having an 18-sec delay produces effects which are discriminably different from nonreinforcement after a response having a 2-sec delay since the preceding response. However, in previous studies (Ellen & Bate, 1969, 1970), we have shown that septal animals fail to utilize differential internal stimulation as discriminative cues for behavior. Thus, it would appear that the differential internal effects of nonreinforcement of responses having different delays since a previous response are not discriminated by the septal animals and thus no temporal discrimination is acquired. This hypothesis requires more precise specification as to the nature and properties of the internal stimulation which must be discriminated, while at the same time focusing attention upon the bases underlying the failure to discriminate differential effects of nonreinforcement.

REFERENCES

ANGER, D. Dependence of interresponse times upon the relative reinforcement of

- different interresponse times. *Journal of Experimental Psychology*, 1956, 52, 145-161.
- ELLEN, P., & BATE, G. Qualitative differences in the maze performance of rats with septal lesions. *Psychonomic Science*, 1969, 15, 5-6.
- ELLEN, P., & BATE, G. Limbic lesions and cue utilization in the Dashiell maze. *Psychonomic Science*, 1970, 19, 47-49.
- ELLEN, P., & BUTTER, J. External cue control of DRL performance in rats with septal lesions. *Physiology & Behavior*, 1969, 4, 1-6.
- ELLEN, P., WILSON, A. S., & POWELL, E. W. Septal inhibition and timing behavior in the rat. *Experimental Neurology*, 1964, 10, 120-132.
- MACDOUGALL, J. M., VANHOESEN, G. W., & MITCHELL, J. C. Development of post SR and post non SR DRL performance and its retention following septal lesions in rats. *Psychonomic Science*, 1969, 16, 45-46.
- PELLEGRINO, L. J., & CUSHMAN, A. J. *A stereotaxic atlas of the rat brain*. New York: Meredith, 1967.
- WINER, B. J. *Statistical principles in experimental design*. New York: McGraw-Hill, 1962.
- ZURIFF, G. E. Collateral responding during differential reinforcement of low rates. *Journal of the Experimental Analysis of Behavior*, 1969, 12, 971-976.

Attention and conditioned suppression*

C. J. BRIMER†

Dalhousie University, Halifax, N.S., Canada

Experimental rats were first trained to inhibit responding during a TO period that was preceded by a light signal. In subsequent standard CER training, a noise CS was paired with electric shock. When the experimental Ss were tested with the light/noise compound, their response rate during TO was not different from that of control Ss who had had no TO experience. The results were interpreted in terms of the suggestion that animals fail to attend to appetitive cues during conditioned suppression.

In the typical conditioned suppression or conditioned emotional response (CER) demonstration, the presentation of a signal (CS), which has been paired with electric shock (US), is observed to depress the rate of responding for appetitive reinforcement. Although no completely satisfactory explanation exists for the conditioned suppression phenomenon, most investigators have tended to identify the phenomenon with classical conditioning (Kamin, 1965; Lyon, 1968).

A number of years ago, Broadbent (1953) suggested that many of the features of classical conditioning could be interpreted in terms of an attention type of mechanism. Extrapolating this idea to the CER situation would suggest that conditioned suppression occurs as a result of a shift in the

animal's focus of attention. When an aversive CS is presented, the animal ceases to attend to the operant cues and, consequently, ceases to respond. The following experiment, which attempted to test such an idea, involved three main training phases. In the first phase, rats were given discrimination training with a preextinction stimulus. During the second phase, Ss received standard CER training. In the final phase, the Ss were tested with a compound stimulus composed of the preextinction and aversive signals. The prediction was that animals would fail to attend to the extinction cue during the compound test, as indexed by their postsignal behavior.

METHOD

The Ss were adult male hooded rats maintained at approximately 75% of ad lib weight. Out of an original group of 17, 1 animal died during the course of the experiment and 3 other Ss had to be discarded due to experimental errors. Consequently, all of the analyses of the data were restricted to the surviving group of 13 Ss.

Animals in the main experimental condition were first trained to leverpress on a 30-sec VI food-reinforcement schedule. The Ss were then given discrimination training during which a 2-min stimulus signaled a subsequent 6-min timeout period (TO) during which experimental extinction was in effect. The preextinction signal was an overhead light which produced a level of illumination of approximately 2.14 fc, as measured at the rat's normal location in the animal chamber. No external stimulus was presented during the TO period itself. Three signal-extinction pairings were given during each 1-h daily training session. This training had to be continued for approximately 3 months in order to obtain reliable postsignal suppression.

Following the discrimination experience, animals were given standard CER training. The CS was a 3-min 70-dB white noise that terminated with the delivery of a ½-sec 1.0-mA electric shock. There were 4 days of CER training interspersed among the final 10 days of training. On each daily 1-h session either three signaled TO or three CER trials were given. With the exception of the TO periods, the VI food-reinforcement schedule remained in effect throughout each training session.

On the compound test day, the preextinction signal was presented during the final 2 min of the noise CS. There were three compound trials administered during the 1-h test session.

The main features of the experimental training conditions are presented in diagrammatic form in Fig. 1.

During discrimination training, responses were recorded for the 2 min preceding each TO signal, for the 2 min of the signal, and for the three 2-min periods of extinction. Similar records were obtained for the CER training and compound test phases of the experiment.

A "no-extinction" control group received the same training program as the experimental Ss, except that the VI reinforcement schedule remained in effect during the postlight period. The procedure for the "no-shock" group was identical to that of the experimental animals, except that shock was never given at the termination of the noise. There were seven experimental animals, four no-extinction, and two no-shock control Ss.

RESULTS AND DISCUSSION

A summary of the main results is presented in Table 1. The ratio scores were calculated by comparing the response rates during the 2-min signal (or for the post scores, the 2 min

*This research was supported by Grant APA-105 to the author from the National Research Council of Canada.

†The author wishes to express his thanks to Mr. Ronald Van Houten and Mr. John Wright for experimental assistance.

Table 1

Response Ratios Associated With Signals Paired With Extinction and Shock							
		Extinction (TO)		Shock		Compound	
		Signal	Post-Signal	Signal	Post-Signal	Signal	Post-Signal
Experimental	Mean	.57	.18	.01	.32	.01	.28
	Median	.58	.15	.01	.34	.00	.31
	Range	.50-.64	.01-.35	.00-.05	.09-.47	.00-.02	.04-.47
No Extinction	Mean	.54	.42	.00	.40	.00	.34
	Median	.56	.47	.00	.41	.00	.32
	Range	.49-.62	.23-.52	.00-.00	.26-.53	.00-.00	.22-.49
No Shock	Mean	.54	.08	.53	.45	.49	.10
	Median	.54	.09	.53	.46	.50	.10
	Range	.46-.62	.07-.10	.47-.59	.41-.50	.34-.65	.03-.17

immediately following the signal) with the "baseline" VI rate in effect during the 2 min preceding the signal. In the case of the 3-min noise, the last 2 min were employed for the signaled-shock and compound test ratios. The ratio score was calculated in the same way as the suppression ratio employed by Kamin (1965) and Church (1969). With such a ratio, a value of .50 indicates no effect of the signal on response rate. Higher or lower values indicate facilitation and suppression, respectively, with a score of .00 setting the lower limit for complete response suppression. The ratio scores in Table 1 are based on the three combined trials that occurred on the last day of discrimination and CER training and on the single compound test day.

As Table 1 indicates, during the final phase of discrimination training, the experimental and no-shock animals show a small response rate increase during the preextinction signal. Although this was expected on the basis of Leitenberg's (1966) work, the facilitation effect in the present instance was not significantly different from that observed with the no-extinction Ss.

All of the experimental and no-shock animals displayed a lower level of responding during the first 2 min of extinction than during the baseline period ($T = 0$, $p < .01$). Consequently, these animals had lower postsignal response ratios than the no-extinction controls ($U = 3$, $p < .05$). Thus, it would appear that by the end of the discrimination training phase, the preextinction signal had achieved some measure of discriminative control over postsignal responding.

By the final CER training day virtually complete suppression was displayed by the experimental and no-extinction animals during the last 2 min of the noise CS. The animals in these two groups also showed a small but significant attenuation in responding following the aversive

signal ($T = 2$, $p < .01$). This latter effect may have been due to the shock that was presented with the termination of the noise.

Of course, the critical data occur on the compound test day. On this day, the experimental Ss showed as much suppression during the compound stimulus as they did during earlier CER training when the CS was presented alone. Thus, there is no evidence for any preextinction response facilitation or generalization decrement of conditioned suppression. More critically, however, the response rate of the experimental Ss was relatively less inhibited following the compound stimulus than it was following the earlier presentation of the preextinction signal ($T = 4$, $p < .05$). On the other hand, the no-shock Ss showed as much postsignal suppression during the compound test as they had displayed earlier. Reference to Table 1 reveals that the ratio scores of the experimental Ss were as high following the compound, when food was not available, as they were following a CER training trial when food was available. Thus, during the compound

Fig. 1. Outline of experimental conditions.

test the postsignal ratios displayed by the experimental animals were not significantly different from those of the no-extinction controls ($U = 12$, $p < .05$), and these two groups collectively had higher scores than the no-shock control Ss ($U = 2$, $p < .05$).

It seems clear from the data that animals will fail to react to an operant signal when it is imbedded in an aversive CS. As such, these results offer support for the original hypothesis that attention to food cues is suppressed during conditioned suppression. This idea is very reminiscent of the Pavlovian phenomenon of "overshadowing," which has been recently studied by Kamin (1969) and Mackintosh (1971) in the CER situation and by Miles (1969), using an operant discrimination task. In the typical Pavlovian example of overshadowing, a strong and weak stimulus are presented together as a compound CS. Although both stimuli are potentially serving the same function, in fact conditioning occurs only to the strong element. The present experiment extends the generality of such a phenomenon by demonstrating that a stimulus controlling one motivational system may overshadow a stimulus controlling a different system. Furthermore, this occurs even though both stimuli have acquired independent control over responding as the result of previous training. Thus, conditioned suppression may be viewed as an example of overshadowing in which an animal fails to attend to "weak" food-correlated stimuli during the presentation of a "strong" aversive CS.

REFERENCES

- BROADBENT, D. E. Classical conditioning and human watch-keeping. *Psychological Review*, 1953, 60, 331-339.
- CHURCH, R. M. Response suppression. In B. A. Campbell and R. M. Church (Eds.), *Punishment and aversive behavior*. New York: Appleton-Century-Crofts, 1969.
- KAMIN, L. J. Temporal and intensity characteristics of the conditioned stimulus. In W. K. Prokasy (Ed.), *Classical conditioning*. New York: Appleton-Century-Crofts, 1965.
- KAMIN, L. J. Selective association and conditioning. In N. J. Mackintosh and W. K. Honig (Eds.), *Fundamental issues in associative learning*. Halifax: Dalhousie University Press, 1969.
- LEITENBERG, H. Conditioned suppression and conditioned acceleration in pigeons. *Journal of the Experimental Analysis of Behavior*, 1966, 9, 205-212.
- LYON, D. O. Conditioned suppression: Operant variables and aversive control. *Psychological Record*, 1968, 66, 688-694.
- MACKINTOSH, N. J. An analysis of overshadowing and blocking. *Quarterly Journal of Experimental Psychology*, 1971, in press.
- MILES, C. G. A demonstration of overshadowing in operant conditioning. *Psychonomic Science*, 1969, 16, 139-140.