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ABSTRACT

Memory problems are a common complaint of patients with epilepsy (Thompson & Trimble, 1996). The main surgical and/or pharmacological interventions currently used to control epileptic seizures do not necessarily ameliorate existing memory deficits. The present study aimed to investigate the extent to which patients with epilepsy could be taught learning and memory strategies to help them compensate for their memory deficits. The specific mnemonic strategy under investigation was action enactment. Normal control participants consistently show superior levels of recall when they actively enact to-be-remembered action items (e.g., close a book, comb your hair) during encoding relative to passive reading of the items (for review see Zimmer et al., 2001). Extant data suggest that this mnemonic strategy can lead to memory gains in a variety of populations including children (Baker-Ward, Hess, & Flannagan, 1990), patients with Alzheimer's disease (Karlsson et al., 1989), and individuals with autism (Summers & Craik, 1994). A group of 13 patients with intractable seizures and a group of 20 normal controls were compared on their memory of 24 action phrases based on dependent measures of free recall, cued recall, and source discrimination. Half of the items were presented in the no-enactment condition and the other half were presented in the enactment condition. Results suggest memory for items in the enactment condition to be better compared to memory for items in the no-enactment condition for all participants, irrespective of seizure presence or nature. While overall memory performance in the patient group was weaker than the control group, data suggest potential utility of enactment in the development of cognitive rehabilitation techniques.

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MEMORY FOR ACTIONS: THE ENACTMENT EFFECT IN EPILEPSY

Introduction

Approximately 50 million people worldwide are affected by epilepsy (World Health Organization, 2001), one of the most common chronic neurological disorders affecting the central nervous system (McLin, 1992). Approximately 5.1 per 1,000 persons in the United States report epilepsy as a chronic condition (Adams, Hendershot, & Marano, 1999). Epilepsy is characterized by recurrent seizures of various types and is associated with many different etiologies (e.g., hippocampal sclerosis, brain tumor, vascular disease, traumatic brain injury). Epileptic seizures stem from abnormal electrical activity in the brain and may result in episodes of disturbed movement, sensation, perception, cognition, and behavior; each of these disturbances is typically accompanied by disturbances of consciousness (Kolb & Whishaw, 1996; Thompson & Trimble, 1996). Depending upon neurological and environmental factors, the effects of epilepsy on daily life may include academic underachievement, vocational disability, significant emotional distress, high levels of stress, perceived and experienced stigma, as well as social isolation (Hermann, 1992). While there is no single neurocognitive profile that accurately depicts every individual with epilepsy, one of the most frequent complaints of patients with epilepsy is memory impairment. Aldenkamp, Hendriks, and Vermeulen (2000) estimate that 15 to 20 percent of patients with refractory epilepsy (i.e., resistant to medical treatment) have memory impairment. The majority of these individuals report difficulty in acquiring new information (i.e., encoding), reproducing information after a long delay (i.e., retrieval), or both (Aldenkamp et al., 2000).

In general, the main approaches to interventions for seizure control are pharmacological and/or surgical. Unfortunately, these treatments may not ameliorate memory deficits. The more recently developed antiepileptic drugs (AEDs) can reduce seizure frequency by 50 percent or more in 30 to 55 percent of patients with medically intractable epilepsy (Nguyen & Spencer, 2003). Studies examining the cognitive effects of AEDs are inconclusive. Some studies report improvements whereas others report decline in memory performance (Smith, 1991; Thompson, 1991). Naturally, the types of drugs and dosage amounts are critical factors. Several studies suggest that sustained, well-managed administration of AEDs does not adversely impact memory or overall cognitive abilities (Äikiä, Salmenperä, Partanen, & Kälviäinen, 2001; Dodrill & Wilensky, 1992).

In cases where AED treatment is ineffective in controlling seizures, surgery may be used to resect the focus of abnormal activities in patients with identifiable focal seizures (Kolb & Whishaw, 1996). The majority of such surgeries are performed on the temporal lobes and fewer on extratemporal regions (Thompson & Trimble, 1996). Wiebe and colleagues (2001) conducted a randomized controlled trial comparing temporal lobe epilepsy surgery with other medical treatments and reported a seizure-free rate of 58 percent in the surgical group compared with 8 percent in the medical treatment group. With regard to cognitive effects, research has shown that surgery for temporal lobe epilepsy (TLE) can result in additional memory deficits beyond those existing prior to resection of cortical tissues (Helmstaedter, Reuber, & Elger, 2002). "Preoperative ability status, age at the time of surgery, and the extent of the resection of functioning tissues are the most important factors determining postoperative memory reserve" (Helmstaedter et

al., 2002, p. 89). The most consistent finding is a significant decline in verbal memory (e.g., story recall) following surgery on the temporal lobe in the dominant hemisphere depending upon integrity of both the targeted and contralateral anterior temporal lobes (Chelune, 1995; Lee, Yip, & Jones-Gotman, 2002). Deficits in confrontation naming, verbal conceptual ability (Seidenberg et al., 1998), and complex learning and memory (Ivnik, Sharbrough, & Laws, 1987) have also been reported. Findings following nondominant temporal lobe resections are less definitive with respect to changes in nonverbal memory performance as measured by standard visual memory tasks (Lee et al., 2002). Even though negative effects are more commonly observed, improvements in cognitive functioning also have been reported in some cases (Ivnik et al., 1987).

Whether directly related to seizure activity and/or changed by ensuing interventions, memory impairment is present in a substantial percentage of individuals with epilepsy, particularly for verbal memory in patients with left dominant TLE. Therefore, while the main interventions have made great strides in seizure control, additional interventions to improve cognitive functioning are needed to enhance the overall quality of life for individuals with epilepsy. Thompson and Trimble (1996) conclude, "Remedial treatments for neurocognitive deficits, especially in the domain of memory and attention, are urgently required..." (p. 281).

Aldenkamp and colleagues (2000) have provided a useful framework for discussing existing approaches to treating memory deficits. The two basic methods are behavioral and neuropharmacological. The behavioral models include the *reconstruction* and *compensatory* approaches. Reconstruction techniques attempt to use repetitive drilling and practice with memory tasks to improve memory functioning. Such techniques

may be helpful in learning specific items of new information; however, there appears to be minimal improvement in overall functioning and a lack of generalization to novel contexts (Prigatano et al., 1984). Compensatory techniques work to develop strategies to compensate for memory deficits without directly attempting to improve overall capacity. These strategies are commonly implemented through the use of external or internal memory aids.

External memory aids are regularly used by individuals with and without memory impairments. Diaries, planners, PalmPilots™, alarms, and Post-it® notes are all considered types of external memory aids that may be used to provide reminders and reduce memory load. Wilson (2002) and her colleagues have found success using an external aid called NeuroPage, a pager that receives pre-programmed messages at specific dates and times to remind the individual to do certain activities (e.g., feed the dog, get ready to go to a dentist appointment). Since some learning is initially required to become familiar with the external aids, it can still be challenging for individuals with memory impairment.

Internal memory aids or compensatory cognitive strategies include various well established mnemonic techniques. These include visual imagery and various verbal strategies such as the Method of Loci, a cognitive technique for organizing information in order to facilitate recall. For example, given a list of words to remember in order (book, antenna, license, copper, etc.), one could mentally associate each word with a familiar locale like the rooms in one's house (an attic full of books, a television with extended antennas in the den, framed professional licenses in the study, a bedroom wallpapered in copper pennies, etc.). Then, when asked to recall the words after a delay, a *mental walk*

through the house would make recall easier. In theory, memory strategies are generalizable to multiple contexts (e.g., learning cranial nerves, remembering a shopping list); however, it appears few individuals actually do so without specific prompting (Aldenkamp et al., 2000). In a recent study of people with acquired brain injury, the best predictors of use of memory aids (external and internal) were age, length of time since injury, number of aids used premorbidly, and a measure of attention and speed of information processing (Evans, Wilson, Needham, & Brentnall, 2003).

Errorless learning is one of the more widely researched memory rehabilitation techniques. "Errorless learning is a teaching technique whereby people are prevented, as far as possible, from making mistakes while they are learning a new skill or acquiring new information" (Wilson, 2002). For example, suppose a patient would like to learn his new granddaughter's name, Penelope. The clinician would try to minimize interference from trial and error (i.e., guessing) and present the correct response in repeated exposures of gradually decreasing gradations (e.g., Penelo__, Pene__, Pen__, etc.) so the patient is *always right* and only the correct name becomes encoded. Even though training patients using this technique can demand substantial effort from both parties, positive outcomes have been seen in patients with dense amnesia and other organic memory impairments (Wilson, 2002). Tailby and Haslam (2003) have investigated the potential of improving upon the standard errorless learning technique by incorporating elaboration and self-generation strategies. These adaptations resulted in significantly better memory performance, thus encouraging further exploration and development of behavioral methods. Seger, Rabin, Zarella, and Gabrieli (1997) have demonstrated facilitative priming effects of self-generation of verbs to presented nouns that are independent of

hippocampal and diencephalic brain regions that often are compromised in global amnesia. Patients with amnesia performed comparably to normal controls as measured by verb generation response time to novel and repeated noun stimuli. Consequently, verb generation may have the potential to enhance memory rehabilitation in some of the patient populations that suffer the greatest memory deficits.

As noted above, the pharmacological approach is another method of memory rehabilitation. The use of this approach is not nearly as widespread as the behavioral methods, probably due, in part, to the higher potential risks of neurotoxic effects and uncertainty regarding outcomes. However, with increasing use of pharmacological agents in treating neurological disorders such as Alzheimer's disease, it is foreseeable that comparable drugs may be developed to improve memory abilities in patients with epilepsy. Aldenkamp et al. (2000) discuss the following four classes of drugs for memory treatment: non-specific CNS stimulators, drugs to replace depleted neurotransmitters, putative memory modulators, and drugs that increase cerebral blood flow (CBF). Nootropic drugs (a subclass of the CBF drugs) seem to show some potential, but the research still appears to be in the exploratory stages.

The present experiment investigated an additional internal memory strategy that patients with epilepsy could learn to help them compensate for their memory deficits. The specific mnemonic strategy under investigation was *action enactment encoding* (Cohen, 1981; Engelkamp, 1998). When to-be-remembered items are everyday actions (e.g., close a book, comb your hair), normal participants consistently show superior levels of recall and recognition if they actively go through the motions of (i.e., enact) the action items during the encoding process as opposed to simply passively reading the to-be-

recalled items (for review see Zimmer et al., 2001). In initial studies of action memory by Engelkamp and Krumnacker in the 1980s, "The main result was that memory of actions, measured by phrase recall, was much better after performing the actions (.62) than after listening to the phrases (.45), and it was even better than imagining the actions (.53)" (Zimmer & Cohen, 2001, p. 8). Extant data suggest that this mnemonic strategy can lead to memory gains in a variety of populations including children (Baker-Ward et al., 1990), patients with Korsakoff's syndrome (Mimura et al., 1998), patients with Alzheimer's disease (Karlsson et al., 1989) and individuals with autism (Summers & Craik, 1994).

The potential advantage of action enactment has not yet been directly explored in patients with epilepsy. Schwerdt and Dopkins (2001) used an action memory task in several conditions with temporal lobectomy patients to study the extent to which the temporal lobes are involved in source and content memory. Their results confirm that action enactment is worthy of investigation in the epilepsy population. Left temporal lobectomy participants demonstrated rates of memory performance, as measured by action phrase written free recall, of .27 for performed items, .14 for observed items, and .14 for imagined items; right temporal lobectomy participants showed corresponding rates of .30, .26, and .19 (Schwerdt & Dopkins, 2001). If the benefit of enactment in encoding of new memories is mediated by brain regions that have been spared in epileptic patients, it would be expected that such patients could take advantage of behavioral techniques incorporating aspects of action enactment to help them compensate for their memory deficits.

Evidence from recent neuroimaging studies indirectly suggests that individuals with epilepsy may benefit as much as other populations from action enactment. Nilsson and colleagues (2000) conducted a PET study with a group of six right-handed normal control participants, who were scanned during cued recall immediately following each of three types of encoding phases (performed, imagined, silent rehearsal). These researchers found increased retrieval-related activity in motor regions of the brain, particularly the right primary motor cortex, associated with enactment encoding. Nilsson and colleagues (2000) concluded that, "As such these findings predict that patients with different kinds of brain damage, but with an intact motor system, should benefit from encoding support in the form of enactment" (p. 2200). A PET study by Nyberg and colleagues (2001) expanded on previous results by scanning during enactment encoding and retrieval. These researchers scanned ten right-handed normal control participants during three encoding conditions (performed, imagined, silent rehearsal) and the corresponding cued recall condition following each encoding phase. Results revealed differential activity in somatosensory and motor cortex regions during both enactment encoding conditions (performed and imagined) compared to the verbal (i.e., silent rehearsal) condition. Some of these areas, including regions in the left ventral motor cortex and the left inferior parietal cortex, were reactivated during retrieval; the left dorsal parietal cortex and right cerebellum appeared to be specific to the performed enactment condition (Nyberg et al., 2001). It is unclear from existing imaging studies whether some or all of the noted regions need to be intact for patients with neurological damage to demonstrate an enactment effect within normal range. If some or all of these brain regions are spared in the patients with epilepsy, then they may benefit from using action enactment.

The goal of this study was to determine whether the enactment advantage is reliably present in patients with epilepsy and, if present, to evaluate the magnitude of the enactment effect in patients with epilepsy in comparison to normals. The action memory paradigm was used to compare the performance of a group of patients referred by their neurologists for evaluation of medically intractable seizures (including a subset of patients with confirmed epilepsy) and a group of normal controls. Action memory conditions have been implemented in a variety of ways with a variety of possible control conditions (e.g., subject-performed, experimenter-performed and subject-observed). We selected overt verbal rehearsal without enactment (i.e., repeat out loud "drop the cup") as the control condition to maximize the opportunity of observing an enactment effect. The selected enactment and no-enactment conditions differed in several ways (e.g., presence/absence of physical objects) because the focus in the present study was on whether the enactment advantage should be pursued as a rehabilitation strategy. At this initial stage, we did not attempt to determine which of several task differences might be most critical for the enactment effect to emerge. We hypothesized that:

1) the enactment advantage would be present in both the patient and the control groups, and

2) the action enactment effect for patients with epilepsy would be significantly smaller compared to normal controls, assuming that epilepsy may disrupt but not eliminate the normal processing of actions to enhance subsequent recall.

Method

Participants

Fifteen patients with intractable seizures being evaluated in the Epilepsy Monitoring Unit (EMU) at University Hospital in Cincinnati voluntarily consented to participate in the study. Patients were referred by the neurologists and the neuropsychologist at the EMU for possible participation. Exclusion criteria included fine motor impairments (i.e., difficulty with tasks such as writing or using scissors) or significant defects in auditory verbal comprehension. Comprehension ability for participation in the study was determined by correct answers to at least 7 out of the 10 true/false items on the consent form and responding to corrections of any incorrect items; an 80 prorated Full Scale IQ cutoff score also was established. Two patients were excluded based on these criteria. An exception was made to include a patient with a 79 FSIQ score. Patient diagnoses were confirmed on the basis of concordance of 24 hour/video EEG monitoring, neuroimaging results, and neuropsychological findings. The 13 EMU patients included in the analysis consisted of: four patients confirmed to have epileptic seizures (2 left dominant temporal, 1 right nondominant parietal, 1 right frontal); four patients confirmed to have psychogenic seizures; and, five patients for whom the seizure type remains unconfirmed.

Twenty-five normal control (NC) college students with no reported history of seizures or traumatic brain injury consented to participate. One participant was excluded due to a sensory condition; another was excluded because of a significantly low score on the listening comprehension measure; and, three participants were excluded due to administration error. The remaining 20 participants were included in the analysis. They

were recruited through sign-up sheets posted for research credit towards Introduction to Psychology classes. There was no reimbursement provided to participants for participation in the study.

Design and Materials

Participants in both groups (normal controls, EMU patients) received items in two conditions (enactment, no-enactment) followed by assessment of memory through two methods (free recall, cued recall). All participants were presented with 24 items of to-be-remembered actions. The materials were derived from previous studies on memories for actions (Goff & Roediger, 1998; Welch-Ross, 1995) (see Appendix A for list of items used). Half of the items were presented in the no-enactment condition and the other half were presented in the enactment condition. Items were rotated within both groups across the two encoding conditions in a counterbalanced fashion. Four predetermined random orders were used to present the experimental items across subjects.

Procedure

For the patient group, the experiment was conducted in the patient's room at the EMU. Participants in the NC group were tested in the Cognitive Neuroscience Lab in Dyer Hall at the University of Cincinnati.

Following consent (see Appendices B and C for patient and student consent forms) and instructions, the 24 test items were presented singly. Four buffer items were added (two preceding and two following the 24 test items) to avoid potential primacy and recency effects. Memory performance related to these buffer items was not included in

the data analysis. For half the items, the examiner asked the participant to repeat the action phrase (e.g., shuffle the cards) twice verbally (no-enactment condition); for the other half, the participant was asked to verbally repeat and do the action stated in the phrase using provided objects (enactment condition). Approximately five seconds of exposure was added to each of the items in the no-enactment condition to equate the time interval of presentation with the items presented in the enactment condition. In both conditions, the phrases were presented visually in 72-point font on 8 ½ x 11-inch white paper folded in half lengthwise and simultaneously read aloud by the examiner. Items were intermixed with no more than two items in a row presented in each condition (enactment, no-enactment). After all of the items were presented, the participant was given a filler task for approximately ten minutes to avoid active rehearsal of the items. The task consisted of listening to a series of four to six selected passages read aloud by the examiner followed by five comprehension questions for each passage (Shanker & Ekwall, 2000).

After the ten-minute filled delay, a free recall task was administered that required the participant to name (without cues) all the action phrases presented earlier. When the participant did not appear to be able to recall any additional items, a cued recall task was administered. In this task, the name of each object that appeared earlier was given and the participant was asked what action was paired with the object. If the participant was able to name an action for the object, then a source discrimination question was asked, i.e., "Do you remember just repeating the phrase *or* do you remember repeating the phrase and doing the action?" The entire procedure took approximately 30-40 minutes for each participant.

To obtain an estimate of intellectual functioning as a variable for comparing the groups, the Information and Matrix Reasoning subtests from the Wechsler Adult Intelligence Scale – Third Edition (WAIS-III; Wechsler, 1997a) were administered to the NC participants[1]. For the patient group, scores from the standard neuropsychological testing battery administered at the EMU were used in data analysis. The University of Cincinnati Institutional Review Board granted full approval of the current protocol (Appendix D).

[1] This two-subtest combination is one of the short-form combinations recommended by Sattler and Ryan (2001, p.409) for rapid screening of IQ.

Results

Demographic data for the normal control and patient groups is provided in Table 1. There was no statistically significant difference between the two groups in years of education. However, the *t* test results did suggest that the patient group was significantly older in age and had significantly lower prorated WAIS-III FSIQ scores compared to the normal control group. It is noteworthy that an 8-subtest short form of the WAIS-III was used as part of the neuropsychological battery at the EMU; whereas, a 2-subtest version was administered to the normal controls. Additional demographic data for individual patient participants is presented in Table 2 and data on selected memory measures from the EMU battery is provided in Table 3. Overall, the patient group does not demonstrate memory impairment on the standard measures, with the exception of facial recognition.

Table 1

Demographic Characteristics of Control Group and Patient Group

Characteristic	Normal controls (*n*=20)	EMU patients (*n*=13)
Age		
M	21.0	37.8
SD	3.6	11.7
Education (years)		
M	13.0	12.8
SD	1.1	1.3
Prorated FSIQ		
M	115.8	98.2
SD	10.9	11.9
Gender (M/F)	9/11	5/8
Handedness (R/L)	18/2	13/0

Table 2

Individual Demographic Data for Patient Participants by Subgroup

	Patient subgroups												
	Epileptic				Psychogenic				Unconfirmed				
Age	37	32	34	38	40	48	45	42	20	21	24	54	57
Education	14	15	12	11	12	12	12	12	14	12	15	13	12
Age of seizure onset	25	19	9	37	40	47	44	42	0	11	18	54	47
Duration of seizures	12	13	25	1	.5	1	1	1	20	10	6	1	10

Note. Education and Duration of seizures are reported in years.

Table 3

Performance on Selected Memory Measures by Patient Subgroup

	Patient subgroups		
	Epileptic	Psychogenic	Unconfirmed
WAIS-III WMI	94.50 (20.81)	98.75 (13.60)	100.20 (12.34)
WMS-III Logical Memory			
Immediate	10.25 (1.71)	9.25 (1.71)	12.00 (3.32)
Delayed	11.00 (3.16)	9.50 (1.91)	11.00 (4.24)
WMS-III Word Lists			
Total immediate	9.00 (1.41)	10.00 (2.00)	12.00 (3.24)
Delayed	10.75 (2.63)	9.75 (2.22)	11.00 (2.74)
Recognition	8.75 (4.03)	11.00 (1.63)	9.40 (4.10)
WMS-III Spatial Span	9.75 (.96)	10.25 (3.10)	10.80 (1.48)
RMT Faces	4.50 (2.08)	5.50 (2.38)	8.00 (2.12)

Note. M (SD); WMI = Working Memory Index; WMS-III = Wechsler Memory Scale-Third Edition (Wechsler,1997b); RMT = Recognition Memory Test (Warrington, 1984); Scaled scores are given for WMS-III and RMT subtests.

Paired sample *t* tests were conducted to evaluate the presence of the enactment effect in the NC group ($n = 20$) and the EMU patient group ($n = 13$) as well as the two confirmed patient subgroups (epileptic ($n = 4$) and psychogenic ($n = 4$)). The results indicated that the mean proportion of items recalled in the enactment encoding condition was significantly greater than the mean proportion of items recalled in the no-enactment encoding condition for free recall and cued recall in all of the groups examined (see Table 4).

Table 4

Proportion Means (SD) of Items Recalled in Enactment and No-enactment Conditions

	Free recall		Cued recall	
	Enactment	No-enactment	Enactment	No-enactment
Normal controls	.60 (.14)	.18 (.11)**	.97 (.04)	.57 (.15)**
EMU patients	.51 (.15)	.14 (.08)**	.90 (.09)	.49 (.15)**
Epileptic subgroup	.42 (.06)	.13 (.07)**	.88 (.09)	.38 (.17) *
Psychogenic subgroup	.54 (.17)	.15 (.08)**	.92 (.07)	.48 (.04)**

Note. One-tailed, paired t-tests.

* $p < .05$

** $p < .01$

For each participant, proportion of items recalled under the no-enactment condition was subtracted from that under the enactment condition to create a new dependent variable – enactment advantage. Two independent-sample *t* tests were then conducted to evaluate the hypothesis that the enactment advantage for patients with epilepsy would be significantly smaller compared to normal controls. The tests were significant for free recall, but not for cued recall (see Table 5). On average, the patients

with epilepsy showed less of an advantage in their memory for items in the enactment condition versus the no-enactment condition during free recall compared to normal controls. However, this difference was not significant in cued recall. These results remained stable with respect to statistical significance even after the outlier in the epileptic subgroup was removed (see Epileptic subgroup (n = 3) in Table 5). There were no significant differences between patients with psychogenic seizures and normal controls in free recall or cued recall enactment advantage. However, statistically significant differences were not found when the psychogenic subgroup was substituted in place of the normal control group in comparison to the epileptic subgroup. There were no significant differences between patients with psychogenic seizures and either of the subgroups of patients with epilepsy with respect to enactment advantage.

Table 5

Comparison of Enactment Advantage Between Control Group and Patient Groups

	Free recall	Cued recall
	Mean (SD)	Mean (SD)
Normal controls (n = 20)	.42 (.19)	.40 (.15)
Epileptic subgroup (n = 4)	.29 (.04)*	.50 (.24)
Epileptic subgroup (n = 3)	.28 (.05)*	.36 (.05)
Psychogenic subgroup (n = 4)	.40 (.16)	.44 (.10)
EMU patients (n = 13)	.37 (.12)	.41 (.18)

Note. One-tailed, two-sample unequal variance t-tests.

* $p < .01$

In order to investigate the mechanisms contributing to the enactment advantage, some exploratory analyses were also conducted including all 33 participants. Pearson product-moment correlation coefficients were computed among the following variables: age (M = 27.61, SD = 11.38), prorated FSIQ (M = 108.85, SD = 14.12), proportion of items recalled in free recall (M = .36, SD = .09), enactment advantage in free recall (M = .40, SD = .17), enactment advantage in cued recall (M = .40, SD = .16), proportion of correct responses on the listening comprehension filler task (M = .83, SD = .11) (see Table 6). (The proportion of items recalled in cued recall and source discrimination measures were not included due to an observed ceiling effect.) Using the Bonferroni approach to control for Type I error across the 15 correlations, a p-value of less than .003 (.05 / 15 = .003) was required for significance. The only correlation meeting this criterion for significance was between age and the proportion of items recalled in free recall, r (31) = -.53, p = .001. The correlation between the enactment advantage in free recall and listening comprehension approached significance, r (31) = .36, p = .04. Interestingly, the correlation between the enactment advantage in free recall and cued recall was small and not significant, r (31) = .10, p = .58.

Table 6

Correlations Exploring Variable Contributions to Enactment Advantage

	Age	Prorated FSIQ	Free recall total items	Free recall enact. adv.	Cued recall enact. adv.
Prorated FSIQ	-.34				
Free recall total items	-.53*	.31			
Free recall enact. adv.	-.20	.07	.37		
Cued recall enact. adv.	.09	-.20	-.27	.10	
Listening comprehension	.06	.26	.01	.36	.10

* $p < .003$

Partial correlation coefficients were then computed among the same set of variables while holding group (NC vs. EMU patient) constant in order to address the significant group differences in age and IQ stated earlier. A p-value of less than .003 was required for significance using the Bonferroni approach to control for Type I error. None of the 15 partial correlations met this criterion. The following three partial correlations approached significance: age and the proportion of items recalled in free recall, r_p (30) = -.45, p = .009; the enactment advantage in free recall and listening comprehension, r_p (30) = .39, p = .03; and, prorated FSIQ and listening comprehension, r_p (30) = .46, p = .008. These results suggest that the enactment effect is not necessarily related to overall levels of memory or individual differences due to age or IQ. However, the relationship between the enactment advantage and IQ may have been confounded by the two different methods used to estimate IQ. To examine the possible effect of the difference, a two-tailed paired t test was conducted comparing the 8-subtest prorated FSIQ scores of the EMU patients (M = 98.23, SD = 11.89) to a set of prorated FSIQ scores (M = 101.08, SD = 12.26)

calculated using the same two subtests (Information, Matrix Reasoning) used in estimating the normal control prorated FSIQ scores. The results were not statistically significant. This suggests the differences in methodology should not have had a significant impact on the enactment advantage differences found between the groups, even though a greater number of subtests is more reliable and includes measures of memory (e.g., Digit Span).

Two exploratory multiple regression analyses were conducted to predict the enactment advantage in free recall and cued recall. Both analyses included group (NC vs. EMU patient), prorated FSIQ, and listening comprehension as predictors. The linear combination of the three variables was not significantly related to the enactment advantage in free recall, $R^2 = .22$, adjusted $R^2 = .13$, $F\ (3, 29) = 2.65$, $p = .068$; or cued recall, $R^2 = .11$, adjusted $R^2 = .02$, $F\ (3, 29) = 1.23$, $p = .317$. The findings from this analysis are consistent with the correlational analysis in suggesting that the enactment advantage is relatively independent of individual differences in cognitive ability.

Discussion

Results from this study provide further evidence that the enactment effect is present in patients with epilepsy. The enactment advantage appeared to be present in all the subgroups examined and seemed relatively stable across free recall and cued recall in the normal control group and psychogenic subgroup. The heterogeneous nature of the patient sample tentatively suggests the possibility that the location of the lesion may not be critical with respect to enactment, as long as the brain damage is not diffuse. A more comprehensive study with a larger sample size and comparable groups of individuals with epilepsy would be necessary to test such a hypothesis.

The hypothesis regarding the magnitude of the enactment advantage was partially supported by the results. The effect was significantly smaller for the patients with epilepsy compared to the normal controls for free recall, but not for cued recall. One explanation for the lack of significance in cued recall is a ceiling effect that may have suppressed the potential magnitude difference. There were 24 to-be-remembered items and half were presented in the enactment condition. Only four out of the entire set of 33 participants recalled less than 11 of the possible 12 enacted items when given cues. The ceiling effect may also explain the small correlation between the enactment advantage in free recall and cued recall. In future studies, increasing the task difficulty by adding more items during encoding could help clarify the enactment advantage in both cued recall and free recall.

Interestingly, the enactment advantage in the patients with psychogenic seizures was comparable to the normal controls. However, there were no statistically significant differences between the psychogenic subgroup and epileptic subgroups. This lack of

significance may be due to the small sample sizes of the subgroups resulting insufficient analytical power to detect the effect. Considering the means and standard deviations presented in Table 3, there appears to be the potential for finding significant differences between the psychogenic and epileptic groups with a greater number of participants.

There were multiple differences between the enactment and no-enactment conditions in the present study (e.g., presence/absence of physical objects, number of verbal repetitions of the action phrase). The enactment effect could be due to any one of (or combination of) these differences. Additional task manipulations to tease these differences apart are worth investigation. One alternative task manipulation is to not include the objects during encoding. As noted earlier, the intent of this study was to maximize the occurrence of an enactment effect by selecting conditions on opposite ends of the spectrum. A logical next step towards a "purer" enactment condition would be to withdraw the objects. Another option might involve including the objects in both conditions. Schwerdt and Dopkins (2001) presented an array of 24 objects at once for each of their sets of 12 action items. The reported proportions of items recalled in the comparable enactment condition were lower than those in the current study for normal controls and patients with epilepsy. This could be attributed to other task and procedure differences such as additional observed and imagined conditions during the study phase in place of the verbal rehearsal no-enactment condition used in the present study.

Exploratory analyses revealed a significant negative relationship between age and proportion of items remembered in free recall. A partial correlation controlling for group (i.e., college-age control group (M = 21.0, range = 18-32) and older patient group (M = 37.8, range = 20-57)) resulted in a non-significant relationship of age and

proportion of items remembered in free recall; however, there was a distinct trend in the expected direction. Duration of epilepsy could be a related variable to investigate in future patient studies. The evidence concerning the degree to which verbal memory decline observed by some patients with epilepsy is attributable to age and the extent due to duration of epilepsy is unclear (Blum, 2001; Helmstaedter & Elger, 1999).

The possible relationship between the enactment advantage and listening comprehension is noteworthy. This relationship may arise because an uncontrolled mediator such as visual imagery ability or a dimension of intelligence affects both variables. Imagined conditions in combination with measures of information processing (e.g., visual-spatial memory) could be useful in exploring these relationships. The ability to identify the variables contributing to the enactment effect and predict who may benefit could lead to more effective and efficient memory rehabilitation. Future research in this direction is important in providing indications of which mnemonic strategies should be selected for which patients.

The main limitations of the present study were sample size and group differences. The small group of patients with confirmed epilepsy restricted the strength of the findings and interpretation. As noted above, additional studies with larger groups of patients with different types of epilepsy (e.g., right temporal lobe, left temporal lobe) may help elucidate the neurological basis of the enactment effect. Groups matched on age and IQ would have added to the validity of the results. With more participants, the psychogenic subgroup may have served as a better control group to the epileptic subgroup because of their similar testing environments (i.e., hospital room, electrodes glued to the head), equivalent battery of tests, and greater likelihood of comparable psychosocial stressors

from experiencing seizures. With respect to the test battery, it would have been beneficial to have the same data for the normal controls to be able to compare memory performance on standardized measures. The patients generally did not exhibit below average performance on standard memory measures; therefore, conclusions about applications in cognitive rehabilitation are tentative. Results from Schwerdt and Dopkins (2001) suggests further investigation of enactment with patients with significant memory deficits is worthwhile, in that, temporal lobectomy patients with impaired performance on at least two memory measures demonstrated an enactment advantage in their study. Further experiments including patients with varying degrees of memory impairment would help clarify the relationship between level of impairment and magnitude of the enactment effect.

Despite these limitations, all participants in the current study, irrespective of seizure presence or seizure type, recalled more items in the enactment condition compared to the no-enactment condition and many made observations of the effect during the experiment. It is possible that all individuals, memory-impaired or not, may be able to take advantage of enactment to enhance their memory. Methods taking advantage of enactment could be integrated into existing compensatory methods of cognitive rehabilitation for patients with epilepsy experiencing memory deficits at minimal cost. The specific cases in which this strategy is most helpful will be borne out with its use, in combination with additional research.

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APPENDIX A

List of Action Phrases

Sample items:
1. put on the hat
2. shuffle the cards
3. knock on the table

Test items:
1. stretch the rubber band
2. stack the blocks
3. lift the spoon
4. bounce the ball
5. tear the napkin
6. shake the water bottle
7. flip the timer
8. push the toy car
9. crumple the plastic wrap
10. erase the line
11. drop the cup
12. break the toothpick
13. throw the beanbag
14. smell the flower
15. fold the paper
16. close the box
17. cut the ribbon
18. roll the dice
19. look in the mirror
20. tie a knot
21. open the book
22. pick up the jacks
23. zip the purse
24. unscrew the jar lid

Buffer items:
1. copy the square
2. slide the pennies
3. ring the bell
4. draw a circle

APPENDIX B

Patient Consent Form

University of Cincinnati
Consent to Participate in Research Study
Department of Psychology
Principal Investigator: Michelle Eng
(513) 556-5894 / engmt@email.uc.edu

Title of Study: Memory for Actions

Introduction:
Before agreeing to participate in this study, it is important that the following explanation of the proposed procedures be read and understood. It describes the purpose, procedures, risks, and benefits of the study. It also describes the right to withdraw from the study at any time. It is important to understand that no guarantee or assurance can be made as to the results of the study. You acknowledge that you have volunteered to be a subject in an experiment on memory conducted by Michelle Eng under the direct supervision of Dr. Peter Chiu.

Purpose:
The purpose of this research study is to gain a better understanding of human memory processes. This knowledge may eventually be used to enhance cognitive rehabilitation programs. You will be one of approximately 40 participants taking part in this study.

Duration:
Your participation in this study will last for approximately 40 minutes.

Procedures:
During the course of the study, the following will occur: You will be instructed to read phrases aloud and perform simple actions such as *winding a watch* or *clapping your hands*. You will also be given tests of your memories for these phrases and actions. You may also be asked to listen to several short passages and answer questions about each passage. In addition, you may be given some short tests where you will try to define words or rearrange pictures to tell a story.

Exclusion:
You will not be able to participate in this study if any of the following apply to you:
English is not your native language.
You have difficulty with fine motor tasks (e.g. writing, using scissors).

Risks/Discomforts:
There are no reasonable foreseeable risks to your participation in this study. I will monitor your status for any unusual distress so that any discomfort will be minimized. There may be discomforts and risks that are not yet known.

Benefits:
You will receive no direct benefit from your participation in this study, but your participation may help the development of memory rehabilitation programs and improve general understanding of cognitive processes.

Specific Consent for Access to Records:
As a patient of Aring Neurology or the Epilepsy Monitoring Unit at University Hospital, you grant consent for the principal investigator, Michelle Eng, to examine your medical chart at Aring or the EMU and converse with referring physicians to gather clinical data specifically relevant to the study (e.g. demographic information, medical condition, neuropsychological profile). You understand that all of your data will be kept confidential and that identification numbers, instead of your name or any other identifying information, will be used in the records for analysis.

Confidentiality:
Every effort will be made to maintain the confidentiality of your study records. Agents of the University of Cincinnati will be allowed to inspect sections of the research records related to this study. The data from the study may be published; however, you will not be identified by name. Your identity will remain confidential unless disclosure is required by law, such as mandatory reporting of child abuse, elder abuse, or immediate danger to self or others.

Right to refuse or withdraw:
Your participation is voluntary and you may refuse to participate, or may discontinue participation AT ANY TIME, without penalty. Refusal to participate or withdrawal from the study WILL NOT affect access to services or benefits to which you are otherwise entitled. The investigator has the right to withdraw you from the study AT ANY TIME. Your withdrawal from the study may be for reasons related solely to you (for example, not following study-related directions from the investigator, etc.) or because the entire study has been terminated.

Offer to answer questions:
If you have any other questions about this study, you may call Michelle Eng or Dr. Peter Chiu at 513-556-5894. If you have any questions about your rights as a research participant, you may call Dr. Margaret Miller, Chair of the Institutional Review Board – Social and Behavioral Sciences, at 513-558-5784.

LEGAL RIGHTS:
Nothing in this consent form waives any legal right you may have nor does it release the investigator, the institution, or its agents from liability for negligence.

YOU HAVE READ THE INFORMATION PROVIDED ABOVE. YOU VOLUNTARILY AGREE TO PARTICIPATE IN THIS STUDY. YOU WILL RECEIVE A COPY OF THIS CONSENT FORM FOR YOUR INFORMATION.

_____ _____

Participant Signature Date

_____ _____

Legal Representative Signature Date

☐ **If verbal assent/consent was obtained, check this box and have a witness sign and date below.**

_____ _____

Witness Signature (required only for verbal assent) Date

_____ _____

Signature and Title of Person Obtaining Consent Date

_____

Identification of Role in the Study

CONSENT QUESTIONNAIRE

According to the information provided in this consent form, please circle *True* or *False* in response to each statement below.

True False 1. This study is about memory.

True False 2. I will be asked to remember some objects. Later, I will be asked questions about the objects.

True False 3. I do not have to be in this study if I do not want to.

True False 4. I will be paid for my participation.

True False 5. Once I start the study, I have to finish it.

True False 6. My name will not be used in any reports of the study.

True False 7. If I am in the study, I will have better care at the hospital.

True False 8. By signing the consent form, I am allowing the investigator to look at information in my medical chart relevant to the study.

True False 9. Participation in the study requires six hours of my time.

True False 10. The investigator will do her best to make sure I am not too stressed or uncomfortable during the study.

APPENDIX C

Student Consent Form

University of Cincinnati
Consent to Participate in Research Study
Department of Psychology
Principal Investigator: Michelle Eng
(513) 556-5894 / engmt@email.uc.edu

Title of Study: Memory for Actions

Introduction:
Before agreeing to participate in this study, it is important that the following explanation of the proposed procedures be read and understood. It describes the purpose, procedures, risks, and benefits of the study. It also describes the right to withdraw from the study at any time. It is important to understand that no guarantee or assurance can be made as to the results of the study. You acknowledge that you have volunteered to be a subject in an experiment on memory conducted by Michelle Eng under the direct supervision of Dr. Peter Chiu.

Purpose:
The purpose of this research study is to gain a better understanding of human memory processes. This knowledge may eventually be used to enhance cognitive rehabilitation programs. You will be one of approximately 40 participants taking part in this study.

Duration:
Your participation in this study will last for approximately 40 minutes.

Procedures:
During the course of the study, the following will occur: You will be instructed to read phrases aloud and perform simple actions such as *winding a watch* or *clapping your hands*. You will also be given tests of your memories for these phrases and actions. You may also be asked to listen to several short passages and answer questions about each passage. In addition, you may be given some short subtests from the Wechsler Adult Intelligence Scale – Third Edition to estimate your intellectual abilities. You will be asked to perform tasks such as defining words or rearranging pictures to tell a story.

Exclusion:
You will not be able to participate in this study if any of the following apply to you:
English is not your native language.
You have difficulty with fine motor tasks (e.g. writing, using scissors).

Risks/Discomforts:
There are no reasonable foreseeable risks to your participation in this study. I will monitor your status for any unusual distress so that any discomfort will be minimized. There may be discomforts and risks that are not yet known.

Benefits:
You will receive no direct benefit from your participation in this study, but your participation may help the development of memory rehabilitation programs and improve general understanding of cognitive processes.

Confidentiality:
Every effort will be made to maintain the confidentiality of your study records. Agents of the University of Cincinnati will be allowed to inspect sections of the research records related to this study. The data from the study may be published; however, you will not be identified by name. Your identity will remain confidential unless disclosure is required by law, such as mandatory reporting of child abuse, elder abuse, or immediate danger to self or others.

Right to refuse or withdraw:
Your participation is voluntary and you may refuse to participate, or may discontinue participation AT ANY TIME, without penalty or loss of benefits to which you are otherwise entitled. The investigator has the right to withdraw you from the study AT ANY TIME. Your withdrawal from the study may be for reasons related solely to you (for example, not following study-related directions from the investigator, etc.) or because the entire study has been terminated.

Offer to answer questions:
If you have any other questions about this study, you may call Michelle Eng or Dr. Peter Chiu at 513-556-5894. If you have any questions about your rights as a research participant, you may call Dr. Margaret Miller, Chair of the Institutional Review Board – Social and Behavioral Sciences, at 513-558-5784.

LEGAL RIGHTS:
Nothing in this consent form waives any legal right you may have nor does it release the investigator, the institution, or its agents from liability for negligence.

YOU HAVE READ THE INFORMATION PROVIDED ABOVE. YOU VOLUNTARILY AGREE TO PARTICIPATE IN THIS STUDY. YOU WILL RECEIVE A COPY OF THIS CONSENT FORM FOR YOUR INFORMATION.

_____ _____
Participant Signature Date

_____ _____
Signature and Title of Person Obtaining Consent Date

_____
Identification of Role in the Study

APPENDIX D

IRB Approval

UNIVERSITY OF Cincinnati

Institutional Review Board - Social / Behavioral Sciences
University of Cincinnati
G-08 Wherry Hall
PO Box 670567
Cincinnati, OH 45267-0567
Phone (513) 558-5784
Fax (513) 558-4111

July 7, 2003

Michelle Eng, M.A.
235 Loraine Ave. #7
Cincinnati, OH 45220

RE: IRB #02-04-05-01E: "Memory for Actions"

Dear Ms. Eng:

The University of Cincinnati Institutional Review Board – Social and Behavioral Sciences (UC IRB-S) has reviewed and approved the revisions to your protocol (add recruitment site, update both consents). This action does not affect the expiration date of your study, which remains 6-17-04. Thank you for keeping the Board informed.

Should your project extend beyond the expiration date, you must submit a Progress Report form indicating that the project is continuing. No research data can be collected without a current approval of the protocol, thus the investigators must allow sufficient time for the request for renewal to be reviewed and approved **before expiration of the protocol.** If the project is finished before the approval expiration date, the investigators may submit a Progress Report at the time the project is completed. The form and instructions may be found at www.med.uc.edu/irb/scontinueapp.pdf.

If you have any questions, please contact Claudia Norman, IRB-S Program Manager, at phone 558-5784, fax 558-4111 or e-mail Claudia.Norman@UC.edu.

Sincerely,

Margaret Miller/cn

Margaret Miller, Ed.D., R.N.
Chair, UC IRB-S

MM/cn

cc: Peter Chiu, PhD (ML 0376)
Shirley Doxsey (ML 0376)

(p:IRB-S\modifications\02-04-05-01.doc)