Department of Veterans Affairs

Journal of Rehabilitation Research and Development Vol. 35 No. 2, June 1998
Pages 238–244

CLINICAL REPORT

An Assistive Device for Persons with Severe Amnesia

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Abstract—Five persons with severe amnesia were trained to use a device containing items of information relevant to daily activities. The training consisted of a procedure in which requests for information were paired with a tone, and the subject was required to access the device and respond with the answer to the request. The tone was gradually faded, with the goal of having the subject respond to a question alone. All of the subjects learned to consistently access the device and provide correct responses following a request for information. Generalization across requesters and settings in which the requests were made was also achieved. The findings are discussed in regard to the utility of exploiting the relatively well-preserved procedural memory system for rehabilitation of persons with severe amnesia.

Key words: *amnesia, assistive devices, memory.*

INTRODUCTION

Severe amnesia associated with substance dependence, often accompanied by thiamine deficiency, is typically described as persistent, with remission occurring very rarely. Indeed, the *Diagnostic and Statistical Manual of the American Psychiatric Association* (DSM-IV) term for the disorder is ''Substance-Induced Persisting Amnestic Disorder'' (1). The term is essentially equivalent to alcoholic Korsakoff's syndrome, although alcohol is not always the responsible substance. Not only is the disorder chronic and severely disabling, it is generally not effectively remediated by conventional methods of memory rehabilitation. Because of the severe nature of the disorder, the teaching of mnemonic strategies typically does not help these individuals learn faster or more efficiently (2,3). It is generally accepted that the basis for the amnesia is hemorrhaging in the diencephalon, where there is little redundancy and opportunity for transfer of memories to healthy tissue (4). Typically, treatment and rehabilitation outcome for these individuals is extremely poor, and they often need to be confined to institutional settings for indefinite periods of time.

Two recent developments have raised some hope of improving the usually dismal outcome of this disorder. One of them has to do with the discovery of a relatively well-preserved memory system in these individuals, described as procedural, implicit, or nondeclarative memory. Going back to the early study of Cohen and Squire (5), a substantial literature has developed illustrating that persons with severe amnesia can learn new skills. The phenomenon has been demonstrated with priming experiments, perceptual-motor skill learning, and repetitive instruction using a vanishing cues methodology. Glisky et al. (6,7) and Goldstein and Malec (8), using different methods, utilized this information concerning a preserved memory system in successful rehabilitation applications. Glisky and Schacter (9) used the term ''domain-specific knowledge'' to characterize the type of learning without generalization that densely amnesic persons typically achieve.

The second development is advances in electronic technology, allowing for the production of small per-

This material is based upon work supported by the Department of Veterans Affairs Rehabilitation Research and Development Service, Washington, DC 20420.

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sonal reminders that contain information, and that are readily accessed by individuals as aids to keeping appointments or as directories for telephone numbers, addresses, and related information. The development of these devices opens major possibilities for prosthetic memory, or the use of assistive devices to support individuals with memory impairment.

In the present study, we propose an integration of these two developments with the goal of providing an effective memory training program for persons with severe amnesia. The initial basis for our rationale is found in Goldstein and Malec (8), where we showed that persons with extremely dense amnesias could learn and consistently retain items of relevant verbal information through extensive rehearsal. The method used in that study was pure rehearsal within the framework of a multiple baseline design in which one word was taught at a time. It was reasoned further that if these persons could learn those items, they might also be able to learn to use a device that contains items of information of the type we taught, as long as they were capable of physically handling the device. Since most persons with amnesia can read, and have the motor skills needed to use a hand-held computer, it was assumed that physical use of the device would not be a problem. However, it was also assumed that amnesic individuals would forget about the device as readily as they forget about the information it contains. It, therefore, did not seem to be productive to simply give them the device and suggest that they use it when they require information. That is, it was felt that these devices could not be spontaneously used immediately as they are used by individuals without amnesia.

These considerations raised the possibility that it might be possible to train persons with amnesia to use a memory assistive device through exploiting some aspect of the nondeclarative memory system. If that were the case, large amounts of changing information could be made available through a programmable device. The ideal scenario would be the situation in which the person receives a request for information that cannot be remembered: he or she then spontaneously takes out the device and finds the answer. Thus, the goal of the training becomes that of training the person to remember to access the device, rather than to recall the information that it contains.

Based on the skill-acquisition studies of persons with amnesia, it was felt that a promising way of doing the training would be with a rehearsal procedure. We utilized a training method in which a tone was paired with a prompt to use the device following a request for information. The tone was gradually faded in an effort to elicit the motor response of accessing the device with the question alone. The procedure can be considered as a classical conditioning variant, if the tone can be viewed as an unconditioned stimulus and the question, the conditioned stimulus. The method is somewhat different from classical conditioning in that there is no unconditioned response that is always made following the unconditioned stimulus—the tone. However, the pairing of conditioned and unconditioned stimuli with gradual fading of the unconditioned stimulus does resemble classical conditioning. Learning is demonstrated by obtaining the desired response to the question in the absence of the tone.

If successful learning is accomplished, the next question involves generalization. We made a distinction between generalization across persons and across settings. A person with severe amnesia might only make effective use of an assistive device when the original trainer makes the requests for information. Furthermore, effective use may only occur in the same setting in which the training occurred. The rather specific nature of procedural learning and the absence of generalization typically observed among individuals with severe amnesia make these possibilities quite likely. Therefore, the training procedure involved generalization sessions across requesters, across settings, and in situations in which there is a change in both requester and setting.

This study reports findings obtained from a group of densely amnesic persons who went through a program designed to teach them to access a device that contained information they could not remember. It was not the intent of the study to teach them the content of the material stored in the device, but rather to remember to use the device itself. The assumption that such teaching might be successful was based on previous findings showing that persons with severe amnesia can learn new skills through rehearsal or conditioning.

METHOD

Subjects

The sample consisted of five persons who met DSM-IV criteria for substance-induced persistent amnestic disorder. Psychometrically, four of them obtained a General Memory Index on the Revised Wechsler Memory Scale (WMS-R, see 10) at least 20 points below their WAIS-R (11) Full Scale IQ score;

thus meeting psychometric criteria that closely resemble those of Butters and Cermak (12) who used the Memory Quotient (MQ) from the original Wechsler Memory Scale (13) in their research. One subject had only an 11-point discrepancy, but met all other diagnostic criteria for substance-induced persisting amnestic disorder. Those with neurobehavioral disorders other than amnesia were excluded, as were subjects who lacked sufficient reading, visual, or motor ability to use the assistive device. Demographic and psychometric data are contained in **Table 1.** Additional neuropsychological tests were administered to evaluate the severity of memory impairment and to assess the status of language. The memory tests included a word-word paired-associate learning task (14), a three-word short-term memory task utilizing the counting backward distracter technique over delays of 10 and 20 s (15), and the Famous Faces Test (16). The language tests consisted of the Boston Naming Test (17) and two measures of verbal fluency: the Animal Naming Test from the Boston Diagnostic Aphasia Examination (18) and the Controlled Oral Word Association Test (FAS, see 19). Results are presented in **Table 2** and **Figure 1.** With regard to the memory tests, all of the scores reflected severe impairment relative to performance levels reported for controls (12,14). The one exception was Case 5, who did well on the three-word short-term memory task, but had a General Memory Index score in the severely impaired range, could not produce any correct responses on the paired-associate learning task, and produced a steep retrograde-anterograde gradient on the Famous Faces Test.

On the Famous Faces task, **Figure 1** indicates that all subjects demonstrated the retrograde-anterograde gradient expected to be found in individuals with Korsakoff's syndrome. This gradient is produced largely by a decrease in the number of correctly identified individuals during the most recent decade, in this case the 1970s. In some instances, the gradient at this point is quite sharp (as in Case 5), while in others there is a

Table 1.
Demographic and psychometric data.

Case	Age	Years of Education	Verbal IQ	Performance IQ	Full Scale IQ	DRS [1]	GMI [2]
1	61	12	85	75	75	118	50
2	58	12	86	86	85	120	49
3	58	12	78	81	79	122	50
4	59	12	93	99	95	122	84
5	51	14	104	91	98	128	50

[1] Dementia Rating Scale; [2] General Memory Index.

Table 2.
Neuropsychological test data.

Case	Boston Naming Test [1]	Verbal Paired Associate Learning [2]	STM–10″ [3]	STM–20″ [4]	Animal Naming [5]	FAS [5]
1	43	1	2	0	7	20
2	53	5	2	1	10	20
3	51	3	5	4	12	21
4	53	6	9	7	14	40
5	58	0	14	10	11	13

[1] Total Correct; [2] Correct Words out of 30; [3] STM=Short-term memory; Correct words out of 15 with 10 second delay; [4] Correct words out of 15 with 20 second delay; [5] FAS=Controlled Oral Word Association Test; Number of acceptable words.

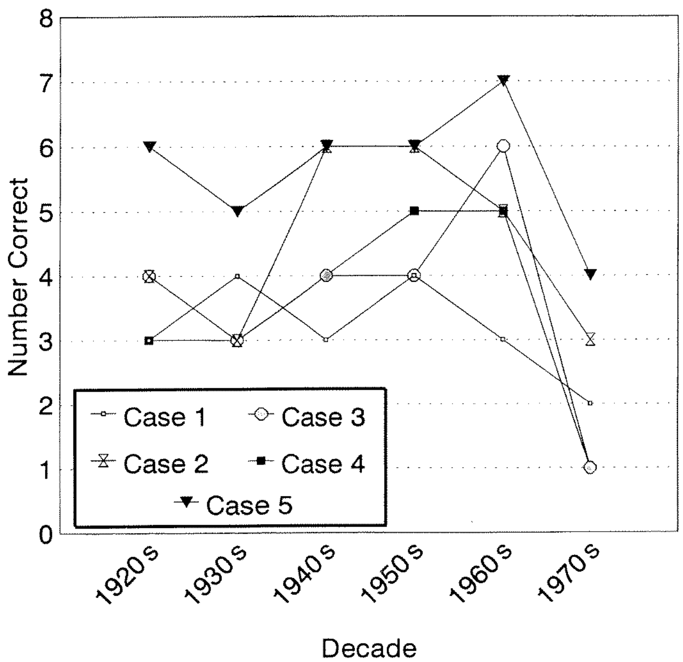

Figure 1.
Famous Faces Test results for the five amnesic subjects.

more erratic, gradual decline (as in Case 1). With regard to the Boston Naming Test, all but one of the subjects fell below the recommended cut-off of 51 correct, but none demonstrated severe word-finding impairment. Similarly on Animal Naming, three of the subjects scored below the recommended cutoff of 12, but none of them demonstrated severe impairment of fluency characteristic of some forms of aphasia. On Controlled Oral Word Association, only one subject performed in the impaired range. The others would be classified as having high or low normal scores. In summary, the tests of memory and language indicated profound memory impairment with sometimes mildly impaired language skills that did not fall into the aphasic range. The mild language deficits noted were not of sufficient magnitude to compromise the training procedure. All subjects received their training at the inpatient facility in which they were resident.

Material

The device was a custom-built, battery-operated apparatus the size of a pocket computer with a two-line LED display window and two buttons. Commercially available personal reminders were not used because of the complexity of the keyboards and operating instructions. The device was programmable by means of a receptacle that could connect it into a computer. The LED display was in a two-line format (e.g., Nurse's Name/Helen Horowitz). The buttons were used to scroll through the items. The device is also capable of emitting the beeping signal used in the training procedure. Only the device itself is needed for work with subjects. **Figure 2** is a computer-enhanced drawing of the device.

Procedure

The training was conducted over a course of daily sessions, divided into an information-gathering session and six training phases. Individual sessions were generally completed in 20 min or less.

Information Gathering

This step involved developing a set of individualized questions to use in the training sessions. Staff members and the subjects themselves identified information with relevance to daily functioning within the care setting. Typical information included the name of the ward, names of staff members, location of facilities within the hospital (e.g., canteen, library), and visiting hours. A question/answer format was developed for this information. The following procedure assured that the subjects did not already know the answers to the questions developed for training purposes. Each was asked the list of questions daily for five consecutive days. Questions retained for the device training procedure were those answered incorrectly on at least three of the five days. A list of six questions was developed in this manner.

Phase 1

A single question was programmed into the device, which was introduced to the subject during the first day of this phase. The subject practiced turning the device on and reading the question and the answer from the LED screen. This procedure assured that he or she could physically manipulate the equipment used in the training. After this introduction, the subject was asked the question: a tone and a verbal prompt to use the device occurred immediately, and the subject's response was recorded. This pairing of the question and the tone/prompt continued for a maximum of 20 trials during each session. A correct response was scored when the subject picked up the device, turned it on, and read the answer out loud. Criterion for successful completion of Phase 1 was the correct response on 10 consecutive trials over 5 consecutive training sessions. After comple-

Journal of Rehabilitation Research and Development Vol. 35 No. 2 1998

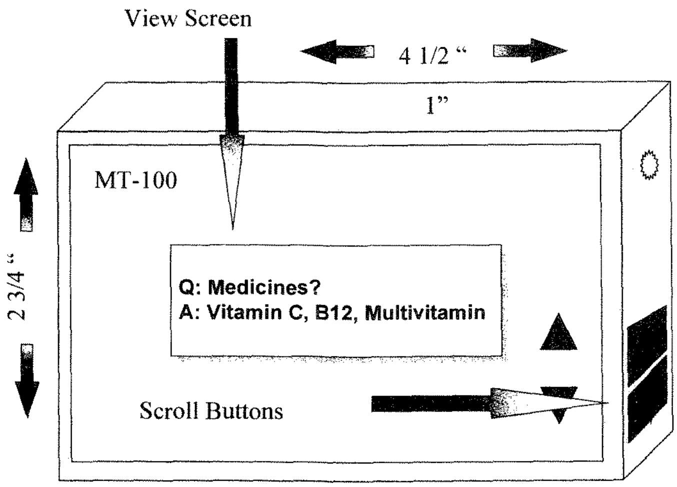

Figure 2.
Computer-enhanced drawing of the assistive device.

tion of this phase, the single question was removed and the remaining 5 questions programmed into the device.

Phase 2

The training procedure remained the same, except that five questions were used during each session and the verbal prompt was only given as necessary. Responses were scored as correct when the person picked up the device, turned it on, identified the correct question, and read the answer out loud. Each of the 5 questions was asked up to 20 times, or until the subject answered each question correctly for 10 consecutive repetitions. Criterion was met when each of the 5 question-tone pairs were responded to by the use of the device for 10 consecutive trials over 5 training sessions.

Phase 3

This phase was devoted to fading the tone. Thus, the same 5-question procedure as described above was used but the tone was eliminated on a random basis. If the device was not used on a trial without the tone, the subject was prompted to respond as he had on those trials in which the tone was present. Again, each of the 5 questions was repeated up to 20 times. Criterion was reached when, for each of the 5 questions, the subject used the device without any cuing (tone or verbal prompt) for 10 consecutive trials over 5 consecutive training sessions.

Phases 4, 5, and 6

The questions in the device were not changed, but the tone was not used during any further training. The actual training procedures remained the same; however, these phases were devised to assess generalization across trainers and settings. In Phase 4, a new trainer conducted the sessions; in Phase 5, the original trainer conducted the sessions in a new setting; and in Phase 6, both trainer and settings were different from the original training. Criteria for these phases were 10 consecutive correct trials for each of the 5 questions over 3 consecutive days.

There was little variation in the number of sessions required to meet criteria for completing the program, ranging from 24 to 27 sessions. A follow-up session was conducted 1 wk and 1 mo following completion of Phase 6, in order to determine whether the subject still used the device to answer questions.

RESULTS

All subjects completed each training phase. The results are summarized in **Figure 3.** This figure indicates the session during which criterion was met by each subject over the course of the training. For example, during learning, a score of 5 would mean that the subject met criterion on the first five training sessions; a score of 6 would mean that criterion was not met on the first session, and a sixth session was needed. In the case of generalization, a score of 3 would mean that the subject reached criterion during the first three sessions, and did not require additional sessions. A Friedman two-way analysis of variance indicated that there was a significant reduction in number of sessions across the six training phases ($\overline{X}^2(5)=20.6$, $p<0.001$). All five subjects met criterion for each phase within eight sessions or less. Furthermore, the number of sessions needed to reach criterion diminished over time. Generalization across trainers and settings was also achieved. **Figure 3** indicates that all subjects required no more than four sessions to meet criteria for the generalization sessions. On follow-up, the subjects spontaneously used the device to answer questions 90 percent or more of the time, indicating that use of the device was generally maintained following training.

DISCUSSION

This study shows that densely amnesic persons can learn to use an assistive memory device to access functionally relevant information in a relatively short

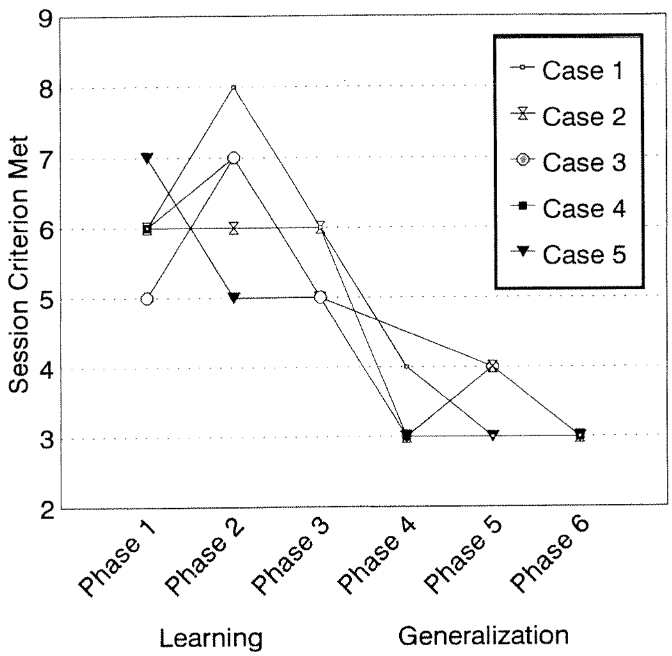

Figure 3.
Assistive device training results for the five amnesic subjects.

period of time. This learning was associated with good stimulus generalization across examiners and settings, and was maintained for as long as 1 month after training was completed. This finding has theoretical as well as clinical implications. Aside from providing another demonstration of the relative intactness of the nondeclarative memory system in persons with Korsakoff's syndrome, the procedural learning accomplished could not be characterized as hyperspecific (6,7). The device was accessed when both stimuli, the trainer who asked the questions and the setting in which the questions were asked, were changed. This finding suggests that the overlearning of procedural tasks appears to increase the likelihood that overlearning of a new skill may promote transfer, as has been shown in studies of semantic memory in persons with amnesia. Butters et al. (20) reported that procedural memory representations, instead of becoming increasingly stimulus-bound, may actually become more elaborated with increasing use, and therefore, support better transfer to a different context. Therefore, it is suggested that in rehabilitation efforts of the type used here, it may be useful to extend practice to the point of overlearning, rather than halting it when minimal criteria are met.

Another aspect of the generalization matter relates to the decrease in number of sessions needed to reach criterion across phases. If it is assumed that this learning was unlikely to have been based on episodic recollection of the previous training sessions, it would appear that the implicit knowledge of the procedure acquired during prior sessions produced an incremental integration of the current phase with this previously acquired knowledge. Thus, the subjects not only learned to access the device to correctly answer a question, but they did so with increasing efficiency. There is evidence, reviewed by Jernigan (4), that verbal implicit memory tasks, such as word priming, may be mediated by neocortical association cortices. Therefore, it is possible that the learning accomplished here was associated with the intactness of these structures in the presence of substantially compromised limbic-diencephalic systems.

From a practical standpoint, the relatively brief course of this training and the ability of procedural memory to generalize to other trainers and settings has important implications for directing rehabilitation interventions and improving the quality of life for persons with severe amnesia. It is noted, however, that it was not possible to obtain long-term follow-up on the present sample, and widespread usage of the device should await an evaluation of outcome at perhaps 6 months to a year following training. Further technological development of the rather primitive device used may make it ''smarter'' and increasingly capable of housing more information of an increasingly complex nature. Alternatively, such advancement might allow for use of the device for individuals with cognitive disabilities that go beyond amnesia. The investigators are now in the process of collecting data from individuals with Alzheimer's disease, a disorder with a much higher prevalence than Korsakoff's syndrome, but often with equally devastating memory impairment.

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Submitted for publication November 19, 1996. Accepted in revised form April 15, 1997.