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LONG TERM MEMORY FOR VERBAL AND NON-VERBAL MATERIAL IN KORSAKOFF PATIENTS

A Thesis Presented

by

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This endeavor is dedicated to those who have provided loving support for all my meaningful endeavors: My parents, and Tony.

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ABSTRACT

Memory for visually presented verbal and non-verbal stimuli were tested over a period of 24 hours in Korsakoff patients and closely matched controls. Korsakoff patients showed a large deficit for purely verbal stimuli. Memory for pictures was considerably better and significantly higher than chance. Memory for complex "non-nameable" stimuli (i.e. shapes with no commonly agreed upon names) was low, and only slightly better than that for verbal stimuli. Controls performed equivalently, and at high levels, for all three conditions. A fourth condition involving aid with stimulus analysis for non-nameable stimuli resulted in improvement in the scores of Korsakoff patients, but a slight decrement in controls' scores. A model is proposed to explain this data. The model suggests that while Korsakoff patients can not encode verbal stimuli directly, their imaginal coding system is intact, and verbal encoding mechanisms can be activated if a link is made via the imaginal system.

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INTRODUCTION

Sergei Korsakoff, in 1889, described a disorder with an etiology of chronic alcoholic intoxication, that he suggested be known as psycho-toxemic cerebropathy (Talland, 1965, p.62). Korsakoff pointed out intellectual deficits over and above the peripheral neuropathy common to alcoholics. He described his patients in the acute stage as being unable to concentrate or make an effort, unable to learn anything new, irritable, and showing a lack of vitality. He attributed the lack of learning largely to apathy, and noted that the defect was in recall rather than in acquisition of information, as his patients would inconsistently remember events from the recent past.

This syndrome has been attributed Korsakoff's name, and has since been studied in greater depth. It is now known that this syndrome can also appear with non-alcoholic precedents, specifically as a result of encephalitic illness and head trauma (Talland, 1965; Warrington, 1976). Where the etiology is alcoholic, it is generally accepted that the deficits are a result of a vitamin deficiency (Noyes & Kolb, 1958; Talland, 1965; Brion, 1969). The alcoholic tends to eat little while he is on a drinking bout, and also has impaired gastrointestinal absorption. He has an even greater vitamin requirement while he is drinking, due to the high caloric effect of alcohol. These factors in combination result in a deficiency of vitamin

B, particularly of niacin and thiamine. A rehabilitory diet high in vitamin B will reverse some of the symptoms of the syndrome. Autopsies of patients with Korsakoff's syndrome have revealed that the most common sites of central nervous system damage are the magnocellular division of the dorsal medial nucleus of the thalamus (DMN), and the medial portion of the mammilary bodies (MB) (Brion, 1969; Victor, Adams & Collins, 1971). In addition, the ventral medial nucleus of the thalamus (VMN) is also damaged in about 60% of the cases (Jones, Moskowitz & Butters, 1975).

Research by psychologists on deficits in Korsakoff's syndrome covers areas of information processing and sensory function, but has concentrated largely on memory loss.

Before the experimentation is reviewed, the memory process in its cognitive and physiological aspects will be briefly considered.

An Overview of the Memory Process

Cognitive Aspects

It seems intuitively reasonable that there are different types of memory processes used to remember events. For example, we report events that have just passed without necessarily being able to report all of them as vividly later. We seem to register immediate memories generally for a shorter period and more completely in their accuracy of detail than we retain our past experiences. William James (1890) originated

the idea that memory has two separate components. He called them primary and secondary memory. These terms are often replaced by short-term (STM) and long-term memory (LTM) respectively. The major evidence from the cognitive literature for this dichotomous view comes from the observations of the serial position effect on recall. It has been found (Norman, 1969, p.107) that when subjects are read a list of words that they are asked to remember, and are then tested by being asked to recall as many as possible, words that appeared at the end and at the beginning of the list have a much greater relative probability of being recalled. Proponents of the dichotomous theory of memory suggest that the two peaks in the serial position are due to two different memory stores. The process that they claim is involved is the following: As the subject hears the first words he begins to repeat them subvocally to himself in an attempt to remember them. As more words get added to the list, for a certain period of time, all of them are being repeated, or rehearsed. Eventually the individual's capacity for retaining words in order to repeat them together is surpassed. Rehearsal of these words then stops, and the individual begins to build up a new list of words to repeat from the words being presented to him. At the point that the capacity for simultaneous repetition of words is first passed, the words at the beginning of the list have been most often repeated. The pro-dichotomy theorists claim that the words at the beginning of the list due to extensive rehearsal have

been transferred into LTM, and are thus available to be recalled. The words in the middle of the list were not repeated enough times to be transferred into LTM. Nor, when the list reading stops, are they being currently repeated and available to STM. Thus they are lost to memory. However the words at the end of the list are most "fresh" and most likely to be new additions to the list of repeated words. They are still in STM, and are thus also available to be recalled. This process and the results are at least highly consistent with the dichotomous view of memory.

Sperling (1960) elaborated the simple ST-LT distinction. He felt that elaboration was necessary as he found that the simple sensory image (the stimulus when it is just perceived, before rehearsal begins) also contains information. As this information can not all be reported, this system does not overlap with STM. This separate and earliest stage of memory is called the sensory image of events that are occurring. Information extracted from this stage is passed on to the second stage or STM. The third, or permanent stage, is LTM.

Waugh and Norman (1965) elaborated the characteristics of STM. They suggested that since rapid decay of material occurs when additional material is added, and additional material would seem to interfere with rehearsal, then rehearsal must be the important mechanism for maintenance of material in STM. Rehearsal can also serve as a mechanism of transfer of material from STM to LTM, as mentioned before.

Does rehearsal always lead to transfer, and is rehearsal the only mechanism of transfer from STM to LTM? Some researchers have shown that rehearsal does not always lead to transfer (Craik & Watkins, 1973). Rehearsal may be used to maintain information in immediate memory. When the individual is not aware that this material must be recalled, he may not have transferred it into LTM. Craik and Watkins attempt to distinguish between repetition, or maintenance rehearsal, and what they term elaborative rehearsal. Elaborative rehearsal can also be conceived of as organization of incoming stimuli. An item can be stored in LTM by organization, i.e. an attempt to relate the item to a pre-existing logical framework, or may create a new logical framework which will incorporate the item into some cohesive unit. Material that is organized and then stored in memory seems to be easier to retrieve and more permanently retained than material that has only been rehearsed (Norman, 1969, p.117).

It should be noted that the ST-LT distinction is being questioned by several researchers. Craik and Lockhart (1972) have suggested that this distinction is not useful as the concept of different levels of processing. One variable that is known to play an important part in memory but is not incorporated into the ST-LT model is the degree of analysis of incoming stimuli. The deeper the level of analysis or processing, the longer lasting and stronger the "trace"

carrying the event in memory. Examples of deeper levels of analysis for verbal stimuli are formations of associations of the word, consideration of the meaning of the word, formation of images on the basis of meaning, etc. Craik and Lockhart propose that memory be seen more as a continuum, with depth of processing levels running into each other, rather than as a dichotomous or trichotomous store.

In spite of the fact that the ST-LT model has come under fire, it should be noted that its critics are not proposing a model that suggests that the dichotomy be replaced by a unitary function recognizing no differences in, for example, duration of retention of stimulus in memory or means of retaining stimulus. The suggestion is more that several different levels rather than two or three seem to exist, and at their limits they seem to be continuous rather than discrete.

In the rest of this paper reference will continue to be made to STM and LTM. The reader is asked to keep in mind that this separation refers generally to attributes of memory that have to be recognized by any model: memory of a just occurring event has several different characteristics than memory for an event in the past.

Physiological Aspects[1]

To briefly recapitulate the two-store concept of memory: Short-term memory has been seen as a temporary process, beginning in the organism immediately after learning. The effects of this process can fade away. However, by consolidation, the short term process can be translated to a permanent one. What is the physiological evidence that there is more than one kind of memory?

Certainly the discovery of a procedure that interferes with one store of memory without affecting the other would be evidence for different kinds of memory processes. Various interventions have been known to interfere with the process of consolidation, or the transfer of memory from short term to long term stores. This is indicated by amnesia only for very recent events.

One such experimental intervention is electroconvulsive shock (ECS) which has been used both in animals and in humans. Rats that are placed in the step-down learning situation, (a shock avoidance procedure that generally produces one-trial learning) and are given ECS immediately after the first trial, do not retain this learning 24 hours later, unlike controls (Krech, et al., 1974, p.437). Chorover and

[1]The bulk of the material in this section has come from recent overviews primarily Carlson, 1977 and Krech, Crutchfield & Livson, 1974.

Schiller (1965) manipulated the length of delay after the first trial for ECS administration from 20 seconds to 14 hours. They found that there is a negative correlation between length of delay before ECS was administered and degree of learning demonstrated 24 hours later. Once ECS administration delay passed 60 seconds, performance was as good as that of controls. These data are consistent with the hypothesis that some kind of coding, requiring time, is necessary to transfer information from short term to long term stores (see Carlson, 1977, pp.546-550 for an alternate explanation for the effects of ECS on memory).

The effects of accidental head injury show a similar pattern (Carlson, 1977, p.540-543; Krech, et al., 1974, p.438). Retrograde amnesia, graded loss of memory most intense for events closest to the moment of injury, is a common result. This is consistent with the two-stage hypothesis. Injury would be expected to interfere with any neural activity before consolidation of memory of very recent events, resulting in loss from STM without transfer to LTM.

Certain kinds of CNS damage and/or removal have also seemed to interfere with the normal two-stage process. Hippocampal removal seems to have drastic effects on the consolidation process. Milner (1970), studying a patient who had a temporal lobectomy, concluded that although LTM was intact and the patient had a good memory for pre-operative events

and STM was intact as the patient had a normal digit span, and could carry on a reasonable conversation, there was no memory for recent post-operative events. Milner proposed that consolidation had been interfered with, and after studies with other patients, placed the locus of consolidation processes in the hippocampus.

Prior to a further consideration of neuroanatomical structures associated with memory, two processes that have been proposed as basic mechanisms of learning will be described. Reverberatory circuits have been proposed as such a mechanism (Krech, at al., 1974, pp.429-234; Carlson, 1977, p.551-555). A reverberatory circuit is a group of interconnected neurons, with memory being represented as a pattern of activity in this circuit. A reverberatory circuit has several characteristics which make it a candidate for STM, and a process that might be the basis for long term changes. Some degree of continuous activity would occur in an interconnected circuit, and this would account for the fact that events are represented in STM for a period of time. STM capacity is limited, as must be units capable of carrying on simultaneous activity in the CNS. Neural firing is known to be disrupted by events like ECS, head injury, etc., also known to interfere with STM (see Carlson, 1977, pp.551-559 for a more complete treatment of the reverberatory circuit as a basis for memory).

A second mechanism that has been suggested as the basic mechanism for learning relates to synaptic changes after experience (see Krech, et. al., 1974, p.43 for a more complete review). A popular concept of change in the CNS after learning has been change in the speed with which an axon can cause a post-synaptic cell to fire. This change could be accomplished a variety of ways, e.g. increase in number of synaptic connections with the post-synaptic cell, larger pre-synaptic axons, narrowing of synaptic cleft. Some evidence consistent with this kind of change as the basis for learning has been: evidence that neural development is incomplete at birth (so change with experience and maturation would be necessary); increase in cortical size and weight upon environmental stimulation; and a decrease in formation of dendritic spines (synaptic connections) in animals raised in impoverished environments.

The next question that will be treated is: given that memory is represented in neural activity of some kind, is representation diffuse or is it focal? It is clear that memory for an event is not carried exclusively over a single synapse or a single circuit. The cortex is known to be essential in complex learning and problem solving (Krech, et al., 1974, pp.419-420). Large amounts of cortical tissue can be removed and memory for simple tasks appears to be unaffected. As long as incoming stimuli can be analyzed, simple memory in

all modalities is retained (see Carlson's review, 1977, pp. 512-514). This suggests that memory is carried redundantly. As there are simply not enough neurons for even a single one to participate solely per memory, each neuron must be involved in the representation of a number of memories.

So clearly, memory for an event is not stored so focally as to be restricted to a single neuron or circuit. Then the question arises as to whether certain kinds of representations are restricted to certain areas of the cortex (e.g. visual memory being carried in visual primary and association areas, etc.) or whether all memories are diffusely represented in all areas of the cortex regardless of their modality.

This appears to be the area of some controversy. Some scientists like Pribram (1971) propose a holographic representation in the cortex, with each part participating in the process of storage, but no single part being essential in the process. Carlson (1977), reviewing the literature, came to the following conclusions regarding the location of stored memory: a) simple single modality memory can be disrupted by lesions in primary or association cortex associated with the modality of the memory. However, a case could be made that performance has decreased because of interference with perception of the stimulus, i.e. damage to the sensory apparatus rather than directly to memory. This criticism would not be valid if learning were tested in a modality

different from the one through which it had been enstated. Cross-modality studies were needed to clarify the results. b) Cross-modality learning is tested by retrieval of memory through responses other than those used to enstate it, e.g. verbal retrieval of visual memories; and tactual discrimination between objects when the discrimination was originally learned verbally. It seems that only in very few cases have cross-modality learning been shown to occur in non-human animals. Hence this method as a tool for separating sensory and memory components was not applicable for most animals. Simply the failure to find cross modal learning in most animals was a suggestion that memory in these animals is not totally diffusely represented. c) Cross modal learning does occur in humans. However since lesioning and ablation experiments with humans are not ethically justified, researchers had to rely on naturally occurring disorders. The observation of disconnection syndromes in humans has provided some light on the situation. Some examples of these syndromes are Wernicke's aphasia and conduction aphasia. In Wernicke's aphasia the damage seems to occur in the auditory association area. Not only do the patients have difficulty with sound discrimination, but problems appear in writing where spelling mistakes increase due to a confusion between similar sounding letters. The explanation for this seems to be that as accurate spelling of a word depends upon its acoustic representation

(and the connection is learned), a disconnection between auditory (sound of letters) and motor (writing of letters) functions could create such a disorder. A syndrome which demonstrates disconnection even more vividly is conduction aphasia. The arcuate fasciculus, the fiber bundle connecting auditory and speech areas is damaged in this syndrome. Now although patients have no trouble spontaneously generating words (as there is no direct damage to Broca's speech area), nor any trouble hearing and understanding (as there is no direct damage to auditory areas), repetition of words, requiring coordination between auditory and speech areas, becomes very difficult.

In summary, for very simple learning, all that seems to be needed is sufficient cortex or subcortical structures to analyze the data. In more complex single modality learning, there is disruption when the modality related association area is damaged. For cross modal tasks, interconnections between association areas must be intact.

The above has dealt largely with the role of the cortex in memory. Another set of neuroanatomical structures, the limbic system, has also been implicated in memory. In Korsakoff's syndrome, although it is unclear where in the limbic system the critical damage must be, and precisely what kind of memory loss occurs, it is clear that there is interference with memory. Briefly discussed earlier was the role of the

hippocampus in memory. It has been suggested that the hippocampus plays an important role in the consolidation of short-term to long-term memory. For an alternate hypothesis of the role of the hippocampus in memory see Carlson, 1977, pp.566 ff.

Sensory Function

Jones, Moskowitz, Butters and Glosser (1975) considered psychophysical scaling of intensity of stimuli by Korsakoff patients and controls, in the visual, auditory and olfactory modalities. The experiment involved three tasks in each modality. Performance in the visual modality was essentially normal. The two out of three tasks in the auditory modality, Korsakoff patients also showed normal performance. However in the olfactory tasks, a severe deficit was obvious.

Jones, Moskowitz and Butters (1975) further investigated the apparent olfactory loss in Korsakoff patients. There are anatomical grounds to suspect that olfactory functions may be compromised in Korsakoff patients. The pyriform cortex receives projections from the olfactory bulb, and itself projects to the magnocellular division of the DMN. The pyriform cortex also sends efferents to the lateral entorhinal area, which connects to the hippocampus and then to the MB. The VMN also receives direct projections from the pyriform cortex. As a control for olfactory compromise due to direct damage of the olfactory nerves from head blows (which are

common to all alcoholics), non-Korsakoff alcoholics were used as controls. It was found that olfactory discrimination was significantly impaired in the experimental group. The pattern of incorrect responses to the experimental tasks suggested that the nature of the deficit was impaired discrimination, rather than an elevated threshold.

Information Processing

Oscar-Berman (1973) tested patients for employment of problem-solving strategies, and modification of these strategies when necessary. The subjects were presented with two-choice visual discrimination problems. The stimuli presented varied in dimensions of color, size, form and position. Subjects were given 16 trials. On two trials, subjects were given feedback that the choice made was correct, and on two others, they were told that the choice was incorrect. This feedback was given regardless of the choice made. Performance on the other 12 trials was an indication of the subjects' adoption of strategy and modification when the strategy was no longer said to be correct. It was found that the Korsakoff subject did adopt strategies, like normals, i.e. if positive feedback was given when the choice was made on the basis of color, he retained this dimension as the basis for choice in consequent trials. Once the normal subjects were given negative feedback following a choice that was made on the basis of a particular dimension, they generally changed

to a new dimension as basis for choice in consequent trials. The Korsakoff patients on the other hand, did not make this modification of strategy following negative reinforcement.

Additional evidence for diminished sensitivity to change in reinforcement contingencies has been provided by Oscar-Berman, Sahakian and Wikmark (1976) using spatial probability learning as a task. This group points out that perseveration in Korsakoff patients might be caused by damage to the limbic system. Animals with lesions in this system show slow acquisition of tasks and increased perseveration. The limbic system might be damaged in Korsakoff patients as: a) the DMN connects the prefrontal cortex to the limbic system, and b) the hippocampus sends efferents to the MB. Perseveration has been noted in Korsakoff subjects by other experimenters, e.g. Samuels, Butters, Goodglass and Brody (1971).

Oscar-Berman and Samuels (cited in Butters, Cermak, Jones and Glosser, 1975) present evidence that the Korsakoff patient analyses fewer dimensions of multi-dimensional stimuli than normal patients do. Subjects were trained in two-choice discrimination task, where stimuli varied in the four dimensions of color, size, form and position. After this training, trials were designed to reveal what dimensions the subjects had been selectively attending to. It was found that while Korsakoff subjects' analyses were limited to one or at most two of the dimensions, normals analyzed more. This limitation

might well be implicated in the tendency of the Korsakoff patient to persevere in the face of negative feedback.

Memory

The early experimenters maintained that STM was intact in Korsakoff patients. Talland (1965) reports that these patients have normal digit spans (p.267), and can produce verbatim sentences of 10 to 12 words (p.268). Warrington (1967, p.218) reports experiments where Korsakoff patients perform equivalent to controls in remembering the spatial position of a dot, and recognizing surnames after a 30-second filled interval. However agreement concerning intactness of STM is far from universal.

Cermak, Butters and Goodglass (1971) conducted a series of experiments to investigate the extent of the loss. They found that when stimulus materials consisted of either consonant trigrams, single three-letter words of high frequency, or three three-letter words of high frequency, performance was near normal when no interval was placed between presentation and free recall. Performance was also tested under conditions of delay. Delay intervals were 3, 9, or 18 seconds long, and were filled with verbal interference (counting backwards from 100) to prevent rehearsal. For all conditions, recall fell drastically, compared to alcoholics or normals, as the delay interval increased. This loss was also seen under conditions of recognition for single consonants and

consonant trigrams presented in both visual and auditory modalities (Cermak, Butters & Goodglass, 1971; Samuels, Butters, Goodglass & Brody, 1971).

Cermak, Butters and Goodglass (1971) conducted an additional experiment to show that the transfer from STM to LTM was impaired. In paired associate learning trials, they found that Korsakoff patients took many more trials to learn, and learned fewer items than normals. The subjects were tested over a period of four days. It was found that those items that were learned early were retained and retrieved. Items not recalled seemed not to have been learned at all (rather than irregularly retrievable, as would have been shown by inconsistent recall). This suggested that encoding into LTM was impaired.

The nature of the deficit was further analyzed by Cermak and Butters (1972). As the deficits in the experiment by Cermak, Butters and Goodglass (1971) may have resulted either from increased sensitivity to interference (and failure to retain items in STM) and/or encoding deficits (and failure to transfer items from STM to LTM), the roles of both were examined. The first experiment compared patients' performance under conditions of high and low proactive interference, to normal controls. Stimuli consisted of consonant trigrams, or 3-letter words of high frequency. Each subject was given trials in blocks of two. The second trial of each block

consisted of presentation of a 3-letter word. The first trial of each block was either a consonant trigram (condition of low proactive inhibition) or also a 3-letter word (condition of high proactive inhibition). Overall performance as measured by free recall after the second trial of each block was much lower for Korsakoff subjects than for normals. Also the decrement in performance when high interference trials were presented were greater in Korsakoff patients than in normals, suggesting that the experimental group is more subject to proactive inhibition than the normal group. A second experiment demonstrated that under conditions of masses practice, Korsakoff patients' performance fell from that under distributed practice, to a greater extent than did that of normals. Again, Korsakoff patients show a greater sensitivity to interference. Finally, an experiment to test the use of subjects of category cues to aid retrieval was conducted. Subjects were read a list of eight words containing two words from each of four categories, e.g. animals, vegetables, etc. They were asked to recall the words. After a record was made of the number of words recalled correctly, the subjects were cued that the second list to be read to them contained words from categories. After this second list, recall was again measured. It was found that while alcoholic controls improved in performance after they had been cued to encode semantically, the performance of Korsakoff patients worsened. This suggests

a failure in encoding. The higher recall under no cue conditions suggest that the patients retain information by auditory means, i.e. by acoustic rehearsal. When they are forced to encode semantically, the auditory re-circulation is interfered with. As their categorization does not effectively result in encoding, performance decreases.

Cermak, Butters and Gerrein (1973) further analyzed the Korsakoff patient's encoding deficit. Repeating the earlier experiment of Cermak and Butters with cuing for category, they added an additional condition where recall was delayed, for both cued and free recall. During the delay of one minute, subjects were instructed to interpolate verbal interference activity (counting backwards from 100 by 2's). After list presentation, under delayed conditions, cued recall was better than free recall. Under immediate recall conditions, Korsakoff patients performed better under free rather than cued recall. Under all conditions, their recall was worse than that of controls. This indicates that the Korsakoff patient can encode on semantic categories when he is cued to do so, and this aids retrieval.

The next experiment was designed to investigate both semantic and acoustic encoding. Patients were given both semantic and acoustic (category and rhyming respectively) cues, before they were asked to retrieve the information. In order to investigate the rate of decay for each of these types of encoding from STS for both experimental and control

subjects, number of trials between the test item and the cue was varied. It was found that the Korsakoff patients recalled fewer items than the controls, and the information decayed faster for Korsakoff patients than for normal controls. However, Korsakoff patients did benefit from both semantic and acoustic cues.

The next experiment in this series tested associative encoding. Again it was found that Korsakoff patients benefit from associative cues.

The last experiment was designed to determine the preferential encoding mechanisms (i.e. the ones used when the subjects are not instructed to encode in any particular manner) of Korsakoff patients. A false recognition task was used. The subject had to read a list of words, and was told to indicate when a particular word was repeated. While some words on the list were repeated, there were also some homonyms, associates and synonyms of words that had preceded. If the subject were to choose one of these words, there would be an indication of his preferred encoding strategy. For example if he were to indicate that the word "see" had been repeated, when the word "sea" (homonym) had gone before, he would be encoding acoustically. A false recognition of a synonym would indicate semantic encoding, and of an associate would indicate associative encoding. Korsakoff patients made more false recognitions than controls. They also made significantly

more homonym and associate errors than controls, and more such errors than synonyms or neutral ones. This indicates a difference in spontaneous preference for encoding strategies. Korsakoff patients seem to prefer acoustic and associative encoding. But such encoding is not as effective, and the patient does not adequately maintain the information so encoded for long periods of time. The lack of spontaneous use of more sophisticated encoding strategies was postulated to be the critical variable in the rapid loss of information shown by the Korsakoff patient.

The experiments considered above have concerned themselves mainly with maintenance of information in STM and transfer from STM into LTM. There is little doubt that this is not the only process that is defective in the Korsakoff patient. Cermak, Butters and Goodglass (1971) did notice that when the Korsakoff patient has to recall information, his performance is not as good as when he simply has to recognize it. This latter procedure aids retrieval, and the improvement in performance suggests that retrieval is impaired in these patients.

Weiscrantz and Warrington (Weiscrantz & Warrington, 1970; Warrington & Weiscrantz, 1970) present evidence to show that if retrieval is aided, performance of Korsakoff patients approaches that of normals. Stimulus materials consisted of high frequency 5-letter words. The experimenters varied method of learning by presenting the material either by the

fragmented word technique (where parts of the letters of each word are progressively revealed to the subject, and he identifies the word as soon as he can), or by the traditional method of reading a list of words three times before the testing trials. Learning was tested under the first condition of fragmented words by recall, recognition, and the fragmented word technique. For the second learning condition an additional means of testing was added: the initial letters technique, where three of the five letters of the word were revealed. Recall was very poor for Korsakoff patients compared to normals, under both learning conditions. However in the testing methods designed to aid retrieval (fragmented letter and initial letter techniques) performance improved to the point where there were no significant differences between control and experimental groups. This leads the experimenters to suggest that it is the retrieval mechanisms that are disrupted in Korsakoff patients, and not the transfer from STM to LTM.

Fuld (1976) used the restricted reminding technique to separately consider storage, retention, and retrieval in Korsakoff patients. This method consists of first presenting a list of words (20 names of 4-footed animals in this case) to each subject, followed by extended recall. Then, the subject was read again the words that he had missed, and told to recall all of the items from the original list again. In

later trials, words were presented again only if the subject had never recalled them in earlier trials. This procedure continued for 12 trials. By this method, encoding can be demonstrated whenever a subject recalls a word that has not been presented on the trial immediately preceding. The total number of items recalled in such a fashion would estimate storage. Retrieval can be measured by comparing recall of encoded items to that of controls. In this experiment, Korsakoff subjects recalled an average of 12 different words at least once, while controls recalled an average of 16.3, suggesting that encoding was significantly impaired. Retrieval also was impaired as controls made an average of 9.4 lapses in retrieval (i.e. failure to recall encoded items), while Korsakoff patients made an average of 18.4 such lapses. This suggests that both encoding and retrieval are impaired in Korsakoff patients.

Thus, while earlier experiments were designed to determine whether either encoding or retrieval was impaired, researchers now seem to have accepted that both are deficient in the Korsakoff patient, and there is a trend towards integrating the losses (see for example, Fuld's discussion). The Cermak and Butters group has recently postulated that it is encoding-for-retrieval that is deficient in the Korsakoff patient (e.g. Cermak, Butters, Jones & Glosser, 1975). This fits in with the memory model described earlier: reliance on

lower levels of organization of incoming stimuli would be expected to result in deficient retrieval.

A different trend has been the consideration of specificity of memory loss. Several experimenters have directed their efforts towards determining the areas where the Korsakoff patient's memory remains intact by varying the material presented in the tasks.

Probably the first experiment using stimuli other than words or letters was conducted by Samuels, Butters, Goodglass and Brody (1971). The experiment consisted of five presentations. Each presentation consisted of a background and three different figures. The backgrounds and figures were taken from the Make-A-Picture-Story Test. The task of the subject was to remember which background was paired with which figures. In order to test his memory the background alone was presented, and the subject had to chose from 20 figures, the three that had been paired with that particular background. Two tests were conducted: one immediately after presentations, and the other 24 hours later. In both conditions, the performance of Korsakoff patients was significantly worse than that of normals.

In 1973, Butters, Lewis, Cermak and Goodglass conducted an experiment using verbal and non-verbal material, in visual, auditory and tactile modalities, to test for both material and modality specificity. The verbal tasks consisted of: trigrams presented visually, trigrams presented through headphones, and

single letters of raised hardened glue, presented tactually. The non-verbal tasks consisted of random shapes presented visually, piano notes presented in sequences of 5, and unfamiliar open figures of raised hardened glue, presented tactually. Recognition was tested both immediately after presentation, and under 2 delay conditions of 9 and 18 seconds. In the delay conditions, subjects were instructed to count backwards from 100 by 2's, to prevent rehearsal. Alcoholics and normals were used as control groups. Under non-delay conditions, for both verbal and non-verbal material, in all modalities, Korsakoff patients performed equivalent to normals. When non-verbal stimuli were used, in visual and auditory tasks, Korsakoff patients performed equivalent to normals in both delay conditions. In the non-verbal task for the tactile modality, performance was equivalent for the 9 second delay, but Korsakoff patients performed much worse under the 18 second delay condition. When verbal stimuli were used, in the visual modality, Korsakoff patients performed significantly worse than alcoholics at the 9 second delay, and significantly worse than either control group at the 18 second delay. In the verbal task, in the auditory modality, under 9 second delay, Korsakoff patients did not perform worse than either control group; however under the 18 second delay condition, Korsakoff patients made more errors than either control group. In the tactile modality,

with verbal stimuli: Korsakoff patients performed worse than either control group at 9 second delays, and worse than normals under 18 second delays. In summary: no group difference were found under non-delay conditions. Under delay conditions, when verbal stimuli were used, except for the 9 second delay in the auditory modality, Korsakoff patients performed significantly worse than at least one control group. Under delay conditions when non-verbal stimuli were used, except for the 9 second delay in the tactile modality, Korsakoff patients' performance was equivalent to that of the control groups. It should be noted that the tactile modality scores were unusual in another aspect: both Korsakoff patients and alcoholics made fewer errors with the verbal than with the non-verbal stimuli. In the other two modalities, verbal errors were more frequent for these groups. This led the experimenters to conclude that "the Korsakoff patient,. . .is unable to acquire new information which is verbal in nature or which requires the aid of verbal mediators or strategies for retention" (p.297).

This conclusion is essentially supported for LTM tasks by El-Wakil (1975). He presented Korsakoff patients and alcoholic controls with 29 slides of common objects. Two presentations of the slides were made on the first day of the experiment, and the experimenter named each slide (e.g. this is a picture of a house, etc.) On the next day, a picture

recognition test was conducted. Two pictures of the same objects were shown to the subjects. Only one of these pictures had been presented on Day 1. The subject was told to pick the picture he had seen the day before (or make a guess if he did not remember). At least 80% of the stimuli were correctly identified by the Korsakoff patients. On Day 3, a verbal recognition test was conducted. Subjects were presented with names of two stimuli, and had to chose the one they had seen the day before (e.g. Did you see a house or a school?). Again, at least 80% of the stimuli were recognized by the Korsakoff patients. Then, a second picture recognition test was conducted. The Korsakoff patients' performance fell slightly, but remained well above chance level. Twenty-four hours later the first of 3 verbal recall tests was conducted. The second recall test was conducted 10 days later, and the third, a week after that one. Severe impairment was obvious in Korsakoff patients. Immediately after the third recall test, a second picture recognition test was conducted. Korsakoff patients' performance increased to well above chance level again, when they were tested in this mode. El-Wakil concluded that the Korsakoff patient's deficit "appears to be quite specific to an inability to endogenously produce verbal stimuli (codes) for information in memory. The information is accessible, but only by means of exogenously produced verbal stimuli which can then gain access to this information, . . . or by means of an accessory system which does

not require verbal mediation" (p.87).

A later experiment by De Luca, Cermak and Butters (1975) investigates the effect of verbal and non-verbal distractor tasks in auditory and visual modalities, on recognition of verbal and non-verbal material. Each patient performed in 8 different conditions. Each condition was a combination of: visual stimulus material (verbal or non-verbal), modality of interference (auditory or visual), and type of interference (verbal or non-verbal). The stimulus materials consisted of consonant trigrams or random shapes. Auditory interference consisted of either counting backwards from 100 by 2's (verbal) or tracking musical notes (non-verbal). Group and condition effects were found to be significant, but modality was not. In all conditions, Korsakoff patients performed worse than alcoholics, except for the condition where verbal material was followed by a non-verbal distractor, where performance was equivalent. In fact it was in this condition that the Korsakoff subjects showed their best performance. Their performance was the worst under the conditions where non-verbal material was followed by non-verbal distractor activity. A second experiment determined that visually presented material is better recalled when followed by non-verbal interference than when followed by verbal interference. In fact Korsakoff patients' performance under the former condition was not significantly different from that of alcoholics. A third experi-

ment used both verbal (consonant trigrams) and non-verbal (random shapes) stimuli, and tested recognition after a 20 second unfilled delay. While alcoholics performed equivalently in both conditions, Korsakoff patients performed worse with non-verbal stimuli. For verbal stimuli, their performance was essentially equivalent to that of the controls. The experimenters noted that: a) verbal material was well retained by Korsakoff patients if it was not followed by verbal distractor activity; b) non-verbal material was disrupted, following both verbal and non-verbal distraction, and even following an unfilled interval. They concluded that as the Korsakoff patient relies on acoustic coding while maintaining the information in STM, recirculation of verbal material will be prevented by verbal activity, but not by non-verbal interference. However there is no such mechanism for the maintenance of non-verbal material, which is consequently lost.

Summary and Statement of the Problem

The experiments concerning the Korsakoff patient's memory disorder can be summarized in the following manner: Memory for verbal stimuli: It has been found that when words or letters are followed by verbal interference, they decay rapidly from memory (Butters, Lewis, Cermak & Goodglass, 1973; De Luca, Cermak & Butters, 1975). The loss could occur either at storage in working memory, or it might be due to a problem in retrieval. Since the loss occurs under recognition as well as recall, the deficit is probably at the storage stage. Further indication that storage in STS is more easily disrupted in Korsakoff patients is that they are more vulnerable to proactive interference, and seem to encode preferentially on acoustic levels (Cermak & Butters, 1972; Cermak, Butters & Gerrein, 1973). Verbal stimuli followed by non-verbal interference, or no interference, are maintained to a degree comparable to controls in short term memory, in both free recall and recognition (De Luca, Cermak & Butters, 1975).

Two experiments at first glance would seem to contradict the last statement. El-Wakil (1975) presents verbal stimuli along with slides, and gets normal recognition but deficient free recall. Cermak, Butters and Gerrein (1971) use no interference and get deficits in learning of paired associates.

It should be noted that El-Wakil's testing for recall was conducted several days after the stimuli were presented. By

this time, stimuli would be expected to be either a) lost from STS (never having been transferred to LTS), b) present in LTS and be easily retrievable, or c) present in LTS and not easily retrievable. As recognition is essentially normal, a) can be ruled out. As recall is not, b) can be ruled out. This suggests that retrieval from LTS could be the problem. Retrieval problems are minimized in De Luca, et al., (1975) experiment, as they test almost immediately after stimulus presentation, when stimuli would be expected to be in active memory.

If acoustic encoding is preferentially employed by the Korsakoff patient in LTS as well as STS, then this can be related to his retrieval problem. Acoustic encoding is sometimes called "maintenance rehearsal" (as opposed to elaborate rehearsal). The acoustic code provides a lower level of organization than the more elaborate codes, e.g. narrative chaining, mnemonic codes, imagery (see, for example, Loftus & Loftus, 1976, 4-10 to 4-14). Level of organization has been related to retrieval (e.g. Tulving & Pearlstone, 1966), and generally, the more highly the material is organized, the easier it is to recall (Loftus & Loftus, 1976, 4-15). Hence the control subject, encoding on higher levels as well as the acoustic, would have a greater probability of correctly retrieving the item, than the Korsakoff whose encoding is primarily acoustic.

Cermak, Butters and Gerrein (1971) used paired-associate

learning as their task, testing both immediately and over a period of four days. It should be noted that this kind of learning probably requires fairly sophisticated encoding, as each stimulus has to be retrieved in response to its pair member. The other experiments, getting results for Korsakoff patients resembling those for normals, require only recognition or free recall, usually from active STM. The Korsakoff patient with his very limited encoding strategies and problems with retrieval, might well be expected to fail at this complicated task.

Thus, for Korsakoff patients, encoding and storage of verbal stimuli in active memory are highly vulnerbale to disruption by verbal interference. Although both recognition and recall are below normal, recognition scores are higher than those for recall, suggesting that retrieval is also a problem. When the Korsakoff patient is allowed to encode without verbal interference, his preferred encoding strategies are fairly primitive. This prevents effective retrieval from LTS, affecting all but the simplest of tasks. Since recognition continues to be possible after long delays after the material has been presented, items do get transferred into LTS, and when retrieval problems are minimized, the Korsakoff patient's performance is comparable to that of controls.

Memory for non-verbal stimuli. The experiments can be divided into those using easily nameable stimuli (El-Wakil,

1975; Samuels, Butters, Goodglass & Brody, 1971), and those using unfamiliar stimuli that are presumably more difficult to name, or "non-nameable" stimuli (Butters, Lewis, Cermak & Gerrein, 1973; Cermak & Butters, 1975).

In the area of nameable stimuli, Samuels, et al. get results indicating that Korsakoff patients are deficient in recognition from both STM and LTM. El-Wakil, on the other hand, shows recognition comparable to controls 18 days after the stimuli had been last presented to the subjects. There are major differences in the two studies that might account for the discrepancy in results. El-Wakil required only that the subject indicate whether or not he had seen the stimulus before. Samuels, et al. on the other hand, required that the patients be able to pair backgrounds with the figures they had seen imposed on them earlier. This task required not only recognition, but also discrimination among the stimuli they had been shown. High vulnerability to proactive interference (Cermak & Butters, 1972) and limited encoding mechanisms have been indicated in the Korsakoff patients' handling of verbal stimuli. It is possible that similar effects might limit encoding of non-verbal stimuli as well. If Korsakoff patients are highly vulnerable to proactive interference for these stimuli, Samuels, et al.'s results would be explained, as there would be interference with encoding and/or storage. If they have a corresponding retrieval problem for these stimuli,again the demanding nature of the task would preclude

high performance scores. Finally, it should be considered that the Korsakoff patient may be using primarily verbal encoding strategies to store nameable material. This would explain El-Wakil's result, as he provides verbal codes for the stimuli, and finds better recognition than recall. Samuels, et al.'s results are consistent with the defect in paired associate learning, as this task requires essentially the pairing of four stimuli to be remembered together.

Thus, two possibilities concerning the Korsakoff patient's handling of non-verbal nameable stimuli are suggested: a) The imaginal system (see Paivio, 1971) is primarily employed by these patients to retain nameable non-verbal stimuli, and Korsakoff patients have a deficit in this system. The deficit could be due to strategies which are easily disrupted, and/or storage in a form that is not condusive to more than simple recognition. Or b) The patients rely primarily on the verbal encoding of names of nameable stimuli. The disruption in the retention of verbal stimuli is responsible for the deficits in the retention of nameable non-verbal stimuli. There is also the possibility, here and elsewhere, that the Korsakoff patients and controls each employ altogether different mechanisms to encode the stimuli they encounter. However, before this is pursied, the most parsimonious explanations should be eliminated.

In the case of "non-nameable" non-verbal stimuli, the results are extremely inconsistent. Patients and controls

can recognize stimuli if they are tested directly after presentation. But once a delay and/or interference is involved, the effect is unclear. Butters, Lewis, Cermak & Goodglass (1973) show on the one hand that non-verbal stimuli in visual and auditory modalities, are retained as well in Korsakoff patients as in controls. They used verbal interference and 9 and 18 second delays. Using verbal interference again, and comparable stimuli in the visual modality, De Luca, Cermak & Butters (1975) find that recognition drops significantly below that of alcoholics. These two sets of results are in direct contradiction to one another, and it is difficult to determine what factor, other than individual differences could have reasonably accounted for this discrepancy.

In the case of "non-nameable" stimuli followed by non-verbal distractors, Korsakoff patients performed worse than alcoholics. However their performance in this condition did not differ significantly from when the distraction was verbal. Alcoholics also performed equivalently and at high levels (90%) under both distractor conditions for non-verbal stimuli. Hence encoding and storage is probably not disrupted in the controls by verbal or non-verbal distraction, but it is disrupted equally in both these cases for the Korsakoff patients. As recognition and not recall was required, the deficit is unlikely to be at retrieval. If verbal encoding mechanisms were being used for these "non-nameable" stimuli (e.g. "a fig-

ure that looks like a cat, except for the pointed part in the corner, etc."), the performance of the Korsakoff patients with the verbal distraction would be explained. It could even be postulated that since these patients have difficulties with verbal encoding, they are unable to come up with codes for "non-nameable" stimuli, hence they can not retain them. However, if controls are using these verbal codes, their performance should be disrupted following verbal interference, and this is not the case.

The picture becomes even more confused when De Luca, et al. find that "non-nameable" stimuli are not retained even after a 20 second unfilled interval, by Korsakoff patients. Verbal material on the other hand, is retained by Korsakoff patients after a 20 second unfilled delay, to a degree equivalent to alcoholics. The controls, unlike the Korsakoff patients, retain both verbal and "non-nameable" stimuli to the same degree following an unfilled interval.

Several possible patterns can be postulated here: a) The controls and the Korsakoff patients are using primarily an imaginal encoding mechanism, and this mechanism is defective in the Korsakoff patient, or b) verbal labels are given to "non-nameable" stimuli; hence the drop in the Korsakoff patient's performance, as he can not, or does not, attach verbal labels as effectively as controls, and so can not recognize after a delay.

The only area that seems to have been satisfactorily covered is that of encoding into and retrieval from STM of verbal stimuli. Some essential questions that remain unclear or uninvestigated are:

1) How efficient is encoding into LTM of verbal stimuli? The only experiments that approach this are: Cermak, Butters & Gerrein (1971), and El-Wakil (1975). The former use a fairly difficult task, and El-Wakil uses both verbal and visual stimuli concurrently, making effects difficult to assess. Hence neither of the above have dealt directly with this question. A possible experiment would involve several presentations of verbal stimuli without interference, and would test for both recall and recognition after a delay (of hours at least).

2) What is the extent of encoding and storage of nameable non-verbal stimuli into STM and LTM, and how effective is retrieval of these stimuli? No experimenter seems to have considered retention after visual presentation of nameable non-verbal stimuli with or without interference, at ST delays. El-Wakil has partially examined the question of LTM, but he added verbal cues to visual presentation. It is therefore unclear whether his results were caused by providing a verbal cue (which the patients could not themselves generate, and needed for retention, as he suggests), or not, as there was no control group that was presented the visual stimulus without

the cue. Samuels, et al. (1971) tested for both ST and LT recognition of non-verbal stimuli, and obtained results suggesting that the Korsakoff patients had severe deficits in their retention. However, as mentioned before, their task was an extremely demanding one. It is not known whether under less demanding conditions, the Korsakoff patient can retain these nameable non-verbal stimuli. It is also unclear whether verbal or imaginal strategies are being used to encode these stimuli. An examination of the effect of various kinds of distractor tasks could illuminate encoding mechanisms.

3) Is there a loss of retention of "non-nameable" non-verbal stimuli in Korsakoff patients in ST conditions? Since two earlier experiments directly contradict each other, a replication would be useful. Verbal and non-verbal interference tasks seemed to affect "non-nameable" stimuli equivalently in Korsakoff patients (De Luca, et al. 1975). Control groups in the same experiment also did not seem to be more affected by a particular distractor task over the other. However, only one experiment has considered the effects of non-verbal distraction on these tasks. Repeated and further investigation into this area, could suggest mechanisms used to encode "non-nameable" stimuli.

PURPOSE OF THIS INVESTIGATION

The proposed experiment is designed to consider:

1) Retention of verbal, nameable, "non-nameable" stimuli as tested by recognition, at a long term interval. In spite of the fact that it is LTM that appears to be impaired when one interacts with the Korsakoff patient, as discussed previously, LTM has not been systematically investigated in the past.

2) The role of an information processing deficit in memory loss in the Korsakoff patient. Several experimenters have found deficits in this area (e.g. Oscar-Berman, 1973; Oscar-Berman, et al. 1976; Glosser, Butters & Kaplan, 1973), suggesting that the Korsakoff patient does not adequately analyze stimuli presented to him. It is possible that this might contribute to a memory deficit. Encoding would not be expected without analysis. If the Korsakoff patient is failing to encode aspects of stimuli that control patients analyze and encode, his memory performance would be expected to be impaired relative to normals. Earlier experiments with complex visual stimuli (De Luca, et al. 1975) expose these stimuli to the subjects for only very short periods of time (2 seconds) and test memory by recognition very soon after. In this experiment, both recognition from LTM after a longer stimulus exposure, and performance after cuing for and aiding with analysis will be considered.

METHODOLOGY

Subjects. The experimental group consisted of two male Korsakoff patients from the Northampton Veterans Administration Hospital. These patients had been diagnosed as suffering from Korsakoff's syndrome. Both these patients had full-scale I.Q. scores (as measured by the Wechsler Adult Intelligence Scale) above 80. Both had Wechsler Memory Scale Quotient scores that were at least one standard deviation below the full-scale I.Q. Neither had any signs of dementia. Two male alcoholics served as the controls. These patients were matched as closely as possible to the Korsakoff patients along the variables of age, I.Q., race, geographical background and past trade. The characteristics of each experimental subject and control are presented in Table 1. Neither control subjects seemed to have a memory deficit.

For subjects K_1 and A_1, I.Q. scores were obtained by testing by the experimenter approximately 24 hours before the testing commenced. Both the other patients had been previously tested less than 18 months before commencement of the experiment, by other individuals. Their scores were obtained from their charts.

TABLE 1

Characteristics of Korsakoff patients (K) and alcoholic controls (A).

	T.M. (K_1)	P.H. (A_1)	A.R. (K_2)	R.M. (A_2)
Age	30	27	62	55
Full Scale I.Q.	88	102	94	95
Verbal I.Q.	89	102	102	100
Performance I.Q.	89	102	84	88
Memory Quotient	60	112	65	89
Employment	construction	assembly	cook	cook
Race	white	white	white	white
Sex	male	male	male	male
Geo. Background	Mass.	Mass.	New York	Vermont

Procedure. Each subject participated under four conditions which will be described below. All stimuli were presented on slides and projected onto a screen. Each condition consisted of two sessions. In the first session of each condition, stimuli were presented to the subject. The slides were presented twice to the subjects on this day. The two presentations were separated by short breaks. The second session, which followed 24 hours later in each condition, was the "test" session, where subjects' memory for the stimuli presented was tested. These recognition trials consisted of presentations of pairs of slides: each pair consisted of one stimulus that had been shown to the subject on the first session, and a stimulus matched to it. The matched stimulus will be described below for each condition. The subjects were asked to indicate, or to guess as they often claim not to remember, which slide they had been shown in the first session.

In order to encourage a high level of motivation, and ideally obtain maximal performance, on the first session of each condition, the subjects were verbally encouraged to attend and were promised rewards at the end of the session. They were also informed that they could earn more the next day if they remembered the stimuli correctly. During testing each correct response was rewarded with a dime.

Experimental conditions: 1) Verbal (V). All stimuli in this condition were concrete words. The slides were presented for 15 seconds each during testing. The subjects had 15 seconds to make their recognition. During recognition trials, the matched stimuli contained the same number of letters, and had the same frequency of occurrence in the English language.

2) Non-verbal "nameable" (NN). Slides of familiar objects were presented in this condition. Two slides were made of objects with the same name. One member of the pair was presented on the first day. The second member was used in the recognition trials as the matched stimulus. Again, stimuli were presented for 15 seconds.

3) Non-verbal "non-nameable" (NR). Stimuli in this condition and condition 4 were chosen to contain a minimal verbal aspect, and so consisted of largely unfamiliar figures. Different kinds of low verbal figures were used, i.e. computer generated random shapes, irregular but symmetric inkblots and open line figures. Each slide was presented for 15 seconds in the first session. For the recognition trials, each slide was paired with another of the same kind (i.e. inkblot, etc.)

4) Non-verbal "non-nameable" "analyzed" (NA). This condition employed the same stimuli as NR. The only difference in the condition lay in the kind of experiment activity during the second slide presentation. In all the other conditions, the

experimenter provided verbal encouragement to look at the slides carefully. In this condition the experimenter asked the subject how he would describe the stimulus in front of him to a blindfolded individual. If no response was forthcoming, the experimenter proceeded to point out different aspects of the stimulus, i.e. drew the attention of the subject to different dimensions.

The stimuli in conditions NN, NA and NR were chosen on the basis of pilot studies conducted with normal subjects (undergraduates from psychology classes at the University of Massachusetts). Of the 12 stimuli in each condition included in this experiment, 7 had been correctly recognized by all of at least 15 normals in the pilot. The other 5 stimuli in these conditions had been chosen to represent varied degrees of difficulty to the pilot subjects, as measured by the number of individuals that made an error in recognition during the test trials. This number ranged from 1 to 5.

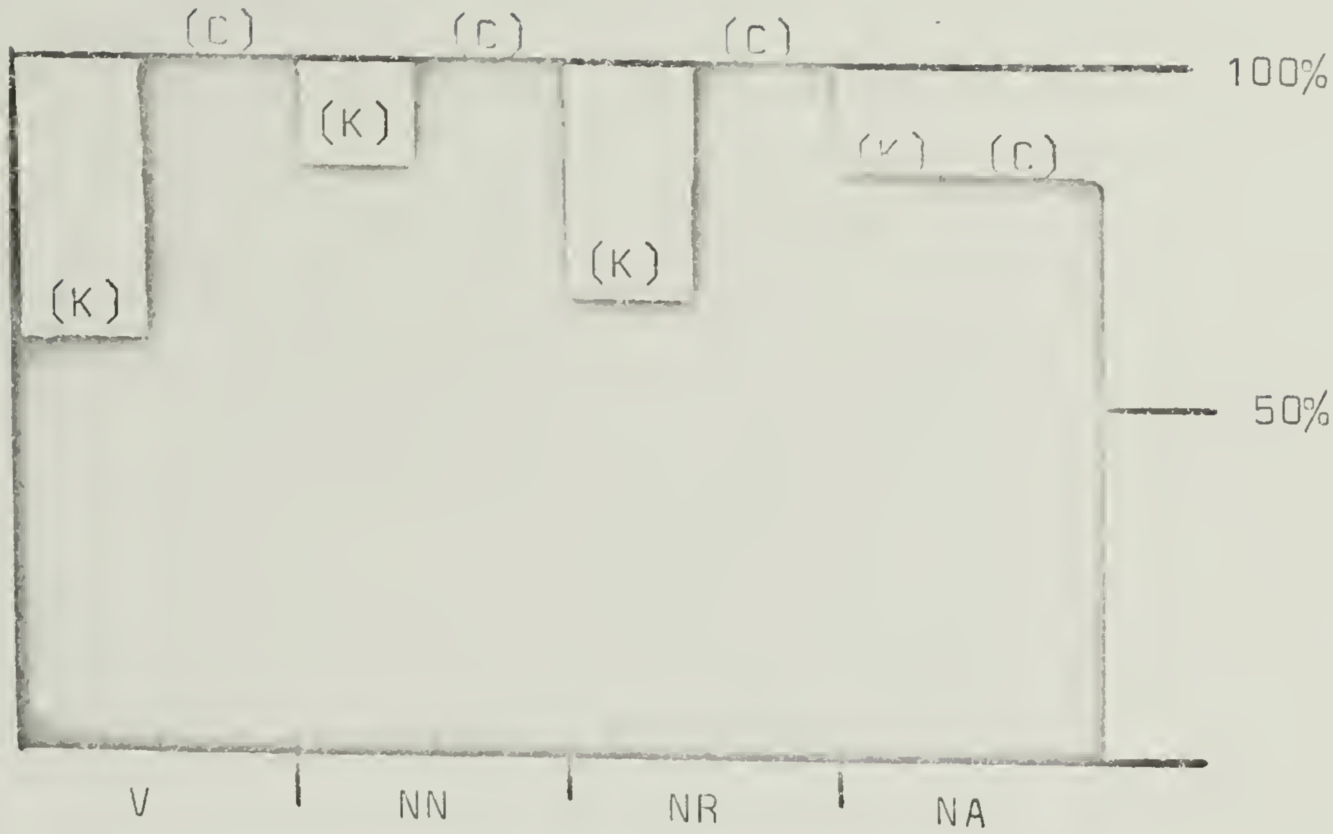
Conditions V and NN were run concurrently, as were conditions NR and NA. NR was presented before NA on the same day, in order to avoid encouragement to "analyze" stimuli in subjects that were not already analyzing for condition NR.

RESULTS

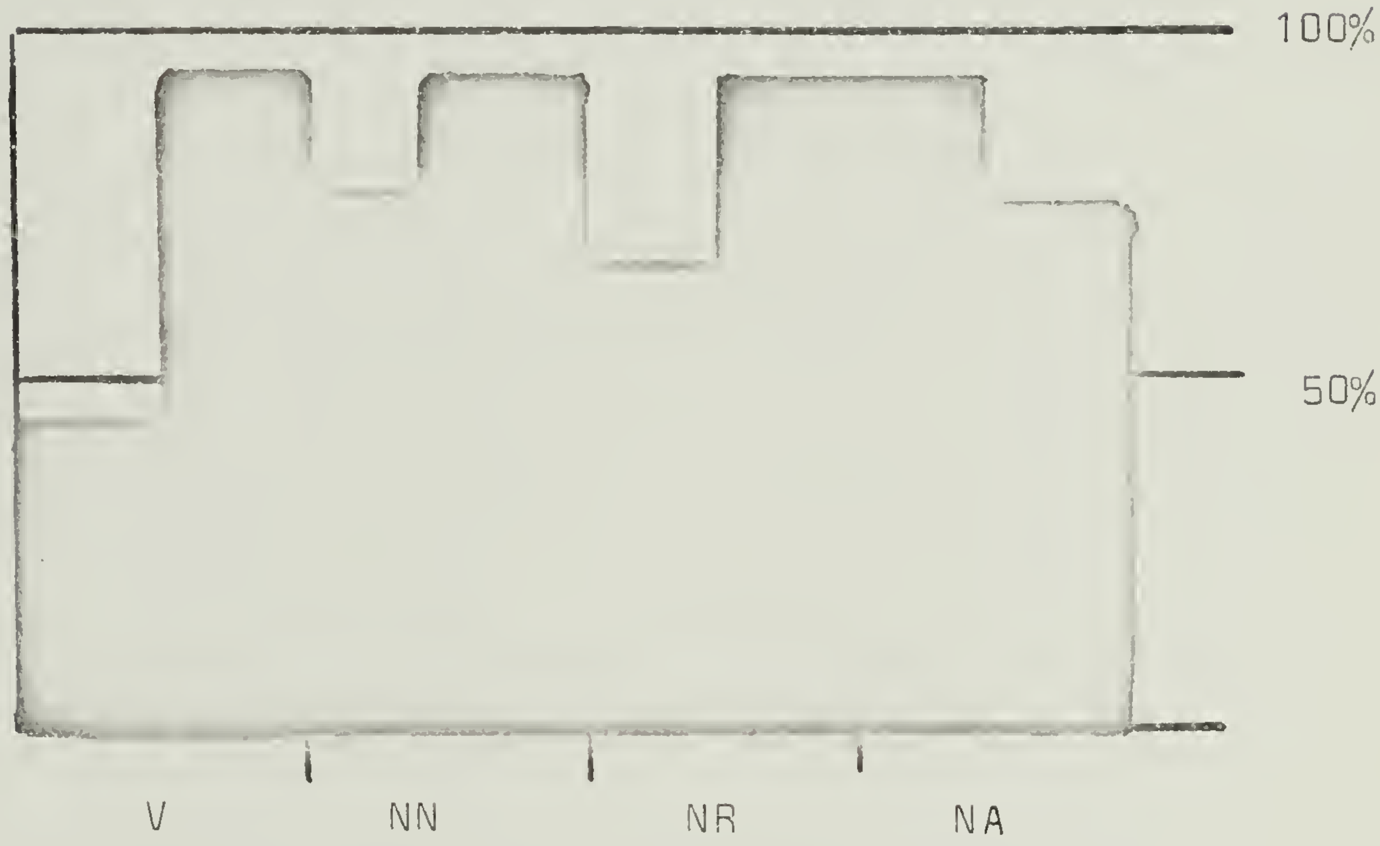
The results in terms of percentage and ratio correct responses are presented in Table 2 and Figure 1. It is clear that in every condition except one, the Korsakoff subject performed worse than his control. The single condition where the control's performance was surpassed is condition NA. Figure 2 shows that when the scores are averaged, this condition remains the single one in which the Korsakoff subjects' performance is better than that of controls.

A within-group comparison reveals that for the controls (both separately and when scores are averaged) performance scores are close to 100% correct in the first 3 conditions, but drop slightly for condition 4 (NA). This latter in each case remains well above chance level. In the case of the Korsakoff subjects, this relationship does not hold. Figure 2 demonstrates that performance does not deviate significantly from chance levels in conditions V and NR. In condition NN, higher scores are obtained that are far from chance levels. The best performance occurs in condition NA, where their performance surpasses that of the controls. Thus the relationship between scores follows separate patterns for the two groups. However the pattern within each group remains consistent.

An analysis of variance was performed on the data. The following probabilities were obtained:



K_1 and A_1



K_2 and A_2

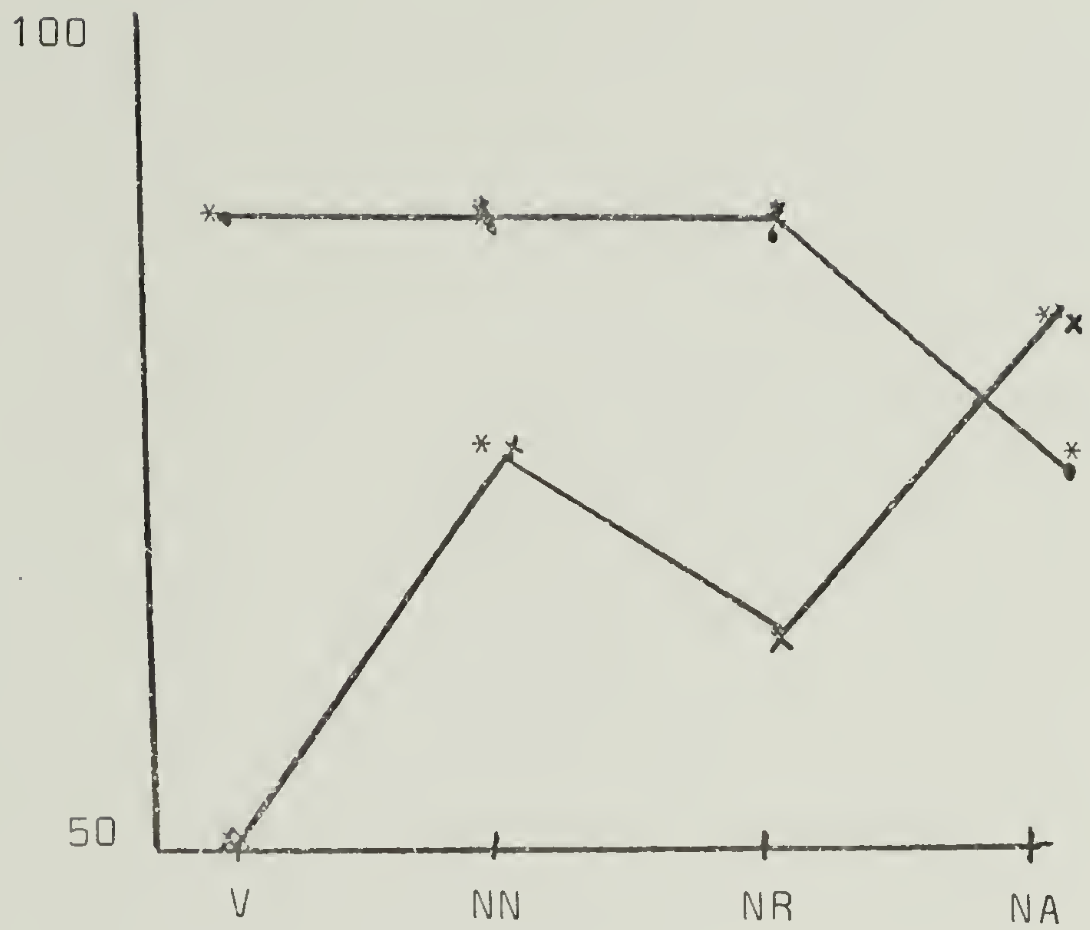
Figure 1. Individual Korsakoff and control subjects performance for each condition. (Shaded area represents Korsakoff subject's score).

TABLE 2

		V	NN	NR	NA
KORSAKOFF	K_1	58%	83%	66%	83%
		7/12	10/12	8/12	10/12
	K_2	42%	75%	66%	92%
		5/12	9/12	8/12	11/12
CONTROL	A_1	100%	100%	100%	100%
		12/12	12/12	12/12	10/12
	A_2	92%	92%	92%	75%
		11/12	11/12	11/12	9/12

Percent and ratio correct responses for each subject for each condition.

FIGURE 2



Korsakoff and control subjects performance averaged over groups.

• = control; x = Korsakoff; * = significantly deviating from chance.

p (group effect) $>$ .10

p (condition effect) $<$ .05

p (interaction effect) $<$ .005

It should be kept in mind that the very small number of subjects in each group severely reduced the power of the test of significance for group effects. On the basis of the binomial distribution, the probability of obtaining 9 or more scores out of 12 correct is $<$ .05. This is represented in Figure 2. As the basis for the discussion, trends rather than statistically significant data alone will be examined.

DISCUSSION

The Korsakoff patients' memory for verbal stimuli is clearly impaired. While controls obtain close to a maximum possible score, Korsakoff patients' performance hovers around chance. There seemed to be no great overlap of words missed within the Korsakoff group (only 2 words were missed by both subjects). In condition NN, Korsakoff subjects' performance improves. The items that give them difficulty overlap with each other to a greater extent, and also overlap with items that were difficult for the controls and for the pilot subjects. One item was missed by all of K_1, K_2 and A_2. All four items missed by Korsakoff subjects had been missed by at least one pilot subject. When the non-verbal performance scores are pooled (i.e. NN + NR + NA) the average score per patient per condition is 9.3 compared to an average of 6 for the verbal scores. For controls, the relationships between these scores is reversed: the average non-verbal score is 10.8, while the average verbal score is 11.5. The verbal system of encoding for Korsakoff patients is apparently malfunctioning. Yet when the scores for NR and NA are compared, the difference is considerable. It seems paradoxical that in individuals who have problems encoding verbal stimuli, performance of non-verbal stimuli can be aided by verbal codes.

Before two simple models that will explain the data above are introduced, some concepts employed in the models

will be presented. The first relates complexity of the stimulus to memory. The common sense idea to be introduced here is that the more complex the stimulus, the more difficult it is to remember, <u>if no cognitive operations are performed on it</u>. It is easier to remember one word than a string of 13, a picture of one object than of several in relationship to one another, etc. The reader may object that this is not the case in actual fact, as we usually recall by ordering in some fashion, by decreasing the separate bits of information that have to be retained. Thus often it is as simple to remember a string of five words as it is to remember one word. This is the second concept to be introduced here, referred to in the cognitive literature as "chunking" or "recoding".[2] One way to reduce small bits of information into a chunk is by giving these bits meaning. This can be done verbally, i.e. by translation and storage as a verbal code. For example, a complex picture can be stored as the name of the object it represents. Another way of giving meaning to a stimulus is by non-verbal means. This could be accomplished by storing a single, high meaning, image against which the stimulus to be stored can be compared. For example, one might note of a stimulus in condition NA,

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[2]For a more complete treatment of this concept, see Norman, 1969, pp.89-96. Only relevant parts of this concept will be included here.

as one subject did, that except for an area on the lower part, it resembles a butterfly. The hypothesis would be that the S would then store his own image of a butterfly. Having seen the stimulus to be remembered as a butterfly, this stored image is evoked when he sees the stimulus to be remembered again, and recognition occurs. This kind of process which results in greater meaning for non-verbal stimuli can be seen as an example of a deeper level of processing which results in facilitated memory (see pp. 5-6).

The first model within which the data can be explained suggests that the difference between NR and NA is due to the fact that the non-verbal system is more efficiently employed in the latter. The pictures in NN, which have immediate high meaning are easily recognized. During condition NR, the immediate meaning of the stimuli is not obvious. Normals give these stimuli both verbal and non-verbal meaning, storing efficiently and recognizing easily. Korsakoff patients do not perform these operations to increase meaning spontaneously. Verbal encoding mechanisms are not functional. Additionally they do not seem to give non-verbal meaning to the stimuli. In NA, the experimenter performs these operations for them. By forcing the subjects to generate an image to relate to the stimulus, the experimenter causes the subject to store this simpler image, to compare the stimulus before him against it, to note the parts that are different, to

store these fewer in number descriptive images, and to recognize the stimulus again more easily.

Thus the role played by verbal activity in NA would be somewhat indirect in this model. The stimulus is named and the name produces an image. The name is not stored. If this model is to be considered a valid one, the high level of consistency between verbal codes given to a stimulus by each patient during sessions 1 and testing must be explained. This high level of consistency could be indicative of retention of verbal codes as a means of improving non-verbal memory. On the other hand, an explanation consistent with the model can be advanced. It could be the case that when the verbal code is supplied by the Korsakoff patient in session 1, the stimulus in front of him looks to him like the image evoked by the name he gives to it. This name is re-evoked by the stimulus itself during testing (rather than retrieved out of memory). When the subject comes up with no image to tie the stimulus to, the experimenter gives him one. By doing this, the experimenter "forces" the subject to see the parallels between the image of the name supplied and the stimulus on the screen. After this, the subject sees the stimulus in relation to that image, and again the name produced in testing is evoked out of the stimulus rather than out of memory.

Normals perform better in condition NR than in NA. This

drop in performance may be the result of interference with a spontaneous process which is efficient in its own right. As Korsakoff patients do not seem to use this spontaneous process, or use it extremely inefficiently, intervention can only be helpful.

The second model to be offered to explain this data also suggests a deficit in encoding of verbal stimuli. Two systems of encoding stimuli exist: verbal and imaginal. The normal individual employs both, while the Korsakoff patient cannot encode directly on verbal levels. This accounts for low scores in condition V for Korsakoff subjects. The imaginal system is intact in Korsakoff patients. This results in scores that are significantly better than chance in condition NN, where the stimuli are complex but can be recoded through non-verbal meaning. When it comes to condition NR where the stimulus is extremely complex and would not be adequately stored through purely imaginal levels, the normal individual activates the verbal encoding system, reducing the complexity of the stimulus by recoding it, resulting in high scores in condition NR. This kind of activation of the verbal encoding system is not spontaneously carried out in Korsakoff patients, who then have no means of reducing the complexity of the stimulus, resulting in decrements in performance in NR. However when verbal codes are provided to the Korsakoff patient (as they are in NA by both the subject himself upon instruction, and by the experimenter) then he is

able to interconnect the imaginal and verbal systems and retain stimuli at high levels, hence the high performance in condition NA. It is important to note that this mechanism of involving verbal processes must be different from the normal verbal encoding mechanism, as that is clearly defective in Korsakoff patients. The normal subjects have an intact verbal encoding system which is encoding spontaneously, and in a fashion superior to that which the experimenter may provide. By forcing verbal code generation, or providing a code, this natural encoding system is interfered with, and performance in NA drops.

The diagram on p.55 represents the proposed model.

In condition V: Normals encode along a, store in the verbal "box", high verbal meaning results in a strong trace, and when required, output d results in high scores. Korsakoff patients cannot encode along a. Encoding takes place along b. The stimulus is extremely complex to be encoded purely along an imaginal level. It has no non-verbal meaning. It is weakly stored in the imaginal "box". Output e is difficult to obtain.

In condition NN: Normals encode along a and b, storing in both verbal and imaginal "boxes". Output d and e result in high scores. Korsakoff patients encode only along b and store in the imaginal "box". High non-verbal meaning of the stimulus results in a strong trace. Output e results with

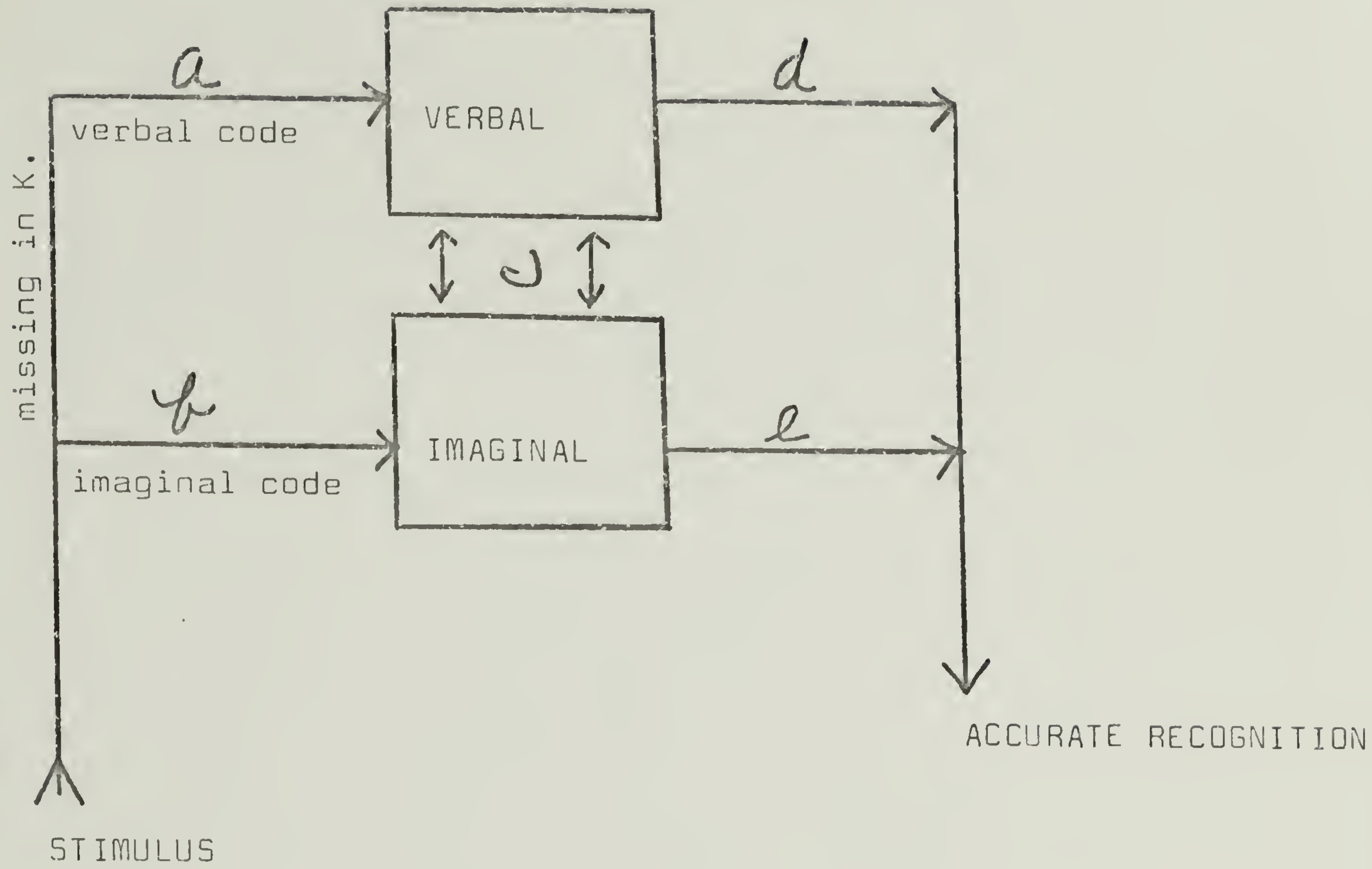

Figure 3. Schematic representation of model of memory.
See text for explanation.

relatively high scores.

In condition NR: Normals encode along a and b, store in verbal and imaginal "boxes", and outputs d and e result with high scores. Korsakoff patients encode only along b. Again the stimulus is too complex to be stored only in the imaginal box (non-verbal meaning level is not high), and storage is weak with output e difficult to obtain. Hence low scores are obtained in NR.

In condition NA: Normals store along b. Storage along a is interfered with the demand to generate verbal codes, or with the experimenter's supply of such codes. The result is porr storage in the verbal "box" and poor storage in the imaginal "box", and lowered scores in condition NA. Korsakoff patients store along b. Since a is non-functional, there is no interference with spontaneous encoding. Verbal ties to images activates c. This results in a strong store in the verbal "box". The result is a weak output along e (as with normals), and a stronger output along d, and a relatively high score.

The important variable that seemed to explain both low scores in V and high scores in NA is that the verbal code is ineffective in aiding Korsakoff patients' memory unless it is tied to an image. This also explains the seeming discrepancy between El-Wakil's (1975) high level of verbal recognition and the low level achieved here. In El-Wakil's

task, when the pictures were shown to the subjects, the word label was also provided ("This is a picture of a house"). The word code was being tied to the image. On later testing the subjects were asked "Did you see a picture of a house or a school?" Verbal recognition levels were high. In this experiment, there was no such link made for the Korsakoff patients, and thus verbal recognition performance was low.

It might be argued that there was a picture supplied: the words were presented on slides. Indeed, it is the contention of this experimenter that it is precisely as complex pictures that the words were stored. Meaning given to this complex non-verbal stimulus would have to be verbal meaning, which is the kind of encoding the Korsakoff is incapable of. The Korsakoff patient had as much trouble remembering the word as an individual who does not read English would. In other words, the code that was used to store the word was not its meaning; it was the shapes that the letters made on the background.

The model claims that while Korsakoff patients were aided in their memory processes by the experimenter supplying them with verbal codes, the normal patients did not so benefit. Their encoding system is superior, they were engaged in its activation, instructions to generate codes verbally were distracting, performance dropped. As the Korsakoff patients

were not engaged in this spontaneous encoding, the link between verbal and imaginal "boxes" could be established, and performance improved. This hypothesis can be strengthened by evidence from the qualitative data gathered (included in the Appendix): a) A_1 missed items 1 and 6 in NA. The only item he could not immediately provide a description for was 6. He also missed item 1, but this item is one that involves a particularly difficult discrimination, and was missed by 5 normals in the pilot study, and by 3/4 of the patients in this study. A_1 voluntarily reported to me that the items he missed were the ones he had the most trouble giving a description to. Unfortunately this does not hold for item 1 for which he provides a most elaborate and precise description. However it does seem to hold true of 1 of the 2 items he missed. Thus there may well be a link between items that the subject had difficulty describing and the items he missed. An additional important observation from this patient's data is that in the single case where the verbal code was generated by the experimenter, retention did not seem to be aided. b) A_2 missed items 1, 6, and 10. The major difference between items 6 and its matched stimulus is not the fact that one of them looks like a hatchet (the verbal code provided by the subject), as both do, but that the shape of the "handle" in each one is different. This cue was provided to the subject, but he does not seem to have used it well. Item 10

is also an item that the subject could not easily give a name to. Thus the observation that performance is dependent on the subject's ability to generate his own code, and the experimenter's code does not help, and seems to hold in his case as well.

There is some overlap between this relationship between Korsakoff patients and controls. Of the 3 items that K_1 had the most difficulty describing, he missed one. The other one he missed is one that he did not describe in any kind of detail, and upon request could not match the words with the picture. Of the 3 items that K_2 had the most trouble describing he missed one. Indeed, one could argue that Korsakoff patients' performance improves in NA simply because they are being forced to attend to the stimuli more closely, that the experimenter's verbal code provision was not an improving variable, and that the items they miss follow the same rule as those missed by normals.

This possibility is reduced when one turns to the qualitative data. The subjects were displaying all the behavioral responses one associates with attending in condition NR, thus it would seem unlikely that performance in NR was due to poor attending, and NA performance was due to forced attendance. In addition: K_1 fed back, on two occasions, the verbal code provided him by the experimenter during stimulus exposure, when asked how he remembered the stimulus. K_2 did this on

two occasions. Thus it is possible that the verbal code was retained.

El-Wakil proposed the hypothesis that the Korsakoff patient has a problem with endogenous generation of verbal codes, and this is responsible for his problem in memory. He came to this hypothesis when he found that Korsakoff patients had high levels of performance when tested for memory for pictures where a) the verbal code had been supplied to them along with the picture, and b) when they did not need to generate a name to remember what they had seen, i.e. memory was tested by recognition rather than recall. Verbal code generation was unnecessary for the Korsakoff patient both during encoding and during retrieval. El-Wakil's experiment did not separate the relative contributions of the two to improved memory. The data from this experiment suggest some elaborations of El-Wakil's hypothesis. It seems that the verbal code required for retrieval, on its own, is not the major source of difficulty. If the information was always present in memory, but not accessible when verbal code generation became necessary, then high scores should have been obtained in condition V where memory was tested by recognition. In NN, the Korsakoff patients' performance was high in spite of the fact that they were supplied with no verbal codes. Either the Korsakoff patient was spontaneously generating his own verbal codes to remember the stimulus (and this would contradict El-Wakil's hyoothesis), or, as is more

likely, he did not need verbal codes to retain pictorial stimuli (this would diminish the significance of high performance of El-Wakil's subjects after verbal codes had been provided). A final observation in relation to El-Wakil's hypothesis is that in NA, when the Korsakoff patient was encouraged to provide his own code, or when he was supplied a code by the experimenter, oerformance did improve. This supports El-Wakil's suggestion that the deficit is related to a loss in verbal code generation during input. However verbal codes were very easily generated during output, and matched those that were generated during stimulus presentation. Thus, while El-Wakil was pointing to a deficit in verbal code generation during both encoding and retrieval, this data suggests a deficit primarily during encoding, i.e. a problem getting the stimulus into memory when verbal codes have to be spontaneously generated, rather than a problem getting it out during testing.

How do these models fit with concepts used in cognitive models of information processing and memory? The concepts of separate encoding systems for verbal and imaginal stimuli is not a new one. Paivio (1976) for example has distinguished between and developed the concepts of the two systems most elaborately. The concept of "chunking", and of encoding along the variable of meaning can be considered a deeper level of processing (see overview of cognitive processes, pp. 4-7) and thus a mechanism that improves memory. Semantic

encoding would be a deeper level of processing in the verbal system, inaccessible to Korsakoff patients. Non-verbal meaning levels, such as can be achieved with pictorial stimuli in condition NN would also be at a deeper level of processing, this time in the imaginal system. What has been referred to as linking words with images could activate both verbal and imaginal systems. Imaginal processing would reach a deeper level, as by verbally linking parts of the meaningless image to other known images of high meaning (e.g. "This looks like a dancer."), different parts of the stimulus would take on non-verbal meaning. This model does not incorporate concepts that are not common in the cognitive literature, nor does it seem to contradict any basic ideas of how memories are formed.

What does this data say about the physiological mechanisms of memory? It has been noted by several experimenters that laboratory animals with lesions in the limbic system do not seem to suffer a major memory loss, though other deficits do exist (see Isaacson, 1974). If the loss in Korsakoff patients is one involving difficulty in using a spontaneous verbal encoding mechanism, it would be reasonable that animals do not show a major memory loss with brain lesions. Carlson (1977) has developed the idea that in humans, the limbic system has evolved to perform functions that it does not perform in animals, namely the consolidation of semantically

encoded information. The data obtained in this experiment would be consistent with such an hypothesis.

Immediate questions and directions suggested by the data that have been presented in this experiment include:

a) Which of the two models described above is more likely? This is a difficult question to investigate. One possible experiment would be based on the following assumption: if the verbal code is directly stored and is responsible for improved memory in condition NA, then a stimulus that has several names will be likely to be given the same name during session 1 and testing. The different names would have all have to describe the stimulus exactly, and be equally familiar in order to eliminate the possibility that it is the stimulus that evokes one name over another, rather than a stored name in memory which is elicited by the recognition task. The problems of designing and carrying out such an experiment are obvious: it is difficult to think of even one stimulus that satisfies the stipulations above.

b) What is the contribution of retrieval difficulty to the memory loss observed in Korsakoff patients. There is no doubt that encoding is defective, as there is a loss even when retrieval is not allowed to be a problem. For verbal stimuli, the relative contribution of retrieval problems to memory loss can be determined by comparing performance during recall to that during recognition. However for non-verbal

stimuli, this separation becomes a problem. The obvious equivalent of recall for non-verbal stimuli would draw on a number of factors other than memory. The subject can be asked to reproduce on paper the stimuli he was shown, but this would draw on his artistic abilities and his fine motor function (the latter is often impaired in Korsakoff patients). Thus confounding variables make the obvious experiment inappropriate.

c) What are the relative contributions of exogenously vs. endogenously generated verbal codes? This experiment was not designed to separate the contribution of the two. It seems from this data that endogenous codes are better for control patients, while the difference between endogenous codes is less for Korsakoff patients. A clear separation would require a 3 x 2 design, with the same 2 groups. The three conditions would consist of NR, one condition where the code would be 100% endogenous (i.e. endogenously generated or non-existent) and one condition where the code would be 100% exogenous (i.e. always provided by the experimenter). If it were found that the exogenous code did not improve control patients' memory over condition NR, while it did aid Korsakoff patients' memory, this would strengthen the model that suggests that Korsakoff and normal patients use verbal codes in different fashions. Although the models suggested do not make an explicit prediction about the relationship

between endogenous and exogenous codes for Korsakoff patients, it would be reasonable to expect that where the Korsakoff patients do generate their own explicit codes, the improvement in memory would be somewhat greater than if the codes were exogenously generated. This prediction would be based on the assumption that the meaning the Korsakoff would give to a stimulus would be more likely to be "meaningful" to him than the meaning given by some other individual. There would be the definite prediction that the control patients' performance would be best in NR, and better in the condition where the code is endogenous than in the condition where it is exogenously generated.

d) This experiment provided data demonstrating that when a word is tied to a picture, memory for an otherwise complex picture improves. Would the relationship hold the other way around? Could memory for words be improved by tying them to pictures? Could a Korsakoff patient remember a word that he imaged, more readily than one he simply saw flashed on the screen? Cermak (1975) attempted imaging as a means of improving memory. He found no significant differences in paired-associate tasks, although there was some improvement upon imaging. As mentioned earlier, paired-associate tasks are more demanding than simple recognition or even recall tasks. Not only does the stimulus have to be generated, the stimulus with which it was paired has to be recognized. Thus the fact

that imaging did not significantly improve performance on a paired-associate task would not rule out its potential improving effect on a simpler task, for example word recognition. An improvement via imaging could be incorporated by the model suggested by this experimenter. On the basis of the model, once the patient imaged the word to be remembered, it would be stored in the imaginal "box". Through repeatedly linking the image with the word there would be input into the verbal "box" via channel c. Now the word would be recognized on the basis of activation of both d and e. Thus the breakdown of a could be easily by-passed, and by imaging to the word, storing the image, linking the stored image to the word, the verbal "box" could be filled, resulting in d and e activation and high levels of performance. Even in less than ideal conditions, if c could not be made functional, simply storage in the imaginal "box" might provide a strong enough trace that the activation of e would be simple and performance would be relatively high. If improvements could be found in Korsakoff subjects' performance via imaging, the possibility of developing this as a therapeutic mechanism would be exciting.

REFERENCES

Brion, S. Korsakoff's syndrome: Clinicoanatomical and physio-pathological considerations. In G. Talland & N. Waugh (Eds.), The pathology of memory. New York: Academic Press, 1969.

Butters, N. & Cermak, L.S. The role of cognitive factors in the memory disorders of alcoholic patients with the Korsakoff syndrome. Annals of the New York Academy of Sciences, 1974, 233, 61-75.

Butters, N., Cermak, L., Jones, B. & Glosser, G. Some analyses of the information processing and sensory capacities of alcoholic Korsakoff patients. In M. Gross (Ed.), Alcoholic intoxication and withdrawal. New York: Plenum Press, 1975.

Butters, N., Lewis, R., Cermak, L., & Goodglass, H. Material specific memory deficits in alcoholic Korsakoff patients. Neuropsychologia, 1973, 11, 291-299.

Carlson, N. Physiology of behavior. Boston: Allyn & Bacon, 1977.

Cermak, L.S. Imagery as an aid to retrieval for Korsakoff patients. Cortex, 1975, 11, 163-169.

Cermak, L.S. & Butters, N. The role of interference and encoding in the short term memory deficits of Korsakoff patients. Neuropsychologia, 1972, 10, 89-95.

Cermak, L.S. & Butters, N. Information processing deficits of alcoholic Korsakoff patients. Quarterly Journal of Studies on Alcohol, 1973, 34, 1110-1132.

Cermak, L.S., Butters, N., & Gerrein, J. The extent of the verbal encoding ability of Korsakoff patients. Neuropsychologia, 1973, 11, 85-94.

Cermak, L.S., Butters, N. & Goodglass, H. The extent of memory loss in Korsakoff patients. Neuropsychologia, 1971, 9, 307-315.

Cermak, L.S., Butters, N. & Moreines, J. Some analyses of the verbal encoding deficit of alcoholic Korsakoff patients. Brain and Language, 1974, 1, 141-150.

Cermak, L.S., Lewis, R., Butters, N. & Goodglass, H. Role of verbal mediation in performance of motor tasks by Korsakoff patients. Perceptual and Motor Skills, 1973, 37, 259-262.

Cermak, L.S. & Uhly, B. Short-term memory in Korsakoff patients. Perceptual and Motor Skills, 1975, 40, 275-281.

Chorover, S.L. & Schiller, P.H. Short-term retrograde amnesia in rats. Journal of Comparative and Physiological Psychology, 1965, 59, 73-78.

Craik, F. & Lockhart, R. Levels of processing: A framework for memory research. Journal of Verbal Learning and Verbal Behavior, 1972, 11, 671-684.

Craik, F. & Watkins, M. The role of rehearsal in short-term memory. Journal of Verbal Behavior and Verbal Learning, 1973, 12, 599-607.

DeLuca, D., Cermak, L.S. & Butters, N. An analysis of Korsakoff patients recall following varying types of distractor activity. Neuropsychologia, 1975, 13, 271-279.

El-Wakil, F. Memory in Korsakoff patients. Unpublished master's thesis, University of Massachusetts, 1975.

Fuld, P. Storage, retention and retrieval in Korsakoff's syndrome. Neuropsychologia, 1976, 14, 225-234.

Isaacson, R.L. The limbic system. New York: Plenum Press, 1974.

James, W. The principles of psychology. New York; Dover Press, 1890.

Jones, B.P., Moskowitz, H.R. & Butters, N. Olfactory discrimination in Korsakoff patients. Neuropsychologia, 1973, 13, 173-179.

Jones, B.P., Moskowitz, H.R., Butters, N. & Glosser, G. Psychophysical scaling of olfactory, visual and auditory stimuli by alcoholic Korsakoff patients. Neuropsychologia, 1975, 13, 387-393.

Krech, D., Crutchfield, R.S. & Livson, N. Elements of Psychology. New York: Alfred A. Knopf, 1974.

Loftus, P. & Loftus, L. Unpublished manuscript, 1976.

Milner, B. Memory disturbance after bilateral hippocampal lesions. In B. Milner & S. Glickman (Eds.), Cognitive processes and the brain. Princeton: Van Nostrand, 1965.

Milner, B. Memory and the temporal regions of the brain. In K.H. Pribram & D.E. Broadbent (Eds.), Biology of memory. New York: Academic Press, 1970.

Norman, D.A. Memory and attention. New York: John Wiley & Sons, 1969.

Noyes, A.P. & Kolb, L.C. Modern clinic psychiatry. Philadelphia: W.B. Saunders & Company, 1958.

Oscar-Berman, M. Hypothesis testing and focusing behavior during concept formation by amnesic Korsakoff patients. Neuropsychologia, 1975, 11, 191-198.

Oscar-Berman, M., Sahakian, B.J. & Wikmark, G. Spatial probability learning by alcoholic Korsakoff patients. Journal of Experimental Psychology, 1976, 2, 215-222.

Paivio, A. Imagery in recall and recognition. In J. Brown (Ed.), Recall and recognition. London: John Wiley &

Sons, 1976.

Paivio, A. Imagery and verbal processes. New York: Holt, Rinehart & Winston, 1971.

Pribram, K. Languages of the brain. New Jersey: Prentice-Hall, 1971.

Samuels, I., Butters, N., Goodglass, H. & Brody, B. A comparison of subcortical and cortical damage on short term visual and auditory memory. Neuropsychologia, 1971, 9, 293-306.

Shiffrin, R.M. & Geisler, W.S. Visual recognition in a theory of information processing. In R.L. Solso (Ed.), Contemporary Issues in Cognitive Psychology. Washington: V.H. Winston & Sons, 1973. (53-102)

Sperling, G. The information available in belief visual presentation. Psychological Monographs, 1960, 74, 498.

Talland, G.A. Deranged memory. New York: Academic Press, 1965.

Tulving, E. & Pearlstone, Z. Availability versus accessibility of information in memory for words. Journal of Verbal Learning and Verbal Behavior, 1966, 5, 381-391.

Victor, M., Adams, R.D. & Collins, G.H. The Weonicke-Korsakoff syndrome. Philadelphia: F.A. Davis, 1971.

Warrington, E. Recognition and recall in amnesia. In J. Brown (Ed.), Recall and recognition. London: John Wiley & Sons, 1976. (217-228)

Warrington, E. & Weiscrantz, L. Amnesic syndrome: Consolidation or retrieval? Nature, 1970, 228, 628-630.

Warrington, E. & Weiscrantz, L. Organizational aspects of memory in amnesic patients. Neuropsychologia, 1971, 9, 67-73.

Waugh, N.C. & Norman, D.A. Primary memory. *Psychological Review*, 1965, *72*, 89-104.

Weiscrantz, L. & Warrington, E. Verbal learning and retention by amnesic patients using partial information. *Psychonomic Science*, 1970, *20*, 210-211.

APPENDIX

T.M. (K_1)

Analysis content for condition NA

1. An arrow form. (E: Where do you see the arrow?) This part here. (E: Anything else it looks like?) (Subject shrugs) (E: See how it has five sides, and is open at the end, and has this pointing part?)

2. uhh...(E: Kind of like an "H" on its side, isn't it? And notice how there is a break here, and the bottom part is kind of fuzzy?)

3. A flower. (E: Yeah, it is kind of. How many petals?) Six. (E: Notice the circle around it?)

4. uhh...Two water horses. (E: I see, this could be their heads?)

5. Railroad track. (E: Or a "T" on its side. See the bar is about halfway down.)

6. Looks like an axe with a bird on it. (E: Is this part the bird? What about this?)

7. A ballet lady with her head upside down. (E: Uh huh, and what's this?) Her arms spread out.

8. A scuba diver's mask. (E: Huh, what makes it look like that?)

9. ...(E: See how it looks kind of like two "L's", but they have the same bottom part?)

10. That's a horse. (E: How come? What part is what?) Its laying on its back.

11. ...(E: What does that look like? Like an "X" maybe with a line running through it?)

12. Could that be a kite? (E: Could be. Show me how.) It looks like a kite, kind of.

T.M. (K_1)

The following are the subject's answers to my question "How did you remember it was that one?"

<u>NR</u>

2. Arms and legs, this one looks like.

3. My brother-in-law has a scuba divers mask, and this looks like it.

4. Looks like sea horses.

5. It curves right.

6. The lounge center has a design like that.

7. Looks like a dancing lady.

10. Upside down it looks like a walking shoe.

11. Two things on top look like antlers.

<u>NA</u>

1. Looks like a horse.

3. Looks like a flower in a circle, or a pinwheel.

4. A sea horse. A pair of them.

5. A railroad track. (E: And the other one doesn't look like a track?) No.

6. I remembred the bird. (E: This part?) Yes.

7. The lines are like a figurine.

8. Looks like a scuba divers mask.

9. The space is shorter (points to the [illegible] distinguishing aspect of the two slides).

10. It has the form of a horse, laying do[illegible]

11. Kind of like a cross (holds up finge[illegible]

A.R. (K_2)

Analysis content for condition NA

1. Don't know what that could be, do you? (E: Well, the dark part is kind of a square with more sides added on, isn't it? And it has this thing coming in here on the right side.)

2. The part on top looks like a bird, flying away. And the other is like a tree stump in the middle, with roots going on the sides.

3. Like a daisy. (E: Yes, and it has a circle around it, doesn't it?)

4. Like two people. (E: This part would be their heads?) Yes, and arms.

5. Don't know what to call that. (E: How about a T on its side Could be a cross, with one side missing.

6. A hatchet with a handle. (E: And this part is the blade?)

7. A bird, isn't it? (E: Sure, could be.)

8. A circle. (E: uh huh, and there is another circle inside, and four lines on the sides, see them?) Yes.

9. Lines. (E: See how it's kind of like an F, lying on its side?)

10. A hatchet. (E: Yes, a part of it could be. Notice how the top is flat?)

11. Doesn't know what I would call this one, do you? (E: How about something like an "X", with a fuzzy line going through it.)

12. A man's head. (E: Can you show mw how it could be that?) Well, there is the mouth down below.

A.R. (K_2)

The following are the subject's answers to my question "How did you remember it was that one?" This question was asked after every correct response in conditions NR and NA. This subject tended to initially answer this question by saying "the shape." When asked "What about the shape made you remember?", he would consistently answer "It is shaped right." Upon being asked "Can you tell me what made you remember it other than it was shaped right?", he would give the following responses:

N.R.

2. The stockings on the feet.
4. I just remembered it.
5. The hat on the head of the one on the right.
6. Its shaped perfect.
7. I just remembered, it's shaped right.
9. Shaped like a question mark.
10. It's a hatchet shaped thing.
11. The wings. The shape of the wings.
12. It's shaped perfect.

N.A.

2. Looks like a treestump, with a bird flying over it.
3. The thing in the middle looks like a flower.
4. That one has a face of a girl.
5. It's a T.
6. Shaped like a hatchet.
7. It has wings, like a bird.
8. I remember the little lines on the side.
9. Like an F, isn't it?
10. Looks like a hatchet.
11. Shaped like a head on both sides.
12. There is a mouth on that one.

P.H. (A_1)

Analysis content for condition NA

1. Pentagon-like figure. A protrusion on the side. The interior is a rectangular shape.

2. This looks like the top of a fir tree. It has two branches coming off the side, and is covered with snow.

3. A six-sided object with a circle inside it. The six petals connect in the middle.

4. This looks like the reflection of an old man, bent over, with his beard trailing on the floor.

5. This is a straight line intersected by a parallel line. On the left side.

6. I don't know how I would describe this one. (E: How about like a hatchet, and this part here would be the handle?) (Slide changes). Like the corner of a square with three protrusions.

7. If the bottom were smaller, this would look more or less like a butterfly.

8. Like a child's ball, seen from the top. A circle on top, and four on all ends.

9. A double L. The bottom line is the same for both.

10. The former of a picture frame. Or a square end.

11. The reflection of an animal with horns, going down a hill.

12. A black space with a knife coming from the top left hand corner, pointing down into a rectangle.

P.H. (A_1)

The following are the subject's answers to my question "How did you remember it was that one?" This question was asked after every correct response in conditions NR and NA.

<u>NR</u>

2. There is a part of the two middle lines which are different. This one has a hook on both, which I remembered.

1. The bottom area is larger.

3. I remembered the outside parts were filled (sole distinguishing aspect of the two pictures.)

4. The specks around the other one are different.

5. Going from up to down, right to left. (sole distinguishing part of picture.)

6. The shape of it.

7. Like a fat bear rug. The other is wider only in parts.

8. They are very different, this one has a flower shape, three petals in the middle.

9. The squiggle wasn't there yesterday. (sole distinguishing part).

10. The direction of this top triangle. (major distinguishing part).

11. This has a straight line.

12. This flat top.

<u>NA</u>

2. Like a fir tree, parts of it.

3. A circle around a flower.

4. This middle part is a reflection with a face and a beard.

5. The line is higher than the other one.

7. Like a butterfly. The other one is more like a bug.
8. This one was easy, because it's like a ball.
9. The line is straighter and the space smaller.
10. The number of protrusions is different.
11. There are two animals coming out of that picture.
12. There are specks around it which are different.

R.M. (A_2)

Analysis content for condition NA

1. Something like a square with a bump.

2. Two lines, and a bar in the middle.

3. Like some kind of flower. (E: uh huh, and notice there are petal-like things in the middle.) Yes.

4. Like a couple of dogs. I can make out their heads and tails.

5. A T, but crooked.

6. An axe, that part. I can't make out the other parts. (E: Maybe the other part could be a handle?) Yes.

7. Like a butterfly, or could be a bat, with wings.

8. Could be a ball.

9. Kind of an F. (E: On its side?) Yes.

10. Gosh. I wouldn't know what to make of this one. (E: Well, see how it looks kind of like a square on top, and it has three hooks going downward) Yeah.

11. Just an inkblot. (E: Kind of like an X isn't it, with a blurred line in the middle?) Oh yeah, I see it.

12. Part of it looks like a diamond, and that part there is like a half moon.

R.M. (A_2)

The following are the subject's responses to my question "How did you remember it was that one?" This question was asked after every correct response in conditions NR and NA.

NR

1. The connections between the middle lines.
2. The dots in the corner.
3. This was easy. I didn't see the other one before.
4. The dots above the picture. I was paying attention to all the lines and things around the picture.
5. Its bigger than the other one.
6. There is a little dot going off to the side on the one I saw.
7. There are dots around it.
8. I know I didn't see the one on the left.
9. I remember there was no line on the one I saw (main distinguishing mark between two pictures).
10. The dots on this side.
11. The things coming up on top. (major distinguishing aspect).

NA

2. The break in the bar. (major distinguishing mark).
3. Looks like a flower.
4. Looks like a pair of animals. And there weren't those spots.
5. A T on the side.
7. I don't remember the lines.
8. There was no picture with small lines, like in that one.

9. It's bigger.

11. I remember the spots around that line.

12. It's shaped like a diamond.