SOME RELATIONS BETWEEN CLASSICALLY CONDITIONED AGGRESSION AND CONDITIONED SUPPRESSION IN SQUIRREL MONKEYS

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During three experiments with squirrel monkeys, stimulus and shock pairings were given in the presence of a bite tube. Experiments 1 and 2 used a conditioned-suppression procedure in which bar pressing was reinforced with food. A transparent shield prevented biting of the bar. When the stimulus was paired with shock, bar pressing decreased (conditioned suppression) and tube biting increased during the stimulus (classically conditioned aggression). When the bite tube was removed on alternate sessions in Experiment 2, there was more suppression when the tube was present, thus suggesting that biting competed with bar pressing. However, this simple competing-response interpretation was complicated by the findings of Experiment 3 where, with naive monkeys, bar pressing was never reinforced with food, yet bar pressing was induced during the stimulus and was highest when the bite tube was absent. The fact that stimulus-induced bar pressing developed indicates that bar pressing in conditioned-suppression procedures, suppressed or not, may be maintained by two types of control—the food reinforcer and induced CS control. The higher rate of induced bar pressing during the stimulus with the bite tube absent confounds a simple competing response interpretation of conditioned suppression. It suggests that shock-induced responses during conditioned suppression could be both contributing to and competing with responding maintained by food, with the net effect depending on specific but ill-defined features of the situation.

Key words: conditioned suppression, aggression, classically conditioned aggression, competing response, displacement, biting, monkeys

Recent experiments have shown that aggressive responding is classically conditionable in fish (Adler & Hogan, 1963; Thompson & Sturm, 1965), rats (Creer, Hitzing, & Schaeffer, 1966; Farris, Gideon, & Ulrich, 1970; Lyon & Ozolins, 1970; Vernon & Ulrich, 1966), and monkeys (Hutchinson, Renfrew, & Young, 1971). Although these effects have not always been strong (e.g., see Dunham & Carr, 1976), a conditioned stimulus (CS) that was followed by an unconditioned aversive stimulus (UCS) such as electric shock gradually came to produce aggressive responding similar to the aggressive responding that had initially occurred only after the UCS. Experiment 1 evaluated the possibility that aggressive responding might also develop along with conditioned suppression of a positively reinforced operant response by giving squirrel monkeys access to

a bite tube as a target of aggression (Hutchinson, Azrin, & Hake, 1966) in addition to the operandum.

If the CS that was followed by shock produced both aggressive responding and suppression of the food-reinforced response, aggressive responding could be added to the list of responses, such as changes in heart rate (de Toledo & Black, 1966; Stebbins & Smith, 1964), defecation, and freezing (Brady & Conrad, 1960; Hunt & Brady, 1955; Hunt & Otis, 1953), that have been found to be correlated with conditioned suppression. According to a competing-response explanation of conditioned suppression, such conditioned responses interfere with the ongoing operant response (see reviews of conditioned suppression by Blackman, 1977; Davis, 1968; and Lyon, 1968). To examine the competing-response notion, the hypothesized competing responses must be manipulated to determine if they affect the degree of conditioned suppression. Experiment 2 compared the extent of conditioned suppression during alternate sessions with and without the bite tube. (The monkeys were prevented from biting the bar.) If biting did develop during the CS, and if more suppression of

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operant behavior (bar pressing) occurred when the bite tube was available, then aggressive responding might be designated a competing response.

However, the simple competing-response interpretation cannot be accepted until the research shows that the tube biting was actually competing with bar pressing maintained by the food reinforcer instead of competing with bar pressing that may have been induced by the conditioned suppression procedure itself (i.e., the same operations that produced the biting). Experiment 3 attempted to determine if a CS paired with shock would induce bar pressing, and, if so, what would be the effect on that induced bar pressing of having an aggressive target (bite tube) present and absent. The subjects in Experiment 3 were naive monkeys for whom bar pressing was never reinforced with food. The development of bar pressing during the CS would indicate the response inductive characteristics of the CS. Further, the observation of more induced bar pressing when the bite tube was absent would suggest that aggressive biting was redirected or "displaced" to bar pressing and raise the possibility that the CS of a conditioned suppression procedure might also induce displaced bar pressing when no aggressive target is available. If so, the present experiments taken together would show greater conditioned suppression when there is classically conditioned tube biting during the CS, but they would also question the extent to which tube biting during conditioned suppression competed with bar pressing maintained by food or competed with induced and displaced bar pressing. The latter possibility would confound the simple explanation of conditioned suppression in terms of competing aggressive responses. It would also suggest providing an aggressive target alternative to permit a cleaner observation of suppression of food-reinforced behavior.

EXPERIMENT 1 THE DEVELOPMENT OF AGGRESSIVE RESPONDING DURING THE CS+ OF A CONDITIONED SUPPRESSION PROCEDURE

To determine if aggressive responding would develop during the CS+ of a condi-

tioned-suppression procedure, squirrel monkeys were provided with a bite tube as a target for aggression in addition to the operandum.

METHOD

Subjects and Apparatus

Five naive squirrel monkeys, deprived to 80% of free-feeding body weight, were tested in one of two nearly identical restraining chairs equipped with tail-electrodes (Hake & Azrin, 1963). The monkeys were restrained in the seated position and prevented from reaching the tail-electrodes by a horizontal waistlock that extended to the walls of the chamber. Electric shock was delivered to the monkey's tail, immobilized by a tail stock, through two brass electrodes that rested on a shaved portion of the tail. To insure a low resistance electrical contact, the shaved portion of the tail was coated with electrode paste (EKG-Sol). The 60-Hz shock lasted 75 msec and was delivered across the tail electrodes through a 10k-ohm series resistor. Since current levels changed in nearly direct proportion to voltage changes over the range of shock intensities used, shock levels were specified as voltages at the secondary coil of the transformer.

The monkeys were free from the waist up. The work space above the horizontal waistlock was 20 cm wide, 30 cm long, and 25 cm high. The response bar was located on the front wall 5 cm to the left of center, 8 cm above the waistlock, and about 12 cm from the seated monkey. The 2.5-cm-wide response bar protruded 1.2 cm from the wall. A downward force of 5 g (.049 N) defined a response and produced a click. The monkey was prevented from biting the bar by a plastic shield about 1 cm away from the response bar and surrounding it. Because the end of the bar was flush with the shield, the monkey had to put his hand under the shield to press the bar. A 1.9-cm-diameter Gerbrands pigeon key was used with Monkey 3 instead of the bar. It was located 5 cm below the bar and recessed .5 cm into the wall. About 5 g (.049 N) of force operated the key and briefly terminated the light that otherwise illuminated the key. The key was covered when the bar was in use by another monkey, and the bar was removed when the key was in use by Monkey 3.

The liquid food reinforcer (Ellison & Riddle, 1961) was available for 3 sec in a .15-ml dipper located to the right of the seated mon-

key. During access to food, the dipper was illuminated while the two 6-W overhead lights and all stimulus lights were off. Water was continuously available from a water spout which protruded about 1 cm from the left wall.

The bite tube (Hutchinson et al., 1966), a 12.7-cm-long rubber hose with a 1.5-cm diameter, was positioned in front of the monkey 5.5 cm above the bar and protruding 4 cm from the front wall. The bite tube was connected to a pneumatic switch calibrated to record pressures over 2 mm Hg, the pressure that has been shown to record biting responses but not other contacts (Hutchinson et al., 1966).

The CS+ and CS- consisted of compound visual and auditory stimuli. The CS+ was a 1.2-cm-diameter red light located midway up the front wall to the left of the seated monkey and a click rate of either 2 or 9 per sec. The CS- was a 1.2-cm-diameter orange light located on the opposite side of the front wall and a click rate of 9 or 2 per second.

Procedure

The conditioned-suppression procedure was basically the same for each monkey, but there were some differences between monkeys to increase low response rates (i.e., schedule of reinforcement), to insure conditioned suppression (i.e., highest shock intensity), and for purposes of systematic replication (e.g., key vs. bar, duration of CS+, click rate). The procedures of Experiments 1 and 2 are summarized for each monkey in Table 1.

A variable-interval (VI) schedule of food reinforcement and the bar shield (Table 1) were introduced after the bar press or key press had

been shaped. The monkeys had at least 8 1-hr sessions on the VI schedule that was in effect during the experiment (Table 1). In order to increase low response rates, some of the subjects in Experiments 1 and 2 were run on tandem schedules with a fixed-ratio 3 (FR 3) requirement going into effect after the variable interval timed out. Because the reinforcers were scheduled at variable intervals, these tandem schedules will be designated as VI except in Table 1.

The CS+ and CS- were presented according to separate variable-time (VT) 10-min schedules. These stimuli lasted 40 or 60 sec and were presented 4 times over 1 hr or 9 times over 2 hr (Table 1). Because of the duration of CS+ and CS- and the equivalent pre-CS time period before each presentation, the VT 10-min schedules spread the CS+ and CS- fairly evenly over the session.

Shock occurred only at the end of CS+: shock was never paired with CS- or with the absence of both CS+ and CS-. To evaluate any unconditioned effects of the CS+ and CS-, 10 to 20 sessions were conducted without shock. The bite tube was present during these sessions. Next, shock was presented at the end of CS+ and was increased in 100-V steps, from 100V to 200V or 300V. A given intensity remained in effect for a minimum of 5 sessions at 100V and 200V and a minimum of 10 sessions at 300V.

The schedule of food reinforcement was in effect throughout the session. For the three monkeys (M-1, M-2, and M-5) tested in the second chair, there were separate but identical schedules of reinforcement in the presence

Table 1

Summary of procedures for each monkey during Experiment 1 (first row for each monkey) and Experiment 2 (second row for each monkey). More than one value for a parameter during an experiment indicates a change for that parameter. (e.g., 0, 100, 200 for shock intensity indicates increases in shock intensity). No entry for Experiment 2 means no change from Experiment 1.

Monkey	Schedule of reinforcement	Sessions	Bar shield	COD (secs)	Duration of CS+ and CS- (secs)	CS+ & CS- /session	CS click	Shock intensity (volts)
1	Tandem VI 2 FR 3	26	yes	3	40	9	Fast	0, 100, 200, 300
		32						300
2	VI 1	26	yes	3	60	4	Fast	0, 100, 200
	Tandem VI 2 FR 3	31			40	9		400
3	VI 2	22	no(key)	no	60	9	Slow	0, 100, 200
		71	no, yes	12, 2				200, 320
4	VI 2	29	no	12	60	9	Slow	0, 100, 200
		47	no, yes	12, 2			Fast	200
5	VI 1	27	yes	3	60	4	Fast	0, 100, 200
	Tandem VI 2 FR 3	34				9		300

and the absence of CS+, so that reinforcers scheduled but not obtained during one CS+ were available during the next CS+. This minimized differences in reinforcement frequency between CS+ and non-CS+ components that might result from suppression during CS+. A changeover delay (COD) between a bite and food was used with 4 subjects, and it lasted 3 sec or 12 sec (Table 1).

Results

Figure 1 shows the rate of biting during CS+ and CS- during the initial exposure to the conditioned-suppression procedure. Immediately or soon after the introduction of shock, biting either developed or increased substantially, and it occurred predominantly in the CS+. The higher rate of biting in CS+ relative to CS- became more evident with continued exposure to the procedure. Prior to shock introduction, three subjects (M-2, M-3, and M-4) had never bit the tube. Following shock introduction, biting started during the 8th CS+ presentation in the 1st session for M-3, during the 2nd session for M-4, and during the 7th session for M-2. For M-1 and M-5, biting had occurred at low rates prior to the introduction of shock but increased immediately following shock introduction and became differentiated with respect to CS+ and CS- within 2 (M-1) and 5 (M-5) sessions.

The average rate of biting during the pre-CS+ and CS+ for the last 5 sessions at each shock intensity are shown in the left-hand columns of Table 2. Although shock introduction affected biting throughout the session, as evidenced by increases in biting during the pre-CS+ at 100V, biting was eventually substantially higher during the CS+. As indicated in Figure 1, the absolute rates of biting during CS- were much lower than during CS+ while the rates of biting during Pre CS- (not shown) were about the same as during Pre CS+.

Figure 2 shows the effects of the CS+ and CS- upon the rate of bar or key responding using a suppression ratio of $A/(A+B)$, where A is responses per minute during the stimulus (CS+ or CS-) and B is the responses per minute during the equivalent period of time prior to the stimulus (pre-CS+ or pre-CS-). Before shock introduction there was usually a slight facilitation during CS+ and CS-, as indicated by the ratios higher than .5. After introduction of shock, consistent suppression

Table 2

Mean number of bites per minute and bar or key responses per minute during pre-CS+ and CS+ for the last five sessions at each shock intensity

Subject	Volts	Bites per min.		Bar or key responses per min.	
		Pre-CS+	CS+	Pre-CS+	CS+
M-1	0	.1	0	51.2	52.3
	100	1.2	29.1	39.2	4.2
	200	.3	17.1	33.0	8.2
	300	.5	8.7	26.0	14.0
M-2	0	0	0	5.6	4.8
	100	0	8.6	2.7	2.2
	200	0	7.1	4.3	1.3
M-3	0	0	0	13.5	16.5
	100	5.3	13.6	6.7	.0
	200	8.2	14.9	5.1	.1
M-4	0	0	0	29.3	42.2
	100	4.5	34.7	14.6	4.9
	200	4.3	40.0	21.1	1.5
M-5	0	6.7	6.9	7.1	7.1
	100	21.0	27.0	3.3	5.9
	200	19.4	41.5	3.3	1.5

developed during the CS+ within 1 or 2 sessions for monkeys M-1, M-3, and M-4, after 8 sessions for M-2, and after the shock intensity was increased to 200V for M-5. The fact that suppression developed in M-2 at about the same time that biting appeared (see Figure 1) suggested a relationship between biting and suppression. Although there were occasional sessions with generalization of suppression to the CS-, particularly during the early sessions with shock, the suppression ratios for CS- at the highest shock intensity were similar to those prior to shock.

The mean absolute rates of bar or key responding during the pre-CS+ and the CS+ are given for the last 5 sessions at each shock intensity in the right-hand columns of Table 2. A comparison of the pre-CS+ response rates prior to shock and at all shock values indicates that shock reduced responding in the absence of CS+ as well as during it. Such general reductions in responding are common in studies of conditioned suppression (e.g., Annau & Kamin, 1961; Hake & Azrin, 1965; Hake, Powell, & Olsen, 1969). However, Table 2 also shows that at the highest shock intensity, responding was suppressed for all subjects during the CS+ relative to the pre-CS+. Slight facilitation or equal rates occurred during the CS- relative to the pre-CS- (Figure 2) at the highest shock intensity.

Fig. 1. Bites per minute during CS+ and CS- at each UCS intensity in the conditioned suppression procedure of Experiment 1.

Fig. 2. Suppression ratio for bar pressing during CS+ and CS- at each UCS intensity in the conditioned suppression procedure of Experiment 1. The suppression ratio is $A/(A+B)$, where A is response rate during the stimulus and B is the response rate during an equivalent period of time immediately before the stimulus.

EXPERIMENT 2 THE EFFECTS ON CONDITIONED SUPPRESSION OF PROVIDING A SEPARATE TARGET FOR AGGRESSIVE RESPONDING

Experiment 2 determined whether the availability of a separate target for aggressive responding would increase the suppression of bar pressing during CS+. This was evaluated by arranging alternate sessions both with and

without the bite tube for at least 30 daily sessions during conditioned suppression with a high shock intensity.

METHOD

For M-1, Experiment 2 began immediately after Experiment 1. For the other four monkeys, changes in the schedule of reinforcement, CS, COD, and shock intensity preceded Experiment 2. For M-2 and M-5 the changes were slight (e.g., schedule of reinforcement and

shock intensity), and Experiment 2 started within 15 sessions of the end of Experiment 1. The major features of the procedure and the number of sessions that the presence and absence of the tube was alternated for these subjects as well as the others are shown in Table 1.

For M-3 and M-4 there were larger procedural changes, so that more time elapsed (80 to 160 sessions) between Experiments 1 and 2. For M-4, shock was terminated for several sessions during which time the CS+ and CS- click stimuli were reversed. Shock was then reintroduced and increased to a high intensity before Experiment 2 started. For M-3 shock was also terminated for several sessions while bar pressing was shaped to replace key pressing. There were further changes during Experiment 2 for M-3 and M-4 (see Table 1). These two monkeys did not have a bar-shield from the outset, and the changeover delay was longer (12 sec) than for the other subjects. The shorter changeover delay and the bar-shield were introduced after several sessions in Experiment 2 (shown on Figure 3). For M-4 shock was subsequently increased to 320V for several sessions (Figure 3).

RESULTS

Figure 3 shows that, for four of the five subjects, conditioned suppression of bar pressing was more severe when the bite tube was present. This effect endured for the 35 to 60 sessions of Experiment 2. For monkeys M-3 and M-4, reduction in the COD (a in Figure 3) or an increase in shock intensity (b in Figure 3) did not alter the major effect. That the more severe suppression with the bite tube present was due to decreases in CS+ bar-pressing rates rather than increases in Pre-CS+ bar-pressing rates can be seen in Table 3. Table 3 shows the average rates of bar pressing during CS+ and Pre-CS+ for the alternation sessions of Figure 3. For the four subjects that showed the effect, bar-press rates during the CS+ were lowest when the bite tube was present. This was also true for Monkey 5 who did not show any consistent indication of suppression whether the bite tube was present or absent. For all monkeys there was slight facilitation of bar pressing during the CS- relative to the pre-CS- (not shown), and the facilitation was greater when the bite tube was absent.

Figure 4 shows the mean absolute rates of biting and bar pressing during successive

Table 3

Mean number of bar responses per minute during pre-CS+ and CS+ for sessions that the bite tube was alternately present and absent

<i>Subjects & condition</i>	<i>Sessions</i>	<i>Pre-CS+</i>	<i>CS+</i>
M-1			
Present	16	27.9	16.3
Absent	16	26.6	21.6
M-2			
Present	16	19.3	1.2
Absent	15	19.8	5.0
M-3			
Present	16	7.7	1.2
Absent	17	8.4	4.5
M-3(a)			
Present	12	7.1	3.3
Absent	12	6.2	4.9
M-3(b)			
Present	7	8.8	4.9
Absent	7	8.0	9.6
M-4			
Present	13	11.6	.6
Absent	14	12.7	5.1
M-4(2)			
Present	10	13.2	.7
Absent	10	12.3	9.1
M-5			
Present	17	7.6	7.0
Absent	17	13.2	13.0

Note: (a) Change-over delay reduced from 12 to 2 seconds and bar shield added

(b) Shock intensity increased from 200 to 320V.

quarters of CS+ for the last 10 sessions that the presence and absence of the bite tube were manipulated. The bottom half of Figure 4 shows that the rate of bar pressing was lower during all four quarters when the tube was present. This was true for all five subjects including M-5, the subject for whom suppression was not evident in Figure 3. As has been shown previously (e.g., Millenson & Hendry, 1967), bar pressing during CS+ declined from the beginning to the end of CS+ whether the bite tube was present or absent. Biting during successive quarters of CS+ (top half of Figure 4) declined for three monkeys (M-2, M-3, and M-4).

The rate of tube biting during the CS+ increased 20 (M-1) to 70 (M-4) responses per min over pre-CS+ biting rates for M-1, M-2, M-3, and M-4. On the other hand, for M-5 (the one monkey that did not show differential suppression in Figure 3 as a function of the presence and absence of the bite tube), the rate of biting in the Pre-CS+ and CS+ were about the same

Fig. 3. The suppression ratio during CS+ is shown separately for the alternate sessions that the bite tube was either present or absent in the conditioned suppression procedure of Experiment 2. For M-3 and M-4, the bar shield was added and the COD reduced from 12 to 2 sec at "a." For M-3, the UCS intensity was increased from 200 to 320V at "b." Table 1 gives the parameter values for all subjects. With the exception of Monkey 5, there were 5 consecutive sessions with the tube present before and after or just after (Monkey 2) Experiment 2.

(28 per min). Hence, the lower rate of bar pressing during both CS+ and pre-CS+ when the bite tube was present could be attributed to the fact that M-5 bit the tube fairly continuously through the session when it was available.

Smaller increases in biting of .5 (M-1) to about 17 (M-3) responses per min occurred from the pre-CS- to the CS- for all monkeys except M-2 who showed a decrease.

Although bar pressing rates were reduced during CS+, all subjects obtained reinforcers

Fig. 4. Rate of biting (top) and bar pressing (bottom) during successive quarters of CS+ for the last 10 sessions that the presence and absence of the bite tube was alternated in Experiment 2. Biting is shown for the last 5 sessions with the bite tube. The rate of bar pressing is shown for the last 5 sessions the tube was absent and the last 5 sessions the tube was present.

during CS+ regardless of the presence or absence of the bite tube or the duration of the COD. For four subjects (M-1, M-2, M-3, and M-5), reinforcers were counted during the CS+ and the resulting rates of reinforcement were .4 to .5 per min (relative to the programmed .5 per min) whether the tube was present or absent. Only M-2 showed a marked decrease in reinforcement density to .1 reinforcer per min when the bite tube was present.

EXPERIMENT 3 THE DEVELOPMENT OF CS+ INDUCED BAR PRESSING INCLUDING DISPLACED AGGRESSIVE RESPONDING

If tube biting during the CS+ is to be viewed as a competing response, it must interfere with bar pressing maintained by the food reinforcer rather than interfere with bar pressing induced by the conditioned suppression procedure itself (i.e., the same drive operations

that produced the biting). The present experiment determined whether a CS paired with shock would induce bar pressing and, if so, what would be the effect on bar pressing of the presence and absence of a target for biting. A previous study of escape from shock showed that removal of the aggressive target resulted in displacement of aggressive responding to bar or key pressing (Hake & Campbell, 1972).

The subjects in the present experiment were naive monkeys for whom bar pressing was never reinforced with food. The induction of bar pressing by the CS+ would be indicated by a higher rate of bar pressing in the presence than in the absence of CS+, while bar pressing that is redirected or displaced aggressive responding would be indicated by a higher rate of bar pressing when the bite tube was absent than when it was present. These effects would question the extent to which tube biting during conditioned suppression competed with bar pressing maintained by food reinforcement or "competed" with induced and displaced bar pressing.

METHOD

Subjects and Apparatus

Ten squirrel monkeys, nine naive and one (M-5) from the previous experiment, were maintained at free-feeding body weights and tested in one of the two chambers. Monkeys 5, 8, 9, 11, 12, and 13 were tested in the first chamber, and Monkeys 6, 7, 10, and 14 were tested in the second chamber.

Since there were no food reinforcers in Experiment 3, a neck yoke (Hutchinson et al., 1966) instead of the bar shield was used to prevent bar biting. The neck yoke allowed the monkey to bite the bite tube, but prevented the monkey from bending his head as low as the bar and biting it. The only other apparatus change was that the response bars now extended 3 cm into the chamber instead of 1.2 cm. Other features of the chambers, including the bite tube and stimulus lights, remained the same.

Procedure

The CS+ consisted of illumination of the red stimulus light and a click rate of 9 per sec, and the CS- consisted of illumination of the orange stimulus light and a click rate of 2 per sec. Each CS presentation lasted 60 sec for the 6 monkeys tested in the first chamber and 40 sec for the 4 monkeys tested in the second chamber.

The basic procedure was essentially the same as in Experiments 1 and 2, except that no food reinforcers were provided. Sessions lasted 2 hr, during which time the CS+ and the CS- were each presented 9 times according to VT 10-min schedules. Sessions without shock occurred prior to the introduction of shock and after the series of shock sessions. Shocks lasted .1 sec. The bite tube was available on alternate sessions.

A minimum of 10 sessions, 5 with the tube and 5 without the tube, occurred at the 2 shock intensities (200V and 320V) and at the initial no-shock condition. Each condition ended when there was no consistent increase or decrease in bar presses and bites over sessions and over a given type of session (i.e., tube present or tube absent). The mean number of sessions at each condition was 16, with a range of 10 to 30. A minimum of 20 sessions without shock was provided to allow responding to return

to its initial level at the conclusion of the experiment. Additional sessions were provided if there appeared to be any consistent trend in responding. Two monkeys completed less than 20 sessions without shock (M-8 and M-10), because all responding had ceased. For those monkeys with at least 20 sessions, the mean number was 28 with a range of 20 to 44.

RESULTS

Figure 5 shows the average rates of bar pressing during CS+ for the last 5 sessions when the bite tube was present and absent at the successive shock intensities. Near zero rates were typical of the naive monkeys during the initial no-shock condition. Only the one monkey, M-5, that was also used in Experiments 1 and 2, bar pressed during the CS+ in the first no-shock condition. During the shock conditions, however, bar pressing developed for all monkeys and the rates were higher when the bite tube was absent for all monkeys except Monkey 6 at 320V and Monkey 10 at both shock values.

Table 4 shows the pre-CS+ and the CS+ rates of bar pressing with the tube present and absent. With the exception of subject M-9, the bar pressing rates were higher during CS+ than at other times during the session. During the shock conditions, M-9 had a high bar-pressing rate outside CS+ which was suppressed during CS+. There was less suppression during CS-. Hence, for this monkey shock sessions induced bar pressing that was not differentially confined to the CS+ periods. With the exception of this monkey and M-14, the two monkeys with the highest rates of bar pressing, the response rates in CS- (not shown) were generally negligible and ranged from 0 to .5 per min. For Monkey 14, CS- rates were also lower (e.g., at 320V the rate during CS- was 8.4 compared to 60.5 during CS+). These data taken together indicate that (a) bar pressing can be induced by introducing shock (all 10 monkeys); (b) bar pressing is highest during CS+ (9 of 10 monkeys, exception M-9); (c) bar pressing is mainly confined to the CS+ (8 of 10 monkeys, exceptions M-9 and M-14); and (d) bar pressing during the CS+ is more frequent when a separate aggressive response (biting) is not possible (8 of 10 monkeys, exceptions M-10 and M-6 at 320V).

Fig. 5. The average rate of bar pressing during CS+ is shown separately for the alternate sessions that the bite tube was either present or absent at each UCS intensity in Experiment 3. The average rate for the last 5 sessions with the tube present and absent is shown for each shock intensity. Bar pressing was not reinforced with food in Experiment 3.

Figure 6 shows the pattern of bar pressing across successive quarters of the CS+ for the last 5 sessions with the bite tube present and the last 5 sessions with the bite tube absent at each shock intensity. Again, Figure 6 shows that bar responding was higher when the tube was absent except for M-6 at 320V and M-10 at both shock intensities. A second noteworthy feature is the frequent pattern of increasing bar pressing over the duration of the CS+. Two monkeys (M-13 and M-5) never showed the increasing pattern across the CS+ but the rest showed an increasing pattern for at least one shock intensity across all 4 cells (M-8,

M-6, M-12, M-9, M-10), the first 3 cells (M-14, M-7), or the last cell (M-11). These patterns are similar to those induced in key pressing (Hake & Campbell, 1972) and bar pressing (Hake & Campbell, 1972; Hutchinson et al., 1971) between shocks scheduled at fixed-time intervals.

The pattern of biting across successive quarters of CS+ for the last 5 sessions without shock and at 320V is shown in Figure 7. With the exception of M-5, the subject continued from Experiments 1 and 2, there was little biting during the first no-shock condition. At 320V, CS+ induced biting for all monkeys except M-10

Table 4

Bar presses per minute during Pre-CS+ and CS+ with bite tube present and absent.

Shock intensity (volts)	Subject	Bar response/min.			
		Tube present		Tube absent	
		pre-CS+	CS+	pre-CS+	CS+
0	M-5	0	.1	1.0	2.9
200		.1	0	.7	1.8
320		.1	.1	1.3	6.9
0		.1	.3	.1	.9
0	M-6	0	0	.1	.1
200		0	35.5	0	48.4
320		.1	7.8	.2	5.9
0		.2	3.1	.3	.6
0	M-7	0	0	0	0
200		0	3.1	0	5.7
320		0	.2	0	.1
0		0	0	0	0
0	M-8	0	0	0	0
200		0	.2	0	.5
320		0	1.0	0	2.1
0		0	0	0	0
0	M-9	.3	.3	.6	.3
200		11.5	5.2	14.6	6.2
320		29.8	6.1	31.1	8.2
0		61.1	25.3	56.7	21.1
0	M-10	0	0	.8	1.1
200		0	19.1	.1	17.4
320		0	14.0	0	13.4
0		0	0	0	0
0	M-11	0	0	.5	1.0
200		0	4.5	.1	15.3
320		0	5.7	.1	20.2
0		.1	3.2	.5	4.5
0	M-12	.2	.9	.2	.6
200		.1	1.2	.2	1.6
320		0	5.7	0	7.4
0		.2	.1	.1	.2
0	M-13	.1	.1	0	.3
200		.2	1.8	.1	6.9
320		.1	1.9	.1	3.9
0		0	0	0	.4
0	M-14	0	0	.2	.4
200		.3	.3	3.5	7.3
320		4.0	18.6	16.4	60.5
0		7.7	2.9	9.8	15.2

that seldom bit the tube and M-8 that never bit the tube. The fact that monkeys M-8 and M-10 did not bite the tube explains why removing the bite tube had no (M-10) or little (M-8) effect on bar pressing for these monkeys.

Of the 10 monkeys, 5 showed a decreasing pattern of biting during CS+ (M-7, M-5, M-14, M-13, and M-6). On the other hand, biting increased for M-9. These patterns of biting during the CS+ are similar to those attained between shocks that are scheduled at fixed

times when both a bite tube and a key or bar are available; a decrease in biting from the beginning to the end of the intershock interval is the most frequent pattern but examples of increases also occur (Hake & Campbell, 1972; Hutchinson et al., 1971).

For all monkeys except M-8 and M-10 who did not bite the tube, the rate of biting increased from the pre-CS+ (means of 4.2 and 3.9 bites per min at 200V and 320V respectively) to CS+ (means of 13.3 and 16.2 bites per min at 200V and 320V respectively) and there was more biting during CS+ than CS- (mean of 4.1 and 5.5 bites per min at 200V and 320V respectively).

The durability of the biting and bar pressing after shock removal is also noteworthy. Pre-shock levels were exceeded in both biting and bar pressing (M-14 and M-6), or biting alone (M-7, M-5, M-12) or bar pressing alone (M-13, M-11, M-9). Only M-8 and M-10 responded at preshock levels in both biting and bar pressing.

DISCUSSION

Classical conditioning of aggression during the CS+ of a conditioned suppression procedure was demonstrated in Experiment 1 by (a) a higher rate of biting during the CS+ than during an equivalent period of time prior to the CS+ (Pre-CS+), and (b) a higher rate of biting during the CS+ than during an equivalent period of time with a similar stimulus (CS-) that was never paired with shock. Pairing the CS+ with shock reduced the rate of bar pressing during the pre-CS+ as well as during the CS+ (see also Annau & Kamin, 1961; Hake & Azrin, 1965; Hake et al., 1969; Hunt & Brady, 1955), but the reduction during the CS+ qualified as conditioned suppression, because (a) there was a lower rate of bar pressing during the CS+ than during the Pre-CS+ as indicated by the suppression ratio, and (b) there was generally no suppression or even slight facilitation during the CS-.

The possibility that biting might be competing with bar pressing and thereby enhancing the conditioned suppression effect was initially suggested by (a) the substantial rates of biting during the CS+ (17, 7, 15, 40, and 42 bites per min for Monkeys 1 to 5 respectively at 200V) and (b) the fact that conditioned suppression did not develop for one subject

Fig. 6. Bar presses per minute during successive quarters of CS+ at each UCS intensity in Experiment 3. The average of the last 5 sessions with the tube present and absent is given for each UCS intensity.

(M-2) until the 8th session, when substantial biting also developed. This possibility was evaluated in Experiment 2 by having the bite tube present or absent on alternate daily sessions. Consistently more conditioned suppression occurred in 4 of the 5 subjects when the bite tube was present. The 1 subject that showed little difference in suppression depending on the presence and absence of the tube did bar press at much lower absolute rates when the tube was present. However, this monkey bit the tube about as much in the absence of

the CS+ as during the CS+, thus precluding much effect of biting on the suppression ratio.

For tube biting during the CS+ to qualify as a competing response, tube biting had to interfere with bar pressing maintained by the food reinforcer rather than interfere with the bar pressing that was induced by the conditioned suppression procedure itself (i.e., by the same drive operations that produced the biting). An important feature of the procedure in this respect was the bar shield that prevented biting the bar; otherwise, the higher

Fig. 7. Average bites per minute during successive quarters of CS+ for the last 5 sessions prior to shock, at the highest UCS intensity, and after shock had been discontinued in Experiment 3.

rates of bar pressing with the tube absent could have been due to biting the bar (e.g., see Azrin, Hutchinson & Hake, 1967; Hake & Campbell, 1972; Pear, Moody & Persinger, 1972; Powell & Peck, 1969). Even though the bar shield prevented the monkeys from biting the bar, the possibility remained that some of the bar pressing during the CS+ with the tube absent was displaced aggressive responding. For example, Hake and Campbell (1972) prevented any contact of the mouth of the monkey with a response key but found that removal of a bite tube during an intermittent-shock procedure resulted in an increase in key presses that either terminated shock according to a fixed-interval schedule or had no effect on the shocks. If this were the case, the higher rates of bar pressing with the tube absent in Experiment 2 could be attributed, at least in part, to bar pressing that was induced by the CS+. Experiment 3 determined whether the CS+ of a conditioned-suppression procedure could induce bar pressing and, if so, what the effect on bar pressing during the CS+ would be with the bite tube present and absent in naive monkeys with no history of food reinforcement for bar pressing. Pairing shock with a stimulus in Experiment 3 indicated that (a) bar pressing could be induced by introducing shock (all 10 monkeys), (b) induced bar pressing is mainly confined to the CS+ (8 of 10 monkeys), (c) induced bar pressing is highest during the CS+ (9 of 10 monkeys), and (d) induced bar pressing during CS+ is more frequent when a separate aggressive response is not possible (8 of 10 monkeys). With no operant reinforcement to produce and maintain bar pressing and without the bite tube to bite, the development of more bar pressing with the tube absent may be in part attributed to displaced aggressive responding. Experiments 2 and 3 taken together show more conditioned suppression when classically conditioned biting develops on a separate target, but they raise questions as to the extent to which the biting of a separate target competes with bar pressing maintained by food reinforcement, the presumed suppressed response, or competes with induced and displaced bar pressing. The results of Experiment 3 confound the simple explanation of conditioned suppression in terms of competing aggressive responses and suggest that evaluation of conditioned suppression without an alternative aggressive target will under-

estimate the degree of conditioned suppression because of the possibility of induced and displaced aggressive responding on the operandum. In fact, the induced bar pressing may explain the trickle of responses that sometimes remain during the CS+ of a conditioned suppression procedure even when responding outside the CS+ is also reduced to a near zero level.

Two aspects of the data from Experiment 3 also question whether all of the induced bar pressing was displaced aggressive responding: (a) some bar pressing was observed even when the bite tube was present, and (b) bar pressing occasionally had an increasing pattern over the CS+. Another possibility is that some of the induced bar pressing was related to other types of responding such as avoidance. Previous experiments have shown an increase in responses with an avoidance history during the CS+ of a negative conditioned suppression procedure (Herrnstein & Sidman, 1958; Sidman, 1958; Sidman, Herrnstein, & Conrad, 1957) and have shown that these responses have a positively accelerated pattern between shocks even when they produce shock according to a fixed-interval schedule (e.g., Byrd, 1969; Kelleher, Riddle & Cook, 1963; McKearney, 1968; Morse, Mead, & Kelleher, 1967). Also, the CS+ of a conditioned-suppression procedure may induce several types of responses, and these responses may differ in the extent to which they interfere with ongoing responses maintained by food reinforcement (see review by Blackman, 1977). For example, Hutchinson and Emley (1977) have found that shocks can induce drinking: biting occurred first after shock, but licking increased soon after the biting had decreased. It may be worthwhile to determine whether induced licking and other types of responses induced by the CS+ increase or interfere with bar pressing. The present results, which question a competing-response interpretation of conditioned suppression in terms of aggressive responses, may not extend to all other responses, because aggressive responses may differ from other potential competing responses in that they are directed toward targets. Other induced responses (e.g., crouching) may not be directed toward targets or for other induced responses (possibly licking), the target may be more specific than is the case for aggressive behavior. For example, future research could reveal that an

induced response such as licking is a competing response if (a) licking was directed toward a lick tube and there was more suppression when the tube was available, but (b) licking was not displaced to the response bar when the lick tube was unavailable. Aggressive responding in this experiment met the first criterion but not the latter.

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