Brain (1969) 92, 885–896.

THE SELECTIVE IMPAIRMENT OF AUDITORY VERBAL SHORT-TERM MEMORY

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INTRODUCTION

THE inability to repeat verbal stimuli has been recorded in the neurological literature as a relatively isolated disability. Wernicke (1874) regarded impairment of repetition as the cardinal feature of conduction aphasia and more recently Goldstein (1948) has discussed repetition defects in the context of central aphasia. Both authors discuss it as a variety of dysphasia. There have been a number of descriptions of the symptomatology of conduction aphasia, the more recent including Dubois *et al.* (1964), Konorski *et al.* (1961), and Geschwind (1965). All these authors emphasize that there is no impairment of the comprehension of speech although the ability to repeat verbal stimuli is markedly impaired. In addition to the repetition defect these patients are reported to have great difficulty with spelling and spontaneous writing (copying writing is intact), and much less difficulty with reading. Expressive and nominal difficulties are present but not necessarily to any marked extent.

Adequate repetition depends on a number of factors, the most important of which are acoustic perception and motor speech capacity. The question arises as to whether defects of repetition occur which cannot be regarded as secondary to other disabilities within the language system and if so what functional systems are impaired.

Few analytical studies of tasks of repetition have been reported. Patients with left hemisphere lesions are known to have a poor digit span (McFie, 1960), a task which demands accurate repetition, but the relationship of this defect to other aspects of language and memory was not examined. Dubois *et al.* (1964) undertook a linguistic analysis of the speech (spontaneous and repeated) of 3 patients with conduction aphasia, and stress that in repetition the difficulty of the task is related to the amount of information in the message rather than the length of the message. Luria *et al.* (1967) report 2 patients in whom the main symptom was an inability to reproduce a series of phonemes, words and digits presented orally, though there was relatively little impairment with visual presentation of the same verbal stimuli. Though this modality-specific defect of verbal repetition is described as a disturbance of "memory" no attempt was made to assess other factors, and the widely accepted differentiation of memory functions into a long-term and short-term component was not considered.

The digit span is a task which many experimental psychologists have used to study short-term memory in contrast to long-term memory; it is thought to be one measure of the capacity to recall from the short-term store (Hebb, 1961). There seems to be a *prima facie* case for considering whether a defect of short-term memory could account for an inability to repeat verbal material. In this paper a single patient is reported in whom there was a profound repetition defect. The proposition that this repetition defect may be regarded as an impairment of verbal short-term memory will be considered.

The question as to whether the organization of memory is a unitary process or a two-stage process has received much attention in recent years. The strongest evidence that there are separate short- and long-term memory systems is provided by the specific and isolated impairment of long-term memory in amnesic subjects. It has been clearly shown that patients with certain localized brain lesions may have a very profound defect of long-term memory, with intact short-term memory and with normal intellectual functions (Drachman and Arbit, 1966). Therefore if it can be established that the short-term memory system can be impaired the interaction of this defect with the functioning of the long-term memory processes including trace formation and retrieval would be of theoretical interest.

Case Report

K. F., a man aged 28, had a left parieto-occipital fracture in a motor-bicycle accident eleven years before, when a left parietal subdural hæmatoma was evacuated. He was unconscious for ten weeks. At first he was very dysphasic, but his speech gradually improved over the next few years.

At the age of 19 in 1959 he started having epilepsy and in 1965 when aged 25 he was admitted under the care of Dr. Denis Williams for the investigation of this. There was a bone defect in the left parieto-occipital region. Power in all limbs was normal, but fine movements were impaired in the right hand. There was no plantar response on the right. Sensation was normal. Bilateral carotid arteriograms were normal. An air encephalogram showed prominent localized dilatation of the left trigone and occipital horn, with some dilatation of the left temporal horn.

Psychological Assessment

K. F. was tested on the W.A.I.S. and obtained a verbal I.Q. of 79 and a performance I.Q. of 113. On the Progressive Matrices he scored 40 out of 60, which is just below the 50th percentile for his age. His relatively poor language functions were reflected in his verbal I.Q. His ability to express himself was halting, and some word-finding difficulty and circumlocutions were noted. Paraphasic errors were rare, and on no occasion were neologisms used. There was a very mild degree of nominal dysphasia, which could only be detected with uncommon names. Receptive speech functions were well preserved. Single instructions were carried out, though there was some difficulty with "longer" messages. Using a task similar to the token test devised by De Renzi (1962), the conceptual difficulty of the message did not impair his performance. Reading a simple text was slow, but reasonably accurate. On Schonell's graded word list he scored just below the 9-year level. Both oral and written spelling were very impaired (at the 6-year level). Memory for day-to-day happenings was good and he had an adequate knowledge of recent and past events.

Immediate memory for the Binet figures was accurate. More detailed tests of long-term memory will be given below. The most striking feature of his performance was his almost total inability to *repeat* verbal stimuli. His digit span was two, and on repeated attempts at repeating two digits his performance would deteriorate, so that on some trials his digit span was one, or even none. His repetition difficulty was not restricted to digits; he had a similar difficulty in repeating letters, disconnected words and sentences. Single verbal items would be repeated correctly with the exception of polysyllabic words which were on occasion mispronounced. An analytical investigation of this repetition defect is here presented.

Experimental Investigation

In this study a number of systematic procedures were devised to determine the basis of the disorder of repetition. In each experiment a standard presentation rate of one item per second spoken by the experimenter was used unless otherwise stated. In each experiment 2 blocks of 10 trials were given for each condition, with the exception of those tasks which involved continuous serial presentation of stimuli.

(1) *Repetition of Numbers, Letters and Words*

Repetition of strings increasing in length of numbers, letters and words was examined. Strings of 1, 2, 3 and 4 items were presented (in this order) for each of the 3 types of verbal material. The numbers and letters were chosen randomly, the only constraint being that no individual item in a string was duplicated. The words were chosen at random from 4 and 5 letter words of high frequency (AA) in the Thorndike-Lorge count. The results expressed both as the number of correct items and number of correct strings is given in Table I.

Table I.—Repetition of Numbers, Letters and Word Strings of Increasing Length

	String length	*1 Item*	*2 Items*	*3 Items*	*4 Items*
Numbers	No. of items correct	20/20	28/40	37/60	37/80
	No. of strings correct	20	12	6	1
Letters	No. of items correct	19/20	21/40	26/60	22/80
	No. of strings correct	19	7	2	0
Words	No. of items correct	20/20	29/40	32/60	33/80
	No. of strings correct	20	13	4	1

Performance on this task of repetition is directly related to the number of items in each string. K. F. can only reliably repeat one item, and the proportion of items correct decreases with increasing string length. In terms of number of strings correct his performance is already faulty for 2-item strings and markedly poor for 3 and 4 item strings. His performance is to some extent determined by the type of verbal material, repetition for numbers being better than for letters.

(2) *Effect of Presentation Rate on Repetition of Numbers, Letters and Words*

Three presentation rates were used, one item per half-second, one item per second and one item per two seconds, for pairs of numbers, letters and high frequency words (4 or 5 letters in length). Three blocks of 10 pairs of each type of verbal stimuli for each presentation rate were used. The order of type of verbal stimuli and presentation rate were randomized using $3\times3\times3$

Latin square design. The results expressed as the total numbers of items correct and the number of pairs correct are given in Table II.

TABLE II.—EFFECT OF PRESENTATION RATE ON REPETITION OF NUMBERS, LETTERS AND WORDS

	Presentation rate	*1 item per ½ second*	*1 item per second*	*1 item per 2 seconds*
2 Numbers	No. of items correct	30/60	45/60	59/60
	No. of strings correct	8/30	20/30	29/30
2 Letters	No. of items correct	23/60	30/60	34/60
	No. of strings correct	5/30	9/30	12/30
2 Words	No. of items correct	26/60	38/60	51/60
	No. of strings correct	2/30	15/30	22/30

As in the first experiment fewer errors occur with repetition of pairs of numbers than letters, and pairs of words are of intermediate difficulty. For all three types of verbal material performance is worst with the fast presentation rate (one item per half-second) and improves with the slower rate of one item per second, and is best with the slowest rate of one item per two seconds.

This result emphasizes the need to consider whether or not faulty input or a failure of registration of auditory-perceptual material could account for his defect of repetition. One possible explanation of his improved performance with slower presentation rates is slow auditory perception of single items, so that with strings of two or more items the perceptual processing is overloaded.

(3) *Auditory Perception*

A number of procedures were devised to determine whether the gross defect of repetition was secondary to impaired auditory perception of verbal stimuli. That is, are individual items, under conditions similar to those in use in conventional repetition tasks, perceived and identified sufficiently accurately to permit subsequent repetition?

Continuous memory span.—This technique needs a subject to listen to a long series of digits exceeding his normal span. He has no knowledge of how long the series is going to be and his task is to recall in the correct order as many items at the end of this list as possible. K. F. was asked to report the last item of each of 10 series of digits and letters ranging in length from strings of 6–12 items. For both numbers and letters his performance was completely accurate. Superficially, this result suggests that each digit or letter is being accurately processed, as at any point in a long series an individual item was correctly reported. Preceding items do not appear to block or prevent the registration of succeeding items.

The objection could be raised that the task could be done without registering each item in turn; the subject noting the end of the series might be able to perceive the final item from the auditory acoustic trace retrospectively. Therefore a matching task was devised in which the subject must perceive each item in order to achieve an error-free performance.

Matching numbers, letters and words.—Number, letter and word strings of increasing length (1 item–4 items) were used for this matching task. Pairs of strings were presented at the standard rate, with a pause of 1–2 seconds between the two strings. Each block comprised 10 pairs of strings, in 5 of which one item was different and in 5 they were identical strings, for example: 739–739 or, alternatively, 438–458. The subject was asked to respond "same" or "different" to each pair of strings. The results expressed as the total number of correct responses (maximum for each condition being 20) are given in Table III.

TABLE III.—MATCHING OF NUMBERS, LETTERS AND WORDS

String length	*1 item*	*2 items*	*3 items*	*4 items*
Numbers	20	19	20	17
Letters	20	18	17	15
Words	20	19	15	19

His performance is accurate for matching pairs of single items for all three types of verbal material. Though errors occur for longer string lengths, K. F.'s performance on this task is good enough with matching single items (the one condition in which the memory component of the task does not exceed his capacity) to suggest again that a failure of registration or faulty auditory perception of verbal stimuli cannot account for his repetition defect. Any interpretation of his better performance in matching than in recall must be treated with some caution. A same–difference judgment is easier than an identification judgment and some correction for guessing is necessary.

It could be argued, however, that matching two strings of items could be achieved at a pre-identification level in the auditory-speech system. That is, the subject is matching on the basis of sound patterns, and not item identification. A further procedure was devised to assess whether verbal stimuli, presented at the same rate as in repetition tasks, are individually identified when the memory component of the task is eliminated.

Identification of individual numbers and letters.—Lists of 20 items comprised one key item which recurred 5 times and 15 items chosen randomly from the same category (numbers or letters). Four lists of numbers in which the key item was 3, 6, 2 and 8 respectively and 4 lists of letters in which the key item was H, X, B and K were presented at a rate of one item per second. K. F. was told the key item for each list and asked to tap each time it was presented. The number of correct responses to key items and neutral items is given in Table IV.

TABLE IV.—IDENTIFICATION OF INDIVIDUAL NUMBERS AND LETTERS

	Key items	*Neutral items*
Numbers	20/20	59/60
Letters	19/20	60/60

Two errors were recorded, one on a number list and one on a letter list. This finding indicates that each individual item can be perceived and identified serially at a rate of presentation comparable to that used in repetition tasks and furthermore there is no deterioration in performance on lists of 20 items, which is comparable to those repetition tasks requiring repetition of 10 2-item strings. Therefore, on this task, which demands rapid acoustic perceptual identification but has no "memory" or verbal response component, performance is not detectably impaired.

Identification of categories of words.—Three lists of 40 words were compiled, of 10 key words belonging to a particular category and 30 neutral words. The categories were: Countries, Colours and Animals; one category represented by 10 different words was used in each of the 3 lists. K. F. was told the category of the key words in each list and asked to tap each time he identified a word as belonging to that category. The 40-word lists were read at an average rate of one per second. The number of correct responses to key words and neutral words is given in Table V.

TABLE V.—IDENTIFICATION OF WORD CATEGORIES

Category	*Key words*	*Neutral words*
Country	9/10	30/30
Colour	9/10	29/30
Animal	10/10	28/30

A maximum of two errors in a forty-word list was recorded. On this task K. F. was required not merely to identify a particular number or letter but to determine whether or not each word belonged to a particular category without prior knowledge of what the individual key words would be. There is no possibility of succeeding on this task by matching auditory percepts at a pre-identification level in the auditory-speech system.

(4) *Articulation and Related Disorders of Language*

Single verbal stimuli were almost invariably correctly repeated; there was some deterioration with two items and a very marked difficulty with three or more. Particularly as K. F. has some expressive speech impairment the question arises as to what extent the phenomenon of gross failure of repetition could be accounted for by articulatory difficulties or dysphasia. It might be assumed that an articulatory defect *per se* would not be directly related to the number of verbal stimuli, but to the difficulty of the individual speech sounds, though the possibility remains that difficulty with articulation of the first item would be followed by greater difficulty with a second if it is necessary to do it quickly. By comparing performance on recall and recognition of verbal stimuli it is possible to assess the role of articulation processes in genesis of the repetition defect.

Recognition by pointing.—Recognition by pointing was assessed for strings of numbers increasing in length from one to four items. Immediately after verbal presentation of each string a card printed with the numbers 1 to 9 arranged randomly in three rows of three was displayed and K. F. was asked to point to the items in the string. The arrangement of the numbers in the choice situation was varied from trial to trial. The number of correct responses for each length of number strings and the number of strings correct is given in Table VI.

TABLE VI.—RECOGNITION BY POINTING

	String length	*1 item*	*2 items*	*3 items*	*4 items*
Numbers	No. of items correct	20/20	34/40	24/60	33/80
	No. of strings correct	20	15	0	0

Recognition of numbers by pointing to each individual item does not result in better performance than conventional repetition of number strings (*see* Table I). If an articulatory defect were contributing to the poor performance in repetition one would expect a significant improvement on this recognition task where no verbal response is required. It may be argued that recognition tested by pointing to written numbers is mediated by sub-vocal repetition. Therefore a situation was devised in which two items must be perceived, but only one must be reported, i.e. part-reporting.

Part-reporting.—The subject was asked to repeat the first or second item of a pair without knowing which item was to be recalled. Two sets of 10 pairs of letters and numbers were presented at the standard rate.

TABLE VII.—PART-REPORTING

	1st item	*2nd item*	*Total*
2 numbers	5/10	3/10	8/20
2 letters	4/10	4/10	8/20

Comparing these results with the first experiment on repetition (*see* Table I) it can be seen that efficiency of part-reporting is shown to be no better than "whole" reporting. As reducing the response load in this way does not improve performance, this finding supports the view that K. F.'s disability cannot be explained as a difficulty in articulating more than one speech sound in rapid succession. It can be shown that in certain circumstances his ability to repeat verbal stimuli is markedly better.

Reinforcement and repetition.—The effect of reinforcement by repeating each individual item of a series on the subsequent repetition of the whole series was tested. Three or four numbers (or letters) were presented individually, and each repeated individually. Immediately after repeating the fourth digit, K. F. attempted to repeat all items in their correct order. The total number of correct responses and the number of strings correct is given in Table VIII.

TABLE VIII.—REINFORCEMENT AND REPETITION

	String length	*3 items*	*4 items*
Numbers	No. of items correct	57/60	69/80
	No. of strings correct	17/20	13/20
Letters	No. of items correct	42/60	51/80
	No. of strings correct	7/20	3/20

This result shows that in certain conditions the actual repetition of more than two verbal stimuli is much improved, which is further evidence against articulatory difficulties being a causal factor in this syndrome. Further examples of conditions giving rise to normal or near-normal verbal responses will be reported in the next section of the results of long-term memory tests.

(5) *Long-term Memory and Learning*

Paired-associate learning.—The paired-associate learning test from the Wechsler Memory Scale (1945) was administered according to the standardized procedure. The test consists of 10 paired associates (6 easy and 4 hard), and the final score is based on 3 learning trials. The mean score obtained by 50 normal subjects with an age range of 20–29 was 15·72 (S.D. 2·81). K. F. obtained a score of 14·5 which is less than one standard deviation below the mean for his age group. K. F. was given a fourth trial on which he recalled all 10 associations; when retested after a delay of six hours on his first trial he recalled 9 out of 10 associations.

Learning of incomplete words and pictures.—Warrington and Weiskrantz (1968) described a technique for measuring learning and retention from recognition of fragmented words and pictures. The method of learning to criterion (two error-free trials) was used and the test was repeated with a twenty-four-hour delay. Number of errors and number of trials to criterion for K. F. and a normal control group of 40 subjects whose age range was 20–40 (mean age 27) are given in Table IX. On this task K. F. performs within the normal range.

TABLE IX.—LEARNING OF INCOMPLETE WORDS AND PICTURES

		Patient		*Control group*	
		Test	*Retest*	*Test*	*Retest*
Gollin pictures	Initial score	14	10	19	10
	Trials	2	1	3	1
Incomplete words	Initial score	23	11	20	11
	Trials	4	2	3	2

Ten-word learning.—A list of 10 high-frequency words was presented auditorily at the standard rate. Subjects were required to recall as many words as possible from the list immediately after presentation. This procedure was repeated until all the 10 words were recalled (not necessarily in the correct order). K. F. needed 7 trials. Twenty normal controls took an average of 9 trials, 4 of the subjects failing on the task after 20 trials (Stevenson, 1967). After an interval of two months he was able to recall 7 of these 10 words without relearning.

(6) *Repetition of Visually Presented Numbers and Letters*

The procedure described in the first experiment, relating repetition to length of string, was replicated using visual rather than auditory presentation of the verbal stimuli. Strings of printed numbers and letters were presented visually at the standard rate of one item per second.

Immediate verbal recall was attempted. The total number of items correct and the number of strings correct is given in Table X.

TABLE X.—VISUALLY PRESENTED NUMBERS AND LETTERS

String length	*1 item*	*2 items*	*3 items*	*4 items*
Numbers	20/20	39/40	48/60	51/80
	20	19	10	6
Letters	20/20	37/40	48/60	46/80
	20	17	11	2

On this task his performance is superior to his recall of auditorily presented numbers and digits (*see* Table I). Only occasional errors occur with 2 item strings and he is still relatively efficient with 3 or 4 item strings. The question arises as to whether his superior performance on this task is directly related to the modality of the input or to the effectively longer exposure of each item. With visual presentation the stimuli are exposed for one second while in the comparable auditory task, using a one second rate of presentation, the auditory stimulus is present for much less than one second. Therefore his ability to repeat tachistoscopically presented verbal stimuli was assessed.

Tachistoscopic presentation of numbers and letters.—Strings of numbers and letters of increasing length (1–4 items) were presented tachistoscopically. A 250 msec. exposure duration was used throughout. K. F. was asked to delay his verbal report of the visual stimuli for two seconds after presentation. The total number of correct items and the number of correct strings is given in Table XI.

TABLE XI.—TACHISTOSCOPIC PRESENTATION OF NUMBERS AND LETTERS

String length	*1 item*	*2 items*	*3 items*	*4 items*
Numbers	20/20	40/40	51/60	52/80
	20	20	15	4
Letters	20/20	36/40	40/60	32/80
	20	16	8	0

His performance is accurate for 1 item strings and the total number of items correctly recalled in the 2, 3 and 4 item strings is greater than with an auditory presentation. Again he has greater difficulty with letters than numbers.

DISCUSSION

An attempt has been made to analyse the marked and specific impairment of repetition in a single patient. This patient had a reliable digit span of one and his performance deteriorated with progressively longer strings of digits. Experimental psychologists regard digit span as involving verbal short-term memory, therefore the possibility was considered that specific impairment of verbal short-term memory could account for his inability to repeat verbal material. To establish this it is essential to show that the repetition defect is not secondary to other disabilities in language.

Two alternative explanations of his disability have been investigated. First, that his repetition defect is secondary to impaired auditory perception, resulting in faulty registration of verbal stimuli and second, whether impairment of motor speech functions could account for his difficulty in repetition. A number of procedures were devised to determine the efficiency of his auditory perception. An explanation of his performance on the continuous span task and on the matching task in terms of a perceptual defect does not appear adequate. Performance on the matching task appears better than on recall; although an exact comparison is impossible without an elaborate theory to deal with guessing corrections, with strings of two or more items his performance is not entirely error-free. As there is a small but definite memory load in this matching task as well as a perceptual component, it is clearly an unsatisfactory way of differentiating between a perceptual and memory defect. More convincing are the results of the tapping tests, where there is no memory component in the task, but rapid successive perception of auditory material is required. No difficulty was encountered on these tasks. It is therefore implausible to account for the disorder of repetition as secondary to impaired auditory perception or faulty registration of verbal stimuli.

The task of recognition by pointing needs no verbal response, yet performance in terms of accuracy is no better than with verbal recall. This finding, with the "part-reporting" finding, strongly suggests that neither impairment of motor speech functions nor faulty articulation were contributing to the repetition defect. Furthermore, there are a number of test procedures in which the patient is able to produce a normal number of verbal responses. His repetition is improved after reinforcement by repeating each item individually and he is able to learn a 10-word list as efficiently as normal control subjects.

A cardinal feature of the repetition defect is that it is directly related to the "memory" load of the task. The original observation of a very poor verbal span, disproportionately bad compared with his comprehensive and expressive language functions, led to the present series of investigations. All subjects have a limited capacity to recall a series of digits or letters, or indeed any verbal stimuli, and this limitation is regarded as a characteristic of the "short-term" memory store (*see* Hebb, 1961). In the present case it is suggested that the capacity of the S.T.M. store is severely reduced so that in any task making demands on this function his performance is impaired.

Specific impairment of long-term memory with intact short-term memory is well recorded in amnesic subjects. It is therefore of interest to consider long-term memory functions in the present case. The patient's verbal learning (auditory presentation) appears to be quite satisfactory; considering that he is dysphasic, it is remarkably good. In these learning tasks he has little or no difficulty in producing a verbal response *per se*. Similarly, his learning and retention of visually presented verbal material (incomplete words) was entirely satisfactory. Therefore, if it is accepted that his short-term memory system is impaired, the finding, when considered with the converse finding in amnesics, that his long-term memory processes are normal, provides evidence for a double dissociation of function within the memory system. Further experimental evidence to support this point of view and a discussion of the relevance of this case for general theories of memory are reported by Shallice and Warrington (1970).

Using this formulation it is possible to account for the effect of presentation rate on his ability to repeat verbal stimuli. Glanzer and Cunitz (1966) have shown that decrease in presentation rate improves recall from the long-term store but does not improve recall from the short-term store. Moreover it is known that in long-term memory the act of recall increases the strength of the memory trace (Horowitz *et al.*, 1966; Tulving, 1967). Therefore, in conditions favouring recall from the long-term memory store one would predict improved performance. In fact this is the case; our patient improves in repetition tasks when the presentation rate is decreased, and when each item is repeated individually before recall (increasing strength of trace) his performance is better.

There are many points of similarity between the present case and those of conduction aphasia reported in the neurological literature, in particular intact comprehension together with severe impairment of repetition. Geschwind (personal communication), however, has suggested that conduction aphasics characteristically have greater difficulty within the sphere of expressive speech functions, yet Dubois *et al.* (1964) state in the conduction aphasic "repetition is as disturbed as spontaneous language, sometimes even more so." It is probable that our patient presents the characteristic defect of conduction aphasia in a particularly pure form, but we cannot exclude the possibility that his is an essentially different syndrome.

Geschwind (1965) reviewed the available anatomical data in published cases of conduction aphasia and concluded that the fasciculus arcuatus, a "tract which runs from the posterior superior temporal region, arches round the posterior end of the sylvian fissure and then runs forward in the lower parietal lobe, eventually to reach the frontal lobe," is the critical site of the lesion. Dubois *et al.* (1964) state that there is invariably damage in the region of the supramarginal and angular gyri of the left hemisphere, but no autopsy findings are available in any of their cases. In the 2 cases reported by Luria *et al.* (1967) the temporo-parietal cortex of the left hemisphere was involved. In the present case the maximum injury was in the posterior parieto-occipital region, which is not inconsistent with the anatomical correlates reported in previous cases of conduction aphasia. There appears to be considerable agreement that damage to the posterior dominant hemisphere is invariably present. Shallice and Warrington (1970) have reported findings which suggest that this short-term memory defect is one of storage rather than retrieval, which is difficult to reconcile with Geschwind's view that conduction aphasia results from a tract lesion.

Many instances of modality-specific cognitive disabilities have been recorded in the neurological literature. These functional dissociations are not only of diagnostic importance but are of considerable theoretical interest. Our patient had greater difficulty in reporting letters and digits presented auditorily than visually (at the standard rate of 1 item per second). Furthermore, his auditory span is shorter than his visual span for letters and digits presented tachistoscopically, though normal subjects have longer auditory than visual tachistoscopic span; this applies even if a delay is introduced before recall to allow the raw visual trace (called by Neisser (1967) the ikon) to decay. In both patients reported by Luria *et al.* (1967) recall of visually presented verbal stimuli was considerably better than recall of auditory stimuli. Such findings have relevance to models to visual memory (e.g. Sperling, 1967, and Neisser, 1967). A superior visual span shows that it must be possible to recall verbal information presented visually without necessarily involving the auditory verbal short-term memory system. Neisser (1967) may have over-emphasized the process by which letters after being identified are retained in an auditory store until recalled. One explanation of these results is that immediate recall of visual-verbal material is at least in part directly from a separate post-perceptual visual short-term memory store.

Summary

A patient is reported who had a gross impairment in the repetition of auditory verbal stimuli after a left parietal injury. His verbal span was reliable for only one digit and a comparable difficulty with letter and word spans was recorded. There was much less difficulty with comparable visually presented verbal stimuli. Verbal learning and verbal long-term memory were not affected. The defect cannot be accounted for by faulty auditory perception or motor speech defect, so a specific impairment of verbal short-term memory is proposed to account for the inability to repeat verbal material. The findings are discussed in relation to the interaction of short- and long-term memory functions and attention is drawn to the modality specificity of the defect.

Acknowledgments

We are most grateful to Dr. Denis Williams for his permission to report our findings on this case. We wish to thank Dr. R. T. C. Pratt and Dr. A. Baddeley for their comments on the manuscript, and Dr. A. R. Jonckheere for helpful discussions.

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(*Received 18 March 1969*)