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Response suppression during stimuli temporally different from the prefood stimulus

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Response suppression was studied in three squirrel monkeys responding on a variable-interval 1-min schedule of food reinforcement. A brief (.75-sec) green light was presented on the response key prior to each food presentation. Responding was recorded before, during, and after longer duration green keylights (30, 20, 10, 5, and 2 sec) interpolated on the variable-interval schedule at predetermined times during an experimental session. Food presentation did not follow the longer duration green lights. Suppression of responding was observed in all animals with all stimulus durations throughout the study. Greatest suppression occurred with the 2-sec stimulus and near the end of a session. Because food never followed the longer duration stimuli, previous hypotheses inferring adventitious reinforcement and reinforcement of less effortful behavior as explanations of suppression were questioned.

Azrin and Hake (1969) found that the presentation of a positive reinforcer after a 10-sec conditioned stimulus (CS) superimposed on a variable-interval (VI) schedule of reinforcement produced less responding during than before the CS. Response suppression with a positive stimulus was thereby demonstrated and has since been replicated by other studies (Hake & Powell, 1970; Miczek & Grossman, 1971; Van Dyne, 1971). "Positive-conditioned suppression" shares many phenomena with "negative-conditioned suppression" (a neutral stimulus paired with negative reinforcement). In both types the suppression ratios are affected by CS duration (Meltzer & Brahlek, 1970; Millenson & Hendry, 1967), they are durable over continued sessions (Kelly, 1973a; Lyon, 1968), and extinction of suppression occurs soon after the unconditioned stimulus (UCS) is no longer paired with the CS (Azrin & Hake, 1969; Annau & Kamin, 1961). However, intermittently pairing the CS with the UCS differentially affects the suppression ratios. In negative-conditioned suppression the size of the suppression ratio is directly related to the percentage of CS-UCS pairings (Willis & Lundin, 1966), whereas in positive-conditioned suppression one study has reported that intermittent pairings lead to less response facilitation if a long CS is used but to greater enhancement if a short CS is used (Meltzer, Hamm, & Niebuhr, 1974).

Meltzer and Brahlek (1970) had previously found that conditioned stimuli of long duration paired with food on each occasion produced response facilitation, while shorter duration stimuli produced suppression of responding. Although there are reports that relatively short duration stimuli can produce response facilitation (LoLordo, 1971), most studies with reinforcement schedules that encourage continual responding have found suppression (Kelly, 1973a, 1973b). Azrin and Hake (1969) suggest that adventitious reinforcement may be responsible for facilitation. A longer CS would allow more opportunity for an organism to respond prior to the UCS. The same explanation is reasonable for suppression. Several studies report that adventitious reinforcement is probably not responsible for either suppression or facilitation (Henton & Brady, 1970; Kelly, 1973a, 1973b). One method to obviate the possibility of such adjunctive behavior in conditioned suppression studies would be to present the CS not followed with the UCS. The elimination of the CS-UCS association entirely would distort the traditional concept of response suppression, hence the present study intermittently paired a brief stimulus with food. Response suppression was then sampled during situations where the stimulus was of longer duration and introduced independently of responding.

METHOD

Subjects

The subjects were three male squirrel monkeys, *Saimiri sciureus*, between the ages of 7 and 9 years. All had participated in previous operant experiments wherein similar manipulanda and stimuli were not used. Each was maintained at 79%-86% of its ad-lib weight for the present study.

Apparatus

A 30.5 x 30.5 x 44 cm stainless steel monkey chamber was enclosed in a larger, sound-isolated wooden box that had vibration insulators and a ventilation fan. A food hopper was located in the center of one wall 6 cm above the floor. A Grason-Stadler Model E8670A response key, transilluminated by either a red

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or green 7-W lamp, was aligned 8 cm above the hopper. A speaker for presenting an 80-dB white masking noise was centered 12 cm above the key. The chamber's Plexiglas guillotine door permitted observation. The door of the wooden box was of double glass covered by a black curtain. The houselight was on continuously. All control and recording apparatus were located in a room remote from the chamber.

Procedure

Each animal was partially deprived of food until he reached 85% of his ad-lib weight and then trained to press the red key to obtain food. Training progressed from a continuous-reinforcement schedule to a variable-interval (VI) 30-sec to a VI 1-min schedule. The VI values were determined by the method of Catania and Reynolds (1968). One-hour sessions were conducted 7 days a week at approximately the same time each day for each subject. Food reinforcement was a 220-mg pellet of Purina Monkey Chow, specially prepared by Stanlabs, Inc. Daily food supplements of Purina Monkey Chow and a portion of an orange were given after each session dependent on the individual's body weight. Water was available in home cages but not in the chamber.

The response key was normally illuminated red. When reinforcement became available under the VI schedule, a response changed the red key to green for .75 sec, and a food pellet was then delivered. The brief green-light food pairing started during initial training and continued throughout the experiment. Baseline rates were obtained when each animal showed no between-session trends for at least six consecutive sessions. Between 25 and 35 sessions elapsed before baseline rates were calculated on all three subjects. Following the sixth baseline session, a 30-sec illumination of the key with the green light was presented at 5, 10, 20, and 40 min in each experimental hour. Food pellets were always obtainable on the VI schedule regardless of the green-light presence. Hence, presentation of the green light on the key had no programmed effect on reinforcement dependencies. Control rates were obtained both immediately prior to and after each long green-light presentation. The duration of the control periods was the same as that of the green-key probe. Five green-key durations, 30, 20, 10, 5, and 2 sec, respectively, were explored. After 12 sessions (48 presentations), the green-key duration was changed. The procedure was the same for each duration and each duration was studied for 12 sessions. To establish that suppression ratios were related to a specific duration and not to the chronological presentation or increment in sessions, 4 to 6 sessions of the 30-sec green light on the key were conducted on completion of the 60 original sessions.

RESULTS

Inasmuch as no primary reinforcement or UCS followed the green-keylight probe, and because of potential competing responses associated with the offset of the green light, the suppression ratio included response rates both before and after the green key. The ratio was $A \div (A + B)$. A equals the response rate during the green key and B equals the mean of the rates before and after the green key. With this ratio, .5 indicates no change, above .5 indicates facilitation, and below .5 indicates suppression.

Although there were no overall response rate differences between baseline and experimental sessions, all subjects showed response suppression throughout the experimental sessions. Only D42 showed an incremental decrease in suppression as the green-stimulus duration decreased. There were no large differences between 30-, 20-, and 10-sec durations; however, at 5 sec E24 showed very little suppression and all animals suppressed the most with the 2-sec green stimulus. According to the Mann-Whitney U test, the suppression ratios for all three animals were no different when the 30-sec green key was presented at the end of the study than they were under the original 30-sec green key. An analysis of variance with nested groups showed differences of borderline significance between the suppression ratios under the other green-stimulus durations ($F = 2.96$, $p < .10$). Duncan's multiple-range test further demonstrated that the 2-sec stimulus occasioned less responding than the 30-, 20-, and 10-sec durations ($p < .05$), that the 5-sec stimulus was not different from the longer durations, and that the difference between 5- and 2-sec durations was not significant except at a borderline level ($p < .10$).

A comparison of the mean suppression ratios as they appear temporally within a session as a function of green-key duration is shown in the upper portion of Figure 1. Means were calculated for each animal on 12 sessions for each duration. During the 20- and 10-sec probes, all subjects suppressed more at the end of the session than at the beginning. This trend also occurred for two monkeys during the 30- and 5-sec durations, producing a mean within-sessions probe curve remarkably similar under the longer duration stimuli. The within-session curve changed at 5 sec and was quite different at 2 sec, as seen in the lower portion of Figure 1.

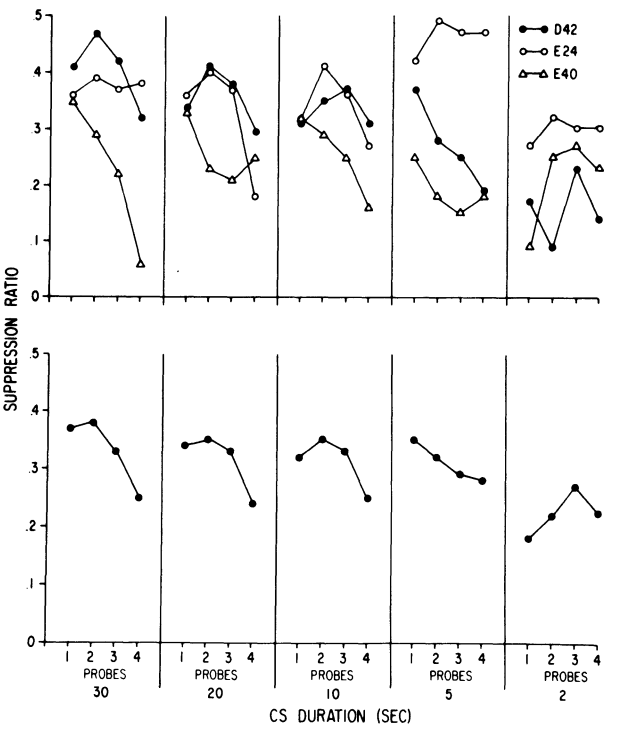

Figure 1. Suppression ratios as a function of intrasession time and green-key-stimulus duration. Probes 1, 2, 3, and 4 refer to the 5-, 10-, 20-, and 40-min probes, respectively, within a session. The data were the means of 12 sessions during each duration. The lower graph represents means obtained from averaging the individual points of the upper graph.

Subjects D42 and E40 tended to suppress less as their overall response rates increased, and there was no significant correlation between suppression ratio and response rate for E24.

Observations of each monkey's performance were taken at random times during each stimulus duration. During the red light, all animals engaged in a stereotyped response pattern, such as jumping repeatedly and then turning in a circle prior to pressing the key. Behavior during the 30-, 20-, and 10-sec green-key durations was similar except that, instead of pressing the key, a monkey would lightly touch the key or press the wall next to it without actuating the key. On the other hand, during the 2-sec and occasionally during the 5-sec duration, behavior was more similar to behavior in the presence of the .75-sec stimulus preceding food. In the latter situation subjects ceased their red-light ritual and stared at the key, simultaneously holding or reaching into the food hopper.

DISCUSSION

Procedure was a primary difference between the present study and previous experiments that studied positive-conditioned suppression. The present study paired the brief green light and the food outside the traditional sampling situation. Also, in the present study, when a brief prefood stimulus did appear, it was always response dependent. Regardless of these differences, response suppression consistently appeared, prompting a reconsideration of prior explanations for the occurrence of suppression. Kelly (1973a) proposed a "why work when you can get it for nothing" hypothesis, saying, essentially, that an organism would not respond because it could wait until the end of the CS and receive reinforcement without any effort. The present experiment emphasized the inadequacy of Kelly's hypothesis as well as that of the adventitious reinforcement hypothesis (Azrin & Hake, 1969) by not having response-independent reinforcement.

In the present study there were no programmed contingencies during the long-duration stimuli that would prevent reinforcement for a keypress, yet the animals tended not to press the key. Although a respondent similar to those proposed by Kamin (1965) and Van Dyne (1971) may have been present, the basis for such conditioning was tenuous. One would expect behavior directed more toward the food hopper and less toward the key to interfere with the keypress. On the other hand, operant "waiting" behavior could have been occasioned by the brief prefood stimulus and, because the longer duration stimuli were the same color, the same behavior transferred to these longer stimuli. If these were "waiting" responses incompatible with keypresses, one would expect that suppression ratios would vary directly with the stimulus duration. Subjects D42 and E40 tended to reflect such a relationship in their data; E24 did not.

Suppression was greatest with the 2-sec green-light duration. One explanation is that the 2-sec stimulus was most similar to the .75-sec stimulus paired with food; hence, behavior associated with the brief food-paired stimulus should most likely generalize to the shortest of the durations. Subjective data in the present study support this explanation. However, a more parsimonious explanation is that the animals rarely responded for the first 2 sec of any stimulus duration, thereby producing almost complete suppression at 2 sec and a linear decrease in suppression correlated with the increase in stimulus duration. Although such linearity did not appear in the present study, the explanation might apply to other studies. That suppression was not due to session number was seen when the terminal 30-sec probes recovered suppression ratios no different from the original 30-sec probes.

Finally, response suppression was shown to be related to the time when the stimulus was presented in an experimental session, a finding not previously reported. The response suppression during the green keylights resulted in few food deliveries in the presence of that stimulus, a coincidence that may have endowed the green key with S^{Δ} or inhibitory response properties. The 23-h interval between sessions could have allowed the properties to dissipate, eventuating in spontaneous recovery demonstrated by the higher suppression ratios in the initial portion of the session.

REFERENCES

ANNAU, Z., & KAMIN, L. J. The conditioned emotional response as a function of the intensity of the US. *Journal of Comparative and Physiological Psychology*, 1961, **54**, 428-432.

AZRIN, N. H., & 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.

CATANIA, A. C., & REYNOLDS, G. S. A quantitative analysis of the behavior maintained by interval schedules of reinforcement. *Journal of the Experimental Analysis of Behavior*, 1968, **11**, 327-383.

HAKE, D. F., & POWELL, J. Positive reinforcement and suppression from the same occurrence of the unconditioned stimulus in a positive conditioned suppression procedure. *Journal of the Experimental Analysis of Behavior*, 1970, **14**, 247-257.

HENTON, W. W., & BRADY, J. V. Operant acceleration during a pre-reward stimulus. *Journal of the Experimental Analysis of Behavior*, 1970, **13**, 205-209.

KAMIN, L. J. Temporal and intensity characteristics of the conditioned stimulus. In W. F. Prokasy (Ed.), *Classical conditioning*. New York: Appleton-Century-Crofts, 1965. Pp. 118-147.

KELLY, D. D. Long-term pre-reward suppression in monkeys unaccompanied by cardiovascular conditioning. *Journal of the Experimental Analysis of Behavior*, 1973, **20**, 93-104. (a)

KELLY, D. D. Suppression of random-ratio and acceleration of temporally spaced responding by the same pre-reward stimulus in monkeys. *Journal of the Experimental Analysis of Behavior*, 1973, **20**, 363-373. (b)

LOLORDO, V. M. Facilitation of food-reinforcement responding by a signal for response-independent food. *Journal of the Experimental Analysis of Behavior*, 1971, **15**, 49-55.

LYON, D. O. Conditioned suppression: Operant variables and aversive control. *Psychological Record*, 1968, **18**, 317-338.

MELTZER, D., & 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.

MELTZER, D., HAMM, R. J., & NIEBUHR, B. R. Conditioned enhancement as a function of the percentage of CS-UCS pairing and CS duration. *Bulletin of the Psychonomic Society*, 1974, **4**, 467-470.

MICZEK, K. A., & GROSSMAN, S. P. Positive conditioned suppression: Effects of CS duration. *Journal of the Experimental Analysis of Behavior*, 1971, **15**, 243-247.

MILLENSON, J. R., & HENDRY, D. P. Quantification of response suppression in conditioned anxiety training. *Canadian Journal of Psychology*, 1967, **21**, 242-252.

VAN DYNE, G. Conditioned suppression with a positive US in the rat. *Journal of Comparative and Physiological Psychology*, 1971, **77**, 131-135.

WILLIS, R., & LUNDIN, R. Conditioned suppression in the rat as a function of shock reinforcement schedule. *Psychonomic Science*, 1966, **6**, 107-108.

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