses. The interval between responding to the sample and selecting a comparison defined latency. The experimenter calculated the response speed as the inverse of the latency.

Stimuli

Figure 1 shows the 2.5-cm by 2.5-cm stimuli used. The letter and number designations of comparison stimuli and class membership, respectively, were unknown to the participant.

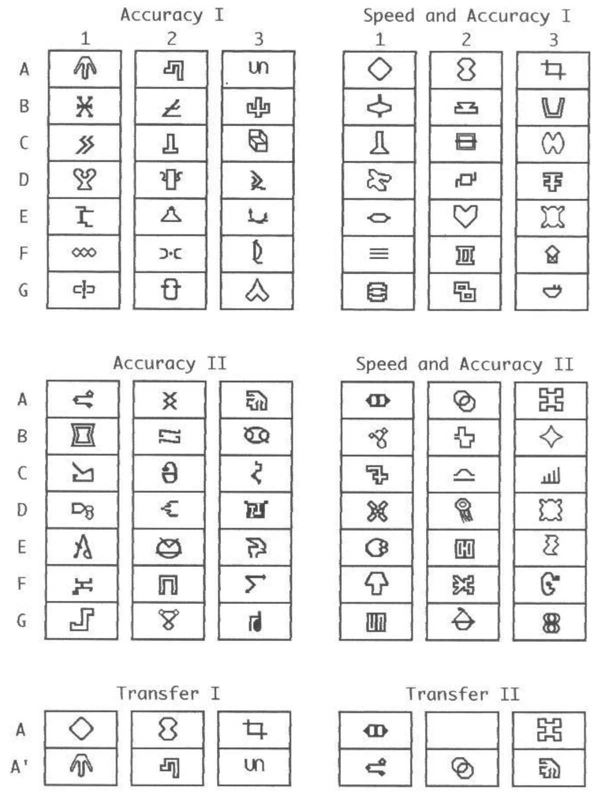

Figure1

General Procedures

Three stages were involved. The first stage established three seven-member classes in 4 conditions: Accuracy-1, Speed-and-Accuracy-1, Accuracy-2, and Speed-and-Accuracy-2. With the exception of Accuracy-1, each condition consisted of two consecutive phases: Paced and Massed. A unique set of stimuli was used in each of the four conditions (see Figure 1). Throughout, matching-to-sample procedures established conditional relations among the four different sets of stimuli. The general procedures, including matching-to-sample, pretraining, accuracy-only, and accuracy-

Table 1

Sequence of conditions and number of sessions for each condition.

Condition / Phase	Number of Sessions
Pretraining	1
Stage 1	
Accuracy 1 (Paced only)	8
Accuracy and Speed 1	
Paced	11
Massed	6
Accuracy 2	
Paced	5
Massed	3
Accuracy and Speed 2	
Paced	10
Massed	17
Stage 2: Review	5*
Stage 3: Transfer	4
Total number of sessions	70

* Review of Accuracy 1 was conducted twice.

and-speed contingencies, as well as the criteria for assessing the formation of equivalence classes, are detailed in Imam (2001, Experiment 2), and are not described further. Table 1 presents the sequence of conditions and the number of sessions per condition.

Stage 1: Demonstrating Equivalence Classes

Four sets of three seven-member equivalence classes were established in two accuracy-only conditions and two accuracy-and-speed conditions. Table 2 shows that each baseline trial appeared a minimum of 60 times by the end of paced training and testing (cf. Imam, 2001).

Paced Phase. Training alternated with testing blocks. Training blocks consisted of baseline trials designated AB, BC, CD, DE, EF, and FG. Testing blocks consisted of 24 1-, 2-, 3-, 4-, and 5-node transitivity (AC, AD, AE, AF, and AG), and equivalence (CA, DA, EA, FA, and GA) trials, respectively, in addition to the applicable baseline trials.

The first training block of AB and BC trials remained in effect until Dina attained at least 90% correct. To keep the number of trial types equal across the blocks of this phase, the number of AB+BC blocks completed determined the number of subsequent paced-training blocks. No programmed consequences occurred in test blocks.

Massed Phase. Testing in the massed phase added the remaining equivalence and transitivity trial types to those tested in the paced phase and included symmetry tests in different blocks. The symmetry, transitivity, and equivalence blocks, presented in that order, contained their respective trial types plus the applicable baseline trials. No programmed consequences occurred in these test blocks.

Stage 2: Review of Stage-1 Classes

Because of the large number of sessions between the completion of the first and fourth conditions (see Table 1), a review of the four conditions of Stage 1 was conducted in two blocks each of symmetry, transitivity, and equivalence tests, to ensure maintenance of the conditional discriminations. Each test block was as described above for the massed phase. The Accuracy-1 review tests were repeated twice because no massed testing followed the first paced phase.

Stage 3: Transfer Training and Testing

Finally, two conditions of transfer-of-speed training and testing were implemented. As shown in the lower portion of Figure 1, in Transfer 1, the three A-stimuli of Speed-and- Accuracy-1 (A) served as samples for the three A-stimuli of Accuracy-1 (A'), using the former's 1.4-s limited hold. In Transfer 2, only A1 and A3 from Speed-and-Accuracy-2 served as samples for A1 and A3 of Accuracy-2, with a 1.3-s limited hold; A2 was always an incorrect comparison (see Figure 1). Each transfer-training block contained six trials of each trial type, making 18 trials in Transfer 1 and 12 trials in Transfer 2. Upon attaining a minimum of 90% correct in two consecutive training blocks with 100% feedback, transfer baseline maintenance blocks were presented without feedback before transfer testing resumed.

RESULTS

Dina formed four independent 3 seven-member equivalence classes and showed transfer of response speeds under the two transfer conditions.

Figure 2 presents the relative frequency distribution of response speeds for correct responses on equivalence trials under the accuracy-only (Accuracy), the speed-and-accuracy (Speed), and the transfer tests. The speed

Table 2

Minimum number of baseline relations presented in paced training and testing.

Block	Baseline Relation AB	BC	CD	DE	EF	FG
Paced Training						
ABC	18	18				
ABCD	9	9	18			
ABCDE	6	6	15	21		
ABCDEF	3	3	3	12	27	
ABCDEFG	3	3	3	6	12	39
Subtotal	39	39	39	39	39	39
Paced Testing						
AC+CA	6	6				
AD+DA	6	6	9			
AE+EA	3	3	6	9		
AF+FA	3	3	3	6	12	
AG+GA	3	3	3	6	9	21
Subtotal	21	21	21	21	21	21
GRAND TOTAL	60	60	60	60	60	60

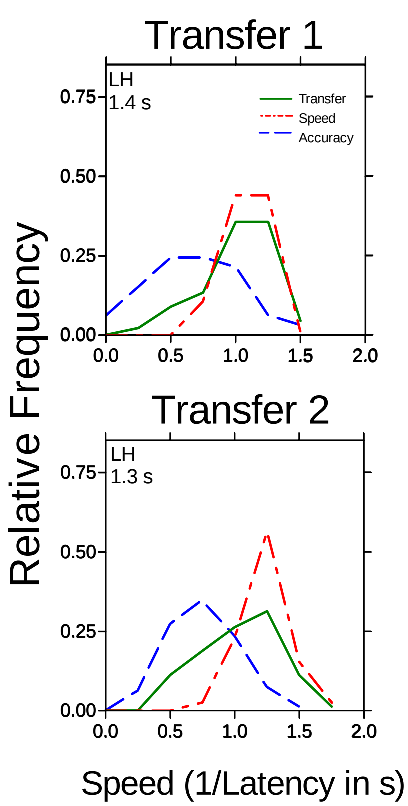

Figure 2

contingencies and transfer training produced skewed distributions of response speeds in the accuracy-and-speed and transfer tests, respectively, showing significant deviations from the normally distributed response speeds of the accuracy-only conditions. Incomplete transfer was indicated by the less leptokurtic distributions of the transfer speeds compared to those of the accuracy-and-speed.

Analyses of variance (ANOVA), conducted using GraphPad (2000) on mean response speeds of equivalence trials as a function of nodal number, assessed nodality in each condition across the three stages. Because each nodal number has unequal numbers of trial types in a LS structure, the number of 1-node, 2-node, and 3-node equivalence trials was equalized as described previously by Imam (2001) and Spencer and Chase (1996). In the paced phases, all trials in test blocks were included in the analyses. Figure 3 presents the mean response speed for correct responses at each nodal number for the paced, massed, review, and transfer phases (the two reviews of Accuracy 1 marked *). Error bars on the mean speed represent SD. Nine of the fourteen cases showed decreasing speed across nodal number, but only two of these (marked α in

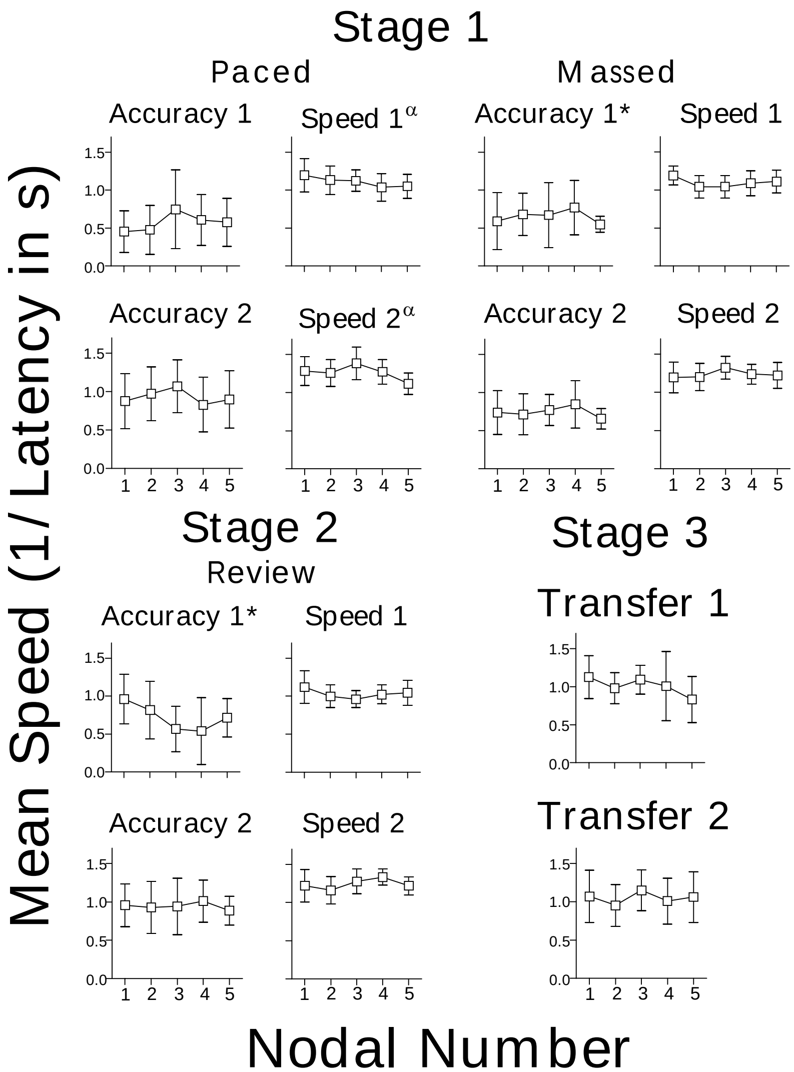

Figure 3

Figure 3) were statistically significant (p < .05). Both of these cases occurred under the speed conditions of the paced phase.

DISCUSSION

After conditional discrimination training, Dina responded faster under the two transfer conditions to non-speed equivalence class members previously not involved in transfer training. Dina's performance demonstrated maintenance and merger of different equivalence classes by means of response-speed transfer through conditional discriminations. The increases in response speeds also indicated different degrees of mergers of class membership, with Transfer 1 exhibiting better merger than Transfer 2 (see Figure 2), although neither showed complete merger. Such incomplete mergers may reflect Dougher and Markham's (1996) observation that class unions do not automatically follow from the participation of stimuli in more than one class. Given that Dina received only one set of transfer testing blocks in the present study, it remains to be seen whether extended testing would yield a more complete merger than was found in the present study. Studies that have shown improved performance under continued testing during equivalence class formation (e.g., Saunders, Saunders, et al. 1988) suggest a similar effect might occur under the present transfer model.

Despite the stringent contingencies in this experiment and the common difficulties of demonstrating equivalence under the LS structure (Fields et al., 1995; Saunders & Green, 1999), Dina formed four independent 3 seven-member classes representing four replications of Imam (2001). The results confirm those of Imam (2001, Experiment 2) in two specific ways. First, in the present experiment, across the paced, massed, and review phases, response speed changed in no systematic way as a function of nodal number, confirming the effects of presenting equal numbers of baseline conditional discriminations (cf. Imam, 2001, Experiment 1; Kennedy, 1991, Experiment 1; Spencer & Chase, 1996). Second, consistent with the pre-transfer results, the nodality effect was absent in post-transfer tests. Thus, in the present study, not only did the pre-transfer tests not show the nodality effect, the post-transfer tests failed to show it as well, precluding previous interpretations of the nodality effect observed in post-class-formation transfer tests but absent among pre-transfer class members (e.g., Fields et al., 1995).

Unlike in typical transfer-of-functions studies (e.g., Barnes & Keenan, 1993; de Rose et al., 1988; Dymond & Barnes, 1994; Fields, Adams, & Verhave, 1993; Fields et al., 1995; Greenway et al., 1996), no new and independent behavioral function was required to achieve the class mergers observed under the two transfer conditions of the present study. These results are consistent with set union and intersection (Sidman, 1994), which suggest that stimuli sharing membership in more than one class defined by different functions would exhibit overlapping characteristics. The results, therefore, support the feasibility of equivalence class mergers modeled after mathematical set union through exclusive use of conditional discrimination procedures. In this respect, this study represents an empirical first step towards a greater understanding of some of the clutter surrounding the theoretical status of transfer of functions (for discussions see Dougher & Markham, 1994, 1996).

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BRIEF REPORT

THE FINANCIAL NEED QUESTIONNAIRE: BEHAVIORAL AND PSYCHOMETRIC SUPPORT FOR THE ASSESSMENT OF FINANCIAL NEED IN MONETARY REINFORCEMENT RESEARCH

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Michael (1982) proposed the establishing operation concept, which refers to events, operations, or conditions that enhance the reinforcing value of a stimulus and increase the frequency of behaviors that lead to this stimulus as a consequence. A parallel concept, abolishing operation, is an event, operation, or condition that decreases the reinforcing value of a stimulus and decreases the frequency of behaviors that lead to this stimulus as a consequence (Michael, 1982). Typically, deprivation functions as an establishing operation and satiation functions as an abolishing operation.

Several non-human research studies (Clark, 1958; Segal, 1959; Dale & Roberts, 1986) have demonstrated the effects of deprivation and satiation on operant responding. Satiation is associated with failure to respond (Reese & Hogenson, 1962), whereas deprivation is associated with increased response rates (Boren, 1959) and decreased sensitivity to reinforcement contingencies (Lewis & Dougherty, 1992; Powell, 1973).

In basic non-human research, food-deprivation levels are quantified as percent of free-feeding body weight or number of hours since last access to food. In human research, some researchers have employed methods to discover variables that might influence the effectiveness of reinforcers. For example, Dougherty, Cherek, and Roache (1994) administered alcohol breathalizer and urine tests to screen for medicinal and street drug use that could affect the participant's response to operant contingencies. In another study, DeGrandpre, Bickel, Rizvi, and Hughes (1993) conducted a choice experiment in which participants earned cigarette puffs. DeGrandpre et al. selected only cigarette smokers as participants, and instructed participants to abstain from smoking 6 hours prior to the study. To ensure that participants were cigarette-deprived, the researchers administered a carbon monoxide (CO) breath test upon the participant's arrival at the research lab.

DeGrandpre et al. (1993) also explored the effects of manipulating financial variables. Specifically, the researchers allotted each participant a set income (i.e., amount of money to spend on cigarette puffs earned during each session). When a participant earned a cigarette puff, they could choose their preferred cigarette brand or a less-preferred brand, which was valued at 1/5 the cost of the preferred brand. The cost of each earned puff was subtracted from the participant's allotted income. Level of income was manipulated across several sessions. When income was high, participants chose to inhale puffs of the preferred brand. When income was low, participants chose less expensive brands. Thus, financial variables can affect the type of stimuli that can function as reinforcers.

Although DeGrandpre et al. (1993) and Dougherty et al. (1994) have advanced the assessment of establishing operations in human research, a draw-back of urine screening and breath testing is the financial investment required to purchase equipment and supplies. Moreover,

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these indices of establishing operations are relatively specific to drug and alcohol research.

Monetary reinforcement is used in a broad range of human research areas. Unfortunately, researchers employing monetary rewards typically make an unsupported assumption that money is a generalized reinforcer, is of equal value, and functions in the same manner for every participant. Variability in participant behavior may be due in part to differences in the motivational value of the rewards employed. If the reinforcing value of monetary rewards (i.e., financial need) can be quantified in advance of the experimental procedure, then one can establish the potential effectiveness of monetary rewards for each participant.

The purpose of the present study was to develop a scoring system, gather normative data, and examine the reliability and validity of a self-report questionnaire that was designed to assess financial need of undergraduate students who participate in monetary reinforcement research. The questionnaire was originally used by Madden and Perone (1999) to screen and select participants for an operant reinforcement study.

PHASE 1: PSYCHOMETRIC SUPPORT

The purpose of Phase 1 was to gather normative data, develop an empirically-derived scoring system, assess test-retest reliability, and examine construct validity for the Financial Need Questionnaire (FNQ) using a large sample of participants.

Empirically-Derived Scoring System

Participants. A sample of 567 undergraduate students enrolled in a West Virginia University (WVU) introductory psychology course participated in phase 1. Participants were 301 females and 264 males aged between 17 and 43 years (*M* = 19, *SD* = 2.41). Ethnic/racial information was given by 547 participants as follows: Caucasian, 88.5%; Asian, 3.5%; African-American, 3%; Hispanic, 1%; and Bi-racial, less than 1%.

Measure. The Financial Need Questionnaire (FNQ) is an 8-item, multiple-choice questionnaire, which assesses current living expenses and spending habits relevant to undergraduate students.

Procedure. The FNQ was distributed to students in 14 introductory psychology sections. Students completed the FNQ either before or after their regularly scheduled class meeting. In addition to the 8 FNQ items, students also provided a rating of overall level of financial need ("Overall, how would you describe your level of financial need? How much do you need money?"). This item was rated on an 11-point-scale, with 0 being none and 10 being extreme financial need.

Results. Scoring of the FNQ was empirically-derived. As shown in Table 1, for each item, the alternatives are scored from 0 to 3 based on the rank of the overall financial need rating (0 to 10), derived from the average overall financial need rating (0 to 10) of participants who endorsed that alternative. For example, for item 1 ("Where do you live?") participants who endorsed alternative "(a) At home with parents" reported an average financial need rating of 5.35, which is the lowest average need among the alternatives. Thus, alternative "a" is scored as 0 whereas alternative "(c) in a fraternity/sorority house" is scored as 3 because participants who endorsed alternative c had an average financial need score of 6.56, the highest financial need among the alternatives. Likewise, alternative "(b) In a WVU residence hall" is scored as 1 because participants, on average, who endorsed this alternative reported the second lowest overall financial need rating, and alternative "(d) In a house/apartment" is scored as 2 because participants, on average, who endorsed this alternative reported the second highest overall financial need rating. The number of participants who endorsed each alternative is shown in Table 1.

By summing scores for each of the 8 items, the total FNQ score can range from 1 to 24, with higher scores corresponding to higher levels of financial need. As shown in Figure 1, FNQ total scores were normally distributed with obtained scores ranging from 4 to 19, and a mean score of 10.75 (*SD* = 3.02). There were no gender

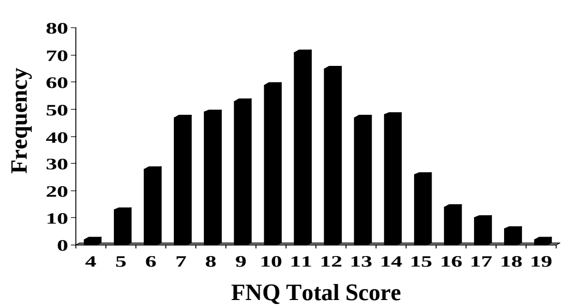

Figure 1

Table 1

Financial Need Questionnaire (FNQ) items, alternatives, and scoring as well as average financial need and number of participants who endorsed each alternative

Item	Alternative	Score	Mean Need Rating	*N*
1. Where do you live?	(a) At home with parents.	0	5.35	48
	(b) In a university residence hall.	1	5.82	307
	(c) In a fraternity/sorority house.	3	6.56	16
	(d) In a house/apartment.	2	5.97	194
2. How are your living expenses (rent, food, entertainment, etc.) paid?	(a) Mostly by parents.	0	5.47	299
	(b) Mostly by scholarship, parents pay the rest.	1	5.56	48
	(c) Mostly by yourself.	2	6.49	150
	(d) Mostly by scholarship, you pay the rest.	3	6.59	49
3. How are your university expenses (books, tuition, fees, etc.) paid?	(a) Mostly by parents.	1	5.70	291
	(b) Mostly by scholarship, parents pay the rest.	0	5.07	88
	(c) Mostly by yourself.	2	6.45	114
	(d) Mostly by scholarship, you pay the rest.	3	6.64	67
4. During an average week, how often do you eat at a restaurant?	(a) Never eat out.	3	6.08	39
	(b) Less than 3 times.	2	5.90	333
	(c) 3 - 7 times.	1	5.74	181
	(d) Almost all meals.	0	5.64	11
5. When you eat out, how much do you usually spend?	(a) Less than $5.	3	6.17	94
	(b) $5 to $10	2	5.81	394
	(c) More than $10	1	5.68	72
6. How often do you have pocket money to buy simple things?	(a) Never.	3	7.41	17
	(b) Sometimes, but there are days when I am broke.	2	6.33	220
	(c) Usually.	1	5.70	204
	(d) Always.	0	5.07	123

Table 1

(Continued)

Item	Alternative	Score	Mean Need Rating	*N*
7. On weekends, if you want to, how often do you have money to go out?	(a) Never.	3	7.00	7
	(b) Sometimes, but sometimes I have to stay home.	2	6.77	150
	(c) Usually.	1	5.77	275
	(d) Always.	0	4.89	132
8. Are you employed?	(a) Yes.	1	5.96	165
	(b) Yes, Federal Work-Study Position	3	6.82	67
	(c) No. I don't have a job but I am looking for one.	2	6.24	178
	(d) No. I don't have a job and I am not looking for one.	0	4.88	152

differences on FNQ scores. There was not enough racial diversity in the sample to examine racial differences.

Test-Retest Reliability

Test-retest reliability was examined to assess the temporal stability of the FNQ.

Participants. Participants were 28 undergraduate students from one of the introductory psychology classes included in the development sample, described above. Participants included 15 females and 13 males, aged 18 to 34 years (M = 19, SD = 3.12). Information about ethnic/racial groups was reported as follows: Caucasian, 96.4% and African-American, 3.6%.

Procedure. After a 17-day interval, the FNQ was re-administered to students before their scheduled class period. Students who completed both FNQ administrations earned 2 extra credit points toward their psychology course.

Results. The relation between FNQ score obtained at each administration was examined using a Pearson product moment correlation, yielding a coefficient of $r = .90$, $p < .001$. Results show that the FNQ demonstrates good test-reliability.

Construct Validity

Construct validity was examined to determine how well the FNQ measures the construct of financial need. Convergent evidence of construct validity was gathered by examining the relation between FNQ scores and other financial need measures.

Participants. Fifty-six undergraduate students participated. Participants were recruited from two WVU introductory psychology classes that were not included in the FNQ development sample. Questionnaires were completed anonymously and demographic information was not reported.

Procedure. The FNQ, described above, was administered along with a financial information questionnaire to assess savings, debt, and surplus money. On the financial information questionnaire, participants listed the amount of money invested in various types of savings accounts (i.e., savings, Christmas club, certificate of deposit, bonds, stock or mutual funds, money market, and other). Participants also listed the amount of money owed for various types of debt (i.e., student loans, credit cards, personal loans, unpaid bills, mortgage, and other). Finally, participants responded to the question, "At the end of the month, after you have paid for what you need (food and rent, etc.) and want (entertainment, etc.), how much money do you typically have left over?"

The FNQ and the financial information questionnaire were distributed before the regularly scheduled class meeting, and participants were instructed to complete the questionnaires at home and to refer to their financial records as needed. The questionnaires were collected at the beginning of each class meeting during a 1-week period following their initial distribution. Each participant earned 2 points of extra credit toward their psychology course.

Results. The mean total FNQ score of 10.6 (*SD* = 2.99) is consistent with the mean score obtained from the development sample. Results reveal that FNQ total scores relate to debt ($r = .36$, $p < .008$), but not savings ($r = -.18$, *ns*) or surplus money ($r = -.20$, *ns*).

PHASE 2: BEHAVIORAL SUPPORT

In addition to the evidence of reliability and validity described above, it is also important to assess predictive validity to determine if a participant's FNQ score can predict reinforcement schedule performance. In the present phase, we assessed the relationship between FNQ score and mixed fixed ratio (FR) differential reinforcement of low rate (DRL) schedule responding to determine if FNQ scores were related to points earned, response rate, and sensitivity to changing schedules of reinforcement. We hypothesized that participants with higher FNQ scores, compared to low scores, would earn less points, respond at higher response rates and be less sensitive to contingency changes. This hypothesis is based on non-human research findings showing that food deprivation is associated with high response rates and less sensitivity to changing contingencies (Boren, 1959; Lewis & Dougherty, 1992; Powell, 1973).

Participants. Twenty-seven Introductory Psychology undergraduate students qualified for participation. FNQ scores ranged from 3 to 17 (*M* = 11.12, *SD* = 3.77). Qualification criteria included completion of no other college-level psychology course work and no previous or current participation in behavior analysis/operant research. Data from one outlier participant was excluded due to the participant's extremely efficient schedule responding and a suspicion that the participant was not naïve to the scheduled contingencies. Participants were 16 females and 10 males, aged 17 to 23 years (*M* = 19, *SD* = 1.66). Information about ethnic/racial groups was reported as follows: Caucasian, 84.6%; Asian, 7.7%; and African-American, 7.7%. Participants earned one cent per point, based on their operant schedule performance. To compensate participants for their time and to encourage attendance, participants received extra credit points toward their psychology course.

Apparatus. All sessions were conducted in a 3-m x 6-m research lab in the Department of Psychology at West Virginia University. Participants were seated at a desk that supported a Hewlett Packard Pavilion computer with color monitor and a keyboard. A Visual Basic program executed on the computer controlled the experimental procedure, and data were stored in a Microsoft Access database.

Procedure. Informed consent was obtained, and the participants completed the FNQ. Afterward, participants responded to an operant schedule (see below) for 80 min, with a 10-min break after the first 40 min. Participation lasted for approximately 2 h. Participants were paid at the end of the session. Before participating in the operant task, participants were instructed to read the followed typed copy of the instructions:

> I am about to participate in a computer activity in which I have the opportunity to earn points worth cash. My job is to earn as many points as possible. Each press of the space bar is an attempt to earn a point. Some presses may produce points and some may not. When I do earn a point, the monitor screen will display a message box for 3 seconds that says, "You scored. Press Enter." When I see that box, I must hit enter immediately to record the point. It is important to hit enter immediately because only recorded points count towards the cash prize. If I have any questions, I should alert the experimenter now.

During the activity, participants were seated in front of the computer monitor. Space bar presses produced points on a mixed FR 32 DRL 6-s schedule. A mixed schedule was selected because it is more difficult to discriminate than less complex reinforcement schedules thereby increasing the likelihood that schedule performance could be explained more by variability in FNQ score than by simplicity of the task.

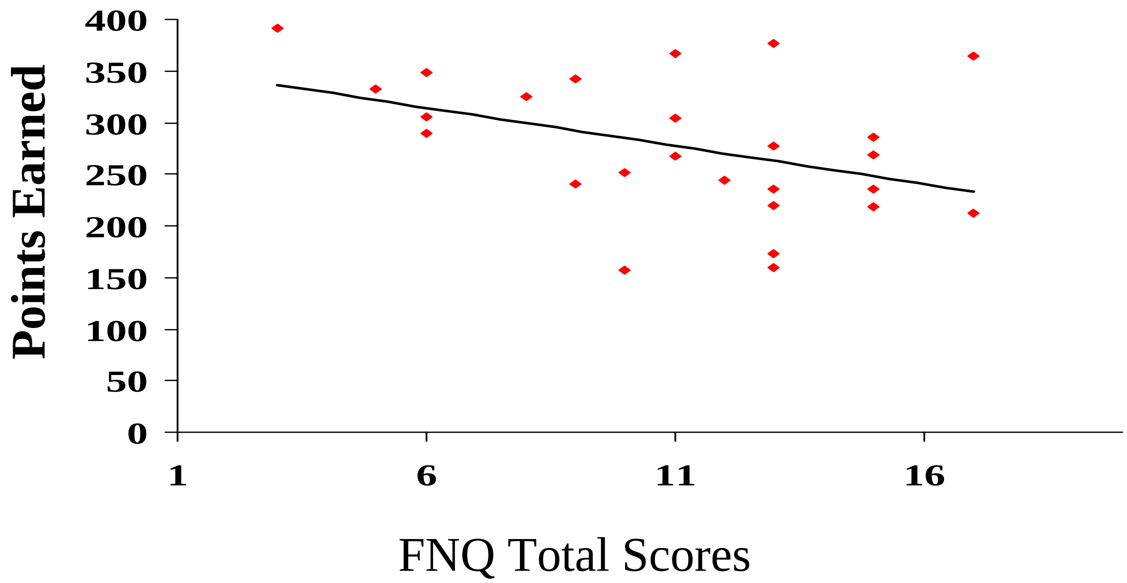

Figure 2

The mixed FR DRL schedule provided points, worth one cent each, for every 32 spacebar presses when the FR schedule was in effect and for every lapse of at least 6-s between presses when the DRL schedule was in effect. The space bar had to be pressed and released to register as a response.

The initial component was selected randomly each session. The FR and DRL components alternated every 2 min, with no stimulus to denote the schedule change. The computer screen remained dark blue throughout the session, except when a message box appeared to indicate "Point Earned." During the appearance of this box, the participant was required to make a consummatory response by hitting the "enter" key on the computer keyboard within a 3-s limited hold. A "Point Recorded" message was displayed for 1 s following engagement in the consummatory response.

Nine of the 26 participants (34 %) earned no points in the DRL component. For these participants, a mixed FR Extinction schedule was the functional contingency in effect. Likewise, 2 of the 26 participants (7 %) did not earn points in the FR component. For these participants, a mixed DRL Extinction schedule was the functional contingency in effect.

Results. As shown in Figure 2 a Pearson product moment correlation analysis yielded a coefficient of $r = -.42$, $p < .03$ between FNQ score and points earned on the mixed schedule. FNQ scores accounted for 17 % of variance in points earned. Figure 2 also shows that high-FNQ scorers tended to show more within-group variability in points earned than low-FNQ scorers.

Figure 3 shows responses per minute for the FR and DRL components across FNQ scores. Responses per minute reflect average response rate across 20 components of each schedule. In the calculation of responses per minute, consummatory response time was subtracted from the 40 min of schedule exposure. Although not statistically significant, there was a trend for low-FNQ scorers to respond at higher rates than high-FNQ scorers in both components.

To determine how effectively participants discriminated between the two components (i.e. responded fast during FR and slow during DRL), a discrimination ratio was calculated for each pair of FR and DRL components. The discrimination ratio was calculated as responses per minute in FR divided by total responses per minute for the pair of components (FR plus DRL). Again, consummatory response time was subtracted in the calculation of responses per minute. Discrimination ratios of .50 reflect equal responding in both components, suggesting no discrimination. Ratios greater than .50 reflect more responding in the FR component whereas ratios

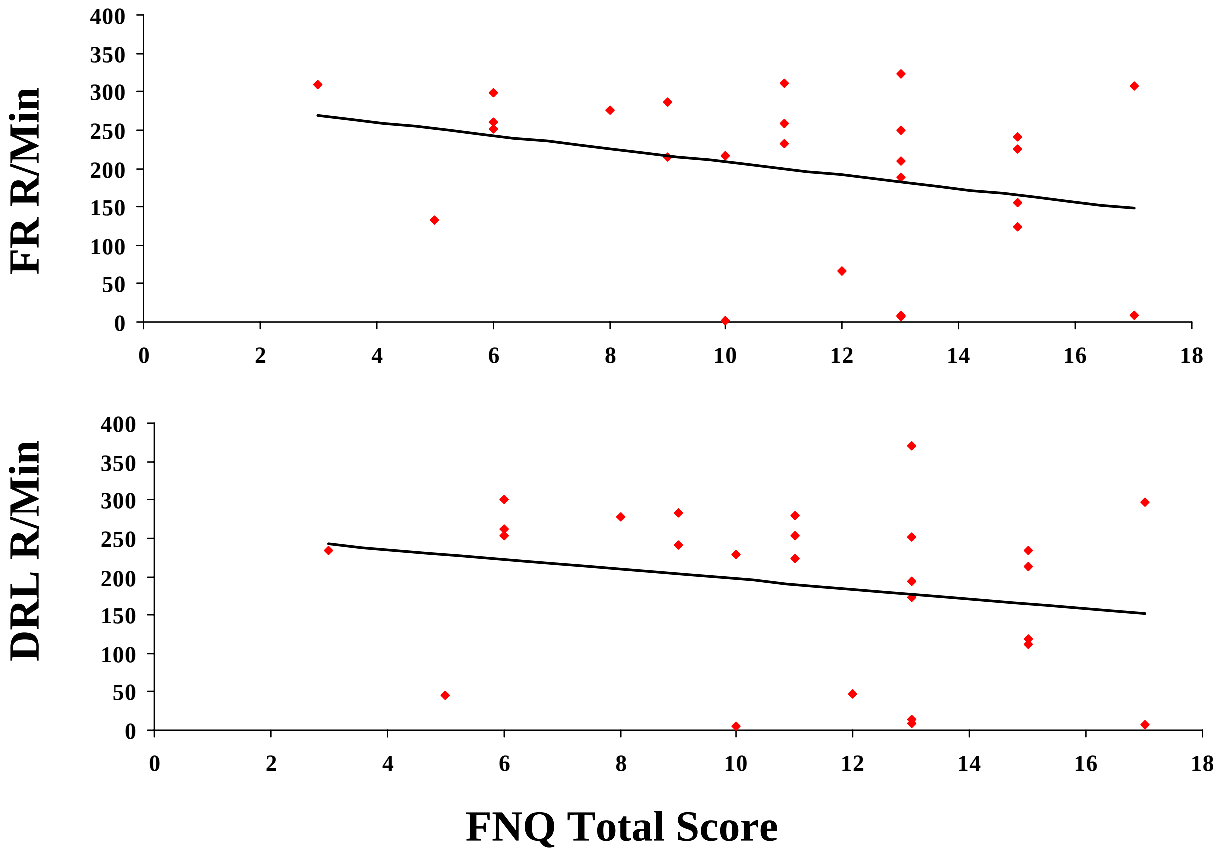

Figure 3

less than .50 reflect more responding in the DRL component.

Figure 4 shows the relation between FNQ score and mean discrimination ratio, which is the average ratio across all 20 pairs of components. A bivariate correlational analysis shows that FNQ scores were unrelated to ability to discriminate between schedules, as measured by the mean discrimination ratio across all 20 pairs of components (r = -.13, *ns*) as well as mean discrimination ratio across the final 10 pairs of components (r = -.25, *ns*). On average, the mean discrimination ratio was .50, with mean ratios ranging from .29 to .65. Overall, participants failed to discriminate the mixed schedule and most participants responded at high rates throughout both components.

DISCUSSION

The Financial Need Questionnaire (FNQ) is an 8-item measure of financial need in undergraduate students who participate in monetary reinforcement research. It can be administered within 5 min, is easily scored, and based upon an empirically-derived scoring system. Psychometric data suggest that FNQ scores are normally distributed. Scores range from 1 to 24, with higher scores reflecting greater financial need. Scores obtained from the development sample ranged from 4 to 19, suggesting that the FNQ has a solid basal and ceiling, meaning there is room in the scoring to detect the most extreme low and high need students. The FNQ demonstrates good temporal stability and shows a strong relationship with reported debt.

Behavioral data show that FNQ scores were negatively correlated with points earned on a mixed FR DRL schedule. However, FNQ score was not related to response rates and discrimination ratio. Thus, it is possible that the FNQ is not a useful predictor of human schedule

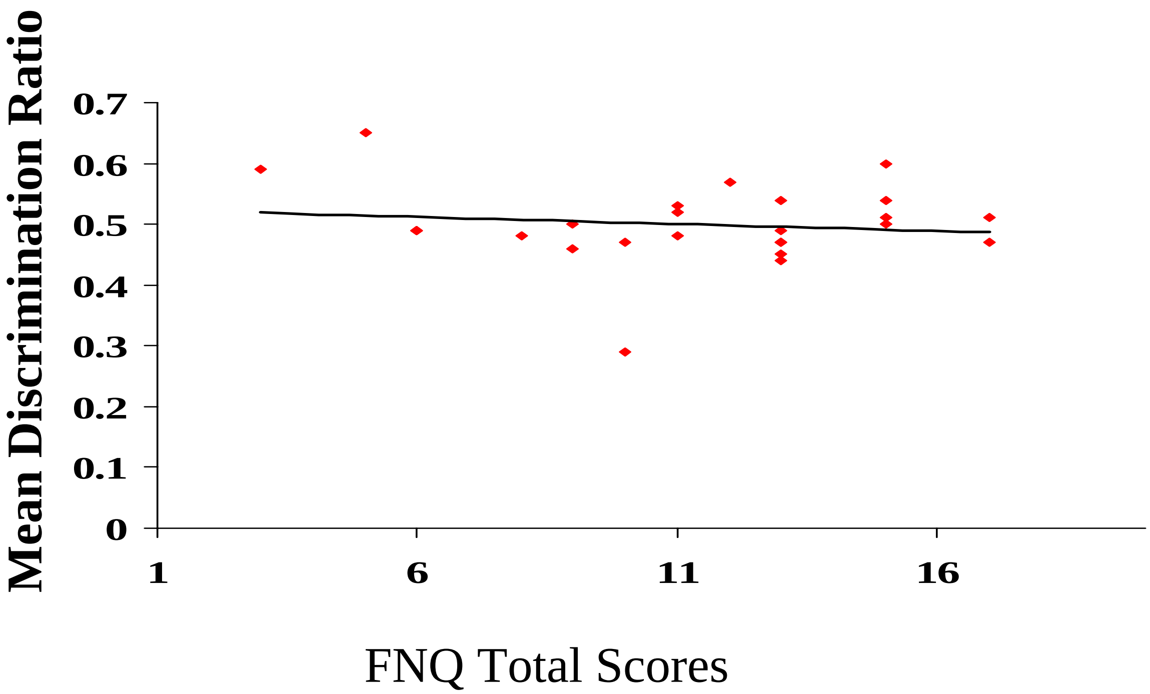

Figure 4

sensitivity. However, although not statistically significant, the negative correlation between FNQ score and discrimination ratio was in the direction of the hypothesis that high FNQ scorers would discriminate less efficiently than low FNQ scorers. Finally, FNQ score was unrelated to response rate.

The finding that low FNQ scorers earned more monetary reinforcers and tended to discriminate better than high FNQ scorers is consistent with the finding that declines in a pigeon's body weight are associated with less sensitivity to a variable-interval (VI) schedule with an omission contingency (Lewis & Dougherty, 1992). The finding that FNQ score was unrelated to response rate is not consistent with the non-human finding that longer periods of food deprivation are associated with higher responses rates during an extinction component of a multiple VI Extinction schedule (Powell, 1973).

One interpretation of the findings is that financial need/debt may not be an establishing operation. Instead, the FNQ is related to debt, which may function as an abolishing operation to decrease the reinforcing value of money. In a non-human analogue, this would be similar to a rat earning food pellets that are consumed by a "debt collector" rat in an adjoining chamber. Another interpretation of the findings is that debt does not abolish money as a reinforcer, but instead establishes the reinforcing value of high rates of earning. In the present study, earnings were relatively small (M = \$2.77), compared to earnings that could have been obtained from a higher-paying job. A final interpretation of the findings is that factors related to high debt may contribute to poorer schedule performance. For example, high debt may be associated with increased stress, poor sleep hygiene, or inadequate nutrition.

The possible influence of financial need on operant performance is one reason for basic researchers to consider using the FNQ to assess financial need in monetary research with undergraduate participants. In single-subject designs, FNQ scores can provide additional information about the participant's history. In between-group designs or replication failures, FNQ scores can be used to examine individual differences. To reduce inter-group motivational differences, participants can be counterbalanced by FNQ scores across conditions.

A final reason to use the FNQ is that this measure is not intrusive. The West Virginia University Institutional Review Board (IRB) approved FNQ administration without comment.

The IRB, however, was reluctant to approve more direct measures of savings/debt/surplus funds. The IRB was concerned about confidentiality and data security issues that may arise if participants are asked to explicitly list how much money they owe or have saved. Although IRBs regulations vary among institutions, this anecdotal report suggests that the less direct nature of the FNQ may ease ethical concerns that arise from gathering highly personal financial information from participants. Also, FNQ scoring is less face valid than more direct measures of financial need, and participants may be less likely to distort FNQ responses.

Future research might examine the relation between FNQ scores and attrition. Our initial purpose in developing the FNQ was to identify undergraduates who reported high financial need because we assumed that high-need individuals would be more likely to maintain participation in monetary reinforcement research. The relation between FNQ scores and attrition remains an important empirical question. Initial research has found that 3 out of 4 high FNQ scorers attended more than 100 sessions in a monetary reinforcement study in which participants earned an average of $4.18 per hour by participating in sessions conducted five days per week (Madden & Perone, 1999). Assessment measures that predict how likely an individual will maintain participation in an operant study may facilitate the research process and enable researchers to decrease the number of drop-outs, especially in studies that require participants to return for an extended period of time.

Future research should explore the relation between FNQ scores and operant performance on other types of reinforcement schedules, especially choice procedures, with varying amounts of monetary reinforcer magnitude. In addition, future research should examine how the reinforcing value of money relates to monetary fluctuations, such as paydays, billing due dates, or weekends.

Finally, it is important to recognize that financial need is only one type of establishing operation relevant to human research. Valid and reliable measures of sleep, intellectual functioning, and drug use will provide a more complete picture of a human participant's history and the antecedent conditions that can affect human behavior.

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BRIEF REPORT

PERCEPTUAL OUTCOMES AS REINFORCERS

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The paucity of basic behavioral research with humans was highlighted almost 40 years ago (Findley, 1966). A recent search of the basic behavioral research journals by the present authors indicated that this situation remains, with only approximately 15% of the research using human participants. It may seem surprising that so few studies use human participants given the apparent practical advantages of doing so. Human participants are readily available, extensively pre-trained, can use a range of complex apparatus and require no feeding or housing. In reality, however, the use of human participants involves a number of practical difficulties: humans generally will not agree to participate in research involving a large number of sessions or sessions lasting more than two to three hours; it is difficult to gain within-session compliance as a result of the often repetitive and simplistic nature of the tasks; and it is often unclear whether the experimental results are a product of the experimentally-arranged contingencies or the instructions given to the participants. Another difficulty, that which is addressed here, lies in the identification of a suitable experimental outcome that will serve as a reinforcer.

Outcomes typically selected for use in animal research, such as food and water, function as reinforcers because the organism has been deprived of those nutritive outcomes. Clearly, any such deprivation is ethically unacceptable when working with humans. Although researchers working with humans have used food outcomes, it is unclear if they function as a reinforcer in laboratory situations given the absence of food deprivation. A related problem is that satiation will diminish the reinforcing effectiveness of the nutritive outcome.

To attempt to overcome the problems associated with nutritive outcomes, researchers often use points exchangeable for access to toys, videos and other items. However, this approach can be expensive, and the effectiveness of the points relies on the establishment of a clear relationship between the points and the post-experimental consequence.

An alternative to using points and nutritive outcomes is to arrange perceptual outcomes, such as the presentation or termination of an auditory or visual stimulus. Such stimuli can be delivered immediately after a behavioral requirement has been met rather than after the experimental session, and are relatively inexpensive. The reinforcing efficacy of perceptual outcomes has also been demonstrated, both in animal and human research. Schwartzbaum (1964), for example, has shown that monkeys will reliably respond in order to gain access to a period of visual exploration. Presentations of brief TV or video segments or brief access to a computer game have also reinforced human behavior (e.g., Hackenberg & Pietras, 2000; Navarick, 1996, 1998). However, the same authors have also shown that longer segments of video or TV footage are preferred to shorter segments and, on the basis of their results, argued that the reinforcing effectiveness of such stimuli depend on whether or not, and to what extent, the stimuli are segmented (i.e., discontinuous). This obvious need for continuity of presentation conflicts with the need in human experimental research to provide multiple, but periodic, presentations of reinforcing stimuli that are both immediate and brief.

Extending earlier work using computer games in human operant research (e.g., Case, 1995; Case, Ploog & Fantino 1990) we have developed a computer-based task, referred to as "Jigsaw", which also uses perceptual outcomes, but avoids the disadvantage of TV/video segments or computer game access. In the jigsaw task, the perceptual outcomes are independent of each other and do not have to happen in a particular sequence or in rapid succession to be an effective reinforcer. The computer jigsaw task is analogous to working on a conventional jigsaw puzzle where

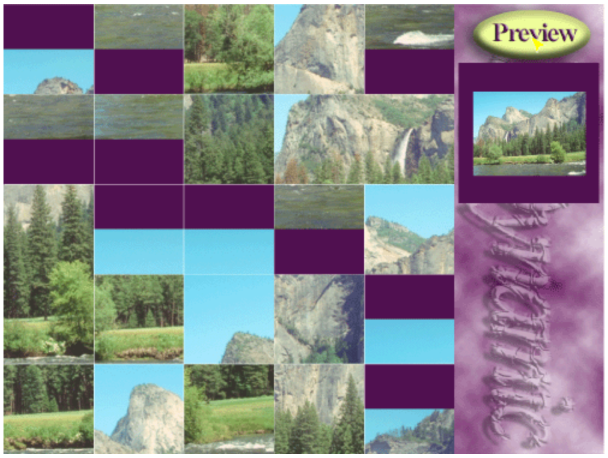

Figure 1

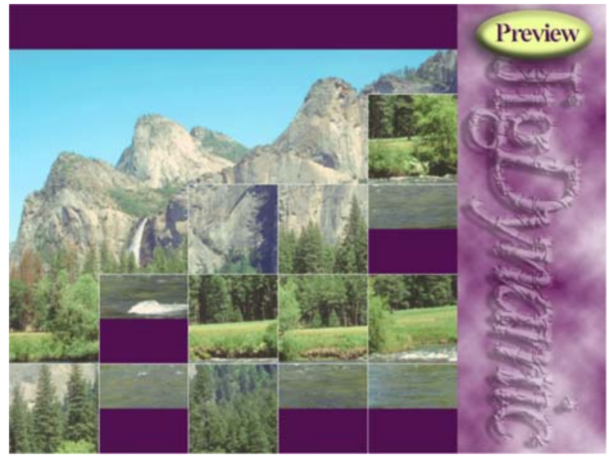

Figure 2

there is no predetermined order or rate in which the pieces need to be shifted, rotated or flipped.

The basic jigsaw task requires the participant to reveal the image on each piece of the jigsaw and/or to rearrange the pieces to complete the picture. The jigsaw program is implemented on a PC under Windows using Direct-X and C++. Figure 1 shows an example of the jigsaw program presented at the start of an experimental session. In this example, the jigsaw consists of 25 pieces laid out in a five-by-five pattern on the left-hand side of the screen. To the right of the jigsaw is a preview button which, when the curser is placed on top of it, displays a small illustration of the completed jigsaw directly beneath it. Figure 2 illustrates a partially completed jigsaw where some of the pieces are correctly joined to an adjacent piece as indicated by the absence of a white line between them. The preview window is not visible in this figure as the cursor is not over the preview button.

Within the basic jigsaw framework the tasks required to complete the jigsaw can be varied in a number of ways. The number of jigsaw pieces can differ, they may need to be revealed by altering their opacity or they may need to be rotated to the correct orientation. Completion of any of the set tasks can be achieved using a range of input devises (e.g., mouse, eye-tracker, joy-stick, graphics tablet) and can be made dependent on a number of different behavioral requirements. For example, successfully relocating a revealed jigsaw piece may require that the piece be moved across the screen at a particular speed using a joy stick, or perhaps revealing a piece may require the depression of a graphic tablet pen within a particular force range, or a rotation of a piece may depend on a particular number of mouse clicks. These behavioral requirements can also be combined. For example, a piece may be revealed by a number of pen depressions of a certain duration and within a certain force range.

In our laboratory, the utility of the jigsaw for use in behavioral research has been established with a range of procedures. In all cases, participants have been highly compliant with the task requirements, ethical concerns such as deception and deprivation have been avoided, and the arranged perceptual outcomes have produced clear and rapid control over the participants' behavior. To date we have used the procedure to look at schedule performance, within session effects and shaping procedures.

Figure 3 presents a brief example of data collected using the jigsaw procedure, examining the effects of increasing FR requirements on jigsaw performance, this is a behavioral-economic method often used to assess reinforcer strength. In this procedure, participants (undergraduate students) could not rearrange the pieces of the puzzle until a red opaque layer, see Figure 4, was removed from all of the jigsaw pieces. Each of the first five pieces, selected with the mouse, required two mouse clicks to remove the layer, the next five pieces required four mouse clicks, the next, eight clicks etc, until the last five pieces, which required 512 clicks each. The data presented here are from one 50-min experimental session and show the results from four participants, with the mean and standard deviation of the inter-response times

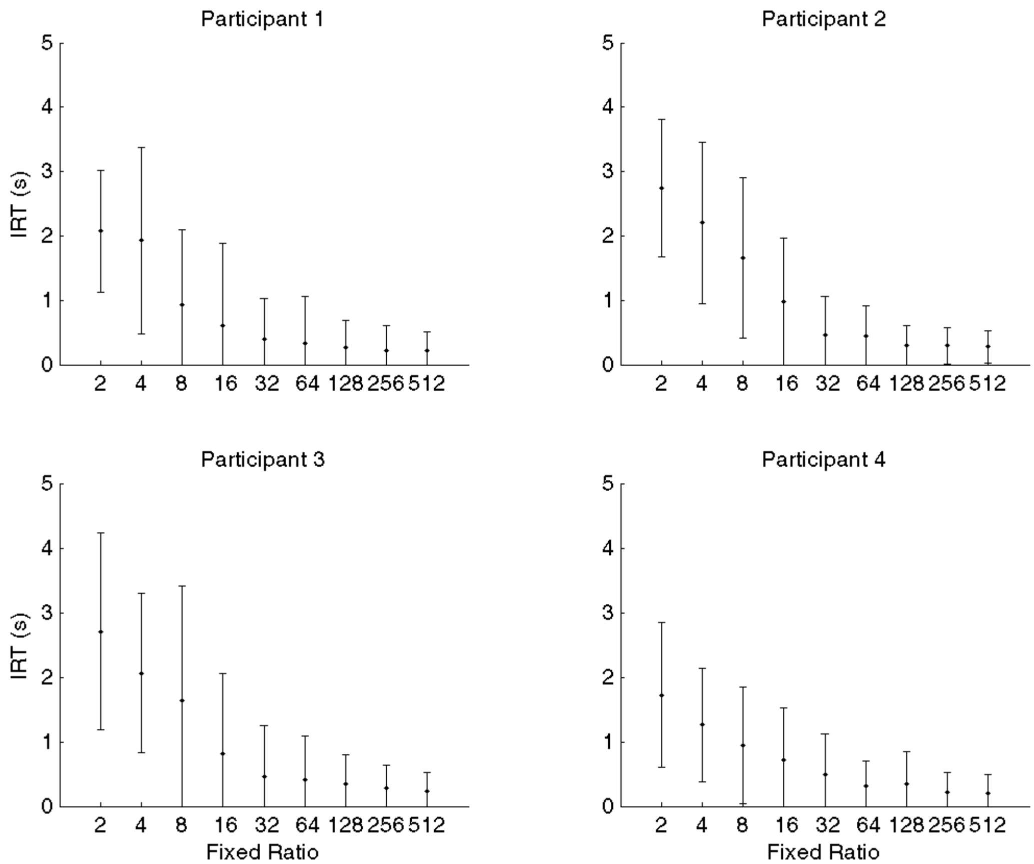

Figure 3

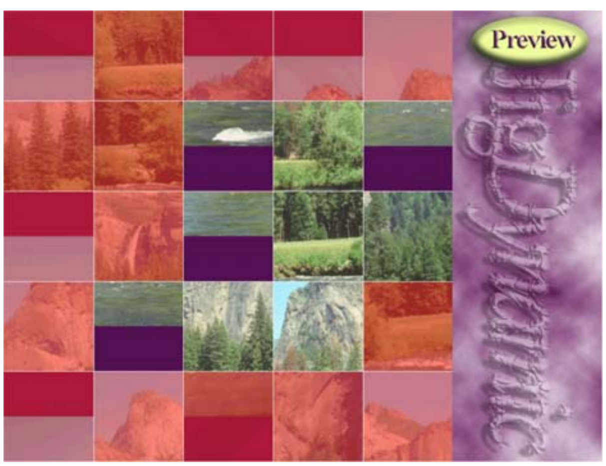

Figure 4

(IRTs) plotted for each of the FR requirements. From Figure 3 it can been seen that the participants continued to respond at the largest arranged FR value (FR 512), even though they could terminate a session at any time. In addition, the participants' IRTs decreased, and therefore their response rates increased, as the FR requirements were increased from FR 2 to FR 512. The data in this figure also provides little indication of satiation effects, as each participant completed the experimental task which required 5110 responses (i.e., moving five jigsaw pieces and therefore completing each FR requirement five times).

Since in the Jigsaw both the typical response requirements and the perceptual outcomes are immediate and brief (i.e., unlike 3-s access to grain) a large range and number of behavioral events can be arranged and recorded in a relatively short period of time (i.e., typically one 60-min session). Because the task is computer controlled, it also allows the manipulation of a broad range of behavioral requirements, including: force, number, location, duration and complex combinations of these, as well as enabling us to use any of a vast range of possible perceptual consequences as reinforcers. However, the most significant outcome of this project is not the jigsaw program itself, but the recognition that rapid and brief perceptual outcomes, of the kind that can be arranged by computers, can serve as reinforcers for adult humans, whilst avoiding most of the problems associated with other kinds of arranged outcomes used with adult humans. It is hoped that in the future the use of perceptual outcomes as reinforcers will open the way to increasing the use of humans in basic behavioral research.

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RESEARCH IN PROGRESS

PAUSING ON MULTIPLE SCHEDULES: TOWARD A LABORATORY MODEL OF ESCAPE-MOTIVATED BEHAVIOR

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An important role for the experimental analysis of human behavior is as a bridge between basic research and application. Traffic on the bridge can go both ways. In the human laboratory, basic behavioral processes uncovered in the animal laboratory can be translated to clinical populations, and clinical problems can be translated into basic behavioral processes.

Among the clinical problems that may benefit from experimental analysis are aberrant behaviors, such as self-injury and aggression, which frequently have an escape function in people with developmental disabilities. Iwata et al. (1994), for example, found that escape accounted for the largest proportion (38%) of 152 cases of destructive behaviors. Significantly, the stimuli that engender such behaviors often are seemingly benign events, such as requests to perform academic tasks (e.g., Carr & Newsom, 1985) or certain activities at particular times of the day (e.g., Charlop, Schreibman, Mason, & Vesey, 1983).

Several findings in the animal literature suggest that such events may be particularly aversive during transitions from favorable (rich) reinforcement conditions to less favorable (lean) ones. First, during postreinforcement pauses (PRPs), pigeons tend to move away from the schedule-correlated stimuli (e.g., Cohen & Campagnoni, 1989), suggesting that transitions from the presence to the absence of food may be aversive. Second, pigeons will peck a key that turns off stimuli correlated with a variety of food-reinforcement schedules (escape responses), particularly just after food has been presented (e.g., Azrin, 1961). Finally, on signaled schedules that alternate (multiple schedules), the longest PRPs and the highest frequencies of escape responses typically occur during the transitions from the richer to the leaner schedule component (e.g., Perone, 2003).

Although these and related studies show that stimuli correlated with rich-to-lean transitions are aversive to pigeons, there are no published data on whether or not such transitions also are aversive to people. This paper reports some preliminary results of an ongoing research program, the ultimate goal of which is to develop a laboratory model of variables that may operate in the natural environment to make otherwise neutral or positive situations aversive to individuals with mental retardation. Toward that end, we reinforced matching-to-sample (MTS) responses on a multiple schedule of monetary reinforcement consisting of rich and lean components. To enhance the potential effect, the lean component had both a relatively large response requirement and a relatively small reinforcer. Based on the aforementioned research with pigeons, we expected the longest PRPs to occur during the transitions from the rich to the lean component, and to see relatively undifferentiated pausing during the other three possible transition types.

METHOD

A man with mild mental retardation participated. He had no other diagnoses, and was not taking psychotropic medications. He sat facing a computer monitor fitted with a touch-sensitive membrane and recessed into a wooden partition. Coins were dispensed automatically

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into a plastic cup mounted to the lower right of the monitor.

A simultaneous, two-choice identity MTS procedure was used. Each trial began with the presentation of one of the two samples at the center of the screen. Touching the sample produced a 0.25-s feedback tone, followed by the presentation of the comparisons in two of the corners. Touching the matching comparison produced the 0.25-s feedback tone, whereas touching the non-matching comparison produced a buzz and a 3-s blackout. The intertrial interval was 0.1 s.

Matching responses were reinforced on a multiple fixed-ratio (FR) 10 FR 60 schedule. The latency to the first sample touch in each component was defined as the PRP. In the rich component, the screen color was red, the stimuli were black less-than and greater-than signs, and 10 matching responses produced a 1-s tone, a quarter, and a 3-s picture of a quarter. In the lean component, the background color was yellow, the stimuli were black, sideways U shapes that opened to the left or right, and 60 matching responses produced a different 1-s tone, along with a 3-s display of the numeral "1" in the center of the screen, indicating that 1 cent had been earned.

Sessions consisted of 41 components that alternated in an irregular fashion, such that 10 of each transition type occurred. That is, there were 10 transitions from rich to lean, 10 from rich to rich, 10 from lean to lean, and 10 from lean to rich. After each session, the subject was paid 1 cent for each lean component completed, and kept all quarters earned. Twenty sessions were conducted. Visual inspection of the mean PRPs from each transition type in the final five sessions indicated no upward or downward trends.

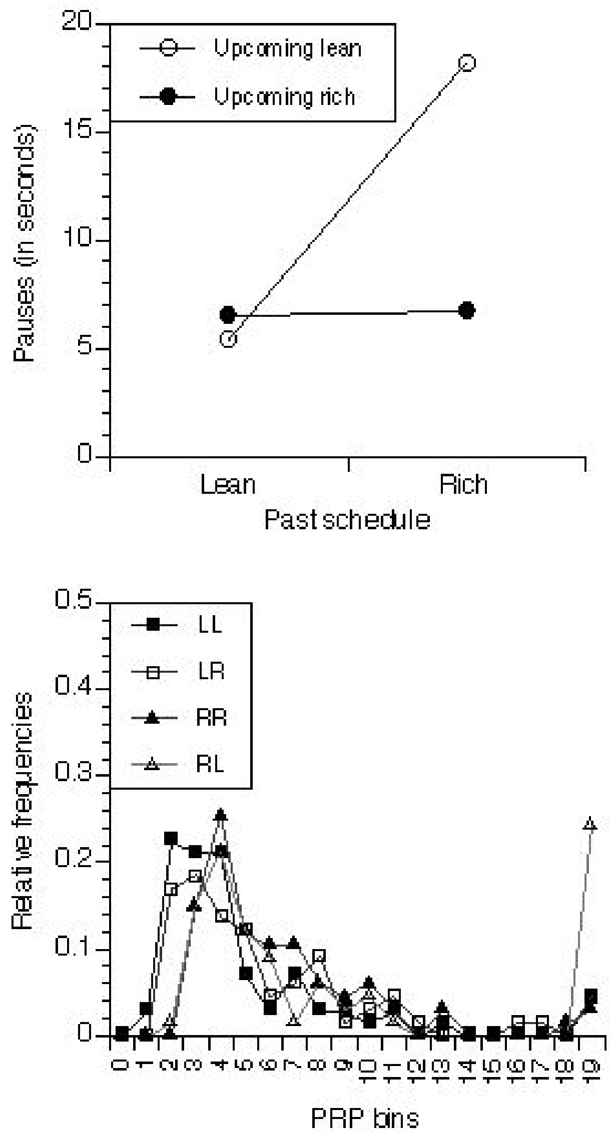

Figure 1

RESULTS AND DISCUSSION

Figure 1 shows means (top panel) and relative frequency distributions (bottom panel) of the PRPs during each transition type, calculated from the last five sessions of the study. Consistent with prior findings (e.g., Perone, 2003), the longest mean pause occurred when the past schedule was rich and the signaled upcoming schedule was lean, whereas the mean pauses in the other three transition types were low and quite similar to one another. This finding is explained by the frequency of PRPs equal to or greater than 19 s, which was considerably higher in the transitions from the rich to the lean component than in the other three transition types.

Although preliminary, the present results indicate that transitions from rich-to-lean reinforcement conditions can generate long PRPs in people, just as they do in pigeons. We currently are studying several variations to the procedure used herein, including some that provide the opportunity for a specific escape response that turns off the schedule-correlated stimuli. If the present findings are reproduced, such procedures may provide a laboratory model for the investigation of the escape-motivated behavior that people with mental retardation often emit in naturalistic settings.

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TECHNICAL INFORMATION

COMPUTER-INTERFACING FOR DUMMIES: INTERFACING PERIPHERAL DEVICES TO YOUR MACINTOSH PC

Bryan Roche and Simon Dymond

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In a previous paper (Roche, Stewart, & Barnes-Holmes, 1999), the graphic experiment generation software PsyScope (Cohen, MacWhinney, Flatt, & Provost, 1993) was reviewed and its relevance to behavioral research in the domain of language and cognition was outlined. Many behavioral researchers have since explored the potentials of this freeware application for the easy generation of behavioral experiments, particularly in the area of derived stimulus relations. In research contexts where the only behavior of importance is subjects' response patterns on a keyboard, the experimenter needs only to arrange for the appropriate task presentations and the recording of responses. All of this is achieved easily using PsyScope, which is available for free download at http://psyscope.psy.cmu.edu/.

Here we provide a brief introduction to the interface features of that program. We believe that this single feature of PsyScope will be invaluable to researchers wishing to establish communication between a PC and any analog or digital recording or stimulating device without the need for basic programming skills.

Why the need to interface?

Behavioral researchers in laboratories around the globe wish to integrate the delivery of computer-based training and testing procedures with the activity of other analog and digital recording and stimulating devices. Some laboratories, for instance, require that computer generated stimulus presentations be tied temporally to the administration of mild electrical stimulation to subjects, the operation of a food chamber, or the creation of an event mark on an ERPs or other polygraph record. Fortunately, most of these common devices allow the direct input of external triggering cables for just this purpose (e.g., a manual event marker for a polygraph, or a manual button press for food delivery in a conditioning chamber). The problem is that arranging for the automated electrical activation of these triggering devices by a personal computer is a sophisticated problem for psychologists who are not experienced computer programmers. For this reason, and for the benefit of other laboratory researchers, we wish to share our own experience in the use of PsyScope in interfacing PCs with a variety of recording and stimulating devices.

The PsyScope Button Box

PsyScope offers an easy solution for interfacing any digital or analog device to your Macintosh PC without the need for programming skills. For this purpose a peripheral piece of hardware known as the PsyScope Button Box must be purchased at a cost of $400 USD (go to http://psyscope.psy.cmu.edu/bbox/index.html for order information). The Button Box is an external response unit designed to serve as a two-way conduit of commands from and to peripheral devices of all kinds. The Button Box is connected to the Macintosh PC via the serial port or USB port (using a serial-USB adaptor). No drivers or additional software is required. Users must simply inform PsyScope that the button box is being used, by selecting it as an input device from the PsyScope menus.[1]

The Button Box houses three large colored response keys that can be used as response keys for any PsyScope script. Many PsyScope users already possess and use a Button Box as a response interface for subjects, but may be

[1] The reader should be aware that an improved version of PsyScope is currently being ported to OSX for the Macintosh. This new version is expected to allow for the creation of voltage outputs within the graphic interface directly from the Macintosh USB port without the need for a Psyscope Button Box.

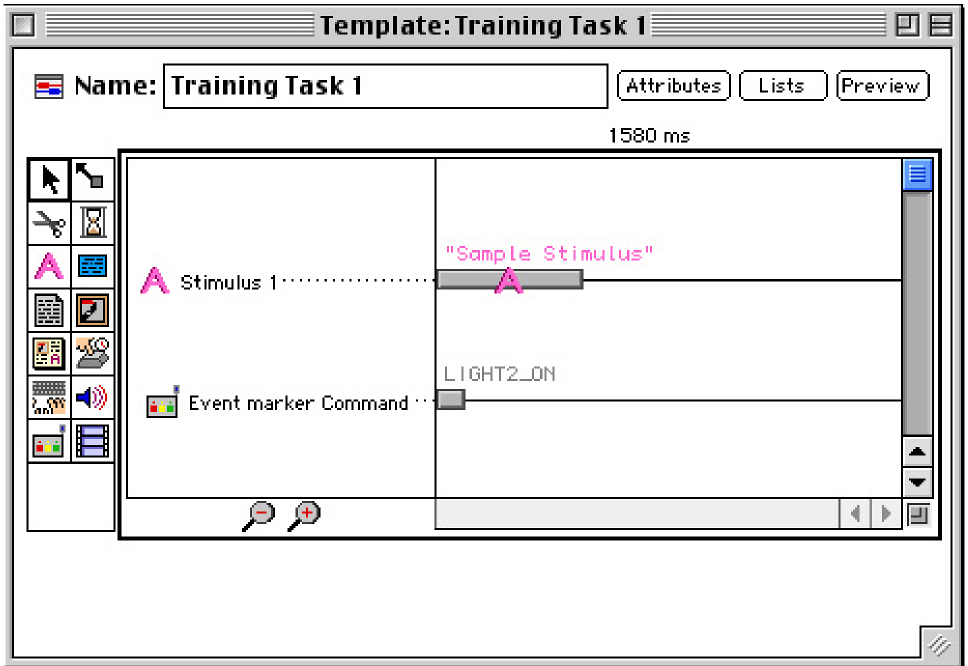

Figure 1

unaware of its potential as an interfacing device. The interface features of the Button Box are made possible by a variety of digital and analog input and output ports housed at the rear of the box. One input port, for instance, is designed to receive a 3.5 mm phono plug so that throat microphones or other sound sources can be used to trigger reaction time recordings or the presentation of stimuli. The use of the microphone input as a stimulus or response event in PsyScope can be achieved entirely through the use of intuitive menus and dialog boxes.

Of particular use for controlling a multitude of external devices is the generic 15-pin output port that we now use extensively in our research. This port transmits a 3-volt pulse whenever one of three lights on the face of the button box is illuminated by the software script created by the experimenter. Thus, creating an event marker for a polygraph machine is as simple as creating a button box light command to coincide with the relevant stimulus presentation. Light commands are created through the graphic interface in the same way as other events in the script. Figure 1 illustrates how the Button Box command is created simply by dragging the Button Box tool from the bottom left of the tool menu to the task sequence on the right, and then double clicking on the command event to specify its features (e.g., onset time, duration) in various menus. Any or all of the three lights may be illuminated simply in this way. Figure 2 shows how the duration of lights can also be varied through the Event Attributes menu. As long as a light is illuminated a 3-volt pulse is being supplied via the 15-pin output port. This means that devices requiring continual power may also be controlled by the PsyScope Button Box.

The fact that the Button Box houses three lights (Red, Green, and Yellow) means that three different cables may be drawn independently from the 15-pin output port, each electrically activated by the illumination of a different light. This feature may be important, for instance, if the researcher wishes a specific computer-generated stimulus to coincide with the triggering of an electric shock stimulator, but also requires that event marks be placed on an ERPs or EEG record to coincide with the occurrence of other events in the PsyScope script at other times (e.g., other discriminative or respondent stimuli). In addition, there are five other live pins that can be used for further independent voltage outputs. These are described in the user manual that comes with the

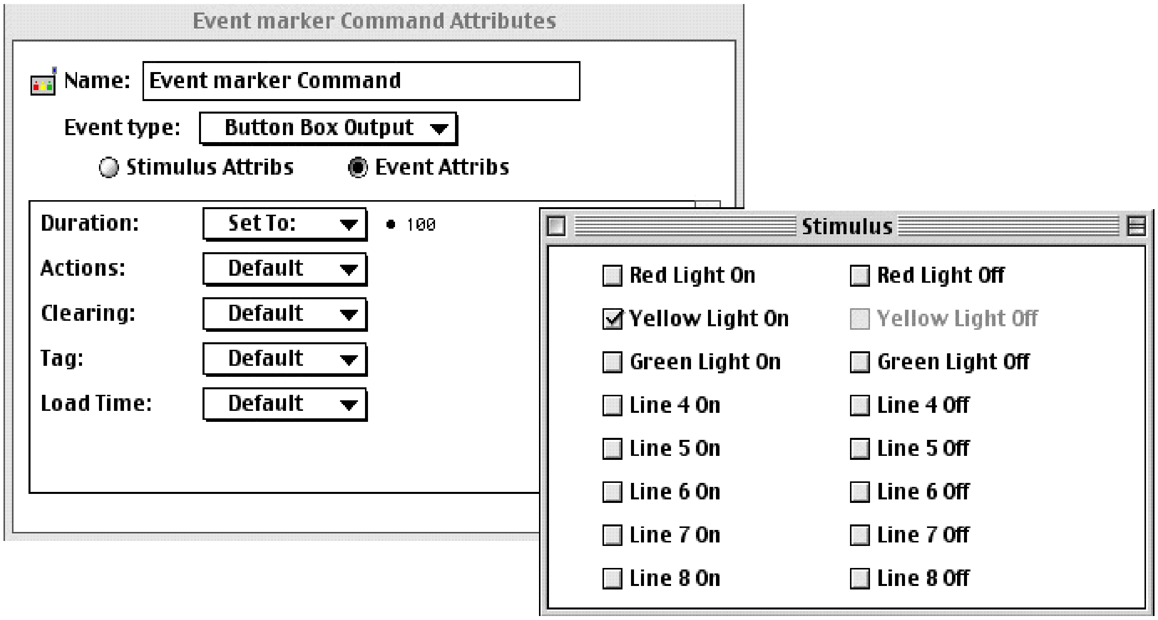

Figure 2

Button Box. The manual also describes how the Button Box can be connected to an IBM-compatible PC for use with other software programs, although this option will require additional computer skills.

A diagram of the 15-pin output port is presented in Figure 3. The active pins for various light illuminations on the Button Box are shown. For instance, a cable connecting the top right pin and the ground pin to the analogue event marker input of a polygraph will carry a 3-volt pulse when the red light is illuminated by the PsyScope script. It requires little technical expertise to create a custom cable with the relevant pins connected to a jack to suit the external device to be controlled.

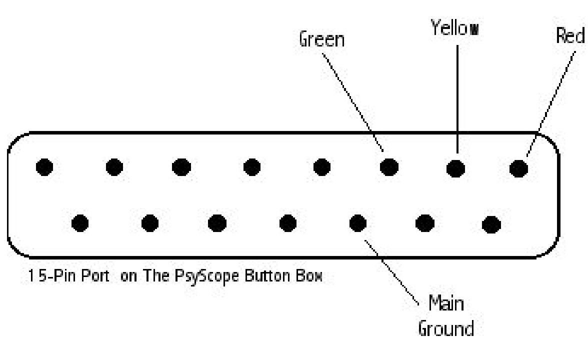

Figure 3

The temporal resolution of PsyScope scripts

PsyScope can control stimulus presentations and the delivery of output pulses with a temporal resolution of 1 ms. High temporal resolution is critical for ERPs, EEG and other polygraph recording. It is important to note, however, the temporal resolution of the vast majority of computer hardware cannot ensure such high resolutions. The PsyScope Button Box also offers a solution to this problem. Specifically, the box itself can be assigned as an independent timing device for all events in the experiment. As the button box is not burdened with the running of system software or the presentation of memory-demanding stimuli (e.g., movie and sound clips) it can ensure accurate timing at each stage of the experiment. To use the Button Box as the external timing device simply select it as the timing device from the PsyScope menus. In any case PsyScope can also record all timing statistics for all events in the experiment (choose the Data Output sub-menu). This will provide feedback in the data file as to the exact onset and offset times of all events. In the authors' experience these usually deviate no more then 3 or 4 ms from the scheduled onset and offset times.

Using the Button Box with iMac computers

As the Button Box was designed primarily for older machines, it assumes connectivity to the

Macintosh computer via the modem serial port. If a researcher wishes to connect the Button Box to a Macintosh via the USB port the following line should be typed directly into the script anywhere towards the beginning of the script, but preferably in the paragraph headed ExperimentDefinitions (choose *Edit This Script* from the *File* menu).

BBoxPort:B

This line switches the default port for the Button Box connection from the modem port to the printer (or USB) port for that script. The PsyScope user should have no other need to see the raw script and will be able to create a variety of interesting and powerfully interactive experiments entirely within the graphic interface.

Download some sample PsyScope scripts

The PsyScope application and a sample respondent conditioning program that controls two external devices may be downloaded from http://www.may.ie/academic/psychology/software.htm. This script can be easily modified to suit researcher's individual needs, or the graphic event marker command events can simply be copied and pasted from one script to another. Relational training scripts for equivalence and other derived relations may also be downloaded at that web site.

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TECHNICAL PAPER

COMPUTERIZED VOICE PRODUCTION AND RECOGNITION USING VISUAL BASIC

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Many researchers have argued that the development of personal computing has transformed the experimental analysis of human behavior over the last two decades (e.g., Cabello, Barnes-Holmes, O´Hora & Stewart, 2002; Dixon & MacLin, 2003). Certainly, the use of personal computers provides important advantages in terms of improving experimental procedures; for example, research ideas can be implemented much more rapidly, validity problems such as the presence of the experimenter are controlled easily, and computer-controlled procedures permit extremely precise application and measurement of relevant variables. Computers are also important because they provide a number of important research tools that would not otherwise be available. Consider the recent advances in neuroimaging techniques (e.g., Dickins, Singh, Roberts, Burns, Downes, Jimmieson, & Bentall, 2001; DiFore, Dube, Oross, Wilkinson, Deutsch, & McIlvane, 2000; Staunton, Barnes-Holmes, Whelan, & Barnes-Holmes, 2003), or the use of reaction times as a dependent variable (O'Hora, Roche, Barnes-Holmes & Smeets, 2002; Staunton, Barnes-Holmes, Whelan & Barnes-Holmes, 2003).

The current article focuses on one of the new research-useful capabilities provided by modern computers, which we will call 'voice technologies'. In the current context, voice technologies will be used to refer to text-to-speech capabilities (programming a computer to read text aloud), and to voice recognition capabilities (programming a computer to recognize natural human speech). Therefore, the first part of this article will deal briefly with the installation of voice technologies in any PC computer. In the second part, the use of both text-to-speech and voice recognition capabilities will be described, together with examples that show how to employ them using the Visual Basic 6 programming language. Finally, we will suggest some uses for this technology that have arisen within our own research programs.

THE MICROSOFT VOICE ENGINE

Among the different research programs that Microsoft conducts, that of voice-based technology appears to be one of the most promising. Recent advances from the Microsoft group dedicated to this technology, coupled with the increasing power of modern computers, have allowed the development of the Microsoft Speech SDK, a computerized voice system that has been made available at no cost to a wide community of users. The website http://www.microsoft.com/speech/ contains a great deal of information about the Speech SDK.

In the current article, we will focus on SDK version 5.1 for Visual Basic 6. However, there are also versions for the newest Visual Basic.NET, the use of which does not differ greatly from the principles described below. Installation of the voice system requires visiting the web address http://www.microsoft.com/speech/download/SDK51/ and downloading the SpeechSDK51.exe file to your computer (the file is about 68 MB, so it might take a while depending on your Internet connection). Once the download is finished, the user should double-click the file to run the installer program. The set-up process is relatively easy, and the user is required only to specify the location on the hard disk where the voice engine is to be placed. After the file copying process, the

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For further information about the use of Visual Basic for the development of experimental software, visit the web address http://www.may.ie/academic/psychology/vbindex.shtml.

voice engine is ready to be used. In case the reader finds any problem installing the Speech SDK (or writing any of the examples included below), please email the authors.

VOICE CAPABILITIES IN VISUAL BASIC

Text-to-Speech Capabilities

One feature of the voice engine, with immediate application for experimental procedures, is the capability it provides to program a computer to read text aloud. What follows is a step-by-step example that illustrates how straightforward it is to implement this capability using the Speech SDK within Visual Basic (if you are unfamiliar with the Visual Basic programming language, we recommend that you first consult a recently published article in this journal; Cabello, et al., 2002).

First, select New Project from the File Menu. When a new project with a blank form is generated, select Components from the Project Menu (pressing CTRL and T simultaneously produces the same result), which will open the components menu. Here you will find a list of different controls that are installed in your computer, and that can be managed by Visual Basic. Scroll down through the list, select the 'Microsoft Voice Text' component, and press the OK button. To build the current example, place a Text box at the top of the blank form, a Command button at the bottom, and change the text in the button to 'Talk' using the Caption property. Then, click on the TextToSpeech control (the small mouth at the bottom of your toolbar), and place a Text-to-speech control in the bottom right corner of the form, which should look like the form displayed in Figure 1.

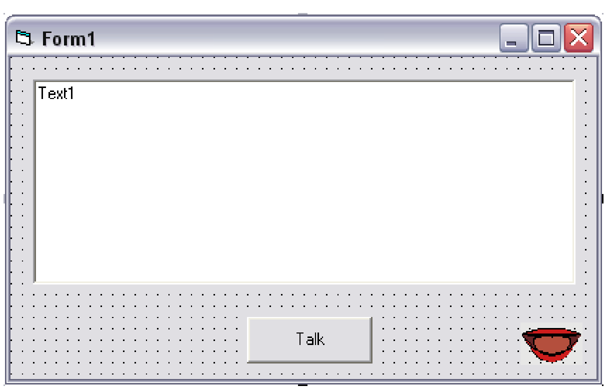

Figure 1

Following the completion of the above sequence of steps, add the code that will control your program. To do this, double-click the Command button, and add the code indicated in Figure 2 under the Command1_Click Section.

```
If Text1.Text <>"" Then

        TextToSpeech1.Speak  Text1.Text

End If
```

Figure 2

Now, when the program is run and the 'Talk' button is pressed, the computer will read aloud the text entered in the Text box (if any). Of course, this is only a very simple demonstration of the use of the voice engine, and there are dozens of parameters that can be customized. For example, the computer voice can be changed to different types (including male and female voices) using the CurrentMode property of the TextToSpeech control, and the speed of the voice can be changed using the Speed property. Furthermore, external files can be used in XML format, that allow for the implementation of very precise and subtle pronunciations. A description of these capabilities is beyond the scope of the current article, but we recommend the documentation included with the SDK package for further reference.

Voice Recognition Capabilities

Apart from the text-to-speech capabilities described above, the Speech SDK offers a powerful human speech recognition system. Although a simple example may readily be built using Visual Basic, its use is more complex than the Text-To-Speech capability, and thus some knowledge of Visual Basic programming is required to fully understand the example. There are numerous books that would assist in this regard, but "Visual Basic for Behavioral Psychologists" by Dixon and MacLin (2003) provides a particularly good introduction to the Visual Basic language.

To generate the example, select New Project from the File Menu to create a new Visual Basic project with a blank form, and place a List box and a Command button within the form. Next, change the Caption property of the button to 'Start'. Your form should now look like Figure 3.

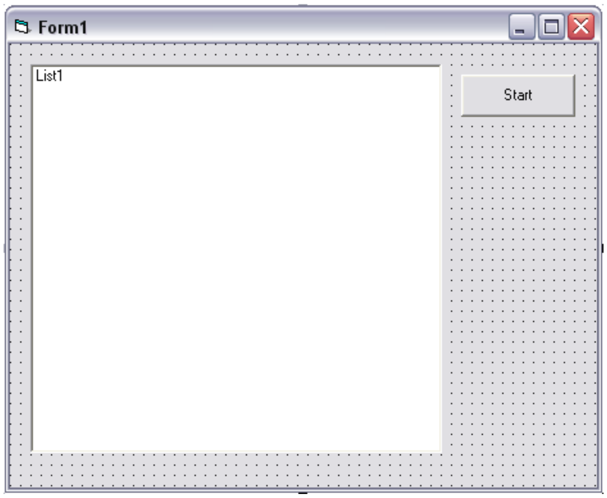

Figure 3

At this stage, there are a few steps that are necessary in order to use the recognition capabilities of the software. These steps involve adding a reference to the objects contained within the Speech SDK (in other words, the Visual Basic software is being told that the SDK will be used). To do this, select References in the Project Menu, select 'Microsoft Speech Object Library' from the list, and press OK. Once the Speech library has been activated, add the code in Figure 4 in the Declarations section of the Code Window. To do this, click the left list placed at the top of this window, and select the '(General)' section.

```
Option Explicit

Dim WithEvents Context As SpSharedRecoContext

Dim Grammar as ISpeechRecoGrammar
```

Figure 4

This code will generate two variables that are defined within the Speech library that you have just activated: Context will create a context for the recognition process, and Grammar will store those words that have been previously recognized. Next, double-click the Command button and type in the code in Figure 5 under the Command1_Click section that will start the voice system when the 'Start' button is pressed.

```
If (Context Is Nothing) Then

        Set Context = New SpSharedRecoContext

        Set Grammar = Context.CreateGrammar (1)

        Grammar.DictationLoad

End If


Grammar.DictationSetState SGDSActive
```

Figure 5

Finally, add the code in Figure 6 at the bottom of the Code Window (after the code above), in order to create a function for the recognition process itself.

```
Private Sub Context_Recognition (ByVal StreamNumber as Long, _

            ByVal StreamPosition as Variant, _

            ByVal RecognitionType as SpeechRecognitionType, _

            ByVal Result as ISpeechRecoResult)


    List1.Additem Result.PhraseInfo.GetText


End Sub
```

Figure 6

Although the foregoing code may appear somewhat daunting, especially if you have little or no experience with computer programming, spending a little time reading an introductory textbook on Visual Basic will help you understand the underlying logic.

Now, connect a microphone to your computer, run the program, start talking slowly, and see how the computer recognizes your words. Bear in mind, when running the program for the first time, the recognition will not be very accurate. This is because the Speech SDK must be trained to distinguish between vocal sounds and noise, and to distinguish particular words in the vocal stream. To train your computer, go to the Speech section of the Control Panel in Windows, and select the Train Profile button (see Figure 7). The subsequent training process, which involves reading aloud different pieces of text, does require

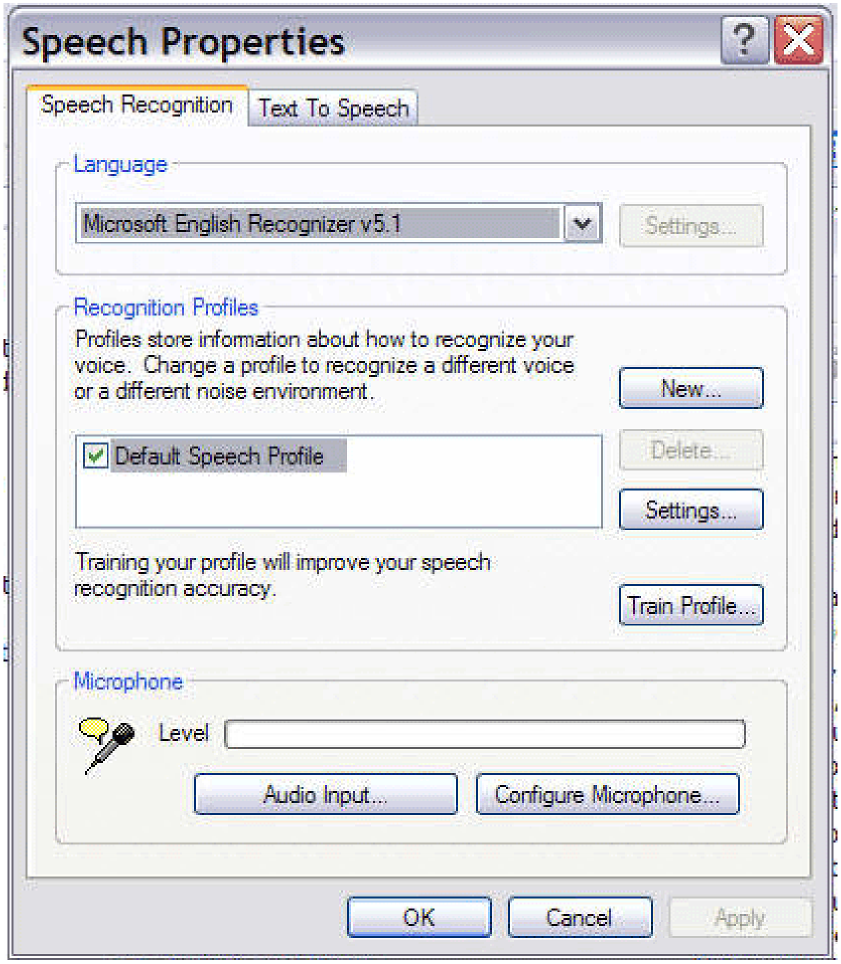

Figure 7

a little time, but doing so dramatically improves the recognition accuracy.

Finally, as was the case for the text-to-speech example, there are numerous options for customizing the voice recognition capability. Of particular interest is the option to define a task-specific grammar, and set the voice engine to recognize only the words contained within that grammar. Again, this process is extensively detailed in the help file provided with the Speech SDK package.

ADVANTAGES AND POSSIBLE USES

In the current article, we have described some examples that show the power of the Microsoft Speech SDK for Visual Basic 6. Indeed, text-to-speech and voice recognition capabilities have been implemented in just a dozen lines of code. We believe that the use of this specific SDK to implement voice production and recognition within experimental procedures has several important advantages. First, the Speech SDK is used within the context of Visual Basic, which is arguably one of the most flexible, user-friendly, and easy to learn programming languages currently available to the behavioral researcher. Second, the Speech SDK can be customized to a great extent, thus providing the ability to adapt its use to very specific research needs. Finally, the SDK can be used in a simple PC computer thus reducing the resources needed to access these powerful capacities within the behavioral laboratory.

There are numerous research areas in which the Speech SDK software might be used for the development of voice-controlled procedures. For example, we are currently developing a Visual Basic program in which the subject has to select among different comparison stimuli using the spoken words LEFT, RIGHT, or CENTER, and another program in which different relations (e.g., BEFORE/AFTER, SAME/DIFFERENT) are responded to using the spoken words TRUE and FALSE (pretraining the Speech SDK to recognize this limited number of words requires no more than a minute per subject). Of course, these are relatively simple uses of the SDK software, but other more ambitious uses might also be pursued. For example, numerous sets of spoken feedback and/or instructions could be presented to a subject contingent upon specific performance criteria. And perhaps, most ambitious of all, a sophisticated Visual Basic program could be written to selectively reinforce specific verbal utterances, constituting a type of on-line protocol analysis in which the protocols themselves are used to increase or decrease particular verbal operants (e.g., Cabello, Luciano, Gomez & Barnes-Holmes, in press; Wulfert, Dougher, & Greenway, 1991). In attempting this final application of the SDK to behavioral research, of course, one would first need to expose the voice recognition software to extensive training of the relevant subjects' voice patterns. Nevertheless, the benefits of doing so, in terms of increased experimental precision and reliability, would likely outweigh the time and effort required to undertake the initial training.

In any case, the Speech SDK, combined with the Visual Basic programming language, clearly provides a powerful set of laboratory tools that the behavioral researcher can readily employ at a relatively low cost. In particular, a little Visual Basic programming along with the SDK will allow an investigator to explore the effects of spoken language on behavior (in the form of instructions and feedback) and to use spoken words and phrases, uttered by subjects, as responses that can be analyzed, in vivo, and thus consequated as ongoing behavioral events. In short, a little investment in the technical skills required to master Visual Basic can open up a rich vista of research opportunities for both the beginning and seasoned behavioral researcher.

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STUDENT PAPER WINNER: ABSTRACT

A SENIOR CITIZEN'S SELF-MANAGEMENT OF POSITIVE AND NEGATIVE INNER BEHAVIOURS

Emma Cobane

UNIVERSITY OF ULSTER - COLERAINE, IRELAND

This investigation evaluated a senior citizen's self-management of positive and negative inner behaviours, namely thoughts and feelings. Throughout the course of the study every instance of positive and negative inners per day was counted, recorded and charted on a Standard Celeration Chart. Following baseline (Condition A), the initial intervention strategy involved the introduction of timed counting procedures, varying between 30-seconds and 1-minute in duration, during which the participant was instructed to free/tally as many positive inners as possible (Condition B). Resultant data led to the implementation of response-prompt practice and assessment procedures (Condition C), which included SAFMEDS and a personalised response-prompt worksheet designed by the participant for use during daily 1-minute counting periods. Behaviour maintenance was determined by a return to baseline (Condition A) and subsequent follow-up assessment (Condition D). The main finding was that response-prompt procedures (Condition C), particularly the personalised response-prompt worksheet, proved most effective in increasing the frequency of positive inners, both during daily 1-minute counting periods and throughout the day, whilst reducing the frequency of daily recorded negative inners. The implications of these findings in relation to future research and applications are discussed.

STUDENT PAPER WINNER: ABSTRACT

TEACHING CHILDREN WITH AUTISM USING CONDITIONED CUE-VALUE AND RESPONSE-MARKING PROCEDURES: A SOCIALLY VALID APPROACH

Corinna Grindle

UNIVERSITY OF SOUTHAMPTON, UNITED KINGDOM

Five children with autism were taught to match printed words to corresponding pictures. Participants' speed of learning was compared across three training conditions, each involving a 5-s delay of reinforcement, using a within-participants alternating treatments design. In the cue value condition, a verbal phrase of approval (e.g., "good!") was delivered only after correct responses and again after a 5-s delay when a primary reinforcer was delivered; in the response marking condition, an attention-eliciting verbal cue (e.g., "look!") was delivered after both correct and incorrect responses, but not prior to the primary reinforcer; in the delay only condition, there were no cues during a 5-s delay. Performance in the no-cue control was inferior to both the cue-value and response-marking conditions, but there was little difference between the latter two conditions. The implications of these results for facilitating learning in applied settings are discussed.

STUDENT PAPER WINNER: ABSTRACT

THE BEHAVIOURAL ECONOMICS OF CIGARETTE SMOKING: THE CONCURRENT PRESENCE OF A SUBSTITUTE AND AN INDEPENDENT REINFORCER

Matthew Johnson

UNIVERSITY OF VERMONT

The present study examined the consumption of cigarettes and two alternative reinforcers in dependent smokers. Cigarette price (response requirement) increased across sessions while alternatives were available at a fixed price in four phases of availability: 1) cigarettes alone, 2) cigarettes and nicotine gum, 3) cigarettes and money, and 4) cigarettes, nicotine gum, and money. Cigarette consumption decreased with increasing price throughout. In the cigarette and nicotine gum phase, nicotine gum consumption increased with cigarette price, indicating nicotine gum to be a substitute for cigarettes. In the cigarette and money phase, money consumption increased slightly with cigarette price, indicating money to be an independent reinforcer for cigarettes. When all three reinforcers were present, money again served as an independent reinforcer. Nicotine gum consumption increased with cigarette price, but the degree of increase was diminished to the level of an independent reinforcer. Cigarette consumption decreased modestly when nicotine gum was available, and to a larger extent when money or both alternatives were available. The results imply that in some contexts an independent reinforcer such as money may be more effective at reducing drug use than a pharmacological substitute.

STUDENT PAPER WINNER: ABSTRACT

TOPOGRAPHY OF EYE MOVEMENTS UNDER SELECT AND REJECT CONTROL

Atli Magnusson

THE NEW ENGLAND CENTER FOR CHILDREN

When performing a discrimination task, responding can either be under Select or Reject control. Select control refers to when selection of a stimulus results in reinforcement and Reject control refers when rejection of a stimulus and picking another stimulus results in reinforcement. Given a constant Reject or Select control it is possible to measure differences in responding with some test for stimulus equivalence. Outcome on reflexivity, transitivity and equivalence tests are opposite when responding is under Reject control than under Select control. Response topography of eye movements were recorded with ISCAN eye tracking equipment. Research on observing behavior in the context of simple discrimination has indicated that observing responses are more frequent toward stimuli correlated with reinforcement than stimuli correlated with extinction. In conditional discrimination it is the Sd that is correlated with reinforcement, which is the 'correct' comparison when responding is under Select control, and the 'incorrect' comparison when responding is under Reject control. Therefore it was predicted that eye movements toward the incorrect comparison would be relatively more frequent towards the incorrect comparison when responding was under Reject control than under Select control. Results from both participants, were according to the prediction.

STUDENT PAPER WINNER: ABSTRACT

REINFORCER MAGNITUDE AND HUMAN VARIABLE RATIO PERFORMANCE

Carla-Jayne Strickland

UNIVERSITY OF SOUTHAMPTON, UNITED KINGDOM

The application of Killeen's (1994) Mathematical Principles of Reinforcement (MPR) has previously been limited to use with non-human participants. The aim of the current research was to determine if human performance on variable ratio (VR) schedules was described by a bitonic function over a range of VR schedules as predicted by MPR. It was also predicted that response rates would be higher when participants earned more money per reinforcer. A computer-based experiment employed a masking technique of searching a map for treasure. Participants' behavior of clicking the mouse button the correct number of times was reinforced according to a serious of VR schedules: VR 25, VR 50, VR 100, VR 200 and VR 400, with reinforcers of 0.10 UKP or 0.05 UKP. Participants experienced both reinforcer magnitudes in a counterbalanced order. Only one participant demonstrated the bitonic pattern in response rates. An order effect was also noted between the counterbalanced conditions: participants appeared to work harder in the second condition they experienced possibly to either protect their earnings from a possible reduction or to benefit from the richer reinforcers.