- GLASSER, A. J., & ZIMMERMAN, I. L. *Clinical interpretation of the WISC*. New York: Grune and Stratton, 1967.
- GRAHAM, E. E. Wechsler-Bellevue and WISC scattergrams of unsuccessful readers. *Journal of Consulting Psychology*, 1952, 16, 268-271.
- HARTMAN, J. S., & ELLIOTT, L. L. Performance of deaf and hearing children on a short term memory task. *Psychonomic Science*, 1965, 3, 373-374.
- HARTUNG, J. E. Visual perceptual skills, trigram pronouncibility and the reading achievement of young deaf children. Unpublished doctoral dissertation, Washington University, St. Louis, Mo., 1968.
- OLSON, J. R. A factor analytic study of the relation between the speed of visual perception and the language abilities of deaf adolescents.

- Journal of Speech & Hearing Research*, 1967, 10, 354-360.
- ROBECK, M. C. Subtest patterning of problem readers on the WISC. *California Journal of Educational Research*, 1960, 11, 110-115.
- WITHROW, F. B. Immediate memory span of deaf and normally hearing children. *Exceptional Children*, 35, 1, 1968.

NOTE

1. We wish to thank teachers and children of the Webster College School for their assistance and cooperation during the fall and winter of 1967-1968. This research was supported in full by a U. S. Public Health Service, Department of Health, Education and Welfare research grant from the National Institute of Neurological Diseases and Blindness.

The interaction of response M and %ORM in paired-associate learning

DONALD R. YELEN and DELPHINE YELEN, Washburn University, Topeka, Kans. 66621

The interaction of response meaningfulness (M) and percentage occurrence of response members (%ORM) was investigated in two experiments. Results of both experiments indicated that early in training high-response M items produced larger differences between %ORM groups than low-response M items, but that the reverse was true late in training. Previous failures to obtain a significant M by %ORM interaction were attributed to the use of response measures which are not sensitive to the reversal of the interaction with training.

There has been relatively little empirical support for the presence of an interaction between response meaningfulness (M) and the percentage occurrence of response members (%ORM) in paired-associate learning situations. Some support for a M by %ORM interaction has been inferred from a comparison of the materials and results of the studies which first manipulated %ORM. That is, Schulz & Runquist (1960), using adjectives, reported small differences between their %ORM groups, while Goss,

Morgan, & Golin (1959), using nonsense syllables, reported relatively large differences between their %ORM groups. Since the effects of %ORM were greater with low-M materials than with high-M materials it was inferred that M interacted with %ORM. However, subsequent studies which simultaneously manipulated response M and %ORM either failed to find a M by %ORM interaction (Wilcoxon, Wilson, & Wise, 1961), or reported relatively weak interactions of response M and %ORM (Goss, Nodine, Gregory, Taub, & Kennedy, 1962).

The present experiments were conducted to determine if the M by %ORM interaction had been masked by the trials-to-criterion measure used in all of the previous investigations. If the M by %ORM interaction is confined to the early stages of learning, as suggested by Schulz & Runquist (1960), it is possible that the interaction would not be reflected in a trials-to-criterion score. Therefore, the present experiments used the number of correct responses during paired-associate learning trials as the response measure.

EXPERIMENT 1

Materials

All Ss learned the same eight-item paired-associate list. The stimuli were eight

high meaningful trigrams (Noble, 1960); the responses were four low (*m* ranging from 2.69 to 3.21) and four high (*m* ranging from 9.77 to 10.87) meaningful dissyllables (Noble & Parker, 1960).

Procedure

Ten male and 10 female introductory psychology students were randomly assigned to each of two experimental conditions—100% ORM and 25% ORM. The Ss learned by the study-test method. In the 100%-ORM condition, each stimulus appeared with its response on study trials and each stimulus appeared alone on the succeeding test trial. In the 25%-ORM condition, one high-M response and one low-M response occurred on each study trial. No response member was repeated until all other responses had been presented, thus each response occurred once in every four study trials. Each stimulus appeared alone on each of the test trials. For both groups, four different orders of items were used on study trials and four different orders on test trials to prevent serial associations.

A Stowe memory drum was used to present the lists. The items appeared at a 2-sec rate and the intertrial interval was 4 sec. All Ss received a total of eight study and eight test trials.

Results

An analysis of variance was performed on the number of correct responses on each of the eight trials with %ORM as a between-Ss effect and Response M and trials as within-Ss effects. A significant triple interaction of M by %ORM by Trials (presented in Fig. 1) was obtained ($F = 3.32$, $df = 7/266$, $p < .01$). As the figure shows, performance was higher under 100% ORM conditions than under 25% ORM conditions, and better with high-M responses than with low-M

Fig. 1. Mean number of correct responses as a function of Response M, %ORM, and trials.

Fig. 2. Mean number of correct responses as a function of Response M, %ORM, and trials.

responses. However, as the figure also suggests and the analysis of variance confirmed, the M by %ORM interaction changes with the stage of practice. Early in training the difference between performance levels of the 100% ORM and 25% ORM groups is larger for high-M responses than for low-M responses, while by Trial 8, this relationship has changed so that the difference in performance levels of the 100% ORM and 25% ORM groups is approximately the same for low-M and high-M responses.

Since it appeared from the present data that the performance curves for the high-M responses were converging and the low-M curves were still diverging at the end of eight trials, it seemed desirable to repeat Experiment 1 using a larger number of trials in order to determine whether or not the M by %ORM interaction would be reversed at a later stage of training. Accordingly, Experiment 2 was performed using the materials of Experiment 1 but giving 16 study and 16 test trials to all Ss.

EXPERIMENT 2

Procedure

Ten male and 10 female introductory psychology students were randomly assigned to each of three experimental conditions—100% ORM, 50% ORM, and 25% ORM. Except for the addition of the 50%-ORM group and the change in number of trials from 8 to 16, the procedure used in Experiment 2 was the same as that described for Experiment 1. In the 50%-ORM condition, two low-M responses and two high-M responses were paired with their stimuli on each study trial. No response was repeated until all others had been presented once; thus, each response was paired with its stimulus once every two study trials.

Results and Discussion

An analysis of variance was performed on

the number of correct responses per trial with %ORM as a between-Ss effect and Response M and trials as within-Ss effects. As in Experiment 1, the triple interaction of M by %ORM by Trials (presented in Fig. 2) was significant ($F = 1.90$, $df = 30/1919$, $p < .01$). Again, performance was better with high-M responses than with low-M responses, and the higher the %ORM the better the performance level, although the differences between 100% ORM and 50% ORM are small. The characteristics of the M by %ORM interaction at the various stages of training are similar to those found in Experiment 1. On the first seven test trials, differences among the %ORM groups are larger for high-M responses than for low-M responses. From Trial 8 through Trial 16, differences among the %ORM groups tend to be larger for low-M responses than for high-M responses. Since the nature of the M by %ORM interaction tends to reverse with trials, it seems clear that when fairly prolonged training is given and a response measure such as total number of correct responses is used, a nonsignificant M by %ORM interaction can be expected. In the present study, for example, the overall M by %ORM interaction failed to reach the .05 level of significance. Thus it seems clear that at least part of the ambiguity about the M by %ORM interaction currently existing can be attributed to the response measures used.

It has generally been assumed that the effects of %ORM are greater when low-M responses are used than when high-M responses are used. The present experiments show that this assumption is correct only in the later stages of training. Early in training, at least with the materials used in these studies, performance is so poor on low-M items that omission of a response has very little effect. The low-M responses are unavailable to the S as a result of the %ORM

operation but they are also unavailable in the S's repertoire of responses. Thus, a certain number of exposures of the responses are required in the 100% ORM group before the responses become available for pairing and the superiority of the 100%-ORM group can be manifested. With the high-M responses, on the other hand, the responses can be assumed to be available in the S's repertoire so that making the responses experimentally unavailable to the partial %ORM groups results in the immediate superiority of the 100%-ORM group. Thus, early in training %ORM has a greater effect with high-M responses than with low-M responses. As training progresses, the performance curves for the high-M items approach the asymptote, with the differences between %ORM groups necessarily becoming smaller as this level is reached. Performance on the low-M items, however, is still far from the asymptotic level at the end of 16 trials in the present study and the differences between %ORM groups are maintained. Thus, in the last eight trials, differences in %ORM are larger for low-M items than for high-M items. Even for the low-M items, however, there is a trend toward convergence of the %ORM groups within the last eight trials.

The present data suggest that the detrimental effects of omitting responses are largely confined to the early stages of training and are rapidly overcome. It seems clear, as others have suggested, that there must be some compensatory facilitation in the partial %ORM groups and that this facilitation is in some way produced through the presentation of the stimuli without their response members.

REFERENCES

- GOSS, A. E., MORGAN, C. H., & GOLIN, S. J. Paired-associates learning as a function of percentage of occurrence of response members (reinforcement). *Journal of Experimental Psychology*, 1959, 57, 96-104.
- GOSS, A. E., NODINE, C. F., GREGORY, B. N., TAUB, H. A., & KENNEDY, K. E. Stimulus characteristics and percentage of occurrence of response members in paired-associates learning. *Psychological Monographs*, 1962, 76, (13, Whole No. 531).
- NOBLE, C. E. Measurements of association value (a), rated associations (a') and scaled meaningfulness (m') for the 2100 CVC combinations of the English alphabet. *Psychological Reports*, 1961, 8, 487-521.
- NOBLE, C. E., & PARKER, G. V. C. The Montana scale of meaningfulness. *Psychological Reports*, 1960, 7, 325-331.
- SCHULZ, R. W., & RUNQUIST, W. N. Learning and retention of paired adjectives as a function of percentage occurrence of response members. *Journal of Experimental Psychology*, 1960, 59, 409-413.
- WILCOXON, H. C., WILSON, W. R., & WISE, D. A. Paired-associate learning as a function of percentage of occurrence of response members and other factors. *Journal of Experimental Psychology*, 1961, 61, 283-289.