DISCRIMINATIVE CONTROL OF PUNISHED STEREOTYPED BEHAVIOR IN HUMANS

SHANNON S. DOUGHTY,[1,2] CYNTHIA M. ANDERSON,[1] ADAM H. DOUGHTY,[3] DEAN C. WILLIAMS,[3] AND KATHRYN J. SAUNDERS[3]

WEST VIRGINIA UNIVERSITY,[1]
PARSONS STATE HOSPITAL AND TRAINING CENTER,[2] AND
UNIVERSITY OF KANSAS[3]

The purpose of this experiment was to establish discriminative control of responding by an antecedent stimulus using differential punishment because the results of past studies on this topic have been mixed. Three adults with mental retardation who exhibited stereotypy not maintained by social consequences (i.e., automatic reinforcement) participated. For each subject, stereotypy occurred frequently in the presence of a stimulus correlated with nonpunishment of stereotypy and rarely, if ever, in the presence of a stimulus correlated with punishment of stereotypy. Latency measures showed that the antecedent stimulus correlated with punishment served as the discriminative stimulus for the suppression of stereotypy. These results are important insofar as they show that discriminative control by an antecedent stimulus develops with punishment, and because it sometimes may be desirable to establish such control of socially inappropriate behavior.

Key words: autism, punishment, stimulus control, mental retardation, stereotypy, humans

---

When punishment effects are demonstrated in the basic animal laboratory, unconditioned positive reinforcers, such as food deliveries, usually maintain the punished response, and the animals are food deprived (see Baron, 1991, for a review). In addition, unconditioned punishers usually are used (e.g., electric shock). In contrast, laboratory studies of human subjects, which also typically involve arbitrary responses such as button presses, maintain these responses by conditioned reinforcers such as points and/or money (e.g., O'Donnell, Crosbie, Williams, & Saunders, 2000). Moreover, conditioned punishers, such as point loss, typically are used. Thus, there has been little overlap in punishment procedures across basic-animal-laboratory and basic-human-laboratory studies.

The human operant laboratory can serve as an interface between basic research and application by examining clinically relevant behavior under well controlled conditions. Although the human laboratory has demonstrated the suppression of responding maintained by conditioned reinforcers through conditioned punishment (e.g., O'Donnell et al., 2000), there have been fewer demonstrations of punishment of psychologically important behavior maintained by primary reinforcement in humans—at least in the basic literature. This fact may be contrasted with the applied-behavior-analytic literature in which punished behavior often is of great psychological importance, as evidenced by extreme allocations of time and effort to the responses. For example, persons with autism, according to diagnostic criteria (American Psychiatric Association, 1994), engage in stereotypic behavior for an amount of time that is in excess of typically developing individuals, and this behavior can interfere with learning, independent functioning, and/or socialization. In addition, clinical service and applied research must follow ethical guidelines in considering less aversive interventions and conditioned punishers (e.g., Miltenberger, 1997).

This research partially fulfilled the first author's Ph.D. requirements, and was presented at the 2004 meeting of the Association for Behavior Analysis in Boston, MA. Parts of this research were funded by NIH grant HD18955. The third author was supported by NIH grant T32 HD 7525. Mike Perone, Kent Parker, and Jennifer Margrett made many contributions to this research, and Laura Cruz, Colleen Eisenbart, and Brandi Zirk assisted in data collection and analysis. Pat White provided editorial assistance. Shannon Doughty is now with Carolina Coast Behavioral Services, Charleston, SC. Cindy Anderson is now with the University of Oregon, Eugene, OR. Adam Doughty is now with College of Charleston, Charleston, SC.

Address correspondence and reprint requests to Shannon Doughty, Carolina Coast Behavioral Services, P.O. Box 80901, Charleston, SC, 29416 (shannon.doughty@comcast.net) or to Dean Williams, University of Kansas, Parsons Research Center, 2601 Gabriel, Parsons, KS, 67357 (deanwms@ku.edu).

doi: 10.1901/jeab.2007.39-05

Despite these and many other procedural differences between the basic-animal-laboratory, basic-human-laboratory, and applied-service-delivery studies involving punishment, sweeping generalizations about the effects or lack of effects of punishment have been made. Of primary importance are the notions that punishment produces undesirable side effects such as nonselective suppression (e.g., Bolles, Holtz, Dunn, & Hill, 1980); that stimuli correlated with a punishment contingency become conditioned aversive stimuli themselves (e.g., Sidman, 1989); and the ephemeral nature of response suppression when punishment is discontinued (see Sidman). The generality of these observations has not been examined directly. Thus, the generalization of these assumed characteristics of punishment from preparations using food-reinforced behavior and electric shock to situations involving conditioned reinforcement and conditioned punishment is unknown (Dinsmoor, 1998).

One area in which the human and nonhuman animal literatures are particularly discrepant is discriminative stimulus control established with differential punishment (Doughty, Doughty, O'Donnell, Saunders, & Williams, in press). It usually is accepted that discriminative stimulus control may be developed using differential punishment in a manner similar to that of the discriminative stimulus control that develops using differential reinforcement (e.g., Baron, 1991). This acceptance is based on results from basic research using nonhuman animal subjects. Recent results from human-laboratory studies, however, have shown that discriminative stimulus control may be more difficult to obtain in human subjects (e.g., O'Donnell & Crosbie, 1998; O'Donnell et al., 2000).

A recent review of the basic and applied literature involving stimulus control and punishment revealed a great deal of ambiguity regarding the form of stimulus control that has been established under conditions of differential punishment (Doughty et al., in press). Thus, the recent human findings may not be as discrepant from the animal findings as they first appeared. The traditional procedure for producing and demonstrating discriminative stimulus control through differential punishment involves a multiple schedule in which a reinforcement schedule is in effect in one component and a conjoint reinforcement and punishment schedule is in effect in the other component. The stimulus correlated with the conjoint-reinforcement–punishment-schedule component (e.g., a red key) will be called the S^{Dp}, hereafter (see O'Donnell, 2001), and the stimulus correlated with the reinforcement-schedule-only component (e.g., a green key) will be called the S^{D}, hereafter. If a lower response rate occurs in the presence of the S^{Dp}, the conclusion often would be that stimulus control by the red key had been demonstrated (i.e., S^{Dp} control). Unless responding is suppressed completely, however, reduced response rate alone does not provide conclusive evidence that the S^{Dp} is functionally the discriminative stimulus for response suppression. Response suppression may be controlled by the initial punisher delivery in the red-key component, such that rates are lower only after the punisher is delivered. To rule out this interpretation, response suppression must be shown in the presence of the red key, but before or in the absence of punisher delivery.

In the classic report of discriminated inhibitory control with punishment, Honig and Slivka (1964) reported the development of control by S^{Dp} following multiple-schedule training of differential punishment. In the absence of delivery of the punishing stimulus, however, there was discriminative control by key color in only 1 of the 3 pigeons. These data are not consistent with a clear demonstration of control by S^{Dp} (see also Weisman, 1975), and illustrate conditions in which the effects of punishment do and do not maintain when the contingency is removed. There also have been diverse results regarding the establishment of stimulus control by the S^{Dp} via differential punishment in the human operant laboratory (O'Donnell & Crosbie, 1998; O'Donnell et al., 2000). Using college-student subjects, a fixed-ratio 1 (FR 1) schedule of point loss (i.e., response-cost punishment) was added to the existing reinforcement schedule in the presence of one stimulus. Although response rates were lowest in the component with punishment, responding only decreased in that component after the first punisher was delivered. Further attempts to establish stimulus control by the S^{Dp} also failed (see also Birnbrauer, 1968). O'Donnell et al. obtained stimulus control by the multiple-schedule stimuli rather than by the delivery of the punisher only after instructions were used. Differential responding then was observed, demonstrating clear stimulus control by the multiple-schedule stimuli rather than by the delivery of the punisher (also see Rollings & Baumeister, 1981).

Given conflicting results in studies by Honig and Slivka (1964), Weisman (1975), O'Donnell et al. (2000), Rollings and Baumeister (1981), and other studies, questions remain regarding the conditions under which control by the S^{Dp} occurs. The present experiment was conducted to determine whether an unambiguous demonstration of punished responding controlled by an S^{Dp} could be obtained in human subjects whose limited verbal repertoires precluded the use of instructions. In addition, the responses selected for punishment in the present study were maintained by natural contingencies and were psychologically important to the subjects, as evidenced by their high probability of occurrence (e.g., over 80% of intervals) in nearly every context. High-probability responses have received attention in the literature, and they play a central role in some theories of reinforcement. For example, wheel running can be used to reinforce lever pressing (e.g., Iversen, 1993), and the opportunity to engage in stereotyped behavior has been used to increase appropriate vocalizations (Charlop, Kurtz, & Casey, 1990).

Automatically reinforced behavior is of particular interest in application precisely because the maintaining stimulation is difficult or impossible to control. Thus, extinction is difficult or impossible to use to suppress the behavior (cf. Rincover, 1978). Stereotyped behavior is defined as repetitive, high-rate motor or vocal mannerisms, usually with no known functional environmental consequences. Examples include pacing in captive lions and twirling objects in front of the eyes in persons with autism, mental retardation (MR), and mental illness (e.g., Bodfish & Lewis, 2002; Kennedy, 2002). When severe, these responses can occupy significant amounts of an individual's daily activity, and they can be difficult to reduce with reinforcement for alternative, acceptable responses (e.g., Garner, Meehan, & Mench, 2003; Lovaas, Litrownik, & Mann, 1971). Like wheel running in rats, stereotypy often is maintained by the automatic stimulation from the behavior (e.g., Vollmer, 1994).

The purpose of the present study was to determine whether the suppression of an automatically reinforced response could be brought under control of the S^{Dp} using a conditioned punisher in functionally nonverbal adults with MR. Stereotypy remained unpunished in one multiple-schedule component and was punished in a different component. Importantly, in addition to reporting overall occurrence of the response (i.e., response differentiation), a dependent measure functionally equivalent to the latency to the first response in each component was used to determine whether control by the S^{Dp} had been obtained. That is, if responding were not suppressed completely in the punishment component, a much longer latency in that component as compared to latency in the unpunished component would show that suppression was controlled by the S^{Dp} and not the punisher delivery. Therefore, this latency measure is essential to demonstrating control by the S^{Dp} in cases where suppression is not complete. Without it, the differential response rates otherwise would not clearly demonstrate the source of the discriminative control.

METHOD

Subjects

Subjects were 3 adults with severe-to-profound MR whose stereotypy was shown to be maintained by sensory stimulation in an analog functional analysis (Iwata, Dorsey, Slifer, Bauman, & Richman, 1982/1994; see Appendix A). Subject TS was a 45-year-old male with severe MR, profound deafness, and legal blindness. The precise nature of this visual impairment was undetermined due to his limitations in communication. Subject TS received 5 mg of Loxapine Hydrochloride twice daily throughout the experiment. Subject CB was a 40-year-old male diagnosed with profound MR and Down syndrome; he received 1500 mg of Valproic Acid daily for seizures at a constant dose throughout the experiment. Subject PH was a 54-year-old male diagnosed with severe MR and bipolar disorder; he received 900 mg of Lithium Carbonate and 400 mg of Carbamazepine per day throughout the experiment.

Apparatus

Sessions were conducted in a 2.3 m × 2.9 m room equipped with stimuli relevant to each session (see below) and a one-way mirror. The experimenter was in the room during all sessions. Video- and audio-recording equipment were in an adjacent room located behind the mirror, and all sessions were recorded from this room.

Procedure

Stereotypies were defined for each individual subject. Subject TS's stereotypy was hand and arm flapping, defined as moving his arms or hands through the air repeatedly at or above waist level by bending at the wrist or elbow. Subject CB's stereotypy was finger manipulation. Finger manipulation was defined as moving two fingers back and forth repeatedly at or above waist level while his head was oriented in the direction of his fingers and his eyes were open (i.e., he was looking at them). Subject PH's stereotypy was repetitive line drawing, defined as drawing vertical lines on paper. Punisher delivery was a 1-s (Subjects TS and CB), or 10-s (Subject PH), ''hands-down'' procedure. The 1-s procedure involved manually guiding a subject's hands down once the response definition was met, preventing further responding at that moment. For the subsequent 10-s punishment procedure used for PH, after this initial manual guidance, the experimenter's hands remained touching PH's hands with only enough force necessary to prevent the occurrence of the response (i.e., prevent marker use), but not completely to immobilize his hands.

All sessions were videotaped, and human observers recorded stereotypy and punisher delivery using a 5-s interval recording procedure. The entire session duration was divided into 5-s intervals. The duration of stereotypy was measured as the total number of 5-s intervals in which it was observed during *any* part of the interval (i.e., partial interval recording). The 5-s intervals during which the response was prevented for Subject PH (i.e., during the punishment procedure) were not included in this analysis. Instead, 10 s were added to the duration of the punishment component for each punisher delivery that occurred during the component (see *Discrimination training*, below), and these 5-s intervals were included. The percent of the component (i.e., latency to stereotypy) was measured as the number of intervals without stereotypy following the start of the component. Each punisher was recorded such that, for Subjects TS and CB, more than one punisher could occur in each 5-s interval.

Interobserver agreement was assessed in a minimum of 33% of the sessions in each condition. Agreement for stereotypy and punisher delivery was calculated by comparing each observer's records on an interval-to-interval basis. Occurrence agreement was calculated by dividing the number of intervals both observers agreed that an event occurred by the number of intervals either observer scored an occurrence. Nonoccurrence agreement was calculated by dividing the number of intervals both coders agreed an event did not occur by the number of intervals either coder did not score a response. Total agreement was calculated by dividing the number of intervals observers agreed the response did and did not occur by the total number of intervals. All coefficients were multiplied by 100 to obtain a percent agreement score. Interobserver agreement scores are presented in Appendix B.

Each session was 10 min in duration (except where noted for Subject PH). Two to six sessions were conducted per day, with an average of 10 min elapsing between sessions (that occurred in the same day) during which time the participant's time was unstructured and there was casual interaction with the experimenter. Sessions were conducted 5 days per week with few exceptions, and at approximately the same time each day for each subject. Unless otherwise noted, each of the following conditions continued for a minimum of 15 sessions and until responding stabilized. Judgments of stability were based on the percentage of 5-s intervals with stereotypy (i.e., occurrence) and the proportion of the component that elapsed prior to the first occurrence of stereotypy (i.e., latency). These measures were judged stable when they did not exhibit a systematically increasing or decreasing trend (excluding only an upward trend in baseline or trend in the opposite direction of what would be expected in the extinction condition for CB), or considerable bounce, determined by visual inspection, for at least six consecutive sessions. If, in discrimination training, responding was suppressed in both components, the discriminative stimuli were changed, and baseline data were collected with new stimuli.

Baseline. Initially, a two-component multiple schedule was in effect. Each session had two 5-min components separated by the time it took to change the stimuli (approximately 1 to 2s). The order of the two components was determined randomly with two restrictions: the same order did not occur more than three consecutive times, and each sequence occurred six times in each 12-session block. The stimuli presented in baseline sessions differed across subjects. For Subjects TS and PH, the stimuli were black wristbands placed over the wrist of the dominant hand (no-punishment component) versus the absence of that wristband. For Subject CB, the stimuli were two orientations of the swivel chair in which he sat. In the component with punishment, the chair was turned such that the subject sat facing a red wall and the experimenter (i.e., facing toward E), and the component began with the experimenter saying, ''I'm here now.'' In the component without punishment, Subject CB faced a blue wall with his back to the experimenter (i.e., facing away from E), and the component began with the experimenter saying ''Alone time.'' These stimuli were individually chosen for each subject after 2 subjects (CB and PH) experienced failure to discriminate between conditions with previous stimuli (i.e., red/green cards for CB and PH; music on/off, wristbands on/off for CB). Throughout baseline, games and toys were available for Subjects TS and PH, but not for Subject CB (CB did not have access to items because he remained seated throughout the session due to limited mobility). In addition, a Sesame Street Muppets© movie was played for Subject TS, and paper and markers were present for Subject PH.

Discrimination training. Stimuli were identical to those stimuli used in baseline. Punishment was implemented in one of the multiple-schedule components. There were no programmed consequences for stereotypy in the other component. The punisher for Subjects TS and CB was a 1-s hands-down procedure. For Subject PH, the punisher initially was a 1-s hands-down procedure with verbal reprimand, but was changed to a 10-s punisher without reprimand (as described above) to increase the effectiveness of punishment. Because of the relatively long duration of Subject PH's punishment procedure, 10 s were added to the duration of the punishment component for each punisher delivery that occurred during the component. Discrimination training concluded when the above-described stability criteria were met in addition to the following criterion: the percentage of the component elapsed prior to the first interval scored with stereotypy was less than 30% for the no-punishment component and greater than 70% for the punishment component in the final six sessions.

In a subsequent condition, for each subject, the schedule was changed slightly such that each session consisted of four 2.5-min components. For Subjects TS and CB, this change occurred after stimulus control was demonstrated with 5-min components to demonstrate further control by the S^{Dp}. For Subject PH, this change occurred in an effort to promote S^{Dp} control by increasing the number of component changes he received in each session. The condition remained in effect for at least six sessions and until responding stabilized.

One subject, CB, was exposed to extinction of the punishment contingency. Punishment was removed for 18 sessions (i.e., the only difference across components was the exteroceptive stimuli) to determine the necessity of continuing the punishment contingency after control by S^{Dp} occurred.

RESULTS

Table 1 summarizes the conditions presented and the number of sessions in each condition for each subject. The figures show data only for the final (successful) discrimination training conditions and the baselines before those conditions. Table 2 shows the means and ranges of dependent measures in the last six sessions for baseline and discrimination training for each subject. Figure 1 shows the occurrence of stereotypy in the final six sessions of baseline and, in three-session blocks, all of the discrimination-training sessions. Data are shown as three-session means for discrimination training because of the large number of sessions.

Table 1

Number of sessions and session descriptions.

Subject	S^D	S^{Dp}	# of Baseline sessions	# of Training sessions	Component duration	Outcome
TS	wristband	no band	29	31	5 min	Met stability criteria
	wristband	no band		7	2.5 min	Met stability criteria
CB	blue wall/ away from E	red wall/ toward E	33	29	5 min	Met stability criteria
	blue wall/ away from E	red wall/ toward E		52	2.5 min	Met stability criteria
PH	wristband	no band	21	93	5 min	Failure to develop control by S^{Dp}
	wristband	no band		5	1 min	Complete suppression
	wristband	no band		3	5 min	Failure to develop control by S^{Dp}
	wristband	no band		20	2.5 min	Met stability criteria

Table 2

Mean and range of the results of the last six sessions for baseline and discrimination training.

Subject	Condition	% Stereotypy	% Elapsed
TS	Baseline Punishment	60.6 (40–75)	
	No Punishment	65.3 (36.7–83.3)	
	Discrim Punishment training	0.6 (0–1.7)	94.5 (70–100)
	No Punishment	62.2 (18.3–88.3)	7.8 (0–43.3)
CB	Baseline Punishment	66.4 (48.3–86.7)	
	No Punishment	76.9 (38.3–91.6)	
	Discrim Punishment training	0.6 (0–3.3)	94.5 (66.7–100)
	No Punishment	74.2 (48.3–91.7)	6.7 (0–20)
PH	Baseline Punishment	74.5 (70–80)	
	No Punishment	75 (60–83.3)	
	Discrim Punishment training	0.9 (0–1.7)	82.2 (60–100)
	No Punishment	71.4 (46.7–88.3)	17.8 (3.3–36.7)

Note. The data presented are for the following measures: percentage of intervals scored with a stereotypical response (% Stereotypy) and percentage of component elapsed prior to first response (% Elapsed), respectively. Means are presented first in columns, followed by ranges in parentheses.

The top panels of Figure 1 show, for each subject, the percentage of 5-s intervals in which stereotypy was recorded (i.e., duration[1]). The bottom panels show the percentage of the session that elapsed prior to the first recorded response (i.e., latency[1]). The numbers in each graph are the component duration (in min). For all subjects, responding was high and undifferentiated in baseline. Within the first three sessions after the punishment contingency was implemented, fewer than 10% of the intervals in the punishment component contained stereotypy. Stereotypy remained at high levels in the no-punishment component. Subject CB showed some suppression in the nonpunished component, but not to the extent in the punished component.

The bottom panels show the latency to the first response (and thus, to the first punisher) in the component for those same sessions. Latencies were short and undifferentiated early in discrimination training. Clearly distinguishable discrepancies in latencies developed after three- and five-session blocks (9 and 15 sessions) for Subjects TS and CB, respectively.

[1] The percentage of 5-s intervals is presented rather than absolute latency or duration so as to facilitate direct comparison, because the session durations differed across conditions. Shorter sessions limit the maximum absolute duration of stereotypy and latency to the duration of the session. The functions for the relative measures and the absolute values are identical except for the scales. The relative measure of percentage of component elapsed was used to keep axes constant. Calculations are based on 180, 90, and 36 intervals for the 5-, 2.5-, and 1-min components, respectively. To calculate absolute latencies, consider the component durations at the top of Figure 1.

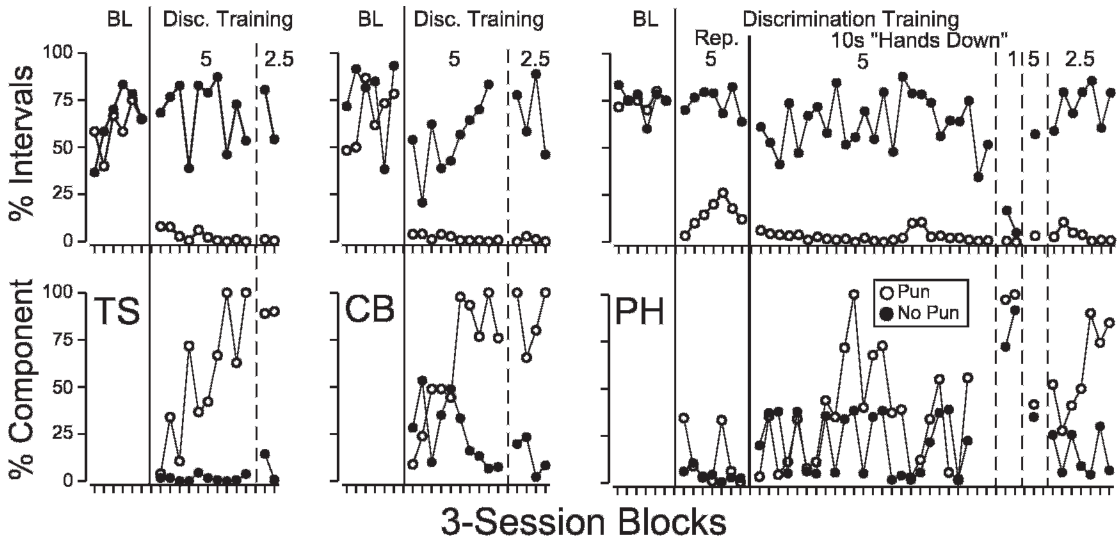

Fig. 1. Results of discrimination training for each subject. Solid lines separate baseline from discrimination training. Dotted lines separate conditions within discrimination training. Numbers represent the component duration in minutes. ''Rep'' in PH's graph indicates the brief condition where the 1-s hands-down with reprimand was used before it was changed to a 10-s procedure without reprimand. Unfilled circles show data from the punishment component, and filled circles show data from the no-punishment component. The left, center, and right panels show data for Subjects TS, CB, and PH, respectively. The top panels show the percentage of intervals scored with stereotypy. The bottom panels show the percentage of the component that elapsed prior to the first interval scored with stereotypy. Only the final six sessions are presented for baseline (top graphs), and all other conditions contain data across the entire condition in three-session blocks.

For these 2 subjects, the latency data remained differentiated when the component durations were shortened to 2.5 min. For Subject PH, however, differential response latencies did not develop under the 5-min component condition. When component durations were changed to 10 one-min components per session, responding was suppressed in both components. There was a brief return to 5-min components, after which the component duration was changed to 2.5 min. After four blocks with 2.5-min components, differential latencies were established.

Extinction of the punishment contingency was conducted for one subject, CB, to probe the persistence of the discrimination when the punishment contingency was removed. The upper graph of Figure 2 shows the occurrence of stereotypy for Subject CB as a function of the presence or absence of the punishment contingency (excluding baseline) with 2.5 min components. With the punishment contingency in effect, stereotypy occurred primarily in the no-punishment component. In the absence of this contingency (punishment extinction), however, stereotypy gradually increased in the component previously correlated with punishment. When the punishment contingency was reinstated, the previously low levels of stereotypy returned. The lower graph of Figure 2 shows that the latency results were similar to the aforementioned findings. Mean latency was high when the punishment contingency initially was in effect, gradually decreased when the contingency was removed, and increased when it was reinstated.

DISCUSSION

Response rates were equivalent across multiple-schedule components prior to the initiation of punishment. The hands-down procedure was a functional punisher; for all 3 subjects, responding decreased in the punishment component almost immediately after the punishment contingency was added. This decrease in stereotypy was not due to the duration of the contingent hands-down procedure, as the procedure was either of brief, fixed duration (Subjects TS and CB) or, in the case of Subject PH whose punishment duration was 10 s, 10 s was added to the compo-

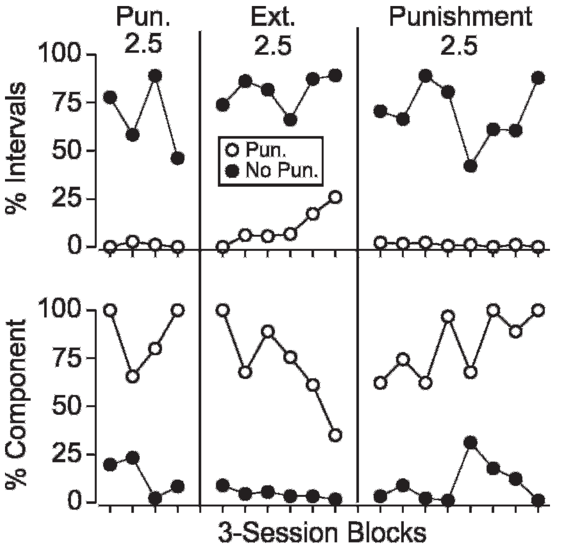

Fig. 2. Data for Subject CB when the punisher was present, withdrawn, and present again (separated by solid lines). Numbers represent the component length in min. Unfilled circles show data from the punishment component, and filled circles show data from the no-punishment component. The top panel shows the percentage of intervals scored with stereotypy, and the bottom panel shows the percentage of the component elapsed prior to the first interval scored with stereotypy. Data are in three-session blocks. The data from the first condition shown are the same as those from the end of the 2.5-min-component shown in Figure 1, and are included for the purposes of comparison.

nent for each punisher delivery. Furthermore, responding came under S^{Dp} control; any responding that occurred in the punishment component occurred much later relative to the no-punishment component. And finally, the present study demonstrated stimulus control in human subjects without the use of instructions. There have been relatively few studies of punishment in human subjects, and some reports have noted difficulties establishing stimulus control without the use of instructions (O'Donnell et al., 2000).

The present study provides a more conclusive demonstration of control by S^{Dp} than many studies in the literature (see Doughty et al., in press, for a critical review) because we measured latency from the presentation of each component stimulus to the first response in the component. Unless responding is eliminated completely in the punishment component, latency data are essential to determining whether the suppression occurs when the component stimulus is presented, or only after the first response produces the punisher. Figure 1 illustrates this issue. Early in discrimination training, there was stable suppression of stereotypy in the punishment component, and clear separation between punishment and nonpunishment components. The decreases in stereotypy, however, occurred only after the presentation of the punisher. Latency increased gradually after stable response suppression was shown.

The undesirable side effects often associated with punishment, including nonselective suppression and the experimenter becoming an aversive stimulus, were not observed in the final conditions of the present study. The suppressive effects were restricted to the punishment component. Moreover, the person who administered the punisher also was present in the nonpunishment component and there was no evidence that her presence suppressed behavior. Note that these deleterious side effects often associated with punishment involve a failure to establish a discriminative stimulus for punishment. Thus, when implementing punishment contingencies, careful attention to stimulus control may prevent many of the objectionable side effects.

One potential confound in discriminated-punishment procedures is that the discrimination can be based on differential reinforcement rather than differential punishment. This result can occur through explicitly programming extinction in the punishment component, which confounds the roles of punishment and extinction (e.g., Silverman, 1971). Extinction was not programmed in the present study. Rather, the study was conducted to address effects of punishment in circumstances under which extinction is impossible to implement. Functional analyses showed that these subjects' stereotypy was maintained by sensory or automatic reinforcement. Because the behavior was automatically reinforced, it was not possible to eliminate the consequences that maintained responding. Moreover, the punisher was delivered only after the response definition had been met, allowing reinforcer contact, and reinitiating responding after the punisher again would produce the sensory consequences of the stereotyped behavior.

Another way that inadvertent differential reinforcement can occur is through the reductions in response rate and concomitant reductions in reinforcement rate that can occur during the punishment component. Given that the response–reinforcer relation in stereotypy was conjugate in nature, with the continuous covariation of the duration of the response and the duration of the reinforcer (Williams & Johnston, 1992), a reduction in the duration of the reinforcer was inevitable with a functional punisher. Thus, although the procedure did not program extinction for stereotypy, there was a significant reduction in the amount of reinforcement obtained under punishment conditions. Many studies of punishment incorporate this feature, especially with strong punishers and/or with an FR 1 punishment schedule (e.g., Orme-Johnson & Yarczower, 1974). The reinforcement-decreasing effects of punishment can be minimized by using a time-based rather than response-number-based schedule of reinforcement, for example, a variable-interval schedule. Such a manipulation would not reflect the goals of the present study, however, which were to study automatically reinforced behavior. It has been suggested that conjugate schedules of the type maintaining stereotypy are very common in nature (Rovee-Collier & Gekoski, 1979), although they have received relatively little attention as compared to discrete responses (wheel running is a notable exception).

The nature of the punishing stimulus used in this study is somewhat ambiguous. The punisher was the physical manipulation of the subjects' hands (the hands-down procedure). The hands-down procedure might have served one or both of two functions. First, it might have served as a positive punisher—if the physical manipulation was itself aversive. Second, it might have served as a negative punisher in that it discontinued the ongoing reinforcement. However, as a negative punisher, it differs from the point-loss procedures typically used with humans (e.g., O'Donnell et al., 2000) in that previously delivered reinforcers cannot actually be removed.

It might be considered a limitation that the present study did not compare response-dependent and response-independent deliveries of the hands-down procedure. In studies that involve electric shock as a punisher, this control for suppression by conditioned emotional responses is important. It is unclear, however, how crucial such a control is when punishers other than electric shock and other ''noxious'' stimuli are used.

Lerman and Vorndran (2002, p. 431) noted recently that ''basic research on punishment has been declining rapidly despite substantial gaps in knowledge'' and that ''further understanding of punishment processes may lead to an improved technology of behavior change.'' The present findings have considerable practical implications. Many individuals with developmental disabilities exhibit undesirable behavior at rates that are socially inappropriate, interfere with learning socially appropriate skills, or are dangerous. Nonpunishment treatments to control, reduce, or eliminate such behavior are preferred, and are attempted first (e.g., Miltenberger, 1997). Punishment contingencies may be necessary, however, under some conditions. Punishment may be a useful treatment when the target behavior is maintained by automatic reinforcement, making it difficult to implement extinction. Moreover, the acquisition of stimulus control without verbal instructions is important because many individuals who exhibit excessive stereotypy have severely limited language repertoires. Also important to potential application is the fact that stereotypy was brought under the control of practical antecedent stimuli, and non-noxious punishers were used. Perhaps most important of all, the punisher rarely was delivered once control by the antecedent stimulus was established.

In summary, this study is one of a very few, with either nonhuman animal or human subjects, that unambiguously demonstrates control by S^{Dp} using differential punishment. This conclusion was made clear by the measurement of response latencies across multiple-schedule components. The study was unique in that it established control by S^{Dp} using differential punishment, but without a noxious stimulus such as shock as a punisher. The present study distinguished itself from other laboratory studies with humans in that stimulus control was established without instructions and verbally sophisticated subjects, and in that responding was maintained by primary, rather than conditioned, reinforcement. Given the relatively small number of studies that have investigated control by S^{Dp}, it is unclear whether the development of stimulus control was influenced by the type of punisher and/or reinforcer (i.e., primary versus conditioned), the schedule of punishment and/or reinforcement (i.e., continuous versus intermittent), or other factors. Thus, more research on stimulus control and punishment, in both the basic and applied arenas, is warranted.

REFERENCES

American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorders* (4th ed.). Washington, DC: Author.

Baron, A. (1991). Avoidance and punishment. In I. H. Iversen, & K. A. Lattal (Eds.), *Experimental analysis of behavior: Part 1* (pp. 173–217). New York: Elsevier Science.

Birnbrauer, J. S. (1968). Generalization of punishment effects: A case study. *Journal of Applied Behavior Analysis*, *1*, 201–211.

Bodfish, J. W., & Lewis, M. H. (2002). Self-injury and comorbid behaviors in developmental, neurological, psychiatric, and genetic disorders. In S. R. Schroeder, M. L. Oster-Granite, & T. Thompson (Eds.), *Self-injurious behavior: Gene–brain–behavior relationships* (pp. 23–39). Washington, DC: American Psychological Association.

Bolles, R. C., Holtz, R., Dunn, T., & Hill, W. (1980). Comparisons of stimulus learning and response learning in a punishment situation. *Learning and Motivation*, *11*, 78–96.

Charlop, M. H., Kurtz, P. F., & Casey, F. G. (1990). Using aberrant behaviors as reinforcers for autistic children. *Journal of Applied Behavior Analysis*, *23*, 163–181.

Dinsmoor, J. A. (1998). Punishment. In W. T. O'Donohue (Ed.), *Learning and behavior therapy* (pp. 188–204). Needham Heights, MA: Allyn & Bacon.

Doughty, A. H., Doughty, S. S., O'Donnell, J., Saunders, K. J., & Williams, D. C. (in press). Stimulus control of punishment effects: Determining the controlling variables. *Mexican Journal of Behavior Analysis.*

Garner, J. P., Meehan, C. L., & Mench, J. A. (2003). Stereotypies in caged parrots, schizophrenia and autism: Evidence for a common mechanism. *Behavioural Brain Research*, *145*, 125–134.

Honig, W. K., & Slivka, R. M. (1964). Stimulus generalization of the effects of punishment. *Journal of the Experimental Analysis of Behavior*, *7*, 21–25.

Iversen, I. H. (1993). Techniques for establishing schedules with wheel running as reinforcement in rats. *Journal of the Experimental Analysis of Behavior*, *60*, 219–238.

Iwata, B. A., Dorsey, M. F., Slifer, K. J., Bauman, K. E., & Richman, G. S. (1994). Toward a functional analysis of self-injury. *Journal of Applied Behavior Analysis*, *27*, 197–209. (Reprinted from *Analysis and Intervention in Developmental Disabilities, 2,* 3–20, 1982).

Kennedy, C. H. (2002). Evolution of stereotypy into self-injury. In S. R. Schroeder, M. L. Oster-Granite, & T. Thompson (Eds.), *Self-injurious behavior: Gene–brain–behavior relationships* (pp. 133–143). Washington, DC: American Psychological Association.

Lerman, D. C., & Vorndran, C. M. (2002). On the status of knowledge for using punishment: Implications for treating behavior disorders. *Journal of Applied Behavior Analysis*, *35*, 431–464.

Lovaas, O. I., Litrownik, A., & Mann, R. (1971). Response latencies to auditory stimuli in autistic children engaged in self-stimulatory behavior. *Behaviour Research and Therapy*, *9*, 39–49.

Miltenberger, R. G. (1997). *Behavior modification: Principles and procedures.* Pacific Grove, CA: Brooks/Cole.

O'Donnell, J. (2001). The discriminative stimulus for punishment or S^{Dp}. *The Behavior Analyst*, *24*, 261–262.

O'Donnell, J., & Crosbie, J. (1998). Punishment generalization gradients with humans. *The Psychological Record*, *48*, 211–232.

O'Donnell, J., Crosbie, J., Williams, D. C., & Saunders, K. J. (2000). Stimulus control and generalization of point-loss punishment with humans. *Journal of the Experimental Analysis of Behavior*, *73*, 261–274.

Orme-Johnson, D. W., & Yarczower, M. (1974). Conditioned suppression, punishment, and aversion. *Journal of the Experimental Analysis of Behavior*, *21*, 57–74.

Rincover, A. (1978). Sensory extinction: A procedure for eliminating self-stimulatory behavior in developmentally disabled children. *Journal of Abnormal Child Psychology*, *6*, 299–310.

Rollings, J. P., & Baumeister, A. A. (1981). Stimulus control of stereotypic responding: Effects on target and collateral behavior. *American Journal of Mental Deficiency*, *86*, 67–77.

Rovee-Collier, C., & Gekoski, M. J. (1979). The economics of infancy: A review of conjugate reinforcement. In H. W. Reese, & L. P. Lipsitt (Eds.), *Advances in child development and behavior: Vol. 13* (pp. 195–255). New York: Academic Press.

Sidman, M. (1989). *Coercion and its fallout.* Boston, MA: Authors Cooperative.

Silverman, P. J. (1971). Chained and tandem fixed-interval schedules of punishment. *Journal of the Experimental Analysis of Behavior*, *16*, 1–13.

Vollmer, T. R. (1994). The concept of automatic reinforcement: Implications for behavioral research in developmental disabilities. *Research in Developmental Disabilities*, *15*, 187–207.

Weisman, R. G. (1975). Stimulus control by response-dependent shock in discriminated punishment. *Bulletin of the Psychonomic Society*, *5*, 427–428.

Williams, D. C., & Johnston, J. M. (1992). Continuous versus discrete dimensions of reinforcement schedules: An integrative analysis. *Journal of the Experimental Analysis of Behavior*, *58*, 205–228.

Received: May 2, 2005
Final acceptance: December 14, 2006

APPENDIX A

Functional Analysis

An analog functional analysis (Iwata, Dorsey, Slifer, Bauman, & Richman, 1982/1994) first was conducted for each subject and included at least five session types: demand, attention, tangible, alone, and control. Two subjects received another session type, idiosyncratic stimulus. No single session type occurred twice in succession, and at least four sessions of each type were conducted. The functional analysis continued until this minimum criterion had been met, and stereotypy was judged to be stable by visual inspection (i.e., minimal bounce and trend). Attention was a brief (3–5 s) delivery of physical contact and/or a vocal statement, with the type of vocal statement different across conditions (see below). Tangible was the delivery of a preferred stimulus (e.g., soda). Prompts (verbal, gestural, and physical) sometimes were used to complete a task (e.g., hand-over-hand prompting).

In the demand condition, the experimenter presented preacademic and daily-living-skill demands using a three-step prompting procedure. If stereotypy occurred, the task was withdrawn for 20 s, and the experimenter turned away from the subject. This arrangement was to determine if stereotypy was maintained by escape or avoidance. In the attention condition, the experimenter delivered a brief verbal reprimand (or, for Subject TS, signed and stated ''Stop'') immediately following stereotypy. This arrangement was to determine if stereotypy was maintained by access to attention. In the tangible condition, a tangible was given for 20 s immediately after stereotypy. This arrangement was to determine if stereotypy was maintained by access to preferred tangibles. In the alone condition, the subject was in the room by himself to assess stereotypy in the absence of social consequences. In the control condition, the experimenter was present and preferred tangibles were available. The experimenter delivered verbal attention (i.e., praise) every 20 s. The idiosyncratic-stimulus condition was conducted for Subjects CB and TS based on staff report that these subjects engage in more stereotypy in the presence of a specific stimulus (in both cases, a television). In this condition, the experimenter was present, no consequences were programmed for stereotypy, and the television was on continuously. The results suggested that stereotypy most likely was sensory maintained for each subject, and that the verbal reprimands in the attention condition may have punished stereotypy for 2 of the subjects (CB and PH).

APPENDIX B

Mean and Range of Occurrence (Occ), Nonoccurrence (NonOcc), and Total Agreement Scores.

Participant	Condition	Percent of sessions	Response	Type of agreement	Percent agree	Range
TS	Baseline	33.3	Stereotypy	Occ	91.2	78.6–100
				NonOcc	78.1	41.7–100
				Total	93.5	87.5–100
	Discrim training	33.3	Stereotypy	Occ	80.6	50–95
				NonOcc	89.1	81.1–99
				Total	92.6	84.2–99.2
			Punisher	Occ	84.6	0–100
				NonOcc	99.7	98.3–100
				Total	99.7	98.3–100
CB	Baseline	33.3	Stereotypy	Occ	92.2	78.9–96.7
				NonOcc	88.6	76–95.6
				Total	95.8	91.7–97.5
	Discrim training	33.3	Stereotypy	Occ	92.8	68.8–100
				NonOcc	96.4	93.8–100
				Total	97.6	94.2–100
			Punisher	Occ	82.1	0–100
				NonOcc	99.6	96.7–100
				Total	99.6	96.7–100
PH	Baseline	49.2	Stereotypy	Occ	96.7	90.5–100
				NonOcc	90.3	76.5–100
				Total	97.4	92.5–100
	Discrim training	33.3	Stereotypy	Occ	91.8	35.1–100
				NonOcc	97.2	78.6–100
				Total	98.1	81–100
			Punisher	Occ	89.9	50–100
				NonOcc	99.4	95.7–100
				Total	99.4	96–100