TRAINING FLUENCY ON CHOICE REACTION TIME TASKS: DOES RESPONSE SPEED GENERALIZE TO FUNCTIONALLY EQUIVALENT STIMULI?[1]

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Precision teachers have underscored the importance of response speed as a measure of performance (Lindsley, 1991), and suggest that effects of training to fluency transfer to the learning of more complex tasks (Binder, 1993). The present study examined the generalization of speeded responding to members of functionally equivalent stimulus classes. It has been shown that the measurement of response latency versus accuracy may yield different estimates of both functional and stimulus equivalence (e.g., Brown et al., 1951; Wulfert & Hayes, 1988). We trained subjects to increase their speed of responding to words of one case, presented within a choice-reaction-time paradigm, and then tested for generalization to those same words in their nontraining case. Our results showed considerable, but not complete generalization, consistent with the findings for stimulus equivalence, and in support, at least on this very basic level, of reports by precision teachers of the generalization of fluency.

Precision teachers, a group of educational researchers and practitioners in the behavior analytic community, emphasize the importance of speed of responding as a measure of performance (e.g., Lindsley, 1991; Binder, 1993). In fact, precision teachers assert that training should continue until the task can be performed automatically or *fluently*. Behavioral fluency is defined as accuracy plus speed of responding. Fluent performance is making the appropriate response "smoothly and without hesitation" (Binder, 1995, p. 3). Among the benefits, of training to fluency, claim precision teachers, are greater retention of skill or learned material, higher resistance to distraction, and application or transfer of training (Binder, 1993). Precision teachers have reported that training for fluency on component behaviors enhances the learning of composite tasks, as in progressing from elementary to more advanced arithmetic operations (Binder, 1993; Gagné, 1983; Haughton, in Johnson & Layng, 1992). Some also claim that fluency training promotes other types of generalization or transfer, such as from instructional to "real world" settings (e.g., back on the job) (C. Binder, personal communication, May 10, 1996; e.g., see Binder, 1989). The present research, intended as the first in a program to explore the generalization of fluent discrimination in the laboratory, investigated the degree to which effects of fluency training generalized across stimuli in the same functional class.

In a previous study (Grabavac, Goldwater & Acker, 1996), we trained subjects to fluency on simple 3-choice CRT tasks. In this experiment, we wanted to determine the extent to which fluent responding generalized to nontraining stimuli that were *functionally equivalent* to the training stimuli. Two or more stimuli are functionally equivalent with respect to a given response to the extent that they exert stimulus control over that response (Hall & Chase, 1991). For example, letters in upper- and lowercase form (e.g., 'a' & 'A') are generally considered to be functionally equivalent stimuli because most people have extensive histories of making an identical response (e.g., saying "a") or an identical class of responses contingent upon the presentation of either stimulus (or any member of that functionally equivalent class of stimuli). Similarly, if a child says "five" when presented with each of the following stimuli: word "five"; word "FIVE"; Roman Numeral "V"; and, Arabic Numeral "5", than each of those stimuli are functionally equivalent stimuli with respect to the child's verbal response (saying "five").

Interestingly, there is evidence to suggest that, among other variables, response latency may affect estimates of equivalence. Brown, Bilodeau, and Baron (1951), for example, demonstrated that stimuli that would clearly have been members of one of two perfectly discriminated stimulus classes as measured under normal (non-speeded) conditions, were associated with a gradient of responding under conditions of speeded responding. Studies of stimulus equivalence, using a matching-to-sample paradigm, have shown that response latency is sensitive to the "nodal distance" separating stimuli within an equivalence class (Fields et al., 1995), and is, perhaps, more sensitive than measures of choice performance or accuracy (cf., Wulfert & Hayes, 1988, p. 137). In this experiment, we studied simple discriminative responses to upper- or lowercase words, presented within a choice-reaction-time (CRT) paradigm. During CRT training, a series (2 or more) of different stimuli are presented to subjects, and they are typically instructed to press the response key paired with each stimulus as quickly and accurately as possible. Whereas words of differing case may be functionally equivalent with respect to reading responses under normal conditions, there is evidence, for example, that subsequent measures of identification under tachistoscopic conditions may yield higher scores when tested in the same case as previously presented (e.g., Jacoby & Hayman, 1987). That is, the latter measure of generalization revealed a different estimate of the functional equivalence of upper- and lowercase words. We trained subjects to increase their speed of responding to words of one case, and then tested for generalization to the other case.

METHOD

Subjects. Five female-undergraduate students participated in this experiment.

Apparatus. Choice reaction time (CRT) training occurred on an IBM-compatible computer using a program called ***Speeded Discrimination Training*** or ***SDT***.

Procedure.

Training and generalization stimuli. Two 3-choice CRT

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(see Table 1) tasks were created for this experiment. Training and generalization stimuli differed only in case. So, for example, if a subject's training stimuli were the number stimuli in lowercase form, her generalization stimuli were the number stimuli in uppercase form.

Pretest & CRT training. Prior to CRT training, subjects completed a pretest to establish that the training and generalization stimuli were functionally equivalent under nonspeeded conditions. During the pretest, both training and generalization stimuli were presented, and subjects were instructed to take as much time as necessary to *correctly* respond to the presentation of each stimulus. Next, subjects engaged in long-term (6-8 weeks) CRT practice (see Grabavac, Goldwater, and Acker, [1996a]).

Generalization test. On the final training day, subjects completed a brief test to assess the extent to which fluent responding transferred to the generalization stimuli. Here, on every second trial (15 seconds of stimulus presentations and responses to stimuli), the training stimuli were replaced with generalization stimuli. Subjects completed two blocks of 14 trials of CRT practice during this generalization test.

Data analysis. Differences in level of fluency on training and generalization stimuli were assessed by looking at each subject's raw *rate-correct-per-minute (RCPM)* data. RCPM was calculated by dividing the number of correct responses per trial by the total response time (in seconds, summed across all responses) and multiplying that value by 60.

Before proceeding with the analysis, a couple of points should be noted. First, performance on Trial 1 of the generalization task was of potentially greatest interest as a pure measure of generalization, because it was only on this trial that subjects had no prior history of practice of rapid responding to these stimuli. Second, in the absense of complete generalization of fluent responding, subsequent data (i.e., trials 2-14) provide information about the rate-of-gain of speeded responding. Since each subject's early and late training data were used to evaluate the degree of transfer to training and generalization stimuli in the generalization test phase, the former data were included along with each subject's generalization data.

RESULTS

As expected, there were no systematic differences in accuracy between the training and generalization stimuli during the nonspeeded pretest condition. The generalization data, presented in Figures 1 & 2, illustrated that four subjects (S1-S4) were more fluent on the training stimuli (i.e., initial RCPM on the training stimuli was higher than that on the generalization stimuli) on trial 1, whereas the remaining subject (S5) demonstrated comparable fluency on both tasks on the initial trial. Throughout the remainder of the generalization phase, subjects' RCPM scores on the training stimuli were generally higher than those on the generalization stimuli. However, clearly, much generalization of fluent responding to the functionally equivalent stimuli resulted from the prior fluency training. In fact, often RCPM scores on the training stimuli were only marginally higher on those on the generalization stimuli. Overall, then, subjects demonstrated considerable though not complete generalization of fluent responding.

CONCLUSION

Data collected in the present experiment provide some support for the claim made by precision teachers concerning the generalization of fluency. Here, after long-term fluency training on CRT tasks, subjects demonstrated considerable fluency on the generalization stimuli, which were functionally equivalent to the training stimuli. Similar findings were reported by Ross (1970), who found that subjects, after completing extensive training on single-character classification tasks (which is similar to a 2-choice CRT task), performed comparably to levels achieved late in training when the stimuli were switched from upper- to lowercase. In addition, these data, along with those of Brown et al. (1951), Jacoby and Hayman (1987) and Wulfert and Hayes (1988) raise awareness to the relative sensitivity of different response characteristics used in the measurement of equivalence. Overall, the present findings suggest that further study of fluency generalization may be useful both to precision teachers and to equivalence researchers.

Table 1
Category task stimuli.

Animal	Colour	Sport
deer	blue	golf
tiger	green	track
horse	white	tennis
sheep	purple	hockey
rabbit	yellow	soccer

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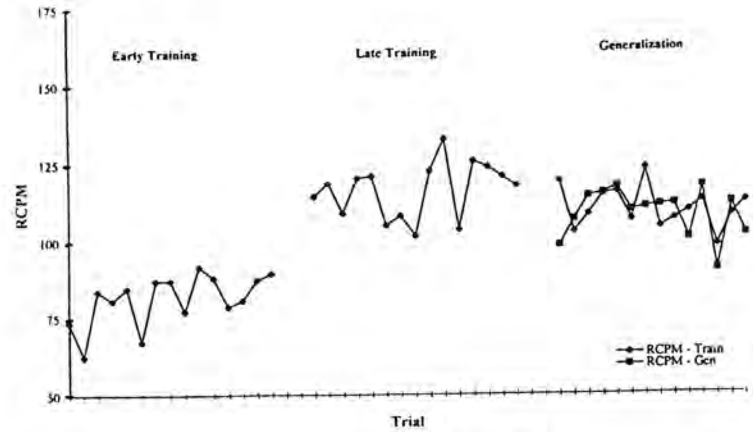
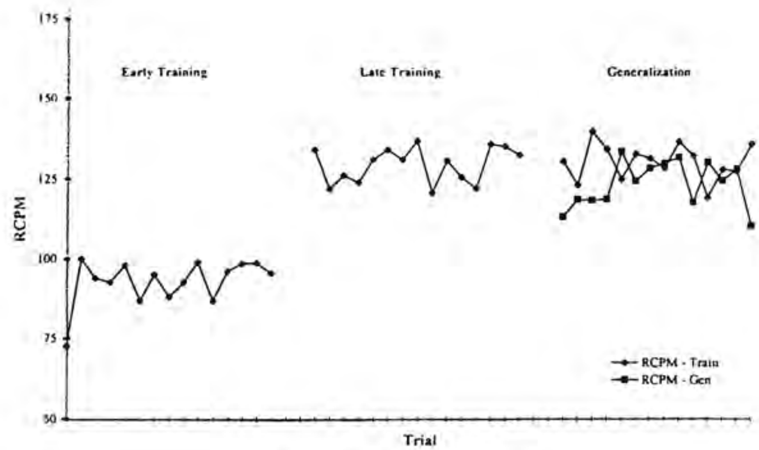


Subject 1's Generalization Data



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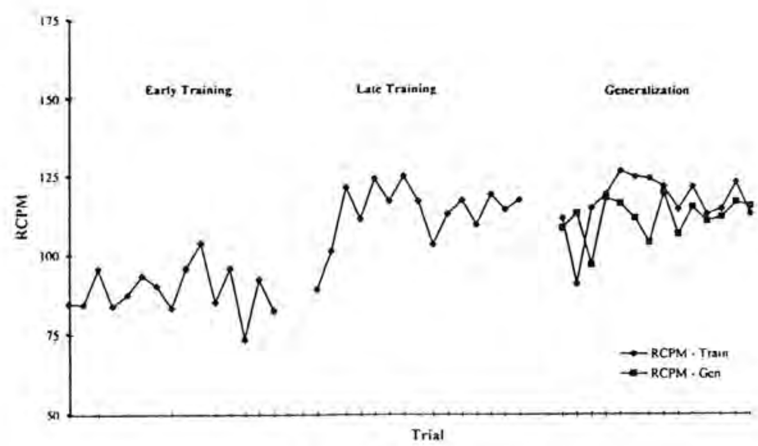
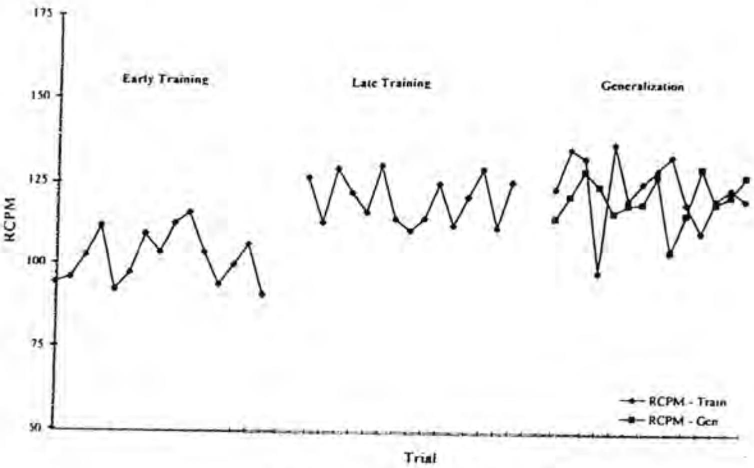
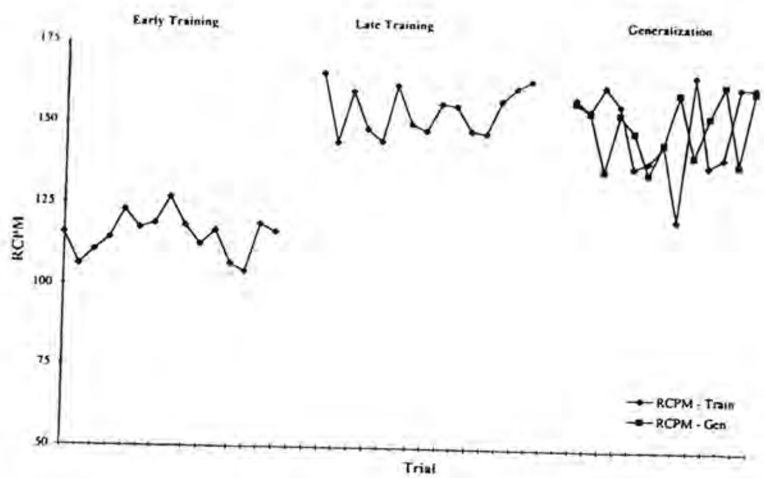


Subject 3's Generalization Data

Figure 1. Raw rate-correct-per-minute (RCPM) for S1-S3, who trained on the category task. (Note that each figure contains the raw RCPM data collected on the training task during early and late training, and RCPM data collected on the training and generalization tasks during the generalization phase.) As these data illustate, all subjects demonstrated greater fluency on the training stimuli on Trial 1 of the generalization test. Furthermore, all subjects demonstrated greater overall fluency on the training stimuli. However, clearly, much generalization of fluent responding to the functionally equivalent stimuli (i.e., generalization stimuli) resulted from the prior fluency training.



Subject 4's Generalization Data



Subject 5's Generalization Data

Figure 2. Raw rate-correct-per-minute (RCPM) for S4 & S5, who trained on the number task. (Note that each figure contains the raw RCPM data collected on the training task during early and late training, and RCPM data collected on the training and generalization tasks during the generalization phase.) As these data illustrate, S4 demonstrated greater fluency on the training stimuli on Trial 1 of the generalization test, whereas S5 was equally fluent on both tasks. Furthermore, S4 demonstrated greater overall fluency on the training stimuli, whereas S5, again, demonstrated relatively comparable fluency on both tasks. Clearly, much generalization of fluent responding to the functionally equivalent stimuli (i.e., generalization stimuli) resulted from the prior fluency training.