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STIMULUS CONTROL OF PUNISHMENT EFFECTS: DETERMINING THE CONTROLLING VARIABLES

CONTROL DE ESTÍMULOS DE EFECTOS DEL CASTIGO: DETERMINANDO LAS VARIABLES CONTROLADORAS

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ABSTRACT

The study of discriminative stimulus control of responding maintained by positive reinforcement has a long-standing and dominant role in the behavioral literature. In contrast, the literature on discriminative stimulus control of response suppression by punishment is small and moribund. Investigating the form of stimulus control that develops under conditions of punishment is a topic in need of further attention for both theoretical and practical reasons. In preparations wherein stimulus control can develop (e.g., multiple schedules), at least two stimuli can come to exert discriminative control over response suppression: an antecedent discriminative stimulus (e.g., multiple-schedule stimulus) and the punisher delivery itself. We reviewed the experimental and applied literatures involving punishment and found only a few unambiguous demonstrations of operant stimulus control by an antecedent stimulus. We discuss limitations in methods, and conventions of data analysis and presentation, that preclude unambiguous conclusions regarding the establishment of antecedent stimulus control with punishment. A consideration of these limi-

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tations is important because they bear on both basic and applied issues in behavior analysis.

Key words: stimulus control, punishment, response suppression, method, data analysis, basic research, applied research.

RESUMEN

El estudio del control discriminativo de estímulos de una respuesta mantenida por reforzamiento positivo ha jugado un papel extenso y dominante en la literatura conductual. En contraste, la literatura sobre el control discriminativo de la respuesta de supresión por castigo es pequeña y moribunda. Investigar la forma del control de estímulos que se desarrolla bajo condiciones de castigo es un tópico que necesita más atención por razones teóricas y prácticas. En preparaciones en las cuales el control de estímulos se puede desarrollar (e.g., programas múltiples), al menos dos estímulos pueden llegar a ejercer un control discriminativo sobre la supresión de la respuesta: un estímulo discriminativo antecedente (e.g., estímulos en programas múltiples) y la entrega misma del castigador. Revisamos la literatura básica y aplicada sobre el castigo y encontramos sólo unas pocas demostraciones claras de control de estímulos operante por un estímulo antecedente. Discutimos las limitaciones de los métodos, así como las convenciones de análisis y presentación de datos, que impiden conclusiones claras sobre el establecimiento de un control de estímulo antecedente con el castigo. Una consideración de estas limitaciones es importante porque son relevantes para problemas básicos y aplicados en el análisis de la conducta.

Palabras clave: control de estímulos, castigo, control aversivo, revisión.

STIMULUS CONTROL OF PUNISHMENT EFFECTS: DETERMINING THE CONTROLLING VARIABLES

Discriminative stimulus control refers generally to differences in responding as a function of a changed stimulus context. Antecedent stimulus control typically is established through differential reinforcement of a response in the presence of one stimulus versus a different stimulus. Stimulus control is shown, for example, by higher response rates in a multiple-schedule component with reinforcement than in a component with extinction. The importance of discriminative stimulus control to the analysis of behavior has been acknowledged from the beginning of behavior analysis, and currently is an active area of research (e.g., Saunders & Williams, 1998). Procedures for establishing stimulus control through differential reinforcement, such as multiple

schedules of reinforcement and extinction, are so standard that failures to establish stimulus control are considered exceptional.

The complementary process to reinforcement is punishment. Whereas reinforcement contingencies specifically increase the probability of a response, punishment contingencies selectively decrease response probability. As a complementary process, antecedent stimulus control over responding through differential punishment is predicted. Stimulus control by punishment is suggested, for example, by lower response rates in a multiple-schedule component with a conjoint schedule of reinforcement and punishment than in a component with only a reinforcement schedule. Given the latter description, however, the discriminative stimulus for response suppression is ambiguous. One of two stimuli may be exerting discriminative control: the antecedent discriminative stimulus (i.e., the multiple-schedule stimulus) or the punisher delivery itself (see Azrin & Holz, 1966). Discriminative control of response suppression by the antecedent stimulus (hereafter, S^{Dp} control; see O'Donnell, 2001) would be indexed by relatively low response rates (or no responding) from the *outset* of each multiple-schedule component correlated with punishment (i.e., before a punisher delivery occurs). On the other hand, discriminative control of response suppression by the punisher (hereafter, S^{P} control; see O'Donnell) would be indexed by relatively low response rates (or no responding) only *after* the first punisher delivery in each component with punishment.

To begin to appreciate the importance of determining the source of stimulus control over the effects of punishment, consider the following statements by Sidman (1989), "…people who use punishment become conditioned punishers themselves… All the side effects that shocks generate, we, too, will generate. Anyone who uses shock becomes a shock" (p. 79). At least two points follow from Sidman's statements: (1) the establishment of S^{Dp} control results *automatically*, and (2) from a practical standpoint, this establishment has *undesirable* consequences.

The point regarding the automatic establishment of S^{Dp} control follows from Sidman's (1989) statements because he suggested that, as long as a punishment contingency is in effect, the mere presence of an antecedent stimulus is sufficient to establish that stimulus as a punisher. Recent studies have been designed to examine S^{Dp} control in the human operant laboratory because such control only had been reported with animals (e.g., Honig & Slivka's, 1964, demonstration of graded response suppression). In our work, discriminated response suppression appeared to be established readily under multiple schedules, but attempts to replicate Honig and Slivka's generalization gradients revealed that response suppression was under S^{P} control. S^{Dp} control developed only under conditions involving delayed punisher delivery

and instructions (O'Donnell & Crosbie, 1998; O'Donnell, Crosbie, Williams, & Saunders, 2000).

Was it difficult to generate S^{Dp} control in our work because of the various procedural differences across studies with animals and humans? Or, are the conditions that produce S^{Dp} control simply not well understood? To address these questions, we reviewed the punishment literature to determine the extent to which S^{Dp} control has been demonstrated, as well as to describe the features of studies that have investigated stimulus control and punishment.

Describing the conditions under which S^{Dp} control is generated is important for practical reasons, which returns us to the second point that follows from Sidman's (1989) comments. That is, it is important to delineate the conditions under which S^{Dp} control is established because the application of punishment has been said to have undesirable consequences. According to Sidman, one reason to avoid the use of punishment in applied settings is that the person (e.g., the parent) who punishes becomes aversive. If, however, the conditions that produce S^{Dp} control are not understood well, then it is unknown whether a person correlated with punishment is, first, a discriminative stimulus for the effects of punishment and, second, a conditioned punisher.

METHOD

The method and results of our review are condensed here; further information can be obtained by request. We reviewed experimental and applied studies that involved punishment and discrimination training. Experimental studies had animal and human subjects, and applied studies used clinically relevant responses that were established extra-experimentally. A published article contributed more than one experiment if each experiment satisfied the inclusion criteria.

Each experiment primarily was examined for the source of stimulus control over response suppression. Experiments labeled *S^{Dp} control* yielded unambiguous evidence of discriminative control over response suppression by the antecedent stimulus correlated with punishment. Experiments labeled *S^{P} control* yielded conclusive evidence of discriminative control over response suppression by the punisher delivery. Experiments labeled *ambiguous control* showed response suppression; however, the methods, and/or the data analysis and presentation, did not allow a definitive determination as to the source of control over that suppression. In a few experiments labeled *ambiguous control*, the response suppression shown by *some* subjects appeared to be under S^{P} control; however, this result was not representative of a sufficient number of subjects to be labeled *S^{P} control*.

An outcome was labeled ambiguous if it had one or more of the following three characteristics. First, it was ambiguous if there was a continuous punishment schedule and the absence of local data analyses that could have revealed the source of stimulus control (e.g., cumulative records, latency measures). In these experiments, it was not possible to determine whether response suppression occurred only after the delivery of a punisher, as opposed to after the onset of the antecedent stimulus. Because of the continuous punishment schedule, *overall response rates* could have been extremely low if, for example, a response occurred at the outset of each multiple-schedule component and then ceased after a punisher presentation. Second, an experiment had ambiguous control if extinction was in effect simultaneously with punishment. That is, if, when conditions changed to punishment the reinforcement schedule that previously had maintained responding was changed to extinction, the experiment was said to have ambiguous control. In these experiments, although there could have been stimulus control, it was unclear whether the response suppression was due to extinction, punishment, or some combination thereof. Third, an experiment had ambiguous control if there was no assessment of the unconditioned effects of a punisher presentation per se. In other words, an experiment had ambiguous control if there was not a comparison involving the effects of response-dependent and response-independent punisher deliveries (i.e., a control for conditioned emotional responses, or a CER control). In these studies, although there could have been S^{Dp} control *and* response suppression, it was ambiguous as to whether there was *operant* stimulus control, as opposed to stimulus control based on other factors (i.e., respondent processes).

Several other characteristics of each experiment were noted. These characteristics included the year of publication, the subject species, whether stimulus control was a focus of the experiment, the schedules of punishment and reinforcement, the stimuli used as punishers and reinforcers, the response, the discrimination procedure, and whether there was stimulus-generalization testing.

RESULTS

We reviewed 56 experiments from the experimental literature and 11 experiments from the applied literature. Stimulus control was the focus of the majority (80%) of these 67 experiments. Only five experiments conclusively demonstrated S^{Dp} control, and another seven conclusively demonstrated S^{P} control. Fifty-five experiments had an ambiguous outcome. Of the experiments that had ambiguous control, 44 were experimental studies and 11 were applied studies. Furthermore, 22 lacked a CER control, 16 had a continuous punishment schedule without providing evidence that responding decreased prior to

the delivery of the punisher, and one confounded the effects of extinction and punishment. The remaining 17 experiments with ambiguous control had more than one of these limitations.

Table 1 summarizes most of the key characteristics of the reviewed experiments, approximately 80% of which were published before 1990. Rats, humans, and pigeons primarily were the subjects. The majority of the experiments used shock as the punisher, and maintained responding with primary reinforcement. The experiments with conclusive demonstrations of S^{Dp} control shared several features. They all were experimental studies, used shock as a punisher, and had an intermittent (primary) reinforcement schedule. In addition, the majority of them had pigeon subjects and intermittent punishment schedules. There were no conclusive demonstrations with human subjects (but see *Discussion*).

	Rat Subjects	*Human Subjects*	*Pigeon Subjects*	*Shock as Punisher*	*Primary Reinforcer*	*Intermittent Reinforcement Schedule*	*Continuous Punishment Schedule*
Total (67)	28	23	14	44	43	42	37
S^{Dp} (5)	1	0	4	5	5	5	1
S^{P} (7)	4	2	1	5	5	7	3
Ambiguous (55)	23	21	9	34	33	30	33

Table 1. Characteristics of the reviewed experiments. The Total row shows the number of all of the experiments that had each characteristic (out of 67). The S^{Dp} row shows the number of only the S^{Dp} experiments with each characteristic (out of 5), the S^{P} row shows the number of only the S^{P} experiments with each characteristic (out of 7), and the Ambiguous row shows the number of only the Ambiguous Control experiments with each characteristic (out of 55).

The experiments with S^{P} control also all were experimental studies and shared several characteristics with the S^{Dp} studies (e.g., shock and primary reinforcement), except that they primarily had rat subjects. The experiments with an ambiguous outcome did not share as many features as did the experiments labeled as showing S^{Dp} and S^{P} control. More than half of these experiments, however, did involve a continuous punishment schedule, an intermittent (primary) reinforcement schedule, and used shock as the punisher.

To appreciate better the characteristics of the studies we reviewed, below is a detailed description of one study that demonstrated S^{P} control (Weisman, 1975) and one study that demonstrated S^{Dp} control (Azrin, 1956). Weisman examined differential responding of pigeons across multiple-schedule

components. In the first condition, a solid green key was transilluminated in one component, and a white line appeared on the green background in the other component. A multiple variable-interval (VI) 5-min VI 5-min positive reinforcement schedule initially was in effect. In the next condition, reinforcement continued as previously scheduled, but electric shock followed every response in the presence of the white line. Following this training, there were four stimulus-control probes interspersed within a single test session: two 1-min presentations of only the white line (i.e., not on the green background) in the absence of shock delivery and two 1-min presentations of the green key (i.e., without the white line) with response-dependent shock. All other multiple-schedule components during this single test session remained unchanged. Despite training in which shock was correlated only with the white line, in the first "line-only no-shock" probe, the pigeons initially responded at a lower rate, but responded at high rates throughout the rest of those probes. Response rate during the green-light probes was indistinguishable from other punishment components in that rates decreased only after the presentation of the shock. Results suggested that responding was under the control of the shock rather than the white line.

Azrin (1956) provided a demonstration of S^{Dp} control. Pigeons were exposed to a two-component multiple schedule in which a VI punishment schedule (Procedure D) operated in one component (correlated with an orange light), and a VI positive reinforcement schedule was in effect in both components. The effects of this procedure were compared to an identical procedure except that a variable-time (VT) "punishment" schedule replaced the VI punishment schedule (Procedure C). Cumulative records were presented for both procedures, so within-component response patterns could be examined. In Procedure D, the VI punishment schedule almost immediately led to complete response suppression in the presence of the orange light. Response rates during the reinforcement-only component, however, either increased slightly or did not change. After the discontinuation of the punishment conditions, responding in the presence of the orange light remained completely suppressed for several sessions before recovering to pre-punishment levels. These outcomes suggest that the orange light correlated with punishment was an S^{Dp}. Responding in the multiple-schedule component with the VT punishment schedule in Procedure C was suppressed slightly, indicating that the orange light exerted both operant and respondent stimulus control.

DISCUSSION

Our review of the experimental and applied literatures revealed only a few experiments that conclusively demonstrated S^{Dp} control. These few experiments

showing such control had relatively similar characteristics. Responding, key pecking by pigeons in all cases except one, was maintained by an intermittent schedule of primary reinforcement, and was punished by shock according to, in all cases except one, an intermittent schedule. We found only one study that did not demonstrate S^{Dp} control that had each of the latter characteristics (Honig & Slivka, 1964). Although that study had suggestive evidence of S^{Dp} control, it was labeled as ambiguous because it did not have a CER control, and because only one of three pigeons showed response-rate decreases controlled by the antecedent stimulus. Overall, the two most prevalent limitations we found with regard to concluding that an experiment showed S^{Dp} control was the absence of a CER control and the operation of a continuous punishment schedule without data to confirm that responding decreased after the onset of the antecedent stimulus and before the first punisher presentation. Our main findings, therefore, have implications for the study of stimulus control and punishment in general, and more specifically in the context of Sidman's (1989) comments noted in the introduction.

Given the results of our review, it seems premature to conclude that an antecedent stimulus in a three-term punishment contingency automatically will function as a punisher itself. In only a few published articles, and only under relatively limited conditions, was there convincing evidence of S^{Dp} control. Given our results, an important step in the study of stimulus control and punishment is to use specific methods and data analyses to determine definitively the feature(s) of the environment that become discriminative for the effects of punishment. These methods and analyses include an assessment of the unconditioned effects of punishers, a greater reliance on molecular measures of responding, and the maintenance of the reinforcement schedule that is maintaining punished responding. It should not be concluded from our review that S^{Dp} control *only* could be established under relatively limited conditions. Instead, the primary conclusion is that the generality of the conditions under which S^{Dp} control can be generated is unknown because the majority of studies have yielded ambiguous findings.

Our finding that there were no conclusive demonstrations of S^{Dp} control with human subjects is unfortunate for both experimental and applied reasons. In the case of the former, given the typical arrangement in the human operant laboratory, it is important to determine whether such control can be established with conditioned punishment, conditioned reinforcement, and minimal instructions. In other words, research from the human operant laboratory can yield considerable information as to the different forms of stimulus control that develop under different conditions involving punishment. In general, three key aspects of the applied experiments we reviewed forced them into ambiguity, with the first two aspects already mentioned above (i.e., no CER control and a continuous punishment schedule without local data analyses). The third as-

pect that raised concerns was that the punishment procedures used in some of the applied experiments we reviewed *might* have confounded the effects of extinction and punishment. For example, a procedure that involves the interruption of a response that is reinforced by self-stimulation may result in suppression of that response via punishment, extinction, or some combination thereof. Related then to the second point raised by Sidman's (1989) comments, even under conditions in which a particular person could have been established as a discriminative stimulus for the effects of punishment, it was unclear whether that establishment occurred.

The discussion of human operant research involving punishment raises a caveat to consider regarding the inclusion of a CER control in general and in studies involving *conditioned* punishers specifically. We found approximately 20 experiments that would have been labeled as showing S^{Dp} control had they included a CER control (e.g., Brethower & Reynolds, 1962; Doughty, Anderson, Doughty, Williams, & Saunders, 2007; O'Donnell et al., 2000), and about half of these experiments had human subjects and conditioned punishers. This latter finding raises the question of how important it is to include a CER control in experiments that use conditioned punishers. A second question that is occasioned by our results is that of how important it is to have a CER control in every experiment that uses shock as a punisher. The value of including a CER control as a function of the type of punisher used in a particular experiment warrants both further study and discussion.

To illustrate the importance of isolating the controlling stimulus under conditions of punishment for issues in applied behavior analysis, consider the generalization of treatment effects involving the reduction of severe behavior problems from the clinic to the home. To increase the probability of generalization, the discriminative stimuli for problem-behavior reduction in the clinic should be specified such that these stimuli can be used at home. If the discriminative stimulus for punishment in the clinic is the punisher delivery itself, then the transfer of antecedent stimuli to the home will not increase the probability of obtaining generalization because these stimuli are not discriminative for response suppression.

Given both the results of our review and the importance of stimulus-control research involving punishment for both theoretical and practical reasons, it is unfortunate that this type of stimulus-control research is declining. We found only a few experiments on the topic of stimulus control and punishment published since 1990. In keeping with the goal of this special issue, we conclude by noting that increased efforts to understand how stimulus control develops under conditions of punishment not only will inform our basic knowledge base regarding stimulus control, but it also could allow for a more judicious application of punishment in clinical settings.

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