POSITIVE CONDITIONED SUPPRESSION: EFFECTS OF CS DURATION¹

KLAUS A. MICZEK AND SEBASTIAN P. GROSSMAN

UNIVERSITY OF CHICAGO

During a brief conditioned stimulus (15 or 30 sec) that terminated with the response-independent delivery of banana pellets, operant responding reinforced by other food pellets according to a variable-interval schedule of reinforcement was suppressed in the squirrel monkey. Conditioned stimuli of longer duration (1, 2, and 3 min) did not reliably affect the rate of operant performance. Brief conditioned stimuli generated homogeneous response patterns of nearly complete suppression. Increasing the CS duration did not enhance responding, as previously reported, but led to alternate bursting and pausing, which suggested a loss of control by the conditioned stimulus. The results suggest that the magnitude of "positive" or "negative" conditioned suppression reflects the strength of the classical conditioning process.

Thirty years ago, Estes and Skinner (1941) introduced an experimental paradigm to assess "anxiety" and "fear". A short-duration stimulus (CS) was superimposed on ongoing positively reinforced operant behavior, and at its termination an electric shock (negative US) was presented. After repeated pairings, the rate of operant responding was suppressed during the presentation of the CS. Originally, the reduction in response rate was used as a measure of "conditioned anxiety" (Estes and Skinner, 1941). More recently, it has been interpreted as a "conditioned emotional response" (CER) (Brady and Hunt, 1955) or simply "conditioned suppression" (Lyon, 1968).

An enhancement of operant responding has been observed in the same paradigm during the presentation of a CS that precedes a positive US (Herrnstein and Morse, 1957; Brady, 1961; Henton and Brady, 1970). However, response suppression has also been observed under these conditions (Azrin and Hake, 1969), and it has been suggested that the enhancement might be due to a superstitious responding. However, these studies differed considerably in the parameters of the experimental procedure for both the operant baseline and the superimposed Pavlovian setting.

It has been suggested that the direction and degree of change in response rate during a CS that precedes a positive US may be a function of the CS duration (Meltzer and Brahlek, 1970; Henton and Brady, 1970). Long CS-US intervals have been reported to produce a slight

enhancement, whereas short intervals resulted in response suppression (Meltzer and Brahlek, 1970). These observations suggest that the parameters of the classical conditioning procedure might be important determinants of the effects of the CS on concurrent operant behavior. The present experiments were undertaken to investigate this possibility further.

METHOD

Subjects

Two mature male squirrel monkeys (*Saimiri sciureus*), weighing 710 and 800 g, were maintained at 80 to 85% of their free-feeding body weight during the experiment. Water was freely available at all times except during the daily test session. After the session, each monkey received about 30 g of Rockland Laboratory Primate Diet. Twice during the week the restricted diet was supplemented with bananas.

Apparatus

A restraining chair similar to the one described by Hake and Azrin (1963) was used (Lehigh Valley Model 1619). The subject was

¹This research was supported by U.S.P.H.S. grant MH 10130-06 to S. P. Grossman. The authors wish to thank Dr. John R. Thomas for his helpful comments throughout the conduct of the experiment. Reprints may be obtained from S. P. Grossman, Department of Psychology, University of Chicago, Chicago, Illinois 60637.

kept in a seated position by a waist lock. A metal lever protruded through a 1.3-in. (3.5-cm) slot on the left side of the front panel 2.3 in. (6 cm) above the waist level. A relay click provided response feedback. A Ralph Gerbrands feeder, installed behind the front panel, delivered 45-mg Noyes pellets. A Foringer feeder, mounted outside the chamber enclosure, delivered 190-mg Ciba banana pellets. Both types of pellets were delivered into a food receptacle mounted in the center of the front panel. On the left sidewall, a solid-state miniature signal device (Mallory sonalert) was mounted 9 in. (22 cm) above the waist level and generated a sound of 80 db SPL (as measured by a Bruel and Kjoer, Type 1613). All scheduling and recording were achieved by conventional electromechanical circuits, digital counters, and cumulative recorders in an adjacent room.

Procedure

Before the initial session and during the remainder of the experiment, both monkeys were deprived of food for 23 hr. After magazine training, the animals were shaped to press a lever for Noyes food pellets. The reinforcement schedule was gradually altered until both subjects showed a stable performance on a 10-sec variable-interval schedule of reinforcement (VI 10-sec). The VI schedule requirements were slowly increased to 45 sec, with a range of intervals between 0 to 90 sec, and maintained at this level throughout the rest of the experiment. A 60-min session was scheduled daily. After the VI performance had stabilized according to the six-session stability criterion established by Schoenfeld, Cumming, and Hearst (1956), a 45-sec tone was presented four times during the session at irregular intervals. When the tone ceased to affect the ongoing VI behavior, as assessed by the Kamin inflection ratio (see below), the CS duration was shortened to 30 sec and three Ciba banana pellets were delivered independently of responding as the unconditioned stimulus at the termination of the tone. The response-dependent reinforcer (Noyes pellets) for lever pressing continued to be delivered according to the VI 45-sec schedule. After 16 sessions under these conditions, the CS duration was decreased to 15 sec for Monkey MP 1 because the 30-sec CS did not produce any appreciable change in lever pressing. Both subjects were

maintained for a minimum of 20 sessions under the conditions that produced reliable suppression. Finally, the CS durations were increased for both monkeys to 1 min (five sessions), 2 min (seven sessions), and 3 min (five sessions).

RESULTS

During the brief CS that terminated with the response-independent delivery of banana pellets, the rate of responding for other food pellets was markedly suppressed. Conditioned stimuli of longer duration did not reliably affect the rate of responding (see Fig. 1). A ratio, equal to $B/A+B$ (where B represents the number of responses during the CS and A the responses during a period immediately preceding the CS of the same length as the CS) was used as a measure of the effectiveness of the CS (Annau and Kamin, 1961). A ratio of 0.50 indicates no change in responding; a ratio of 0.00 indicates complete suppression. Any ratio above 0.50 reflects rate enhancement. The mean response rate maintained under the variable-interval schedule was 38.5 responses per minute (SD 6.25) for Monkey MP 1 and 14.5 responses per minute (SD 2.61) for Monkey MP 2.

After some habituation, both subjects showed essentially no change in responding during a 45-sec tone. A shorter (30 or 15 sec) tone followed by the US (three banana pellets) suppressed responding after a few sessions. After the tenth session, MP 2 always responded at less than half of its normal rate and in most instances at less than a fourth of its control rate during a 30-sec CS. Monkey MP 1 did not respond reliably to this CS but demonstrated a response suppression to about one-half of its normal rate when a 15-sec CS was introduced. Monkey MP 1 responded about twice as much as Monkey MP 2 under normal conditions and this difference in baseline may be responsible for the differential effectiveness of the longer CS.

After maintaining both subjects for more than 20 sessions under conditions that resulted in response suppression, the CS duration was increased. An increase to 1, 2, or 3 min abolished the suppression in both monkeys. Responding during the long CS durations was characterized by alternate bursting and pausing, which led to overall ratios of 0.40

Fig. 1. Changes in the suppression ratio during the CS preceding a positive US as a function of CS duration for each of two monkeys. A suppression ratio of 0.50 (dotted line) represents no change in responding during the CS relative to the control rate. Ratios less than 0.50 reflect response suppression during the CS.

to 0.50, indicating no change (see right portion of Fig. 1).

Samples of the cumulative response records of Monkey MP 1 (see Fig. 2) demonstrate these changes. The brief CS generated a homogeneous and uniform response pattern and the CS produced a nearly complete suppression, with the exception of an occasional response. When the CS duration was increased, both subjects started to engage in frequent bursts of responding and developed an irregular response pattern.

DISCUSSION

Ongoing operant behavior was suppressed during the presentation of a stimulus that was previously paired with a positive US. This replicates in the monkey the findings reported by Azrin and Hake (1969) for the rat. In the present experiments, the response-dependent and response-independent reinforcers were of

the same modality. This avoids complications due to possible interactions between food and water reinforcers. The two reinforcers were, however, qualitatively and quantitatively different to reduce the possibility of superstitious conditioning.

The magnitude of the suppression observed in the present experiment is comparable to that seen in experiments that employ shock as the US, suggesting that similar parametric limitations may apply to conditioned suppression in both paradigms. The temporal parameters of the CS determine, at least partially, conditioned suppression with a negative US. [The briefer the CS and the less frequent the CS-US presentation, the more suppression of the concurrent operant behavior (Stein, Sidman, and Brady, 1958; Kamin, 1965)]. The present results, as well as the work of Meltzer and Brahlek (1970), suggest that only a short-duration CS suppresses ongoing operant behavior when a positive US is used.

Fig. 2. Selected cumulative records for Subject MP 1 before, during, and after the CS and US presentation. The event pen was deflected for the duration of the CS. Momentary deflections of the event pen represent the delivery of the response-dependent reinforcer. The response-independent banana pellets are presented at the termination of the CS.

Increasing the CS duration in the present experiment did not enhance responding as previously reported (Henton and Brady, 1970; Meltzer and Brahlek, 1970). Instead, a disruption of the response pattern occurred that suggested a loss of stimulus control by the CS. Meltzer and Brahlek (1970) reported that a 2-min CS that preceded a positive US slightly enhanced rate, whereas conditioned stimuli of brief durations produced marked suppression. Other investigators have reported enhancement effects (Brady, 1961; Herrnstein and Morse, 1957), and Meltzer and Brahlek have suggested that CS duration might be the variable that determines whether response suppression or enhancement occurs. Our observation that CS durations up to 3 min failed to produce enhancement of responding questions the generality of this interpretation. It is possible that several factors, including the number of contingent reinforcements scheduled during the CS, as well as other schedule parameters,

may be important determinants of responding during the CS.

A consideration of procedural differences between the present experiments and those that have observed response enhancement, suggests that a positive US may facilitate responding only when (1) a DRL schedule is used that is especially prone to disruption due to stimulus change (Herrnstein and Morse, 1957; Henton and Brady, 1970); (2) quantitative and qualitative similarities between the response-dependent and response-independent reinforcer lead to superstitious responding (Azrin and Hake, 1966); (3) the presentation of the CS and US is delayed by a fixed amount of time when a lever-press occurs at the scheduled time (Henton and Brady, 1970) (this procedure establishes contingencies that may lead to adventitious reinforcement of either increased or decreased responding); or (4) reinforcers of different modalities are used for the maintenance of the operant baseline and the Pavlovian procedure, thus increasing the possibility of reinforcer interactions.

The suppression of operant behavior during a CS that signals the delivery of an aversive shock (negative US) is commonly interpreted as a reflection of "anxiety" or "fear" (*cf.* Brady and Hunt, 1955). Since the same degree of suppression can be achieved by stimuli that signal the delivery of a positive US, conditioned suppression cannot serve as a useful index of one emotional state. Azrin and Hake (1969) suggested that a "general emotional state" may account for response suppression during both a pre-reinforcement and pre-shock stimulus. This interpretation attempts to find a common denominator for suppression on the basis of formal and functional similarities between the positive and negative paradigm. To widen the traditional anxiety type interpretation to one that embraces a general emotional state of preparedness does not, however, adequately describe the distinguishing characteristics of both behavioral alterations.

The parametric limitations of the experimental paradigm and the functional similarity of the effects of food and shock suggest an alternative interpretation. The conditioned suppression paradigm was originally conceptualized in terms of the superimposition of a classical conditioning procedure on ongoing operant behavior. The Pavlovian conditioning process involves the association of a neutral

stimulus with an unconditioned stimulus until the former acquires some of the properties of the US. These considerations suggest that other ongoing behavior will be disrupted in proportion to the strength of the CS-US association. A closer CS-US contiguity forms a stronger bond between the two stimuli and the conditioning process is more powerful (Kamin, 1965). Thus, with regard to the conditioned suppression paradigm, one can predict: (1) a briefer CS will suppress ongoing behavior more severely than a longer one, and the degree of suppression during the CS will be similar whether shock or food serves as the US, and (2) the suppression of the ongoing operant behavior reflects the strength of the classical conditioning process.

REFERENCES

- Annau, Z. and Kamin, L. J. The conditioned emotional response as a function of intensity of the US. *Journal of Comparative and Physiological Psychology*, 1961, **54**, 428-432.
- Azrin, N. H. and Hake, D. F. Positive conditioned suppression: conditioned suppression using positive reinforcers as the unconditioned stimuli. *Journal of the Experimental Analysis of Behavior*, 1969, **12**, 167-173.
- Brady, J. V. Motivational-emotional factors and intracranial self-stimulation. In D. E. Sheer (Ed.), *Electrical stimulation of the brain*. Austin: University of Texas Press, 1961. Chap. 30.
- Brady, J. V. and Hunt, H. F. An experimental approach to the analysis of emotional behavior. *Journal of Psychology*, 1955, **48**, 285-293.
- Estes, W. K. and Skinner, B. F. Some quantitative properties of anxiety. *Journal of Experimental Psychology*, 1941, **29**, 390-400.
- Hake, D. F. and Azrin, N. H. An apparatus for delivering pain shock to monkeys. *Journal of the Experimental Analysis of Behavior*, 1963, **6**, 297-298.
- Henton, W. W. and Brady, J. V. Operant acceleration during a pre-reward stimulus. *Journal of the Experimental Analysis of Behavior*, 1970, **13**, 205-209.
- Herrnstein, R. J. and Morse, W. H. Some effects of response-independent positive reinforcement on maintained operant behavior. *Journal of Comparative and Physiological Psychology*, 1957, **50**, 461-467.
- Kamin, L. J. Temporal and intensity characteristics of the conditioned stimulus. In W. F. Prokasy (Ed.), *Classical conditioning: a symposium*. New York: Appleton-Century-Crofts, 1965. Chap. 7.
- Lyon, D. O. Conditioned suppression: operant variables and aversive control. *The Psychological Record*, 1968, **18**, 317-338.
- Meltzer, D. and Brahlek, J. A. Conditioned suppression and conditioned enhancement with the same positive UCS: an effect of CS duration. *Journal of the Experimental Analysis of Behavior*, 1970, **13**, 67-73.
- Schoenfeld, W. N., Cumming, W. W., and Hearst, E. On the classification of reinforcement schedules. *Proceedings of the National Academy of Science*, 1956, **42**, 563-570.
- Stein, L., Sidman, M., and Brady, J. V. Some effects of two temporal variables on conditioned suppression. *Journal of the Experimental Analysis of Behavior*, 1958, **1**, 153-162.

Received 20 August, 1970.