Between-groups incentive effects on conditioned suppression*

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Rats licking 32% sucrose suppressed to a preaversive CS just as much as did those licking 8% but recovered their base-line response rates faster following shocks. It was suggested that an earlier finding of greater suppression under low incentive (Vogel & Spear, 1966) could have been due to the use of a recovery-time measure of suppression—a measure that confounds CS-elicited suppression with rate of recovery of base-line responding.

An assumption which for years has played a central role in analyses of conflict is that "The amount of inhibition necessary to overcome any tendency may be used as a measure of the strength of that tendency [Morgan, 1923]." A corollary of this statement is that the stronger any behavioral tendency, the harder it should be to inhibit. Ayres (1968) established behavioral tendencies of different strengths in two groups of rats by reinforcing them with either 8% or 32% sucrose for barpressing on a VI schedule. As indexed by response rate, the strength of responding in the group pressing for 32% sucrose was about three times that of the group responding for 8%. Yet when a CS paired with shock was presented to both groups, their barpressing was suppressed during the CS to the same extent. Since suppression was moderate in the 8% group, the failure to obtain stronger suppression in that group was probably not due to a floor effect. And since the dependent measures were sensitive to the effects of the intensity of the shock paired with the CS, insensitivity of the measures will also not account for the null effect of incentive observed.

It is possible, however, that the very differences in response rates used to assess the strengths of the behavioral tendencies were responsible for the null effect of incentive on suppression. Blackman (1968) has shown that high response rates are correlated with strong suppression. Since the effects of response rates on suppression are the opposite of the presumed effects of the motivational variables with which

response rates covary, it is possible that in Ayres's experiment, the response-rate effects on suppression and the incentive effects cancelled out, leaving the obtained null effect. What is needed, then, is a paradigm in which motivational variables can be manipulated without producing changes in response rates.

In the present study, dipper licking was chosen as the response to be suppressed because it is relatively insensitive to variations in incentive. As in earlier work, shock intensity was manipulated to permit assessment of the sensitivity of the dependent measures. Without such an assessment, null effects of the incentive variable would be uninterpretable.

SUBJECTS

Sixty male albino Sprague-Dawley rats, 85-90 days old, were obtained from Dennen Animal Industries, Gloucester, Mass. After a week of adaptation to the colony their food intake was limited to 3-5 g daily until they reached 80% of their free-feeding body weights, at which they were maintained throughout the study.

APPARATUS

The apparatus has been described in detail elsewhere (Quinsey & Ayres, 1969). Basically, it consisted of six Gerbrands operant-conditioning chambers with dipper feeders from which licks were monitored by Grason-Stadler drinkometers. The CS was the onset of a 1,000-Hz, 84-dB tone and the simultaneous offset of an 87-dB white noise normally on for masking. The US consisted of scrambled shocks from six Grason-Stadler E1064 shock sources.

Sucrose solutions of 8% and 32% concentration were made daily with tap water and presented in .1-cc dipper cups. The experiment was run in two replications: In the first, the odd-numbered experimental chambers were provided with the 8% solution and the even-numbered ones with the 32%; in the second, the placement of the two concentrations was reversed.

PROCEDURE

On the sixth day of restricted feeding,

all Ss were taught to lick sucrose from the dipper cups; half received 8% sucrose, half 32%.

Following dipper training all Ss were run through 10 consecutive daily sessions given at approximately the same time every day. The first two were CS-habituation sessions designed to adapt out novelty effects of the CS. In these sessions the dippers were repeatedly raised for 3 sec (making sucrose available) then lowered for 2 sec through the 15-min session. Licking was cumulated for each S at the end of each minute. The CS was presented for 1 min during Minute 10 and again during Minute 14.

The next session was a 20-min fear-conditioning session, in which Ss were assigned to one of four conditioning groups or to a pseudoconditioning group. Each group contained six Ss trained to lick 8% sucrose and six trained to lick 32%. Conditioning was conducted off the base line, i.e., dippers were not presented during the session. The conditioning groups received 10 presentations of a 15-sec CS coterminating with a 1-sec shock US of .5, .8, 1.6, or 2.5 mA, depending on S's group assignment. The mean interval between CSs was 93 sec. The pseudoconditioning group received the same 10 CSs and 10 2.5-mA shock USs, but with no contingency between CS and US. The presentation times of CSs and USs for the pseudoconditioning group were determined independently, using a table of random numbers. Since the dippers were not presented during conditioning, the acquisition of suppression was not measured.

On the next 3 days the extinction of suppression was measured. In each session the dippers were again presented repeatedly, and the 1-min CS occurred without shocks in Minutes 6 and 10. These minutes were chosen because some apparent, satiation in the 32% sucrose group had been noted starting around Minute 13 in the CS-habituation sessions.

The six sessions described above constitute Phase A of the experiment. Phase B consisted of four sessions. The first was a reconditioning session identical to the conditioning session in Phase A. The second was a 15-min licking session with no CSs or shocks. The dippers were merely presented repeatedly to allow base-line lick rates to fully recover before testing for suppression. In the last two sessions the extinction of suppression was measured as in Phase A. These two sessions will be called Reextinction Days 1 and 2.

TREATMENT OF DATA

The data were analyzed in the form of both raw response rates and suppression ratios, $D/(B + D)$, where D represents the number of responses during the 1-min CS

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Fig. 1. Panel A. Mean response rates for the two incentive conditions among the conditioning groups. Panel B. Mean suppression ratios for the two incentive conditions among the conditioning groups. The offset of white noise was the CS in the first extinction session. Panel C. Mean suppression ratios for the four conditioning groups and pseudoconditioning group. Each data point for habituation is the mean of two habituation sessions combined.

and B represents the number of responses in the 1-min before the CS.

RESULTS

Two major findings emerged from this research. First, in the conditioning groups, Ss licking 8% sucrose never suppressed reliably more to the CS than Ss licking 32%, and only on Extinction Day 1 was there even a tendency ($p = .20$) for them to do so (see Fig. 1B). The mean response rates of the two sucrose groups are shown in Fig. 1A. On Extinction Day 1 the baseline rate of the 8% group was reliably lower than that of the 32% group ($p < .05$). But on Extinction Days 2 and 3 and on Reextinction Days 1 and 2, the

response rates of the two groups were very similar. In other words, incentive had no effect on CS-elicited suppression regardless of what it did to response rates. (There was also no interaction between sucrose concentration and shock intensity.) The null effect of incentive on suppression does not appear to be due to a floor effect, since suppression to the CS in the 8% group was moderate. Neither does it seem to be due to the insensitivity of the dependent measures, since those measures were sensitive to the effects of shock intensity (Fig. 1C). In fact, with the one exception of the 2.5 conditioning group in Phase A (Fig. 1C), the effects of shock intensity on

lick rate resemble those on barpressing. This result confirms the work of James & Mostoway (1968) and extends it to the off-the-baseline conditioning paradigm. Analyses of variance, followed by Newman-Keuls tests, indicated that on Extinction Day 1 the 1.6-mA conditioning group suppressed more than did the pseudoconditioning and .5 conditioning groups; the 2.5 and 1.6 conditioning groups suppressed more than all other groups on Reextinction Day 1 and more than the pseudoconditioning and .5 conditioning groups on Reextinction Day 2 (all $ps < .05$).

The second major finding to emerge was this: In Extinction Day 1 and recovery, that is, in the sessions immediately following fear conditioning, the baseline rates of Ss in the 8% sucrose group were suppressed more than were those of Ss in the 32% group (both $ps < .05$). The difference between the rates was most pronounced in the first 5 min before CSs occurred, suggesting that high incentives attenuate suppression to static apparatus cues. Further analysis on the response rates in the first minute revealed that the response rate differences were due mainly to the larger number of zero responders in the 8% than in the 32% sucrose group. This was particularly true during Extinction Day 1 ($\chi^2 = 4.19$, $p < .025$). This result indicates that the 8% Ss waited longer before licking than did the 32% Ss; thus, the incentive effect actually occurred before Ss had tasted the incentive in that session.

An incentive effect which might affect interpretation of the suppression data described above was a reliable Sucrose by Minute interaction in the analyses on raw response rates. As indicated earlier, this effect was apparently due to satiation in the 32% group late in the session. Although reliable, these effects were small; and, since CSs were placed early in the session, the suppression data are presumably uncontaminated by satiation factors. This contention is supported by the lack of reliable Sucrose by Trials interactions in any of the suppression sessions.

DISCUSSION

Incentive did not affect CS-elicited suppression of licking; but, after fear conditioning, Ss in the 32% sucrose group recovered their base-line response rates faster than did Ss in the 8% group.

Vogel & Spear (1966) found more CS-elicited suppression in Ss licking 4% sucrose and 11.5% sucrose than in Ss licking 32%. But their dependent measure was the time to complete 10 licks in the presence of a CS turned on after Ss had accumulated 100 licks in a test session following CS-US pairings. Since this

measure does not compare response rate during the CS with response rate in its absence, the incentive effect reported may have reflected differential recovery rate of base-line responding rather than differences in CS-elicited suppression. The present study suggests that sucrose concentration affects the former but not the latter.

Another possible explanation for the discrepancy between the Vogel and Spear findings and ours is as follows: It may be that when base-line rates are just recovering from the effects of shock, those maintained by low incentives are particularly fragile. But once the base lines have approached their normal levels, they are equally robust. Vogel and Spear gave suppression tests after their Ss had completed only 100 licks. Our tests were given after a much longer period of recovery. In Ayres's study, too, suppression tests were widely spaced apart, allowing response rates to recover in between. This hypothesis, of course, is completely ad hoc and does not follow from any theory we know of; yet it does describe what happened in the three studies, and it does make sense of the present finding that incentives appeared to affect suppression to static apparatus cues but not suppression to a dynamic CS.

Regardless of what the reason for the discrepancy is, one thing seems apparent:

In the present study and in that of Ayres (1968), there was a lack of covariation between response strength as indexed by barpress rate and by resistance to CS-elicited suppression. This finding, along with that described earlier by Blackman (1968), seems to reaffirm Logan's position (Logan, 1956), that fast behaviors are not necessarily strong behaviors; they're just different.

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shorter than 120 sec or (2) multiple daily sessions where the *within-session ITI* was shorter than 120 sec and the *between-session ITI* approached 24 h.

In view of the scarcity of ISI studies involving very long ITIs with the single-session procedure and the inherent ambiguity of the ITI variable in multiple sessions, it was considered worthwhile to examine the rate of response acquisition and, in particular, the ISI function when the ITI was 24 h, i.e., when there was only one trial per day. Earlier pilot work had suggested that as trials per day decreased from 15 downward, the acquisition rate observed over training days was not greatly altered, and the ISI function became substantially flattened.

SUBJECTS

The Ss were 24 male New Zealand rabbits, 90-120 days old, obtained from Johnsons Rabbitry, Coldwater, Michigan. Throughout the experiment, the Ss were maintained on ad lib food and water.

PROCEDURE

Forty-eight hours prior to the first experimental session, a small nylon loop was sutured into S's right nictitating membrane. On the following day each S was placed in a Plexiglas restraining box for a 10-min habituation period. During this period, as in the experimental sessions, tailor hooks which served to retract the eyelids and deliver the shock US were fastened by adjustable Velcro straps to the inferior and superior lids of the right eye. Movements of the nictitating membrane across the eye were monitored by a small photoelectric transducer, mounted on the S's head by means of a muzzle-like assembly and mechanically coupled to the loop in the membrane. Signals for the transducer were amplified and recorded by a Beckman Type R dynograph.

On each of 12 subsequent days Ss received one paired CS-US presentation. The CS, a 1,000-Hz tone at 93 dB SPL, was presented for either 350 msec or 1,350 msec. The US was a 3-mA 60-Hz shock delivered across the eyelids and

The classically conditioned nictitating membrane response: The CS-US interval function with one trial per day

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Acquisition rates for the classically conditioned nictitating membrane response of the rabbit were determined, using one paired presentation of tone and shock per day for 12 days, in Ss trained at a CS-US interval of either 250 or 1,250 msec. Although both groups displayed substantial conditioning, the 1,250-msec group was significantly superior to the 250-msec group, in marked contrast to the usual findings of experiments dealing with the CS-US interval parameter. Results are interpreted primarily in terms of the role of the orienting response in CR acquisition.

The function of the CS-US interval (interstimulus interval or ISI) in the rate of acquisition of a classically conditioned response is one of the most thoroughly investigated variables in the conditioning literature. One generally finds a concave down function of acquisition rate to ISI, peaking for the nictitating membrane

response (NMR) of the rabbit around 250 msec (Smith, Coleman, & Gormezano, 1969; Schneiderman & Gormezano, 1964).

The procedure for obtaining the ISI function has involved, with a few exceptions (e.g., Frey & Ross, 1968), either (1) a single conditioning session where the intertrial interval (ITI) was

Fig. 1. Mean percentage of CRs of Ss in either the 250-msec or the 1,250-msec condition.