system in skin. It seems reasonable that the effects would have been more pronounced had the 1.0-min rest period been omitted from the experimental time sequence. The effect of this variable will be studied in future experiments.

REFERENCES

- Békésy, G. von. Synchronism of neural discharges and their demultiplication in pitch perception on the skin and in hearing. *Journal of The Acoustical Society of America*, 1959, 31, 338-349.
- Cohen, L. H., & Lindley, S. B. Studies in vibratory sensibility. *American Journal of Psychology*, 1938, 51, 44-63.
- Cornsweet, T. *Visual perception*. New York: Academic Press, 1970.
- Elliott, D. N., & Fraser, W. R. Fatigue and adaptation. In J. V. Tobias (Ed.), *Foundations of modern auditory theory*. Vol. I. New York: Academic Press, 1970.
- Hahn, J. F. Vibrotactile adaptation and recovery measured by two methods. *Journal of Experimental Psychology*, 1966, 71, 655-658.
- Hahn, J. F. Tactile adaptation. In D. R. Kenshalo (Ed.), *The skin senses*. Springfield, Ill.: Thomas, 1968a.
- Hahn, J. F. Low-frequency vibrotactile adaptation. *Journal of Experimental Psychology*, 1968b, 78, 655-659.
- Sato, M. Response of Pacinian corpuscles to sinusoidal vibration. *Journal of Physiology*, 1961, 159, 391-409.
- Talbot, W. H., Darian-Smith, I., Kornhuber, H. H., & Mountcastle, V. B. The sense of flutter-vibration: Comparison of the human capacity with response patterns of mechanoreceptive afferents from the monkey. *Journal of Neurophysiology*, 1968, 31, 301-334.
- Verrillo, R. T. Effect of contactor area on the vibrotactile threshold. *Journal of the Acoustical Society of America*, 1963, 35, 1962-1966.
- Verrillo, R. T. Specificity of a cutaneous receptor. *Perception & Psychophysics*, 1966, 1, 149-153.
- Verrillo, R. T. A duplex mechanism of mechanoreception. In D. R. Kenshalo (Ed.), *The skin senses*. Springfield, Ill.: Thomas, 1968.
- Wedell, C. H., & Cummings, S. B. Fatigue of the vibratory sense. *Journal of Experimental Psychology*, 1938, 22, 429-438.
- Zwislocki, J., Pirodda, E., & Rubin, H. On some poststimulatory effects at the threshold of audibility. *Journal of the Acoustical Society of America*, 1959, 31, 9-14.

(Received for publication July 5, 1974.)

Bulletin of the Psychonomic Society
1974, Vol. 4 (5A), 486-488

Arousal and memory*

JOHN GORMLY and JOSEPH LALKA

Rutgers—The State University, New Brunswick, New Jersey 08903

The following study was designed to see if the relationship between arousal and recall interval is sufficient to account for data on differential recall of arousing and nonarousing events. Similar studies allegedly support a Freudian model of unconsciously motivated repression. Skin conductance was continuously recorded while 96 undergraduates attempted tasks similar to those which appear in tests of intelligence. Ss attempted the tasks under one of eight experimentally induced conditions designed to produce various levels of arousal. The experimental manipulations, which were intended to create arousal through varying amounts of threat to a person's self-esteem, were not successful in producing differential arousal in high and low threat conditions; all conditions were highly arousing to the Ss. Therefore, the design was not suitable for its intended purpose. There was, however, a significant and replicated relationship between the number of sessions of testing S agreed to attend and arousal across the temporal duration of the first session ($p < .05$ for males and $p < .01$ for females).

*This research was supported by a grant from the Research Council of Rutgers University. Requests for reprints should be sent to: John Gormly, Department of Psychology, Rutgers College, Rutgers University, New Brunswick, New Jersey 08903.

Theoretical research in psychology has often utilized memory as a primary dependent measure. Investigations in the area of perceptual defense have yielded results

which indicate decrements in recall for events which threaten a person's self-esteem (Alper, 1946; Glixman, 1949; Rosenzweig, 1943). These findings are described as support for Freudian theory's model of unconsciously motivated repression (Eriksen & Pierce, 1968).

Results from basic research on the interaction of Arousal by Recall Interval, however, may provide an alternate explanation for the findings described above. Kleinsmith and Kaplan (1964), using a measure of skin conductance to indicated physiological activation, demonstrated that paired-associate learning during low levels of skin conductance resulted in high immediate recall and rapid forgetting, while learning during higher levels of skin conductance produced the opposite pattern, low immediate recall and improved recall at a later time. This interaction of Arousal by Recall Interval has been confirmed by additional studies (Butter, 1970; Kaplan & Kaplan, 1970; Osborne, 1972). It may be that conditions which threaten a person's self-esteem also increase physiological activation, and it is the relationship between physiological activation and memory which produces low recall of ego-threatening material, not the defense mechanism of repression. The following study was designed to investigate this alternative explanation for recall of ego-threatening events.

RESEARCH DESIGN AND HYPOTHESES

Ninety-six undergraduates were given 14 tasks of the kind which might test intelligence. There were eight treatment conditions, produced by crossing three factors: (1) ego-involvement factor—the Ss were told they were taking an intelligence test, and if the E terminated their performance on an item, it indicated failure for the item, or they were told we were collecting normative information, and if the E terminated their performance on an item, it indicated that he had enough information regarding that item; (2) proportion of interruption—Ss were interrupted on nine tasks (64% interruption), or they were interrupted on five tasks (36% interruption); (3) recall interval—Ss recalled the tasks which they had attempted immediately after attempting them, or they recalled them 1 week later.

We assumed that high ego-involvement conditions would be more arousing than low ego-involvement conditions and that the higher proportion of task interruptions would be more arousing than the lower proportion of task interruptions. Level of skin conductance was the measure of arousal. Under these conditions of arousal, we hypothesized that the relationship between arousal and recall interval would be sufficient to account for the memory data: interrupted tasks would be more poorly remembered in immediate recall and would be better remembered in the delayed

recall condition. We hypothesized that this relationship would exist for both high ego-involvement and low ego-involvement groups, even though there would be no treatment to reduce the ego-threatening significance of task interruptions for the high ego-involvement groups before their second session.

METHOD

Subjects

Ninety-six students who were enrolled in undergraduate psychology courses in Rutgers College served as Ss. The sexes were equally represented in all eight treatment conditions.

Procedure

When the S reported to the laboratory, he or she was given instructions which created conditions of either high or low ego involvement, while being prepared for the measurement of skin conductance from the end digits of the first and third fingers of the hand the person did not use for writing. Skin conductance was recorded throughout the testing session using a constant voltage circuit (.45 V). There were 14 tasks, which included problems from the Wechsler Adult Intelligence Scale: object assembly, block design, digit symbol, picture arrangement, and picture completion. The other tasks were: card sorting, a math problem, unscrambling a sentence, pencil mazes, a task which required the person to mentally fold a set of squares into a cube, mirror tracing, taking apart interlocking metal pieces, a numerical relations task, and an embedded figure task. The 14 tasks were presented in differing orders to the Ss. Nine orders of task presentation were made in which a particular task never held the same ordinal position more than once. By using different stimulus sets, the probability that any given task was interrupted was equalized. The third, fifth, eighth, twelfth, and thirteenth tasks were key tasks; the E either interrupted or allowed the S to complete these tasks, depending on the S's high or low interruption assignment. Throughout the time S was working on the task, a 3 x 5 in. index card with the name of the task printed on it was on the table before S.

Following the fourteenth task, the immediate recall groups were given time to write the names or descriptions of the tasks they had just attempted. The delayed recall groups had to return in 1 week, presumably to continue testing. When they returned for the second session, the first thing they did was to recall the name or a description of the tasks they had attempted at the earlier session. This group knew before they attended the first session that they had obligated themselves to attend two sessions of testing.

RESULTS

In order to verify our assumptions regarding degree of arousal and treatment conditions, skin conductance was scored for (1) the highest level during the 10-sec interval which began at the end of each task (interrupted or completed) and (2) the increase in skin conductance from the lowest level of skin conductance in the 5-sec interval before the end of each task and the highest point from the interval described above. All data were corrected for individual differences in range of responding as described by Lykken and Venable (1971).

Contrary to our assumption, there were no main effects in the skin conductance data for the

ego-involvement and proportion of interruptions factors. There was, however, a substantial interaction of Recall Interval by the Temporal Ordering of Tasks. This interaction was present for both male Ss ($F = 1.78$, $df = 13, 540$; $p < .05$) and female Ss ($F = 2.60$, $df = 13, 540$, $p < .01$). Ss who were to return for a second session had increasing arousal over the duration of the first session while Ss who were to attend only one session had decreasing arousal over time; these findings are illustrated in Fig. 1.

An analysis of variance for the memory data with ego-involvement, proportion of interruptions, recall interval, and condition of the item (interrupted or completed) as factors revealed no significant main effects. Only one of the two-way interactions was significant, the interaction of Proportion of Interruptions by Condition of the Item. Under the conditions of low interruption, interrupted tasks were recalled better than completed tasks; under conditions of high interruption, completed tasks were recalled better than interrupted tasks. This interaction ($F = 4.41$, $df = 1, 80$; $p < .05$) is illustrated in Fig. 2.

DISCUSSION

The study was not suitable for testing the hypothesis regarding the differential recall of interrupted and completed tasks as a function of recall interval. In comparing the level of arousal found in this study with other studies on psychological stress (Gormly, 1971 and in press), it appears that all groups of Ss in this study were highly aroused. Perhaps the number of interrupted tasks in the low interruption condition (36% interruption) was too high, and the challenge or threat of testing situations for a highly selected student body may have dwarfed the intended impact of our treatment conditions.

Fig. 1. The relationship between recall interval and physiological activation across the duration of the first experimental session.

Fig. 2. Differential recall of completed and interrupted tasks as a function of the degree of interruption.

Clearly, the commitment to return for another testing session changed the significance of the first session. The substantial increase in skin conductance for those who were to return the following week both surprises and puzzles the authors.

The interaction in the recall data for proportion of interruption and whether the task was interrupted or completed may have a simple explanation. It is well documented that people have a better percent recall for short lists relative to longer lists (Woodworth & Schollosberg, 1954, p 705). Both treatment groups (high proportion of interruptions and low proportion of interruptions) had better percent recall for the five item list. If it is fair to conjecture that the Ss sorted their experiences into two groups of tasks, completed tasks and interrupted tasks, then both treatment groups simply had a better percent recall for their shorter list.

REFERENCES

- Alper, T. G. Memory for completed and incompleted tasks as a function of personality: an analysis of group data. *Journal of Abnormal & Social Psychology*, 1946, 41, 403-421.
- Butter, M. J. Differential recall of paired associates as a function of arousal and concreteness-imagery level. *Journal of Experimental Psychology*, 1970, 84, 252-256.
- Eriksen, C. W., & Pierce, J. Defense mechanisms. In E. F. Borgatta & W. W. Lambert (Eds.), *Handbook of personality theory and research*. Chicago: Rand McNally, 1968, Pp. 1007-1040.
- Glixman, A. F. Recall of completed and incompleted activities under varying degrees of stress. *Journal of Experimental Psychology*, 1949, 39, 281-295.
- Gormly, J. Sociobehavioral and physiological responses to interpersonal disagreement. *Journal of Experimental Research in Personality*, 1971, 5, 216-222.
- Gormly, J. A Comparison of predictions from consistency and affect theories for arousal during interpersonal disagreement. *Journal of Personality & Social Psychology*, in press.
- Kaplan, S., & Kaplan, R. The interaction of arousal and retention interval: ipsative vs normative scoring. *Psychonomic Science*, 1970, 19, 115-117.
- Kleinsmith, L. J., & Kaplan, S. Interaction of arousal and recall interval in nonsense syllable paired-associate learning. *Journal of Experimental Psychology*, 1964, 67, 124-126.
- Lykken, D. T., & Venable, P. H. Direct measurement of skin conductance: a proposal for standardization. *Psychophysiology*, 1971, 8, 656-672.
- Osborne, J. W. Short term and long term memory as a function of individual differences in arousal. *Perceptual & Motor Skills*, 1972, 34, 587-593.
- Rosenzweig, S. An experimental study of repression with special reference to need-persistent and ego-defensive reactions to frustration. *Journal of Experimental Psychology*, 1943, 32, 64-74.
- Woodworth, R. S., & Schollosberg, H. *Experimental psychology*. New York: Holt, Rinehart, & Winston, 1954.

(Received for publication July 25, 1974.)