REFERENCES

- ANDERSON, D. C. Higher-order conditioning in the infrahuman organism: Implications for response analysis, motivation theory, and a human model. *Journal of Utah Academy of Letters, Arts and Sciences*, 1968.
- ANDERSON, D. C., PLANT, C., JOHNSON, D., & VANDEVER, J. Second-order aversive classical conditioning. *Canadian Journal of Psychology*, 1967, 21, 120-131.
- ANDERSON, D. C., PLANT, C., & PADEN, P. Conditioned suppression of a running response as related to competing responses, drive, and basal skin resistance level. *Journal of Comparative & Physiological Psychology*, 1967, 63, 282-287.
- BROGDEN, W. J. Higher-order conditioning. *American Journal of Psychology*, 1939, 52, 579-591.
- BROGDEN, W. J., & CULLER, E. Experimental extinction of higher-order responses. *American Journal of Psychology*, 1935, 47, 663-669.
- BROWN, J. S., KALISH, H. I., & FARBER, I. E. Conditioned fear as revealed by magnitude of startle response to an auditory stimulus. *Journal of Experimental Psychology*, 1951, 41, 317-328.
- DAVENPORT, J. W. Higher-order conditioning of fear. *Psychonomic Science*, 1966, 4, 27-28.
- ECCHER, W., & CULLER, E. Reciprocal facilitation of the conditioned and conditioning mechanisms. *Journal of Comparative Psychology*, 1941, 31, 223-231.
- FINCH, G., & CULLER, E. Higher-order conditioning with constant motivation. *American Journal of Psychology*, 1934, 46, 596-602.
- JOHNSON, D. E., & ANDERSON, D. C. Acquisition of a second-order classically conditioned response. *Canadian Journal of Psychology*, in press.
- MCALLISTER, D. E., & MCALLISTER, W. R. Second-order conditioning of fear. *Psychonomic Science*, 1964, 1, 383-384.
- MYERS, A. K. Instrumental escape conditioning to a low-intensity noise by rats. *Journal of Comparative & Physiological Psychology*, 1965, 60, 82-87.
- PAVLOV, I. P. *Conditioned reflexes*. Trans. by G. V. Anrep. London: Oxford University Press, 1927.
- SMITH, O. A., McFARLAND, W. L., & TAYLOR, E. Performance in a shock-avoidance conditioning situation interpreted as pseudoconditioning. *Journal of Comparative & Physiological Psychology*, 1961, 54, 154-157.

NOTES

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Second-order fear conditioning as revealed through augmentation of a startle response: Part II¹

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An auditory startle stimulus was presented 1, 17, and 27 sec following termination of a second-order, classically conditioned, fear-evoking CS. Forward second-order conditioned Ss consistently exceeded the startle magnitudes of backward second-order conditioned controls at all intervals. An analysis of movement during the CS₂-startle intervals indicated that a postural interpretation could not account for startle augmentation in experimental Ss. A drive-like construct was posited to handle these data.

Anderson, Johnson, and Kempton (1969) found that a classically conditioned second-order stimulus (CS₂) can augment an auditory-produced startle response when the startle stimulus was presented 17 and 27 sec, but not 1 sec, following termination of the CS₂. However, their design confounded both the time of testing and

possible extinction of the effect of the CS₂ with manipulation of the CS₂-startle stimulus interval. This study was designed to correct these latter problems.

During the interim between this and the study of Anderson et al (1969), Kurtz & Siegal (1966) provided empirical support for the possibility that a fear-evoking stimulus may augment a startle reaction because of learned postural adjustments (which presumably were conducive to such facilitation), rather than through alterations in motivation level as postulated by Brown, Kalish, & Farber (1951). Kurtz & Siegal (1966) proposed that foot-shock produces postural changes which can become associated with the CS, and that these postural changes are uniquely sympathetic with the startle response. Hence, presentation of the fear-evoking CS in concert with an auditory startle stimulus could produce an augmented startle reaction because of some presumed additive combination of CS-produced postural changes to the startle reaction per se. These authors concluded support for their position because they failed to obtain

CS-produced augmentation of startle when the US had been delivered through the back rather than the paws of their Ss during conditioning.

Importantly, these authors neglected the possibility that a back-shock also may have produced unique postural changes, but which could have been antagonistic to the typical startle reaction evinced by the startle stimulus. The CS, as a source of drive, still could have augmented any reaction which had a high probability of occurrence in its presence. Since the back-shock-produced conditioned posture may have been associated with the CS, such would simply have introduced the element of response competition into the startle-augmentation procedure. Interestingly, a more direct test of the postural vs drive-augmentation hypotheses would simply be to tally and analyze the number of movements during the interval between CS termination and presentation of the startle stimulus. No movements during this CS-startle stimulus interval would reflect maintenance of a CS-produced postural adjustment. If movement occurred, such would suggest disruption of the presumed postural adjustment. Further, in order to retain a postural-adjustment hypothesis, the number of movements during the CS-startle interval should be negatively correlated with the magnitude of jump, and that control Ss should move with less vigor. Thus, the present investigation both attempted to unconfound certain features of the study of Anderson et al (1969) and to evaluate the postural vs drive-augmentation hypothesis using the strategy outlined above.

SUBJECTS

The Ss were 32 male albino rats, randomly selected from the experimental and control groups of another study (Johnson & Anderson, 1969). Age and prior experimental experiences at the beginning of this study approximated those of the Ss of Anderson et al (1969).

APPARATUS

The apparatus was that of Anderson et al (1969).

PROCEDURE

The procedure was similar to that of Anderson et al (1969). Adaptation to the stabilimeter chamber involved 3, rather than 2, days of presentation of the startle stimulus in an otherwise identical preconditioning adaptation procedure. Conditioning treatment was exactly the same as for the Ss of Anderson et al (1969). The test procedure was altered in the following manner.

Twenty-four hours following conditioning, the Ss were administered five additional startle stimuli (1-min average interstimulus interval) to determine whether

conditioning-produced baseline changes had occurred. Furthermore, this procedure preceded testing on *each* of the 3 test days. Following startle rehabilitation on each test day, the 10-sec CS₂ was presented, the offset of which preceded the startle stimulus by 1, 17, or 27 sec. The sequence of CS₂-startle stimulus intervals was randomly selected for each S for each day such that each S received all three intervals in a different order on respective test days.

RESULTS

The data were read in the same manner as by Anderson et al (1969). Figure 1 summarizes the mean log startle magnitude (in millimeters) for the three startle-adaptation days preceding conditioning. As can be seen, these preconditioning startle baselines were identical for both groups and indicated that previous experimental experience, *per se*, was ineffective as far as differential startle reactions were con-

cerned. However, it is to be noted that this habituation function differed from Anderson et al (1969) in that, while there was a slight trials effect ($p < .05$), neither the days nor the Days by Trials interaction effects approached significance. Apparently, startle-habituation functions differ between albino and hooded rats (cf. Moyer, 1963).

Figure 2 not only summarizes the CS₂-produced startle data, but also portrays the median log startle magnitude for each of the series of five startle-adaptation pretest trials of the 3 test days. A Groups by Days ANOVA was performed on this latter data. All F s were approximately 1 (± 0.3). A Groups by Intervals by Days ANOVA for the test data produced significant F s for groups ($F = 5.89$, $df = 1/30$, $p < .025$), and for the Intervals by Days interactions ($F = 5.04$, $df = 1/30$, $p < .05$), but not for any other effect. The mean log startle magnitude for experimental Ss consistently

Fig. 1. Mean startle magnitudes (log mm) for experimental and control groups on startle-adaptation trials prior to conditioning. The symbol FC_{BC} indicates a forward contingency for first-order conditioning (FC) and a backward contingency for second-order conditioning (BC). Similarly, FC_{FC} represents forward conditioning contingencies for both orders of training.

exceeded that of controls following CS₂ presentation.

Movement preceding, during, and immediately following the CS₂ was defined as any pen deflection which exceeded the baseline by 1 mm or more. Table 1 summarizes the mean number of movements (per second) for experimental and control Ss for appropriate respective intervals preceding and during CS₂ presentation, as well as during the CS₂-startle stimulus interval for each of the test days. The data of Table 1 clearly indicated that both groups exhibited considerable movement during the CS₂-startle interval (especially for the longer durations, i.e., the 17-sec and 27-sec intervals). A Groups by Intervals by Days analysis of movements before and during CS₂ presentation did not produce any F s greater than 1. However, a similar analysis of movements during the CS₂-startle stimulus interval produced a significant F for the days ($F = 4.27$, $df = 1/30$, $p \leq .05$) effect, and the Days by Intervals interaction ($F = 3.15$, $df = 1/30$, $p < .09$) approached reliability. Trial by trial correlations for each group between the number of movements during these respective intervals and appropriate startle magnitudes were low, mostly positive, and not significant. Last, an appropriate analysis was performed to determine whether there was a decrease in movement during the CS₂-startle stimulus interval relative to respective equivalent pre-CS₂ periods. There were approximately as many increases as decreases in frequency of movements during this interval for both groups and no significant effects were obtained.

DISCUSSION

The data of this experiment represented a clear replication of Anderson et al (1969), and an extension of Brown et al (1951) in that presentation of a fear-evoking stimulus

Fig. 2. Mean log startle magnitudes following CS₂ offset. The far left-hand column of each frame represents median startle magnitudes for five presentations of the startle stimulus preceding testing on each day. The first test point of each day represents the 1-sec CS₂-startle stimulus interval. The second and third test points represent 17-sec and 27-sec intervals, respectively.

(the CS₂ in this case) can be the occasion for augmentation of a startle reaction. Further, that a CS whose potency was "once-removed" from the original reinforcing state of affairs (i.e., shock) was capable of such facilitation was important support for the notion that a second-order response is not *always* transitory and unstable. The results of the analyses of movement preceding, during, and immediately following CS₂ presentation in the test situation provided convincing evidence that a postural or bodily adjustment hypothesis (such as that posed by Kurtz & Siegal, 1966) could not readily account for the augmented startle observed in the experimental Ss. That is, despite substantial movement during the CS₂-startle stimulus interval for experimental Ss (thus indicating disruption in the integrity of any possible CS₂-produced posture), startle facilitation was observed relative to controls. Further, the lack of strong or negative correlations between frequency of movement and magnitude of startle also suggested discard of the postural notion.

Interestingly, unlike Anderson et al (1969), startle facilitation was observed on Test Day 1 as well as on the remaining 2 days, and true "augmentation," characterized by the differences between respective baseline and test responses, was observed. That is, CS₂-produced startle magnitudes for the control group remained roughly the same as those observed on the preconditioning, startle-adaptation days. Further, the lack of conditioning-produced alterations in baseline startle magnitudes (probably due to strain differences) possibly accounted for the clear differences between experimentals and controls on the test trials of Test Day 1. Baseline alterations were not present to obscure the facilitation produced by the CS₂.

Perhaps the most curious aspect of these data was the finding of marked augmentation of startle both at the 17-sec and at the 27-sec intervals. If, as implied by Brown et al (1951), startle augmentation is the result of increased activation produced by the fear-evoking CS₂, how can one account for the facilitation in startle from presentations of the startle stimulus which were introduced considerably after CS₂ termination? Since our data provided little or no support for the postural hypothesis, it appears as though we are yet held to a drive construct. Probably the most likely explanation at this time would involve incorporation of a

Table 1
Movements (per second) Prior to, During, and Within the CS₂-Startle Stimulus Intervals for the Respective 1-, 17-, and 27-sec Periods.

	Movement (No./sec) During the Respective 1-, 17-, and 27-sec CS ₂ -Startle Stimulus Intervals								
	Day 1			Day 2			Day 3		
	1-sec	17-sec	27-sec	1-sec	17-sec	27-sec	1-sec	17-sec	27-sec
	1-sec	17-sec	27-sec	1-sec	17-sec	27-sec	1-sec	17-sec	27-sec
Group FC _{FC} (Experimentals)	.13	.18	.18	.38	.26	.16	.25	.17	.18
Group FC _{BC} (Controls)	.06	.13	.19	.56	.13	.24	.00	.22	.18
	Movement (No./sec) During Each CS ₂ Presentation								
	Day 1			Day 2			Day 3		
	1-sec	17-sec	27-sec	1-sec	17-sec	27-sec	1-sec	17-sec	27-sec
	1-sec	17-sec	27-sec	1-sec	17-sec	27-sec	1-sec	17-sec	27-sec
Group FC _{FC}	.21	.22	.16	.37	.34	.18	.32	.30	.26
Group FC _{BC}	.14	.11	.21	.21	.24	.28	.20	.25	.19
	Movement (No./sec) During Respective 1-, 17-, 27-sec Intervals Prior to CS ₂ Presentation								
	Day 1			Day 2			Day 3		
	1-sec	17-sec	27-sec	1-sec	17-sec	27-sec	1-sec	17-sec	27-sec
	1-sec	17-sec	27-sec	1-sec	17-sec	27-sec	1-sec	17-sec	27-sec
Group FC _{FC}	.31	.11	.18	.25	.29	.11	.19	.25	.16
Group FC _{BC}	.12	.18	.14	.25	.24	.28	.56	.32	.21

drive-decay notion. Here, it could be assumed that the increment in arousal produced by CS₂ presentation dissipated only over time following termination of the higher-order stimulus. Thus, it might be asserted that the CS₂-produced excitatory level reached a maximum sometime during its presentation, and that its termination was the occasion for a *gradual* dissipation of emotionality. While such a drive-decay notion appears intuitively reasonable, there remain some curious problems with the data which reduce its convincingness in handling our findings. For example, a drive-decay notion might have been more acceptable were augmentation to have been consistently maximal at a CS₂-startle stimulus interval of somewhat shorter duration. That is, a maximal CS₂-produced excitatory state immediately following its termination, rather than 27 sec later, would appear more likely. A considerable decrement in activation level should have been observed at this latter time interval. Obviously, if a drive or arousal construct is the more suitable for explaining our phenomenon, preconceptions pertaining to its decay properties appear in need of revision. Nevertheless, there is a considerable body of evidence to suggest that physiological indices of emotion also have a very gradual decay rate over time, and that *complete* physiological recovery from an emotionally charged situation may take hours rather than minutes or seconds. Unfortunately, there

have been few behavioral studies designed to systematically assess the temporal characteristics reflected in dissipation of an emotional state.

REFERENCES

- ANDERSON, D. C., JOHNSON, D., & KEMPTON, H. Second-order fear conditioning as revealed through augmentation of a startle response: Part I. *Psychonomic Science*, 1969, 00, 000-000.
- BROWN, J. S., KALISH, H. I., & FARBER, I. E. Conditioned fear as revealed by magnitude of startle response to an auditory stimulus. *Journal of Experimental Psychology*, 1951, 41, 317-328.
- JOHNSON, D., & ANDERSON, D. C. Acquisition of a second-order classically conditioned response. *Canadian Journal of Psychology*, in press.
- KURTZ, K. H., & SIEGAL, A. Conditioned fear and magnitude of startle response: A replication and extension. *Journal of Comparative & Physiological Psychology*, 1966, 62, 8-14.
- MOYER, K. E. Startle response: Habituation over trials and days, and sex and strain differences. *Journal of Comparative and Physiological Psychology*, 1963, 56, 863-865.

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