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RESEARCH IN PROGRESS

ON THE DIFFERENTIAL IMPACT OF POSITIVE AND NEGATIVE REINFORCEMENT

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As illustrated by debates over one-factor versus two-factor theories of punishment and negative reinforcement, behavior scientists long have wondered whether appetitive and aversive events affect behavior through similar mechanisms. Largely overlooked in these debates is a conceptually simpler issue that has attracted considerable attention outside of behavior analysis: Regardless of their mechanisms of action, on a unit by unit basis, do consequences based on appetitive and aversive events have equal *amounts* of influence on behavior? Behavior analysts have said little on this issue, but cognitive research on decision making (e.g., Kahneman & Tversky, 1979) supports a differential-impact hypothesis by suggesting that losses exert greater impact on behavior than equal-sized benefits. The experiments on which this conclusion is based, however, have uncertain generality, focusing largely on verbal responses to hypothetical, anticipated consequences.

Most operant experiments with nonhumans can shed limited light on a differential-impact hypothesis because they employ qualitatively different appetitive (e.g., food) and aversive (e.g., electric shock) consequences that cannot be compared on the same measurement scale without special procedures (Farley & Fantino, 1978). Operant experiments with human subjects offer a distinct advantage in the present context, because their procedures often arrange consequences based on point gains and losses, making it possible to directly compare the relative effects of equal-sized appetitive and aversive consequences. Ongoing research in our laboratory employs concurrent schedules of reinforcement as a means of doing this. Here we present preliminary data that illustrate our approach to evaluating the differential-impact hypothesis.

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For the sake of simplicity, we focus mainly on aversive control in the form of negative reinforcement, because (a) it can be procedurally quite similar to positive reinforcement, and (b) its effects on response strength can be measured directly (unlike punishment, which can be evaluated only in terms of the extent to which it reverses the effects of other operations). We employ concurrent schedules of positive reinforcement, involving money gains of amount *X*, and negative reinforcement involving the cancellation of money losses of amount *X*. In a two-ply concurrent schedule in which the responses produce qualitatively different reinforcers, preference for (i.e., differential impact of) one reinforcer is indicated by a consistent biasing of response allocation (a change in intercept; Baum, 1974). Thus, if one type of reinforcer is more potent than the other, relative response rate will consistently exceed relative reinforcement rate for the behavior maintained by that consequence.

As far as we can determine, only two published studies have examined concurrent schedules of positive vs. negative reinforcement in humans using equal-sized money outcomes (Ruddle, Bradshaw, & Szabadi, 1981; Ruddle, Bradshaw, Szabadi, & Foster, 1982). Both found that humans matched positive to negative reinforcement with no consistent bias, suggesting equal control by the two types of consequences, but the studies have limitations. For example, different types of schedules were used to arrange positive versus negative reinforcement, and there were problems regarding the independence of response options. One study employed no changeover delay, and the other employed a changeover procedure that could have created safety periods during which no money losses could occur on the negative-reinforcement schedule just after a switch (thereby reinforcing changeovers). We seek to improve upon the procedures of Ruddle and colleagues as a means of better evaluating the differential-impact hypothesis. Our ongoing investigations employ independent, identically-structured, concurrent schedules of variable-cycle (VC) positive and negative reinforcement. Thus, in positive reinforcement, the first response within a cycle immediately produces point gain (that gain is "forfeited" at the end of a cycle with no responding). In negative reinforcement, the first response in a cycle immediately cancels a point loss (which occurs at the end of a cycle with no responding). We have resolved the problem of adventitious safety periods by programming a changeover cost (a fixed-ratio response requirement on a changeover button) rather than a changeover delay.

The experimental task is based closely on that of Madden and Perone (1999). Consequences are point gains and losses (see below), and conditions are run to stability. In a pilot study, all subjects but one exchanged points for course credit (for exchange procedures, see Critchfield, Schlund, & Ecott, 2000). For these subjects, session earnings were supplemented during negative reinforcement conditions to prevent sub-zero session point totals (we feared that subjects might quit the experiment in such cases). Thus, a counter, not visible on the subject's screen during sessions, tallied session earnings and was displayed at session's end. At the start of a session, the counter was set equal to the programmed session rate of point loss that would accrue following no responding on the negative reinforcement schedule. One subject (S504) exchanged points for money and did not receive supplements to session totals.

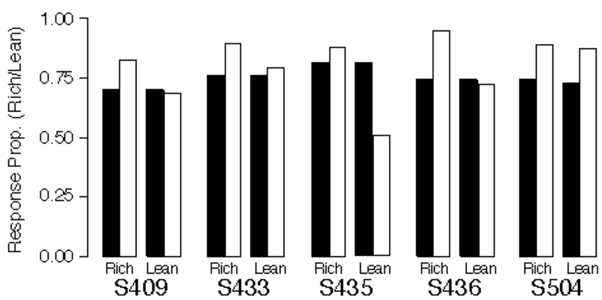

Figure 1

Figure 1 summarizes the response-allocation results of the pilot study. Subjects completed four conditions under a 5:1 (VC 12 s VC 60 s) reinforcement ratio. In one pair of conditions (labeled "Rich" in the figure), both schedules produced positive reinforcement during baseline (black bar), and then negative reinforcement was substituted on the rich-reinforcement alternative during the subsequent condition (white bar). A consistent increase in preference for the rich alternative suggested a negative-reinforcement bias. In the other pair of conditions ("Lean"), the positive-reinforcement baseline condition was repeated, and then negative reinforcement was substituted for the lean-reinforcement alternative.

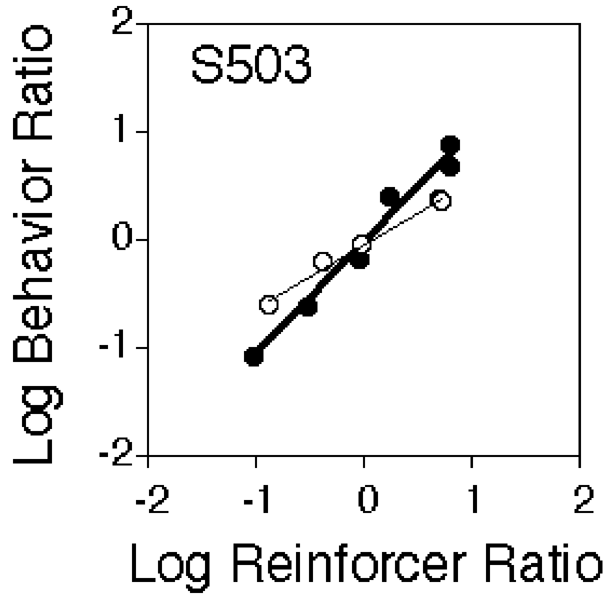

Figure 2

Under these conditions, there was no systematic change in preference, suggesting that effects seen in the "Rich" conditions may have had some basis other than a reinforcer bias.

Now underway are studies in which each subject provides two complete matching functions, one involving positive reinforcement only and one involving both positive and negative reinforcement, across a range of relative reinforcement rates. Figure 2 shows response-matching data from one subject who worked for money and received no session-total supplements. Compared to an all-positive-reinforcement baseline, the introduction of negative reinforcement for one response option (filled data points and dark regression line) induced no bias, but did increase the slope of the response-matching function (equivalent to magnifying rich-side preference in Figure 1). If replicated, the latter effect would provide the first provisional support for an as-yet untested prediction by Davison and Nevin (1999) of a slope-increasing "differential outcomes effect" in matching.

So far, contrary to assumptions in cognitive decision research (Kahneman & Tversky, 1979), our results suggest no systematic differential impact of positive and negative reinforcement (and this outcome appears not to depend on minor procedural variations like session earnings supplements and exchanging points for money vs. course credit). It is difficult to affirm a null hypothesis, but if this finding holds up under more systematic investigation, it will raise interesting questions, not about positive and negative reinforcement, but rather about the procedural differences between operant and cognitive investigations that bear on a differential-impact hypothesis.

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RESEARCH IN PROGRESS

DEVELOPING A PROCEDURE TO MODEL THE ESTABLISHMENT OF INSTRUCTIONAL CONTROL

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In a recent paper, we suggested that an agreed account of the referential properties of rules and instructions has yet to be developed (O'Hora & Barnes-Holmes, 2001). In order to address this fundamental issue, procedures are required that establish referential or 'specifying' properties in previously neutral stimuli. The present report summarizes the rationale for this research and outlines procedures that we are currently developing.

Skinner (1969) distinguished between rule governed behavior and contingency-shaped behavior. Skinner suggested that contingency-shaped behavior is acquired through direct exposure to environmental consequences, whereas rule governed behavior is controlled by "rules derived from the contingencies in the form of injunctions or descriptions which *specify* occasions, responses and consequences" (Skinner,1969 p 160; emphasis added). Although other researchers have suggested revisions of Skinner's approach to rules and rule following (Chase & Danforth, 1991; Hayes & Hayes, 1989; Schlinger, 1993; Zettle & Hayes, 1982), Skinner's definition of a rule as a contingency specifying stimulus remains the most influential within behavior analysis.

The empirical literature on instructional control stemmed largely from Skinner's (1969) definition of a rule. Recently, however, researchers have argued that the term 'rule' should be avoided because it has been used to refer both to antecedents of behavior and to outcomes of behavior (O'Hora & Barnes-Holmes, 2001; Ribes-Inesta, 2000). In the current report, therefore, we will use the term 'instruction' to refer to verbal antecedents of the type used in the empirical literature on rule governance and instructional control.

Over ten years ago, Hayes and Hayes (1989) argued that the conception of instructions as contingency specifying stimuli has one major weakness. Specifically, these authors contended that Skinner did not provide a functional-analytic definition of the term 'specify'. As a result, a wide variety of stimuli have been utilized in the empirical investigation of instructional control, including: "Press 3 and you will lose 17 points" (Schmitt, 1990), "You must choose one of the three bottom figures that is the most different with respect to the top one" (Martinez-Sanchez & Ribes-Inesta, 1996 p.308), "Go fast" (Hayes, Brownstein, Zettle, Rosenfarb, & Korn, 1986), and the presentation of a small dot that signaled a correct response (Danforth, Chase, Dolan, & Joyce, 1990, p. 100).

In each of the foregoing examples, and in many others, one might say that an instruction specifies a contingency. Nevertheless, when pressed to explain how a stimulus comes to specify a contingency, difficulties arise. For example, if a stimulus that specifies a contingency is simply considered a discriminative stimulus, the term 'specify' becomes redundant, and so too, one might argue, does the concept of an instruction. The abandonment of the terms 'instruction' and 'specify' may indeed be considered an attractive option on the grounds of parsimony (cf. Vargas, 1988), but if instructions are to be defined simply as discriminative stimuli, a further problem arises. Specifically, an instruction may control responding in the absence of an explicit history of reinforcement for following that instruction, and this fact is difficult to reconcile with the established definition of a discriminative stimulus (see Schlinger, 1993 for a detailed discussion). Rather than abandon the concepts of instruction and 'specifying', therefore, we suggest that a clear and precise definition of the term 'specify' is required.

Recent research in the area of derived stimulus relations has suggested one approach to a functional analysis of the term 'specify', and to instructional control more generally (Chase & Danforth, 1991; Hayes & Hayes, 1989; Hayes, Gifford, & Hayes, 1998). More specifically, Relational Frame Theory (RFT) suggests an approach to instructional control in terms of the derived relations involved. As an example, Hayes and Hayes (1989) conceptualized a simple instruction in terms of Before and After relations and relations of co-ordination or sameness. The instruction "When the bell rings, then go to the oven and get the cake" can be conceptualized in terms of the participation of the words in equivalence relations with actual events (e.g., the word "bell" with actual bells, the word "oven" with actual ovens), and the contextual control of relational cues for Before and After relations (i.e., "when", "then", "and" establish the sequence; bell BEFORE oven BEFORE cake, or by mutual entailment; cake AFTER oven AFTER bell). We recognize that this interpretation may not capture the intricate subtleties of instructional control in the natural environment and, in its current form, may be somewhat simplistic. Nevertheless, it constitutes the first step towards the analysis of instructional control as a form of derived relational responding. Moreover, RFT provides a clear functional-analytic definition of the term 'specify'.

The RFT approach to instructional control lends itself readily to experimental investigation. As mentioned earlier, a simple instruction from the perspective of RFT may involve responding in accordance with the derived relations of Same, Different, Before, and After. In the experimental work we are currently conducting, the first stage involves establishing the functions of Same, Different, Before and After for four abstract stimuli (e.g., !!! as Same, %%% as Different, etc.) using a complex computer-based pre-training procedure[1] (broadly similar to the relational pretraining reported by Steele and Hayes, 1991). Participants are then exposed to a test for instructional control over sequencing behavior. Figure 1 illustrates a representative test probe. Each test probe consisted of a visual presentation including nonsense syllables, colored squares and the contextual cues established in pre-training (i.e., !!!, %%%, etc., represented in the boxed area of Figure 1 by the uppercase words SAME and BEFORE). Specifically, this probe may be described as follows: C1 Before C2 Before C3 Before C4, where C1 is the same as B1, and B1 is the same as A1 (green); C2 is the same as B2, and B2 is the same as A2 (red); C3 is the same as B3, and B3 is the same as A3 (yellow); and C4 is the same as B4, and B4 is the same as A4 (blue). Participants are then required to enter a four-key response using four colored keys on the computer keyboard based on the network of Before and Same relations. The correct sequence response in this case is Green→Red→Yellow→Blue, (shown below the boxed area in Figure 1). A number of participants have been exposed to this and a variety of related tasks that also involved presenting Different and After contextual cues. Thus far, the predicted response patterns have emerged for 8 out of 14 participants across two experiments.

[1] The reader can download the Psyscope (Cohen, MacWhinney, Flatt, & Provost, 1993) application used in the current work at the Maynooth web-site: http://www.may.ie/academic/psychology/software.htm or see Roche, Stewart, and Barnes-Holmes (1999)

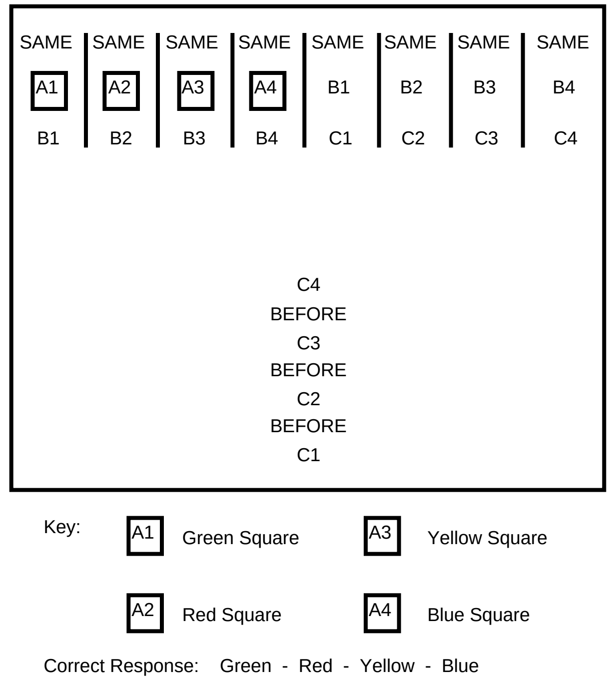

Figure 1

From an RFT perspective, the predicted performances constitute a basic model of instructional control in that response sequences are *specified* by derived Same or Different relations between A and C stimuli, and Before or After relations among C stimuli. In the context of the analysis of complex human behavior, the current research is critical. In order to provide a functional-analytic approach to the specification of contingencies by instructions, the term 'specify' must be defined functionally and demonstrated using previously neutral stimuli in a laboratory setting. The current research represents the first tentative steps towards that goal.

The procedures outlined herein were presented in more detail at the annual conference of the EABG (UK) group in London, April, 2001. The authors welcome suggestions, comments, and questions (denis.p.ohora@may.ie, dermot.barnes-holmes@may.ie, bryan.t.roche@may.ie).

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