Bernstein, Rose, & Ashe (1970) and present studies are largely offsetting. Then, the 30-msec difference in RT found in Table 1, which was obtained with a 2-sec fixed FPD, is consistent with the 24-msec difference obtained with a .5-sec fixed FPD and the 44-msec difference obtained with a 5.5-sec FPD in the earlier study.

REFERENCES

BERNSTEIN, I. H. Can we see and hear at the same time? Some recent studies of intersensory facilitation of reaction time. In A. F. Sanders (Ed.), *Attention and performance*.

Vol. III. Amsterdam: North Holland, 1970 (in press).

BERNSTEIN, I. H., BLAKE, R. R., & CLARK, M. H. Sensitivity and decisional effects in the psychological refractory period. *Perception & Psychophysics*, 1970, 7, 33-37.

BERNSTEIN, I. H., ROSE, R. R., & ASHE, V. M. Preparatory state effects in intersensory facilitation. *Psychonomic Science*, 1970, 19, 113-114.

MORRELL, L. K. Temporal characteristics of sensory interaction in choice reaction times. *Journal of Experimental Psychology*, 1968, 77, 14-18.

TODD, J. W. Reaction to multiple stimuli. *Archives of Psychology*, New York, 1912, 3, No. 25.

SUBJECTS

Ss were three amnesic patients, all of whom were included in our previous studies. One had a right temporal lobe excision (Dimsdale, Logue, & Piercy, 1964); the other two were cases of Korsakoff psychosis. Clinical details of the amnesic patients can be found elsewhere (Cases 1, 5, and 7 in Weiskrantz & Warrington, in press). There were four control Ss, approximately matched in age and intelligence, who were hospitalized for noncerebral neurological pathology.

PROCEDURE

Three lists of eight words were drawn from the AA list of the Thorndike-Lorge (1944) word count. The S was first shown the first two letters of the five-letter word on a card, and asked to guess the word. If he could not do so, he was shown the first three letters. If he still could not identify the word, he was shown the complete word. Each list of eight words was presented in the same sequence until the S could identify every word in the list by seeing only the first two letters. A trial was defined as a presentation of the entire list of eight words, and the error score was defined as the number of additional cards (other than the cards with just the two letters) required for identification of the words. The letters were strong black capitals, 1½ in. tall, printed with a felt pen on white cards, 5 x 8 in.

After learning the list to a criterion of two errorless trials, the S returned to his ward activities and was retested after 1 h, using the identical procedure. Each S was tested on 3 successive days with three different lists of words. The score for each S on any particular trial was the average of his performance on all three lists for that trial. Savings scores were calculated for each by comparing average-errors performance on the first relearning trials with average-errors performance on the first learning trials, according to the formula (Learning - Relearning)/(Learning + Relearning). Also, the mean number of trials to criterion for each S was calculated for learning and relearning sessions.

RESULTS AND DISCUSSION

The results are summarized in Fig. 1, which shows the mean error scores for each group for the first 10 trials of learning and relearning. The general pattern of results is similar to that found with fragmented pictures and words. The amnesic Ss show rapid learning to the criterion, although not as rapid as controls ($p = .057$ by Mann-Whitney U test). Every savings score in both groups was positive ($p = .008$ by the signs test) but the controls show significantly greater savings ($p = .028$ by Mann-Whitney U test). Patients are significantly slower than controls in relearning to criterion ($p = .028$ by

Verbal learning and retention by amnesic patients using partial information*

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Amnesic patients can remember pictures and words over several days if they are given visually fragmented information about them in the retention test. The present study shows that learning and retention occur when the partial information about words is in the form of whole letters. The results tend to discount an interpretation in terms of spared "perceptual learning" in such patients.

Amnesic patients are not amnesic under all circumstances. For example, it has been reported (Corkin, 1968) that the acquisition and retention of motor skills are possible (although evidently not normal) in one patient (H.M.) with bilateral hippocampal lesions. The same patient could also learn very simple visual and tactile maze problems (Milner, Corkin, & Teuber, 1968). The present authors (Warrington & Weiskrantz, 1968a) also found that amnesic patients could retain items presented in a particular form even if such items are not usually retained with conventional testing methods. The procedure, which recalls some earlier "prompting" experiments by Williams (1953), required the S to identify fragmented drawings of pictures or words. Amnesic Ss require progressively fewer cues to identify the drawings. Significant

retention can be demonstrated over days and perhaps even over weeks, whereas conventional methods yield significant retention over minutes at best. The same method also yielded significant retention in Patient H.M. when tested by Milner, Corkin, & Teuber (1968).

Milner (1968) appears to interpret the progressive improvement with the incomplete picture method as a kind of "perceptual learning," and considers that motor learning and perhaps certain forms of perceptual learning may be spared in amnesic patients. The present experiment is designed to determine whether or not the method of providing incomplete information can be extended to verbal material presented in such a way that no perceptual strain is placed upon the S. Instead of using visually displayed words that are randomly fragmented so that even individual letters are not readily identified on first exposure, we used the first two or three whole letters of five-letter words. There was thus no degradation of any particular letter; the Ss had to use perceptually complete verbal subunits of a word to identify the whole word.

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Fig. 1. Mean errors per trial (only first 10 trials are shown) during learning and relearning after an interval of 1 h.

the Ss had been exposed, and was not therefore a general improvement in perceptual recognition or a practice effect. In the present case the verbal material being learned imposed no unusual perceptual demands on the Ss. It seems difficult to argue that learning by the patients in our situation is restricted to "perceptual" learning, even if that were an apt description of our previous results. The question remains as to whether or not there is a common factor in those tasks that amnesic patients can learn and retain.

Mann-Whitney U test). Retention by amnesic patients after 1 h was, in fact, not as good with present material as with the fragmented words (Weiskrantz & Warrington, in press), but of course it is difficult to match the two types of stimuli on a common scale of difficulty.

It is clear that one method of manipulating the task difficulty quantitatively would be to vary the number of possible alternatives for any given incomplete word according to the number of dictionary words that could be formed out of the same first two or three letters. A comparable informational measure would be virtually impossible to derive for the fragmented stimuli used by us previously (and, of course, the latter are technically more difficult to prepare). In a pilot study we have found that the numbers of alternatives is a significant variable for both amnesic and control Ss, both groups learning the lists of few alternatives more rapidly than the lists with many alternatives. It is too soon to say whether or not amnesic Ss will improve at a different rate than controls as the range of alternatives is decreased.

The interesting question, of course, is why partial information should be effective in eliciting stored items in the patients

when the same items are relatively unavailable using conventional methods. The very fact that the material is available to certain methods, coupled with the observations of frequent intrusion errors in long-term recall of amnesic Ss (Warrington & Weiskrantz, 1968b; Starr & Phillips, 1970) suggests that long-term registration and "consolidation" of information of verbal items are more nearly normal than has been commonly assumed. However, the matter is certainly more complex than could be met by the assumption that the patients have an impairment on recall but not on recognition, because on standard recognition tests for verbal items their deficit is, if anything, even greater than on recall (Warrington & Weiskrantz, 1968b). Partial information could be effective for a variety of reasons; our current research is directed towards isolating the critical factors.

Whatever explanation ultimately will emerge as correct, at least the present study extends our previous findings by showing that a different form of partial information is effective in demonstrating retention in amnesic patients. In our previous study using fragmented drawings, the improved performance by patients was restricted to the specific material to which

REFERENCES

- CORKIN, S. Acquisition of motor skill after bilateral medial temporal-lobe excision. *Neuropsychologia*, 1968, 6, 255-266.
- DIMSDALE, H., LOGUE, V., & PIERCY, M. A case of persisting impairment of recent memory following right temporal lobectomy. *Neuropsychologia*, 1964, 1, 287-298.
- MILNER, B. Preface: Material-specific and generalized memory loss. *Neuropsychologia*, 1968, 6, 175-179.
- MILNER, B., CORKIN, S., & TEUBER, H. L. Further analysis of the hippocampal amnesic syndrome: 14-year follow-up study of H.M. *Neuropsychologia*, 1968, 6, 215-234.
- STARR, A., & PHILLIPS, L. Verbal and motor memory in the amnesic syndrome. *Neuropsychologia*, 1970, 8, 75-88.
- THORNDIKE, E. L., & LORGE, I. *The teacher's word book of 30,000 words*. New York: Bureau of Publications, Teachers College, Columbia University, 1944.
- WARRINGTON, E. K., & WEISKRANTZ, L. New method of testing long-term retention with special reference to amnesic patients. *Nature*, 1968a, 217, 972-974.
- WARRINGTON, E. K., & WEISKRANTZ, L. A study of learning and retention in amnesic patients. *Neuropsychologia*, 1968b, 6, 283-291.
- WEISKRANTZ, L., & WARRINGTON, E. K. A study of forgetting in amnesic patients. *Neuropsychologia*, in press.
- WILLIAMS, M. Investigation of amnesic defects by progressive prompting. *Journal of Neurology, Neurosurgery, & Psychiatry*, 1953, 16, 14-18.