RESEARCH IN PROGRESS

MEASURING EFFECTS OF DRUGS ON HUMAN SOCIAL BEHAVIORS

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Psychotropic drugs are widely prescribed for reducing problem behaviors in individuals with mental retardation (MR) and mental illness, but these drugs have received inadequate scientific attention. Clinical usage outpaces research, and efficacy studies seldom provide information on the behavioral selectivity of medications. That is, it is often unknown whether desirable behaviors also decrease as undesirable behavior decreases. Limited progress has been made toward developing a scientific knowledge base of behavioral selectivity, largely because of the difficulty and expense of reliable assessment. Studies of psychotropic medications have generally not included detailed measurement of social behavior in the natural environment. Yet normalization of social interactions is a primary goal of behavioral and drug therapies (DuPaul & Barkley, 1993); therefore, treatments that diminish the quantity and quality of social behaviors are counterproductive.

To our knowledge, we are conducting the first detailed study of psychotropic-medication effects on social interactions in persons with MR. For clinical purposes, the primary data of interest are the quantity and quality of social interactions. In addition, it is important to know whether the subject initiates interactions or merely responds to others. From a more analytic point of view, we would like to be able to identify antecedent events that may "trigger" aberrant or undesirable behavior, as well as those associated with desirable behavior. By measuring the occurrence of such antecedent events, we can determine whether medication changes the subject's response to them, or whether changes in the frequency of the antecedents themselves may be causing changes in target behavior. For example, during the drug trial there may be a reduction in aggression associated with work related demands. This could be due to a drug-related reduction in the aversiveness of demands, or to a coincidental reduction in the rate with which caregivers place work related demands on the subject. This differentiation requires a comprehensive measurement system for recording sequences of events.

METHOD AND RESULTS

We use a behavioral coding and analysis system developed for studying behavioral variables and interventions in classroom settings with behavior disordered children (Mahon, Shores, & Buske, 1999; Shores, Wehby, & Jack, 1999). This system allows for the collection of continuous, real-time data, preserving the sequence of multiple instances of behavior. Observers enter the codes into a hand-held microcomputer using the number keys. Each event is entered as a four-digit code. The first digit represents who emits a behavior (the actor), the second and third digits represent the topography of the behavior, and the fourth digit represents to whom the behavior is directed (the target). For example, if a caregiver asks the subject to stop screaming, the caregiver is the actor, the response is a negative mand, and the subject is the target. We record only caregiver and peer behavior directed toward the subject. A "stop" code is entered when there is no scoreable event for 10 seconds. Each code is time stamped. In addition, the system allows for the simultaneous recording of concurrent behavior, such as stereotyped behavior, and of changes in the environment, such as changes in caregiver or peer proximity.

For analysis we used a sequential interaction program (MOOSES; Tapp, Wehby, & Ellis, 1995 or see http://kc.vanderbilt.edu/~jont/mintro.html for a description) to produce conditional probabilities of target behavior. We also used a second program (SCOPE; available from the authors) which separates the behavior stream into interaction sequences and non-interaction sequences and analyzes the rates of and time spent in the different classes of interactions (e.g.,

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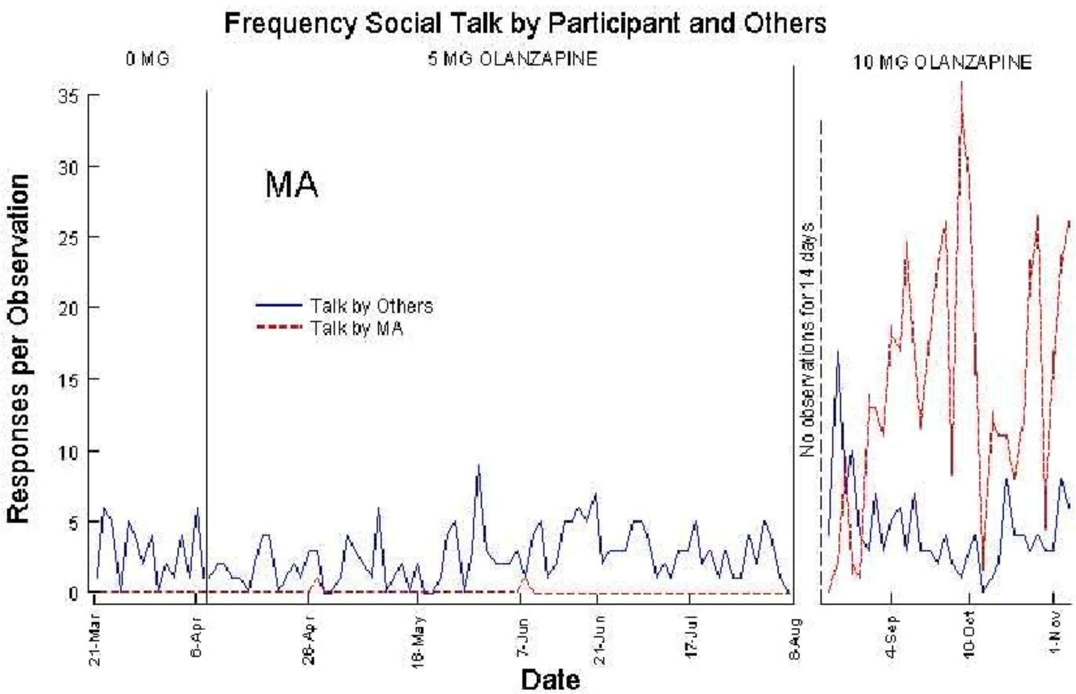

Figure 1

desirable and undesirable interactions, interactions initiated by the participant or by others). By definition, an interaction follows a stop code and involves a coded behavior initiated by one actor followed by a code with a different actor (i.e., subject talks to caregiver followed by caregiver talks to subject). The first code after a stop code is used to classify the interaction as initiated by subject or other and to calculate the relative frequency of subject initiations. Sequences without these reciprocal behaviors are not included in the interaction analysis.

This complex data collection system requires intensive observer training to generate reliable data. In our experience, it is possible to train observers on a system of 25 behavior codes (resulting in over 100 initiator-behavior-target combinations) in about 6 weeks, given a consistent, programmatic approach. Our criterion for training is interobserver agreement (IOA) scores of 80% or higher on each code. In well-trained observers, IOA reliably exceeds 90%. Data presented below were collected by a very experienced observer, but reliability was taken by trainees. Mean occurrence IOA was 76% ranging from 0 to 100% across 43 obtained code combinations.

The use of these measures is demonstrated with data from a 53-year-old woman with mild mental retardation who was diagnosed with major depression. She was withdrawn, rarely spoke, and preferred to stay in bed and socially isolated. She had been highly social prior to the diagnosis of depression. She had been treated with a wide variety of antidepressant, antipsychotic, and mood stabilizing medications without change, and was scheduled for a trial with the atypical neuroleptic olanzapine. We typically conduct 30-minute observations in settings and activities that occur daily and in which other people are available for social interactions. For MA, lunchtime was chosen.

Figure 1 shows the frequency of "social talk" between MA (both initiations and responses) and hospital staff and peers. After a 2-week period without olanzapine, 5 mg was administered daily for 12 weeks. There was no change in the frequency of talk. After the increase to 10 mg, however, there was a marked increase in MA's frequency of "spontaneous" talking.

Figure 2 shows the percentage of observation time spent in interactions initiated by MA and by others for the last 10 observations under 5 mg and 10 mg. For the lack of better descriptions, we call

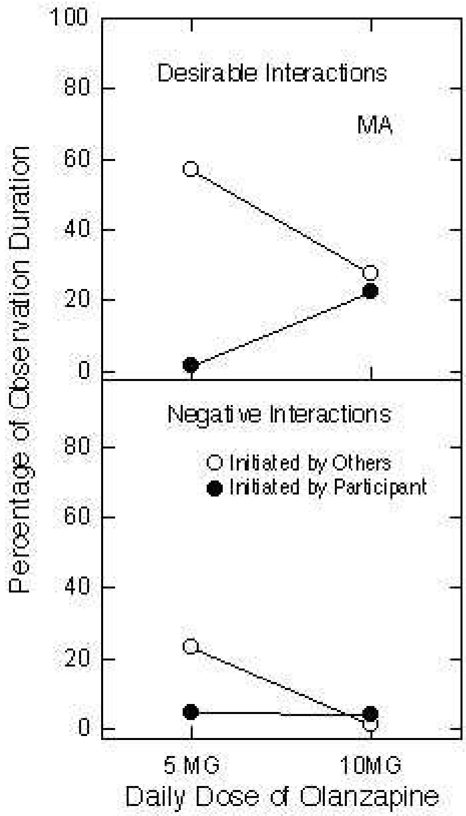

Figure 2

any interaction that includes an undesirable behavior a negative interaction and other interactions "desirable." While interactions occurred for the majority of the observations, MA initiated virtually none of these interactions under 5 mg. Under 10 mg more than 20% of the observation time was spent in desirable interactions initiated by MA. The decrease in negative interactions is also notable.

Table 1 shows, for the five most likely interaction initiations during the last 10 sessions under 5 mg and 10 mg and in order of probability, the initiator, the type of behavior, and the target in each interaction. The only initiated interactions in the 5 mg condition were by other people, and 60% of those were requests or physical prompting to perform specific tasks. In the 10 mg condition, however, MA was the initiator for three of the five most probable initiations, and task related requests by others constituted only 20% of the initiations. Subject and staff behavior indicative of normal conversation, which never occurred under 5 mg, comprise the remainder of the most probable initiation behavior under 10 mg.

DISCUSSION

In the absence of a dosage reversal, it is unclear whether the changes shown with this participant are due to olanzapine treatment or other factors. Our purpose here is to show that the observation system can be used to measure clinically-important changes in social behavior in adults with MR and mental illness. Because we can record the rates of a range of undesirable behavior targeted for reduction, as well as a range of desirable behavior topographies, selectivity of drug effects can be assessed.

In addition, we hope that this line of work might begin to reveal some behavioral mechanisms of drug actions. The sequential analysis allows us to detect changes in sequential dependencies of events. For example, a reduction in self-injurious behavior (SIB) under drug conditions may be traceable to a reduced probability that task demands are followed by SIB. This outcome may be interpreted as a selective reduction of escape/avoidance-related SIB. That is, these measures can indicate which topographical and functional classes are affected by the medication (see Symons et al., 2001). Although there are other methods of obtaining functional and topographical measures (e.g., analog procedures), direct measurement of naturally occurring behaviors has the advantage of being minimally intrusive and having high external validity.

A clinically interesting feature of these data is that they can be interpreted as showing improvement of so-called negative symptoms (i.e., not speaking, poverty of vocalizations and interactions, etc.) characteristic of depression. These measures may also be used to provide a wealth of information on the effects of drugs used in other populations (e.g., children), as well as in applied and basic behavioral research on social behavior.

We are currently using this observation system as part of a double blind, placebo-controlled study of the atypical neuroleptic risperidone. To our knowledge, this is one of the few attempts to assess the selectivity of such drugs in reducing undesirable behavior. The work takes a first critical step in the development of an informative literature on the effects of psychoactive medications in individuals with mental retardation. Evidence that a drug has selective effects may ultimately inform efforts to

Table 1

Five most probable behaviors initiating interactions following a stop code under the 5 mg and 10 mg conditions.

			Conditional probability	
Initiator	Initiating behavior	Recipient	5 mg	10 mg
Other	Mand	Subject	0.495	0.200
Other	Physical guidance	Subject	0.105	0.003
Other	Negative physical	Subject	0.039	0.000
Other	Positive physical	Subject	0.032	0.006
Other	Compliment	Subject	0.029	0.028
Other	Question	Subject	0.000	0.158
Subject	Talk	Other	0.000	0.107
Subject	Question	Other	0.000	0.104
Subject	Compliment	Other	0.000	0.069

discover brain-behavior relations. For example, the clinical efficacy of a drug with specific neurochemical effects is often taken as evidence to support theories of specific neurotransmitter theory of the behavior's etiology. This logic is critically dependent on the selectivity of the drug's effect on the aberrant behavior.

REFERENCES

DuPaul, G. J., & Barkley, R.A. (1993). Behavioral contributions to pharmacotherapy: The utility of behavioral methodology in medication treatment of children with Attention Deficit Hyperactivity Disorder. *Behavior Therapy*, **24**, 47-65.

Mahon, K. L., Shores, R. E., & Buske, C. J. (1999). Issues of conducting research on setting events: Measurement and control of dependent and independent variables. *Education and Treatment of Children*, **22**, 427-443.

Symons, F. J., Tapp, J., Wulfsberg, A., Sutton, K. A., Heeth, W. L., & Bodfish, J. W. (2001). Sequential analysis of the effects of naltrexone on the environmental mediation of self-injurious behavior. *Experimental and Clinical Psychopharmacology*, **9**, 269-276.

Shores, R. E., Wehby, J. H., & Jack, S. L. (1999). Analyzing behavior disorders in classrooms. In A. C. Repp, & R. H. Horner (Eds.), *Functional analysis of problem behavior: From effective assessment to effective support* (pp. 219-237). Belmont, CA: Wadsworth.

Tapp, J., Wehby, J., & Ellis, D. (1995). A multiple option observation system for experimental studies: MOOSES. B*ehavior Research Methods, Instruments and Computers, 27,* 25-31.

RESEARCH IN PROGRESS

MODELING ANALOGICAL REASONING USING THE RELATIONAL EVALUATION PROCEDURE

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Our current work aims to model analogy using the Relational Evaluation Procedure (REP), a novel experimental protocol allowing the rapid generation of derived relations (e.g., Hayes, Barnes-Holmes & Roche, 2001). Recent behavior analytic work has conceptualized analogy as the derivation of equivalence relations between equivalence and other types of derived relations (e.g., more than/less than) and this conceptualization has been successfully modeled in the laboratory (e.g., Barnes, Hegarty & Smeets, 1997). However, previous empirical demonstrations of this model have been based on matching-to-sample (MTS) procedures, which allow only a limited number of analogies to be demonstrated. Our employment of the REP is intended to circumvent this difficulty, thus enabling the development of a model of analogy that captures the often rapid and relatively easy use of analogy in natural language.

BACKGROUND

Barnes et al. (1997) provided the first behavior analytic model of analogy based on responding in accordance with equivalence relations between equivalence relations. In the authors' own words;

> Consider...the following question…: "apple is to orange as dog is to: (i) sheep, or (ii) book?". If "apple" and "orange" participate in an equivalence relation in the context "fruit," and "dog" and "sheep" participate in an equivalence relation in the context "animals" then we would expect a person to pick "sheep" as the correct answer. In effect, the response would be in accordance with the derived equivalence relation between two already established separate equivalence relations...We take the view that equivalence-equivalence responding is an example of a relational network as defined by relational frame theory…(p. 3)

Barnes et al. (1997) trained subjects, using matching-to-sample procedures, to make the following conditional discriminations: A1->B1, A2->B2, A1->C1, A2->C2, A3->B3, A3->C3, A4->B4, A4->C4. Four equivalence relations then emerged: B1<->C1, B2<->C2, B3<->C3, B4<->C4. Subsequent tests then demonstrated the emergence of equivalence relations between equivalence relations (e.g., B1C1<->B3C3) and of equivalence relations between non-equivalence relations (e.g., B1B2<->C3C4).

Stewart et al. (2001) recently extended this model. They argued that, in addition to the arbitrary relations established by Barnes et al. (1997), analogy often involves the abstraction of common formal properties. In the example given above, for instance, the arbitrary equivalence relation between "apple" and "orange" is based, to some degree, on non-arbitrary similarity between actual apples and oranges (e.g., 'sweetness'). Similarly, the arbitrary equivalence relation between "dog" and "sheep" is based on non-arbitrary similarity between actual dogs and actual sheep (e.g., 'four legged-ness'). Thus, the equivalence-equivalence (analogical) relation between the equivalence relations 'apple-orange' and 'dog-sheep' may be traced back to formal relations. Stewart et al. (2001), therefore, attempted to include the role of formal properties in the Barnes et al. (1997) model. Subjects were taught, using matching-to-sample, to choose a particular nonsense syllable in the presence of each of four blue and four red geometric shapes. In a subsequent test, subjects demonstrated equivalence responding based on the abstraction of color by consistently matching nonsense

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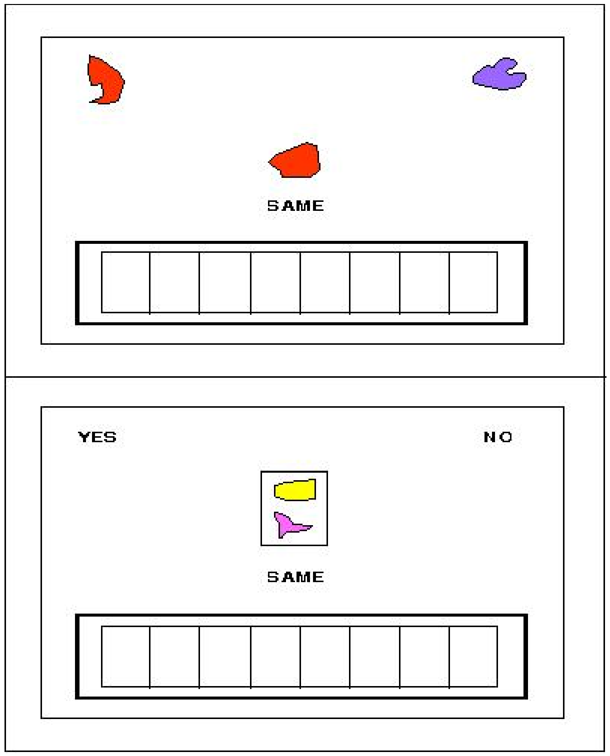

Figure 1

syllables related to same-colored shapes to each other. Subjects then showed equivalence-equivalence responding. Thus, these researchers provided a demonstration of equivalence-equivalence responding based on the abstraction of common formal properties, thereby extending the functional-analytic model of Barnes et al. (1997) to incorporate what they argued was an essential feature of analogical reasoning.

Stewart et al. provided an important extension to the model reported by Barnes et al. However, both these demonstrations were based on matching-to-sample training, which allowed only a limited number of analogies to be shown, and thus these models lacked the generativity characteristic of everyday analogy. In order to demonstrate a more ecologically valid model of analogy, we have adopted the REP, which allows for the rapid generation of derived relations. In what follows, we will describe the REP-based procedures we are currently using to model analogy.

MODELING ANALOGY USING THE RELATIONAL EVALUATION PROCEDURE

The Relational Evaluation Procedure is a protocol that allows subjects to evaluate, or report on, the networks of derived stimulus relations with which they are presented. In the typical approach, subjects may confirm or deny the applicability of particular stimulus relations to other sets of stimulus relations. Our REP-based model of analogy involves seven stages of training and testing.

Stage 1: Establishing SAME and DIFFERENT functions. Subjects are trained, using a delayed, 2-comparison, matching-to-sample format (see Figure 1; upper panel), to choose a comparison the same color as the sample in the presence of an arbitrary shape designated SAME. Similarly, choosing a comparison different in color from the sample, in the presence of an arbitrary shape designated DIFFERENT, is also trained. Thus, the functions of SAME and DIFFERENT are established for these shapes. In Stages 1, 2 and 3, once sufficient training has been received, the subject is tested on a novel set of tasks.

Stage 2: Establishing YES and NO functions. Subjects are presented with two same- or differently-colored shapes, a contextual cue (i.e., SAME or DIFFERENT), and two novel, arbitrary comparison shapes (designated YES and NO; see Figure 1, lower panel). Subjects are trained to choose the YES comparison when the contextual

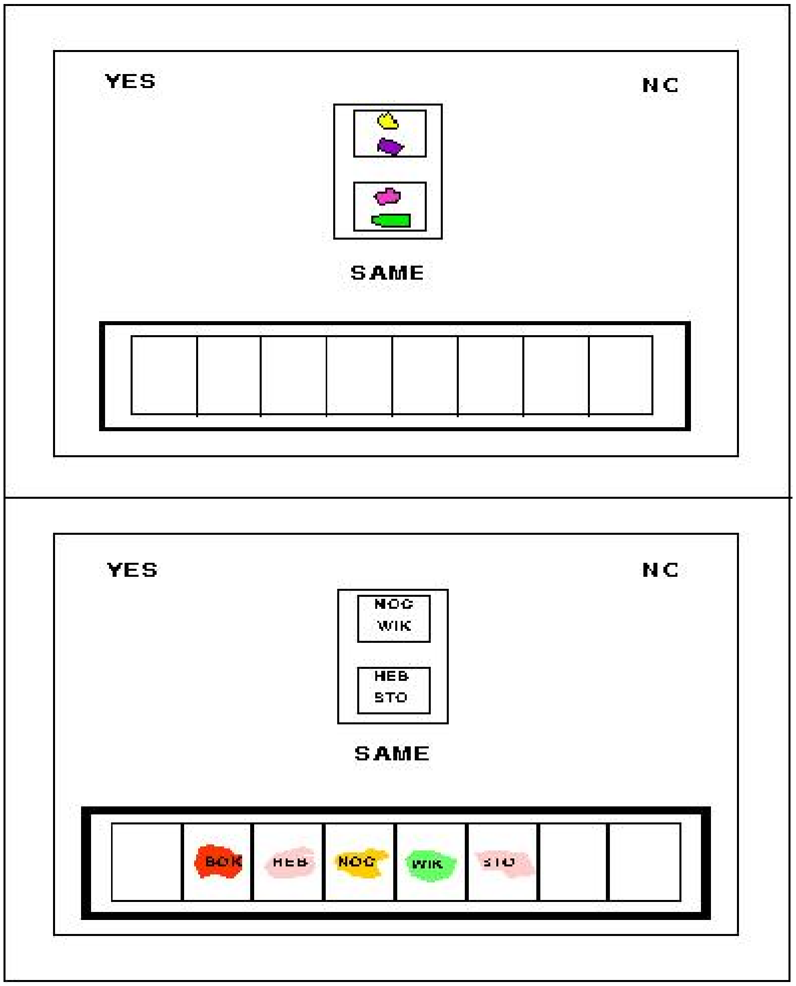

Figure 2

cue correctly corresponds to the relationship between the colored shapes (i.e., 'same color' or 'different color'). If it does not correspond then they should choose the NO comparison. For example, if a green shape appears with a yellow shape, and the DIFFERENT cue is also presented, then choosing YES is trained. YES and NO functions are thereby established in two arbitrary stimuli.

Stage 3: Establishing responding to relations between relations. This stage is similar to YES / NO Pretraining, involving same- or differently-colored shapes, a contextual cue, and the YES / NO comparisons. However, instead of two colored shapes in the box in the center of the screen, there are now two boxes, each containing two colored shapes (Figure 2, upper panel). Subjects are trained to respond in accordance with the relation obtaining between these colored-shape relations. For example, if green and orange shapes (different) appear in one box, and two pink shapes (same) appear in the other box, then the two non-arbitrary relations presented are different. Hence, if the contextual cue is DIFFERENT, then choosing YES is trained, whereas if it is SAME, then choosing NO is trained.

Stage 4: Introducing nonsense syllables. Stage 4 also involves responding in accordance with relations between relations. There is a contextual cue above the chambered box, and above that there is a box in the center of the screen that contains two smaller boxes, each of which contains two stimuli. However, instead of colored shapes, the stimuli in the boxes are nonsense syllables (Figure 2, lower panel). The eight-chambered box at the bottom of the screen now also contains nonsense syllables in black letters superimposed upon various novel colored shapes. Subjects are

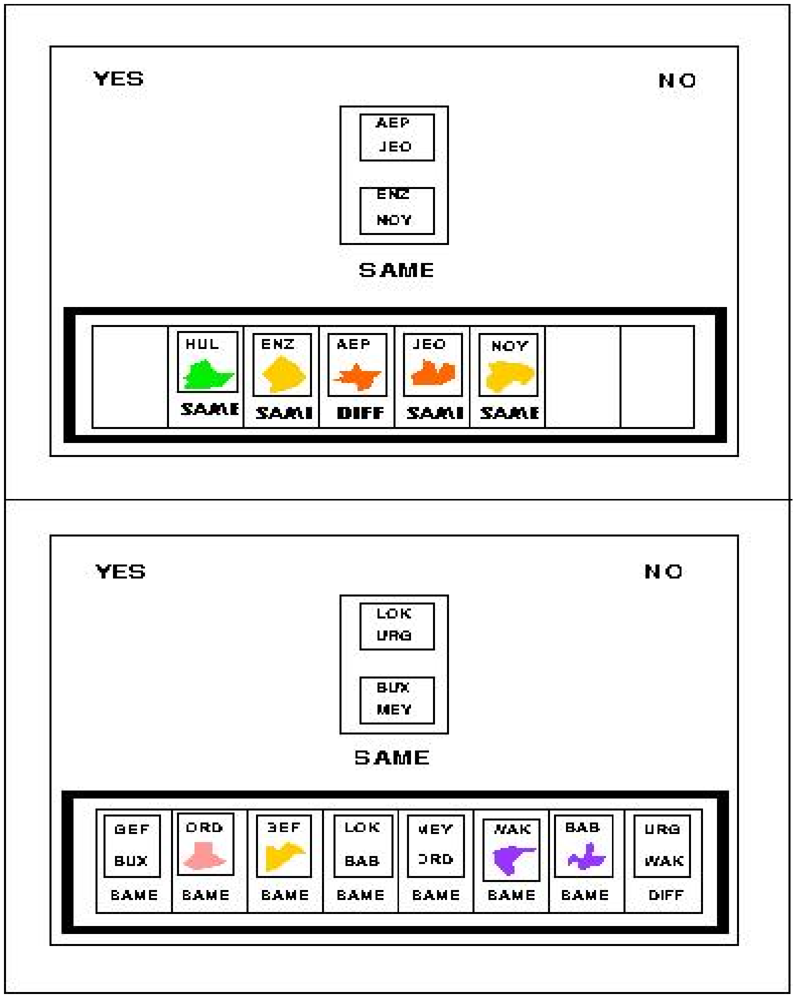

Figure 3

required, based on prior instructions, to look at this lower chamber before looking at the middle and upper portions of the screen. Based on spatial contiguity, the nonsense syllables in the lower chamber might be expected to acquire the color functions of the shapes upon which they are superimposed. In addition, because four of the nonsense syllables appearing in the bottom chamber appear also in the box in the center of the screen, subjects should respond to these four nonsense syllables as "standing for" particular colors, and thus respond in accordance with relations between relations as in Stage 3.

Stage 5: Relating relations based on mutual entailment. This stage is similar to the previous stage, except that the nonsense syllables in each of the chambers are no longer superimposed upon the colored shapes but appear above them (see Figure 3; upper panel). In addition, the nonsense syllable and colored shape in each chamber appear in a box above a particular contextual cue, either SAME or DIFFERENT. Thus, in this stage, subjects are required to observe the two relations (colored shape and nonsense syllable) and the contextual cue in each chamber of the eight chambered box before looking at the images appearing above. Based on an experimental history of responding in the presence of the particular contextual cues, the functions of the nonsense syllables should transform in certain predictable ways for the subjects. More specifically, in the presence of SAME, a nonsense syllable should acquire the same color function as the shape over which it appears, while in the presence of DIFFERENT, a nonsense syllable should acquire a function of 'different color from the shape over which it appears'. Subjects should then respond in accordance with relations between relations in the same manner as in previous stages. The phrase 'mutual entailment' in the title of this sub-section refers to the fact that the relations between the nonsense syllables and the colored shapes, upon which analogical responding is based, are mutually entailed relations (i.e., the nonsense syllables appearing in the upper boxes are directly related to the colored shapes).

Stage 6: Relating relations based on combinatorial entailment. In this stage, the relations between the colored shapes and the nonsense syllables are relations of combinatorial entailment (i.e., the nonsense syllables appearing in the upper boxes are indirectly related to the colored shapes; see Figure 3, lower panel). For example, in one chamber, a purple shape and the nonsense syllable "CUG" may appear together over the "SAME" contextual cue, while in another box, two nonsense syllables, "CUG" and "ZID" may appear together over the "SAME" contextual cue. Thus, subjects may respond to ZID as purple because it is in a combinatorially entailed "SAME" relation with the purple shape. The other nonsense syllables might acquire certain color functions based on a similar process. After that, subjects should respond in accordance with relations between relations in the same manner as in previous stages.

Stage 7: Test for analogy involving novel colors and shapes. This stage is identical to the previous stage, except that it involves completely novel colors and shapes. Hence, this stage should demonstrate numerous, completely novel examples of analogical responding. It is at this point that the REP presents a real advantage over the matching to sample procedure in that generating even one novel analogy using the MTS would require training and testing a whole new set of equivalence relations. In contrast, Stage 7 of the REP allows the experimenter to demonstrate a stream of novel analogies for the subject to solve, some of the advantages of which are mentioned below.

CONCLUSION

Four undergraduate students already exposed to this procedure have produced the predicted performances. Most importantly, in Stage 7, subjects related combinatorially entailed relations based on the abstraction of common physical properties across 24 novel trial-types. In effect, all four subjects demonstrated 24 completely novel analogical responses, and thus, in principle, an infinite number of such responses could be generated using this procedure. This level of complex and genuinely novel relational responding seems to model everyday analogy more closely than the earlier matching-to-sample based procedures. Matching-to-sample allows the training up in a number of hours of a particular analogical relational network. However, in the same period of time, by using the REP protocol, it is possible to train subjects to respond rapidly in accordance with a potentially infinite number of completely novel networks. Thus, this procedure should make the study of relatively complex patterns of analogical and other types of relational responding more efficient. Future REP-based models of analogy, for example, may involve derived relations such as OPPOSITION, COMPARISON, BEFORE / AFTER etc. In addition, stimuli other than simple colored shapes might be incorporated into the analogical network, thus providing more complex and subtle examples of analogy. Furthermore, the effects of other variables (e.g., distractor tasks, the presence of other individuals) on an ongoing stream of analogical responding could be assessed using the REP. Finally, other correlates of analogical responding (e.g., ERPS, fMRI) could also be assessed across multiple analogies in a way that would be extremely difficult if not impossible using traditional MTS procedures.

REFERENCES

Barnes, D., Hegarty, N., & Smeets, P.M. (1997). Relating equivalence relations to equivalence relations: A relational framing model of complex human functioning. *The Analysis of Verbal Behavior*, **14**, 57-83.

Hayes, S.C., Barnes-Holmes, D., & Roche, B. (2001). *Relational frame theory: A post Skinnerian approach to language and cognition*. New York: Plenum Press.

Stewart, I., Barnes-Holmes, D., Roche, B., & Smeets, P.M. (2001). Generating derived relational networks via the abstraction of common physical properties: A possible model of analogical reasoning. *The Psychological Record*, **51**, 381-408.