REFERENCES

Denny, M. R. Relaxation theory and experiments. In F. R. Brush (Ed.), *Aversive conditioning and learning.* New York: Academic Press, 1971.

Dreilinger, C. The backchaining of relaxation in the elimination of active avoidance behavior in rats. Unpublished master's thesis, Eastern Michigan University, 1973.

Estes, W. K., & Skinner, B. F. Some quantitative properties of anxiety. Journal of Experimental Psychology, 1941, 29, 390-400.

Hoffman, H. S., & Fleshler, M. The course of emotionality in the development of avoidance. Journal of Experimental Psychology, 1962, 64, 288-294.

Kamin, L. J., Brimer, C. J., & Black, A. H. Conditioned suppression as a monitor of fear of the CS in the course of avoidance training. Journal of Comparative & Physiological Psychology, 1963, 56, 497-501.

Linden, D. R. Attenuation and reestablishment of the CER by discriminated avoidance conditioning in rats. Journal of Comparative & Physiological Psychology, 1969, 69, 573-578.

Lockard, J. S. Choice of a warning signal or no warning signal in an unavoidable shock situation. Journal of Comparative & Physiological Psychology, 1963, 56, 526-530.

Page, H. A. The facilitation of experimental extinction by response prevention as a function of the acquisition of a new response. Journal of Comparative & Physiological Psychology, 1955, 48, 14-16.

Solomon, R. L., & Wynne, L. C. Traumatic avoidance learning: The principles of anxiety conservation and partial irreversibility. Psychological Review, 1954, 61, 353-385.

(Received for publication November 19, 1973.)

Bulletin of the Psychonomic Society
1974, Vol. 3 (3A), 168-170

Time off from rapid stimulation*

KENNETH S. KELEMAN† and BRUCE T. LECKART
California State University, San Diego, Calif. 92115

A study was conducted to test arousal theory predictions about exploratory behavior in high-stimulation environments. The effect of rapidly changing visual and auditory stimulation on the duration of subsequent S-controlled perceptual deprivation or "time off" from stimulation was investigated. Eighteen Ss were repeatedly exposed to periods of 3, 15, or 30 sec of repadly changing stimulation followed by S-terminated time off. Results showed that time off was longest after short (3 sec) presentations and shortest after long (30 sec) presentations. The results, which failed to support a hypothesis derived from arousal theory notions, were discussed alternatively in terms of limits of sensory input and task demands. The finding of an increase in rate of stimulus change over trials was explained in terms of arousal decrease.

Theoretical explanations of attentional or exploratory behavior under conditions of reduced sensory input have frequently centered around notions of arousal (see e.g., Berlyne, 1960; Fiske & Maddi, 1961; Schultz, 1965; Leckart, Butler, & Yaremko, 1972). Using deprivation experimental paradigms, these authors and other have provided considerable evidence to support the central theoretical notions that: (a) an organism attempts to maintain an optimal level or arousal, and (b) stimulation produces arousal. By contrast, there have been few tests of these notions which have used sensory overload or overstimulation experimental paradigms. Furthermore, the overstimulation results reported so far have not

*The authors would like to thank R. M. Yaremko, Alice Cochran, and Mark Butler for their assistance.

†Now at the University of Utah. Reprint requests should be sent to Psychology Department, University of Utah, Salt Lake City, Utah 84112.

clearly supported predictions from arousal theory.

Ormiston (1958) assumed that the readiness of human Ss to report movement in a phi-phenomenon task was a function of "need for change." Ss were tested before and after exposure to sensory deprivation or sensory bombardment. Results were in the direction predicted from arousal theory in the deprivation condition, while threshold shifts for the bombardment group were not significant. Vodde and Robertson (1969) measured human recognition thresholds for numbers after 15 min of either visual overstimulation or visual restriction. As predicted from arousal theory, the restricted group had significantly fewer errors on the post-test. The overstimulation group, however, did not differ from the control group. Zuckerman & Persky (Zuckerman, Persky, Hopking, Murtaugh, Basu, & Schilling, 1966; Zuckerman, Persky, Miller, & Levin, 1969) have collected both paper-and-pencil and physiological measures after exposing human Ss to visual and auditory overstimulation and understimulation. While not entirely clear, the results indicated that there may have been more autonomic arousal in the overstimulation group.

The present experiment was designed to determine if the arousal theory notion, that stimulation increases arousal, is tenable under conditions of sensory overstimulation. If an organism attempts to maintain an optimal level of arousal when overstimulated, it should display behaviors necessary to decrease the amount of arousal-producing sensory input (Berlyne, 1960; Fiske & Maddi, 1961). To test this notion, a "time off" from rapid stimulation tasks was designed in which Ss controlled the overall rate of stimulation by controlling the duration of a poststimulation period of darkness and quiet (time off).

It was hypothesized that time off would increase as a function of increases in the duration of the preceding period of rapid sensory stimulation. A long time off following a long stimulus exposure would reflect time necessary for an organism to return to an optimal level of arousal. By the same reasoning, short time off following a short stimulus exposure would indicate less overarousal.

METHOD

Subjects

The Ss were 18 male and female students enrolled in summer-term lower division psychology courses at California State University, San Diego. All Ss volunteered to participate at E's request.

Apparatus

The testing booth was a 1.2 x 1.2 m light-and-sound attenuated enclosure placed within a larger room. Each S sat at a small table facing a 30 x 30 cm rear-projection screen located at eye level and approximately 70 cm from the S's face. The booth also contained a set of binaurally wired stereo headphones, the S's stimulus initiation button, and sham GSR electrodes. From outside the booth, visual stimuli were presented from a Kodak Carousel 850 projector with attached Wratten neutral-density filters.

An adjoining room contained programming, tape recording, and support equipment. Stimulation intervals were programmed from electronic timers. A tape recorder was used to provide the auditory stimuli. An event recorder was used to automatically record stimulus presentation and time-off times to the nearest 0.1 sec.

Forty-eight different 35-mm color slides of landscapes, objects, and arrays of objects were used as visual stimuli. Projected image size was 20 x 30 cm with an average brightness of 10.0 mL as measured at a point equivalent to the position of S's eyes. Previous research indicated that free looking times for these stimuli are approximately 11-13 sec each (Leckart & Bakan, 1965). Pure tones of 160, 320, 500, 720, 1,400, 1,700, 1,860, and 2,400 Hz were used as auditory stimuli. These tones were contiguous, of 1.0 sec duration, and of 58-70 dB intensity (re: 0.0002 $dyne/cm^2$). The tone sequence was randomly generated and prerecorded on tape.

Procedure

A S was seated in the booth facing the projection screen and told that the purpose of the experiment was to investigate the effects of external stimulation on the GSR. Instruction credibility was maintained by taping two small stainless steel contacts to the S's fingers. Instructions indicated that the S would be presented with sets of stimuli, a set being one or more slides with accompanying tones. The S was requested to press the stimulus restart button after each set had ended when he was ". . . ready for the next set." The S was asked to attend to the screen and the headphones were placed on his head.

Each S received nine sets of rapid stimulation and each stimulus set was followed by a time-off trial. Rapid stimulation was defined as presentation of visual stimuli at approximately four times their normal or "free looking time" rate in combination with rapidly changing auditory stimulation. The time off trial was defined as the time from the end of the set (when the screen went blank and the tones stopped) to the S's button push which initiated the subsequent set. Stimulus sets were of 3, 15, or 30 sec duration. The 3-sec interval contained 3 sec of continuous auditory stimulation and a concurrent 2.2-sec presentation of a color slide followed by 0.8 sec of darkness (the projector change time). Fifteen- and 30-sec sets consisted of 5 or 10 contiguous repetitions of the 3-sec pattern. Each S received a different block-randomized order of stimulus sets and the slides were randomly assigned across all sets.

RESULTS

Time off in seconds was recorded for each S for each trial. Inspection of the data indicated marked positive skew, so all measures were converted to log time off. Means for each set length blocked over trials are presented in Fig. 1. Inspection of this figure indicates a decrease in time off as a function of blocks for all stimulus conditions. The 3-sec stimulus condition reveals more time off than either the 15- or 30-sec conditions.

An analysis of variance indicated that the stimulus duration manipulation had a significant effect upon time-off duration [$F(2,34) = 3.81$, $p < .05$]. The decrease in time off over trials was also significant [$F(2,34) = 22.34$, $p < .001$], but there was no reliable Time Off by Trials interaction [$F(4,68) = 1.42$, $p > .05$].

DISCUSSION

It was expected that time off would vary directly with the amount of stimulation. Instead, time off decreased with increased stimulus exposure. In order to account for these results in terms of the arousal theory notions, the 3-sec stimulation period would have to be more overarousing than the 15- or

30-sec conditions. This could only be if simple stimulus variation (on-off of stimuli) and not stimulus content were the major contributor to arousal. This redefinition of the arousal source seems inappropriate in light of Fiske and Maddi's (1961) claim that simple variation is generally a weak contributor to arousal.

It is possible that Ss do not allow their arousal level to get above optimal by cutting off excessive stimulation. Information processing theorists conceive of organisms as having limited stimulus or information processing capacity (e.g., Davis, 1957; Broadbent, 1957, 1958; Treisman, 1969), and there is evidence that an increase in the amount of information presented will not produce a corresponding increase in the amount of information assimilated (Broadbent, 1958). Although this would explain a lack of increased time off with increased stimulation, it fails to explain the reliable decrease in time off with increased stimulation.

Perhaps the most satisfactory explanation of the inverse time-off/stimulus duration finding is in terms of task demands. The task did not require Ss to process all the information presented, but only enough for a binary decision: (a) The stimulation is ongoing, take no stimulus initiation action. (b) The stimulation has stopped, restart it. Furthermore, the length of the stimulus set could provide information for that decision. The probability of S's needing to restart the stimulation is low (.33) after 3 sec of stimulation and high (1.0) after 30 sec of stimulation, i.e., onset of time off follows a long series of slides with high certainty and is relatively uncertain when stimulation starts. This task, which required Ss to act on the basis of this probabilistic information is conceptually analogous to reaction time experiments. Given that reaction time increases with uncertainty (Berlyne, 1957), a straightforward derivation follows. Stimulus initiation latency (time off) would vary as a function of the available information. Future research should attempt to separate the effects of task-induced expectancy from the arousal aspects of stimulus presentation.

The second major finding was that time off decreased sharply over trials. This same task decrement has been reported in the logically opposite paradigm where S controls the duration of exposure to the stimulut (Leckart, 1967). Although other explanations are possible, consideration of arousal not only from

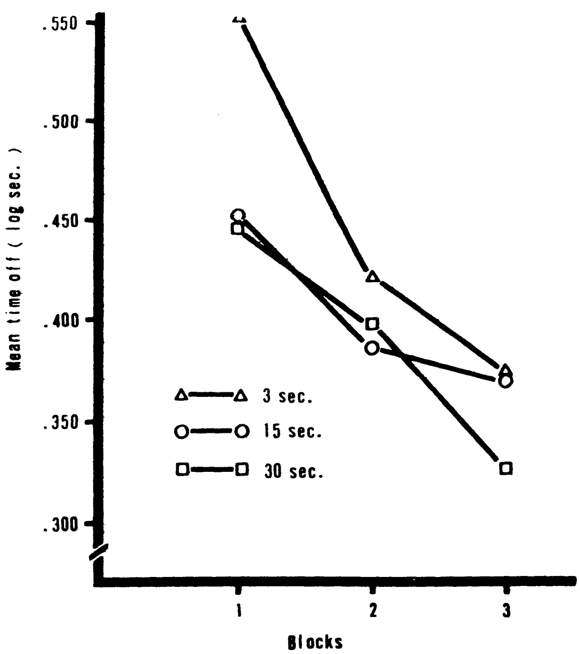

Fig. 1. Mean time off (log sec) as a function of stimulus set length over three blocks of three trials each

the experimental stimuli but from the experiment as a whole would account for the decrease in both situations. Ss may report to an experiment somewhat anxious or aroused (Rosenberg, 1969). As they become familiar with the E's expectations, the task, and the setting, this arousal should decrease. Ss should then become more tolerant of stimulus variation in their environment, which would be reflected in shorter change latencies.

Although the findings of the present study seem adequately interpretable in terms of task demands, these results along with those previously cited (Ormiston, 1958; Vodde & Robertson, 1969; Zuckerman et al, 1966, 1969) consititute a cluster of independent studies which are an anomaly for arousal theory interpretations of exploratory behavior. The claim that none of these studies have really overstimulated Ss seems somewhat unlikely due to the variety of stimulus configurations used. A likely alternative is that prediction from an arousal theory basis may be limited to stimulus deprivation conditions. A different heuristic may be necessary for overstimulation paradigms. One possible candidate for attentional findings may be in terms of the distribution of behaviors on multiple schedules. The plausibility of this alternative is enhanced by the recent vigilance findings of Durham and Nunnally (1973) and comments by Wohlwill (1970) concerning aversive elements in stimulation. In any event, a review and integration of overstimulation findings is currently needed.

REFERENCES

Berlyne, D. E. Uncertainty and conflict: A point of contact between information theory and behavior theory. Psychological Review, 1957, 64, 329-339.

Berlyne, D. E. *Conflict, arousal, and curiosity.* New York: McGraw-Hill, 1960.

Broadbent, D. E. A mechanical model for human attention and immediate memory. Psychological Review, 1957, 64, 205-215.

Broadbent, D. E. *Perception and communication.* New York: Pergammon Press, 1958.

Davis, R. The human operator as a single channel information system. Quarterly Journal of Experimental Psychology, 1957, 50, 177-179.

Durham, R. L., & Nunnally, J. C. The effects of low and high levels of vigilance on subsequent visual exploratory behavior in humans. Bulletin of The Psychonomic Society, 1973, 1, 313-315.

Fiske, D. W., & Maddi, S. R. *Functions of varied experience.* Homewood, Ill: Dorsey Press, 1961.

Leckart, B. T. Task specific decrements in the duration of attention. Psychonomic Science, 1967, 9, 559-560.

Leckert, B. T., & Bakan, .P. Complexity judgments of photographs and looking time. Perceptual & Motor Skills, 1965, 21, 16-18.

Leckert, B. T., Butler, M., & Yaremko, R. M. The looking time perceptual deprivation effect (PDE): A test of the imitation hypothesis. Psychonomic Science, 1972, 26, 323-326.

Ormiston, D. W. The effects of sensory deprivation and sensory bombardment on apparent movement thresholds. Dissertation Abstracts, 1958, 18, 2200-2201.

Rosenberg, M. J. The conditions and consequences of evaluation apprehension. In R. Rosenthan and R. Rosnow (Eds.), *Artifact in behavioral research.* New York: Academic Press, 1969.

Schultz, D. P. *Sensory restriction effects on behavior.* New York: Academic Press, 1965.

Treisman, A. M. Strategies and models of selective attention. Psychological Review, 1969, 76, 282-299.

Vodde, T. W., & Robertson, M. H. The effect of visual restriction or overstimulation upon number recognition. Journal of General Psychology, 1969, 80, 171-176.

Wohlwill, J. F. The concept of sensory overload. Paper presented at Environmental Design Research Association Conference, October 1970.

Zuckerman, M., Persky, H., Hopkins, T. R., Murtaugh, T., Basu, G. K., & Schilling, M. Comparison of stress effects of perceptual and social isolation. Archives of General Psychiatry, 1966, 14, 356-365.

Zuckerman, M., Persky, H., Miller, L., & Levin, B. Contrasting effects of understimulation (sensory deprivation) and overstimulation (high stimulus variety). Proceedings of the 77th Annual Convention of the American Psychological Association, 1969. Pp. 319-320.

(Received for publication October 29, 1973.)