CHAPTER II

REVIEW OF LITERATURE
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A major source of difficulty in defining the memory problems of chronic alcoholics lies in the multidimensionality of memory. Various authors have considered various models of memory. Thus we see a range consisting of dynamic process, viz. encoding, storing and retrieval, a linear model consisting of iconic, short term and long term memory. Apart from this, modality specific memory like tactual, verbal, spatial etc. have also been studied. This has led to a whole gamut of heterogenous research with different components of memory being investigated. Yet the nature and extent of these deficits vary.

The memory deficit in alcoholics has been reflected through psychometric findings, neuropsychological findings and through information processing analysis. Psychometric and neuropsychological findings will be dealt with briefly for understanding the trend. Emphasis will be more in studies involving information processing approach.
The review will be organised along the following lines.

Section I: MEMORY DEFICIT IN ALCOHOLISM

Memory deficit in alcoholics as seen by:

a) Psychometric Tests.
b) Neuropsychological tests.
c) Information processing tests.

Section II. ELECTROPHYSIOLOGY AND ALCOHOLISM

a) Information processing deficit in alcoholics using electrophysiology.

Section III. ELECTROPHYSIOLOGY AND MEMORY

a) P300 and Memory.
b) Dm and Memory.

Section IV: PROCESSING RESOURCES AND ELECTROPHYSIOLOGY.

Section I: Memory Deficit in Alcoholism

Psychometric Studies:

The standard psychometric tests used to assess memory have been Wechsler's Adult Intelligence Scale (WAIS) and Wechsler's Memory Scale (WMS). Immediate Memory was tested by digit span.

WMS failed to demonstrate any persistent or consistent deficit between alcoholics and controls (Butter et al. 1977, Parsons and Prigatano 1977). This is because, though this test is relatively an easy tool to pick up severely amnesic patients, it is not sensitive enough to detect the subtle
memory deficits of detoxified chronic alcoholics. Also, this test does not have the provision for increasing the difficulty level. Virtually, this test has been found to be ineffective in detecting the subtle deficits of chronic, neurologically intact alcoholics.

Wechsler (1941) assessed alcohol related deficit in a systematic, quantifiable manner. Interested in what is now termed as chronic, but neurologically intact alcoholics, i.e., chronic alcoholics with no demonstrable brain damage, he found that there was no evidence of intellectual deterioration, yet demonstrated a curious cluster of deficits from the pattern analysis of subtests. Alcoholics showed deficit in tests of Similarity, Digit symbol, Digit span, Object assembly and Block design i.e., those tasks that reflect reasoning, perceptual organisation and new learning. This type of results have been obtained by other researchers (O'Leary et al 1977, O'Leary et al 1979, Miller and Orr 1980, Loberg 1980).

The most sensitive and discriminating indicator of impairment was found consistently in block design (Holland and Watson 1980, O'Leary et al 1979b). Digit Symbol was found to have the lowest subscale of WAIS profile and highly resistant for reversibility with abstinence (Overall, Hoffman and Levin 1986) followed by Object assembly (O'Leary et al 1977, Loberg 1980). Digit symbol reflects ability for new
learning and object assembly for visual integration and block design reflects abstraction or memory for concepts. Thus again deficits on WAIS reflects deficits in componential processing of memory.

A few other tests used are Bender Visual Retention Test (BVRT), Design Memory Test (Brandt et al 1983, Berglund et al 1977 and Guthrie 1980) and Kendall Memory Test (Guthrie 1980). These tests are considered as screening devices which do not give a consistent picture (Golden 1980).

Digit span as a subtest has been used to assess two types of memory store i.e., immediate memory and short-term memory (Watkins 1977). The two memory stores are not identical as per the storage model of memory (Baddeley 1976). Hence the deficits elicited by the digit span test has been identified as a deficit in memory span in a broader sense.

Thus single test do not adequately describe the memory deficit. The tests that have been used lack the sensitivity and specificity to tap the nature of memory deficit in chronic alcoholics. Either tests like WMS which measure only severe amnestic disorder like korsakoff amnestic disorder have been used, or diagnostic measures like WAIS were used. These tests have a low resolution to evaluate clinically valid parameters of memory such as autobiographical memory, procedural memory, semantic memory and episodic memory. Again encoding, storage and retrieval aspects of memory are not evaluated by these tests.
Another difficulty with psychometric tests lies in isolating the basic component processes impaired by alcoholism. Since most standardised tests involve more processes than what their face construct implies, it becomes difficult to tease apart the process impaired. Unfortunately, most studies used only single test, which at best demonstrate a low score representing an impairment in one of various possible functions. Standard psychometric tests, in reality are quite complex needing many cognitive processes for successful completion. The specificity of the test therefore is restricted to whatever cognitive processes the person used in the test. Therefore interpretation of deficit obtained from single test becomes difficult to be compartmentalised into different memory parameters. Psychometric tests therefore reflected only gross measure.

Neuropsychological Tests:

Neuropsychological batteries have been used on alcoholics. Wilkinson and Carlen (1980) reported that 50% of alcoholic cases found to be normal by neurologists showed significant characteristic impairment when evaluated with neuropsychological batteries, suggesting that they provide a sensitive index of earlier cognitive deterioration. These tests have been accepted to be sensitive to detect brain dysfunction. By inference, the alcoholic patient with deficits on neuropsychological tests have been labelled as brain damaged.
When groups of detoxified, neurologically intact alcoholics are tested with either the Halstead-Reitan Neuropsychological Battery (HRNB) and Luria Nebraska Neuropsychological battery (LNNB), a distinctive pattern of mild cognitive dysfunction appears (Chmielewski and Golden 1980; Goldstein & Shelly 1971). The most commonly obtained deficits have been in certain subtests such as HRNB category test, tactual performance test (TPT), Trail making test and Visual learning and memory test. All these tests show a modality specific memory deficit viz. Visuospatial memory, apart from showing a lateralised right hemispheric deficit.

A trend of memory deficit in the visuospatial modality is seen as the chief memory deficit in neuropsychological studies. This could be due to the higher task demand inherent in visuospatial task rather than modality effect. This can be inferred from studies done in verbal modality such as learning of synonyms (Sharp et al 1977), learning of long word lists without mnemonics (Ryan 1980) or dissimilar paired associate learning (Ryan and Butters 1980, Ellenberg, et al 1980) which demonstrated deficits when difficulty was stepped up. Hence the visual memory deficit can also be attributed to increased level of task demand inherent to visuospatial tests.

The sensitivity of a test in discriminating alcoholics from nonalcoholics (Parson and Leber 1981) and in
discriminating young from old alcoholics (Brandt et al. 1983) lies in the difficulty level of the test.

Information Processing Studies:

The third approach that was used to study memory deficit in neurologically intact chronic alcoholics was information processing approach.

Brandt et al. (1983) attempted to study the reversibility of memory and visuospatial deficits in both young and old chronic alcoholics after short term abstinence (1 to 2 months sobriety), long term abstinence (1 to 3 years) and prolonged abstinence (atleast 5 years). The subjects were tested using Brown-Peterson's Distractor Paradigm, Digit symbol substitution Test, BVRT, Nonverbal and Short term memory and embedded figures. Results showed that there was significant difference between alcoholics and related controls, as well as between young and old alcoholics. Alcoholics who were old performed the worst. There was no significant interaction between group and age. Reversibility of deficits compared between short term abstinence and prolonged abstinence showed that there was significant difference between the two periods with prolonged abstinence group comparable to normals on verbal memory, short term memory and BVRT. Deficits persisted in the prolonged abstinent group in tests like Symbol Digit Substitution Test and Embedded Figures Test. This showed that visuospatial learning was intractible for
recovery even after five years of abstinence. Visuospatial memory was impaired during short term abstinence.

Weingartner and Faillace (1971) administered free recall and serial learning tests to detoxified alcoholics and matched controls. Results showed that recently detoxified alcoholics learnt significantly fewer words than controls but those after 3 weeks of detoxification performed as well as controls, thereby showing that the memory impairment in alcoholics are transient and are a function of acute post alcoholic syndrome which remits after 2-3 weeks spontaneously. Jonsson et al (1962) also showed that memory deficits are not longlasting in alcoholics.

Parson and Prigatano (1977) in their study administered the learning test of LNNB to abstinent alcoholics. Patients were rated as 'moderately impaired' 'severly impaired' or 'not impaired' on Halstead impairment index. Results showed that the three groups did not differ from each other on learning tests. They concluded that even in alcoholics who show neuropsychological deficit, the memory deficit if present at all, was very subtle. Similar findings were obtained by Butters et al (1977) in their study with detoxified alcoholics in whom there were no evidence of verbal learning and short-term memory deficits.
Similarly Becker, et al (1983) studied memory under sets of divided attention in a group of alcoholics and matched controls. The subjects had to identify the first set of the pair, that was presented in study trial, but not in test trial, which can range from, digit to word to face. Results showed that missing face set was significantly difficult for alcoholics of all ages, whereas missing digit was affected in alcoholics over 50 to 60 years. Words were affected only by age and not by alcohol, thereby showing that visuospatial memory was specifically vulnerable in alcoholics. Further research, therefore was done in area of visuospatial memory to segment alcohol effect from age effect Riege (1987) in his study constructed tests with increasing difficulty level in visuospatial domain (Form I and Form II) and administered it to young and old alcoholics and matched normals. Results showed that alcoholics at both age levels were poorer than the age matched controls, thereby showing the neurotoxic effect of alcohol on memory. They showed that visuospatial coding was not faulty in alcoholics due to good performance in Form I, and that the deficit was due to difficulty in increasing the required effort to task demand (Form II).

In summary, the results obtained from information processing tests show that detoxified alcoholics do not suffer from a statistically significant memory deficit. If present, it was transient and predominant in visuospatial
domain. But the study of Reige (1987) showed that this also was not true. Instead the study again showed that the difficulty with chronic alcoholics was to put in increased effort to match the increased task demand of visuospatial tasks.

The three approaches of assessing memory deficit i.e., Psychometric, Neuropsychological and Information processing approaches point to the following:

1) Memory deficits from alcoholism seem relatively mild.
2) They are diffuse and not clearly specific to material or modality.
3) They are apparent in tasks that require effort from the alcoholic.
4) Modality specificity or specificity of deficits in memory for non verbal or visual pattern is an artifact of the task demand rather than due to the effect of modality per se.
5) Age-related deficits are different from that of alcohol-related deficits.

The above findings show that there has been a lack of clarity in the direction of research. This is due to lack of integration of approaches and testing procedures.

Researchers have mostly used tests that might be comparable in procedure but differing in component of
processing. A procedure becomes acceptable, if the myriad of memory processing is both compartmentalised and sequentialised with each segment vulnerable for measurement. Thus in the discussion of memory deficit it becomes important not only to know which tests demonstrated the impairment but also to recognise to what influence each test is sensitive and what functions it has sampled.

Standard tests of memory in reality are quite complex needing many cognitive processes for completion. The psychometric tests and neuropsychological batteries do not offer the flexibility to measure the memory deficits along the continuum in which the deficits are expressed. This level of flexibility to vary the range of task demands with regard to processing as well as to measure memory deficits throughout the continuum, thereby providing scope for fine grain componential analysis, can be achieved, to a very great extent by information processing experiments.

The earlier phase of research did not show a stable pattern of memory deficit. This is because they were not explicitly designed to detect the relatively subtle changes in amnestic processes one might expect to find in chronic alcoholics.

The later part of the research was based on logic obtained by integration of the various approaches. Since information processing approaches offered the maximum
flexibility both with regard to varying the range of processing as well as to measure the level of deficit along a continuum, this approach became the choice for later logic based approaches done in this area for systematic investigation of memory.

Thus, cognizant of Fritsch and Hitzigs (1870) dictum that "the method creates the result" there has been a change in the method of measuring memory deficits in detoxified alcoholics.

To assess the possibility that the simplicity of the tests had been masking the memory deficits of neurologically intact alcoholics, Ryan et al (1980) have done a series of studies based on information processing approaches. They attempted to increase test sensitivity by increasing the difficulty of several learning and memory tests. Hence they redesigned the short term memory and paired-associate learning tests which delineated the severe memory disorder of Korsakoff patients to be sufficiently demanding enough to identify memory deficits in neurologically intact chronic alcoholics.

Multitrial paired associate learning was constructed for verbal-verbal and Digit-symbol pairs. In verbal-verbal pairs a list of 10 unrelated pairs (e.g., neck/salt) were presented in test trials following which the subject was presented with
the first word pair as a retrieval cue for the second word in the pair. Eight such study/test trials were administered. Similarly the symbol digit test requires subjects to learn a list of seven unfamiliar symbols each paired with a one-digit number. Learning ability was plotted over 4 test trials. The STM test assessed the ability of the subject to retain four unrelated words for 15 to 30 seconds, with distractor interpersed to prevent rehearsal.

This new and difficult test battery was administered to three groups of subjects i.e., 18 long term alcoholics (Mean age = 54 years) with a mean of 10 years of drinking and detoxified for 4 weeks, 18 nonalcoholic controls (Mean age = 54.3 years) and 7 Korsakoff patients (Mean age = 54.2 years). To ensure that they were neurologically intact and that the deficits which will be obtained be pure, very stringent exclusion and inclusion criteria were followed. The studies were conducted in steps.

1) Do alcoholics have memory deficit:

The results showed that despite stringent selection criteria, long-term alcoholics were significantly deficient in learning and memory than controls. The performance of detoxified alcoholics fell midway between controls and Korsakoff's in all tasks, thus showing a continent of impairment. This was done by Ryan, Butters, Montogomery, Adinolfi and Didario (1980).
2) Relationship between age and alcohol (Ryan and Butters 1980a)

The second step was extended to determine whether learning and memory deficits would be limited to older alcoholics (Klisz and Parsons 1977, Jones and Parson 1971) or whether they would appear in chronic alcoholics regardless of age. The same remodified tests were used but this time on a group of younger (Mean age = 42.3 years) and older (Mean age 54.2 years) alcoholics matched for years of drinking and to comparable controls. Along with controls a group of elderly (60-65 years) old nonalcoholics were tested. Results show that both younger and older alcoholics were impaired in memory. The severity of this deficit was affected by subject's history of alcoholism and not by age. On the whole in both groups, younger subjects performed better than older in subjects. There was relationship between age and alcoholism variables such that the continuum was as follows:

Young controls < young alcoholics = old control < old alcoholics = oldest controls (60-65) group) thereby showing the independent effect of alcoholism on memory and the additive effect of age.

A similar line of systematic study was conducted in phases by Riege and his co-workers (1976,77,81,84). Measures of memory accuracy were tabulated for each 5 recognition
tests across different modalities (Visual, Auditory and Tactual, Words and Famous Faces). In their study, age accounted significantly for differences. The factor scores from the five factors indicated that age and alcoholism had different effects. Discriminant analysis classified persons according to age and alcoholism. Factors such as Visuoconstructive, Visual recognition and decision criteria separated groups on age, but did not clearly distinguish alcoholics and non alcoholics. Auditory tests, separated the alcoholics from controls. The results of the study emphasize that specific deficits related to memory for complex pattern on auditory items accompany alcoholism and can be separated from age-related impairments. Likewise earlier studies (Earnest et al 1979) show that primary (short-term) memory seems to be unaffected by age, whereas alcoholism exerts influence on tasks of memory span and short-term retention of new information.

Is there distinct levels of memory Impairment?

Ryan and Butters (1980b) examined the possibility that within any sample of neurologically intact alcoholics there exists several distinct levels of intellectual impairment. Detoxified alcoholics were divided into two groups based on the presence or absence of subjective memory complaints and compared to matched controls. Tests used by Ryan et al (1980a) were administered. The results showed that deficits
were not limited to subjects with memory complaints though patients with subjective complaints of memory deficit had a greater impairment on these tests. However WMS and BVRT scores were normal. This data confirm the findings of Ryan and Butters (1980a) that the chronic alcoholic manifests subclinical memory and learning deficits which appear only when tests that require increasing the information processing demands are used.

Ryan (1980) attempted to study the mechanism underlying these memory deficit. They examined the encoding strategy of alcoholics. For this a mental elaboration test (Rohwer 1970) was administered. All these alcoholics were detoxified for one month and their drinking duration was 15 years. Subjects were assigned to either a "No Explicit Mnemonic Condition" wherein a list of 24 pairs of nouns were given for learning or an "Explicit Mnemonic condition" where the same noun was embedded in a sentence and were instructed "to let the sentence help them to remember the two words. It was hypothesised that no explicit condition provides a uniform encoding strategy, whereas explicit mnemonic condition permits the subject to use idiosyncratic strategy. Hence encoding becomes variable.

Results showed that alcoholics did not differ significantly from normals on 'Explicit Mnemonic condition', but in the 'No Explicit Mnemonic condition' alcoholics took
twice as many study trials as controls to reach the criterion. This was interpreted to indicate an encoding deficit.

Interview with the two groups to analyse the processing strategy showed, that controls invariably took an active part to remember and would begin to generate visual or verbal mediators on the first study trial itself. In contrast, alcoholics given the same task initially tended to repeat the noun pairs or to focus on the structural characteristics of the words. When instructed to remember an unrelated noun pair the alcoholic failed to use any strategy reliably, thereby showing the shallow strategy of encoding. Cermak and Butters (1973) also found that Korsakoff's could encode information only at a shallow/phonetic level and were incapable of encoding at a deeper/semantic level.

The study of Ryans et al (1980) demonstrates that though chronic alcoholics have difficulty in encoding, they were not completely incapable. In the explicit mnemonic conditions, they equalled the controls. The critical difference between alcoholics and controls appeared to be in the latency with which alcoholics began using truly effective mnemonics. Initially alcoholics tended to use primitive encoding strategies which required little mental effort, but finally used elaborative rehearsal techniques. Controls, on the other hand, used elaborative rehearsal right from the beginning.
This was true for Digit symbol paired associate learning also. Controls transformed each symbol into some meaningful representation ('Looks like an inverted house' etc.) and thus learned the list quickly, whereas alcoholics focussed more concretely on structural aspect of the symbol and hence learnt slowly. This latter strategy in particularly inadequate because it does not permit subjects to differentiate uniquely one stimulus clearly from another, which leads to proactive interference.

Thus, results of the later studies showed that memory deficits in alcoholics are:

1) Relatively subtle, diffuse and not specific to material or modality.

2) They are apparent in tasks that require effortful processing.

3) Encoding process is deficient in alcoholics.

Research pertaining to the process paradigms being used in the present study are limited.

1) Encoding Paradigm:

Though encoding has been implicated in the study of Ryan et al (1980) the classical levels of processing approach of Craik and Lockhart' (1972) to study encoding has not been used on chronic alcoholics. This approach, on the other hand has been used extensively with Korsakoff amnesics. Korsakoff patients were deficient in semantic encoding (Cermak and
Butter, 1973, Cermak 1979, Cermak and Reale 1978). These studies provide only an indirect evidence and cannot be extrapolated to chronic alcoholics, as there are basic differences between the memory deficits seen in Korsakoff patients and alcoholics. They are:

First, the impairments reflected in anterograde and retrograde amnesia of Korsakoff patients are often pervasive, disproportionately more severe and not restricted to a modality (Butters 1985). Second, the length and rate of alcohol abuse do not seem to determine the severity of the memory impairment in Korsakoff patients, thirdly, whereas alcoholic deficits may develop over many years of heavy drinking, the Korsakoff Syndrome may become florid only in connection with a deficiency in thiamine (Blass and Gibson 1977). Fourthly, the information processing abilities of Korsakoff patients seem particularly vulnerable to interference (Butters 1985, Cermak and Butters 1972) and memory for contextual information (Poulos and Wilkinson, 1984) whereas alcoholics show memory deficits mainly on tasks requiring difficult strategies of encoding (Ryan et al 1980a, 1980b).

2) Storage Paradigm:

Majority of studies, using the storage model have been conducted on acutely intoxicated alcoholics (Rosen and Lee, 1976) normals (Birnbaum and Parker 1977). Storage have also
been studied with regard to state dependent learning (Ryback 1971). Results indicate a disruption of short term memory along a continuum. Normals under intoxication have least deficits in short term memory, followed by social drinkers. Alcoholics have the most severe deficit. Ryback (1971) proposed the 'continuity hypothesis' based on this observation and concluded that the locus of deficit was short term memory (STM). STM was assessed using four unrelated words by Ryan et al (1980) in a group of neurologically intact alcoholics and was found to be poor. But a systematic study of storage process in STM and LTM has not been investigated with this group.

Subjective Organisation:

Studies have shown that alcohol alters the organization required for memory. This has been tested out in intoxicated states of both normals and alcoholics.

Parker and her colleagues (1974) further documented information - processing deficit in their study with 12 hospitalized alcoholics and matched controls using free recall memory and digit span on three different occasion (High dose, moderate dose and placebo dose). All the alcoholics were detoxified and abstinent for three weeks. Multi trial Free Recall test was administered wherein 30 words, composed of 6 words from each of five conceptual categories was administered. Four such study / test trials
were administered in three different alcohol level sessions, with words randomised. The responses were measured in terms of number correct and the degree of category and clustering strategy. Results showed that alcoholics and normals were matched in registration of information. There was decrement in the amount of information registered, number recalled and in the degree of category clustering with the increase in the level of intoxication. However, under all experimental conditions, the alcoholics displayed significantly less clustering than controls, thereby showing deficit in subjective organisation.

Rosen and Lee's (1976) study also document the deleterious effect of alcohol on information-processing strategies in alcoholics and social drinkers. Multi trial list learning task along with category clustering measure was administered to three groups of subjects (8 alcoholics, 8 controls and 8 social drinkers) matched for age, education and Shipley Hartford conceptual quotient scores during sober and intoxicated state. The investigators found that subjects recalled fewer words when intoxicated, with responses being poorly organised in the inebriated state. This finding reinforces the view that the typical intoxicated subject was not using semantically based associative mnemonics in any systematic way. This process in a group who has been detoxified from the effect of alcohol needs to be studied.
Division of Processing Resources

Division of processing resources has been found to be important for the processing of multiple information. This ability has been found to play an important role in memory. Division of processing resources has been studied in clinical conditions like Head injury (Mishra 1989).

Processing resources has not been tested in chronic alcoholics.

Predictors of Improvement:

A number of clinical parameters affect performance of memory tasks. The most important parameters are age (Brandt et al 1983, Riege and Inman 1981, Goldstein and Shelly 1971 and 1982), length of abstinence (Grant, Adams and Reed 1980, Ellenberg et al 1980) and family history of alcoholism (Goodwin 1977, Cadoret et al., 1980).

Most often age has been found to be the single factor that has contributed the difference (Riege et al 1981), followed by length of abstinence. Prolonged abstinence foster better cognitive functioning (> 3 weeks) than short term abstinence (< 1 week). Performance deficits were seen on tests that require multiple step coding in memory, such as the delayed recall of story, HRNB Trailmaking B test and Category test for high risk men i.e., those with a family history of alcoholism (Goodwin et al., 1977). Although it is
not discernible from the tests what function are vulnerable to genetic aspects of alcoholism, prealcoholism lowering of cognitive functions to an extent was due to familial disposition and later alcohol abuse is hypothesized to be additive (Riege 1984).

Section II. Electrophysiology and Alcholism

There is increasing evidence that the ingestion of alcohol results in CNS functional changes. Recording brain electrical activity provides a sensitive measure of alcohol related effects namely, alcoholization, tolerance, withdrawal and long term brain dysfunction. Since the area of the present study is with chronic alcoholics, the review will deal with information processing deficits as reflected by event related potentials (ERP'S) in long term abstinent (>3 weeks) alcoholics.

ERP Deficits in long term alcoholics:

In contrast to the hyperexcitability where there is an increase in ERP amplitude (Begleiter and Porjesz 1977, Coger, Dymond and Serafetinides 1977) that may be apparent upto 3 weeks post withdrawal, studies examining electrophysiological disturbance in alcoholics abstinent for longer periods of time (> 3 weeks) demonstrate CNS hypoexcitability i.e., decreased ERP amplitudes (Porjesz and Begleiter 1985).
Porjesz and Begleiter's (1981c) study in which chronic alcoholics were asked to count double flashes interpersed in a sequence of clicks or flashes showed that alcoholics regardless of the task relevance maintained low amplitudes for $N_2$ in both relevant and irrelevant modality. The findings were interpreted as lack of 'sensory filtering' in chronic alcoholics to differentiate between relevant and irrelevant channels. $N_2$ & $P_1$ have been found to reflect attentional processes (Patterson et al. 1988).

In another study Porjesz and Begleiter and Garozzo (1980) measured the information processing deficit in alcoholics using $P_{300}$ in the target selection visual ERP paradigm. The alcoholics had to differentiate between relevant and irrelevant events as well as they had to match stimuli according to their frequency of occurrence. Recording was done to target, non targets and novel stimuli. The stimuli were geometric figures. Results showed that $N_1 - P_2$ was depressed in alcoholics to all stimuli (target, nontarget and novel) to levels comparable to an irrelevant stimulus hypothesis.

Furthermore, $P_{300}$ amplitude was absent or depressed in alcoholic patients to rare stimuli targets in conditions optimal for recording $P_{300}$. This finding was found in Parietal areas where $P_{300}$ is maximal (Mukundan 1989, Salamy, Wright and Faillace, 1980, Porjesz and Begleiter 1975, 1982b
and 1983). Alcoholics manifested low amplitude $P_3$ components (amplitude and Latency) to both targets and non targets unlike normals who manifested differentially enhanced amplitude in $P_3$ components to target stimuli.

Thus again in another ERP component, alcoholics showed that their major aberration was their lack of differentiation between relevant and irrelevant stimulus and low ERP voltages. This again showed that the underlying brain dysfunction was impaired sensory filtering. This type of result of depressed $N_1$ and $P_2$ along with lack of differentiation between relevant and irrelevant modality has been observed for both auditory (Salamy, Wright, Faillace 1980) and Visual stimuli (Porjesz, Begleiter and Garazzo 1980) Ludwig, Cain and Wilker 1977; Schenkenberg, Dustman and Beck 1972; Dustman et al, 1979 and Salaney, Wright Faillace 1980).

Pfefferbaum et al's (1979) study on chronic alcoholics were at variance with Porjesz and Begleiters (1981) study. Pfefferbaum et al used auditory target selection task on a group of chronic (13 week) abstinent alcoholics and matched controls. They found that chronic alcoholics did not differ significantly from controls on $N_1 - P_3$ amplitude and latency except in $P_3$ latency for rare stimuli. Behavioural measures like RT, number and type of errors committed also did not differentiate the alcoholics from controls.
Many factors could account for this contradictory result. Porjesz and Begleiter's lab has consistently shown decreased $N_1 - P_2$ and $P_3$ amplitude with chronic alcoholics, whereas Pfefferbaum et al's (1979) finds no decrement. This could be due to the difference in patient population tested in the two different laboratories Porjesz et al's (1980) patients were more deteriorated in neuropsychological function (60% of patients impaired in Digit symbol, 40% in trialmaking) whereas Pfefferbaum et al's (1979) patients were within the normal range of HRNB score. Further Porjesz et al's patients were unemployed, recurrent alcoholics with no occupational or social stability whereas Pfefferbaum's were socially intact and younger than Porjesz et al's (1981c) sample. In addition there were also differences in measurement technique and experimental design. Pfefferbaum et al (1979) used Woody's filter to correct latency jitter, whereas Porjesz's et al (1981) used it only afterwards. Latency corrected averages of Porjesz et al (1981) showed that decrement in amplitude was due to decrement in voltage in single trials, rather than latency variability. Pfefferbaum's et al's (1979) design insisted on speed whereas Porjesz et al insisted an accuracy. Earlier studies by Murdock (1976) has already shown speed vs accuracy strategies brings variability in $P_{300}$. The task difficulty varied i.e., the task was a visual target selection paradigm using geometric shapes used by Porjesz et al (1977). An auditory
Tone discrimination target selection procedure was used by Pfefferbaum et al. (1979).

Porjesz and Begleiter (1981c) studied $N_2$ or $N_{200}$ component of ERP in abstinent alcoholics. $N_2$ component is a modality specific negative deflection with maximal amplitude over the occipitoparietal scalp for the visual modality and over central regions for the auditory modality. The latency of $N_2$ reflects stimulus evaluation (Renault and Leserve 1977). It is a better index than RT which is cumulative of stimulus evaluation, response selection, response organisation and overt response. It has also been found to reflect mismatch in processing (Naatanen 1982). Though RT has been reported to be delayed in chronic alcoholics (Talland 1963), yet that aspect of information processing which is delayed and is reflected as delayed RT has not been localised.

The speed of stimulus evaluation was examined using $N_2$, $P_3$ and RT in abstinent alcoholics. The test was an RT study involving easy and difficult line orientation (Porjesz and Begleiter 1985). ERP's were obtained to frequent nontargets (vertical line) and infrequent targets which were easy ($90^\circ$ deviant from vertical) and difficult ($3^\circ$ deviant from vertical) line orientations.
Results showed that $N_2$ reflected difficulty of discrimination as its latency increased with task difficulty even for normals. In contrast, alcoholics showed no such difference. $N_2$ latency, on the whole was delayed in alcoholics compared to normals. This suggested that alcoholics found even easy discrimination difficult. In addition, alcoholics manifested delayed $P_3$ latency even for easy discrimination, the delay reaching the extent of normals latency for difficult task indicating that they find all tasks difficult. The response is undifferentiated and independent of task requirement.

Amplitudes of $N_2$ of alcoholics though significantly reduced than normals, were not significantly different between the easy and difficult tasks unlike normals in whom $N_2$ amplitude was increased with stimulus deviance. RT was not significantly different for the two groups although alcoholics tended to respond faster, with more errors in terms of false alarms and missing targets. This suggests that alcoholics employ different response strategy where they trade accuracy for speed.

$P_3$ amplitudes again showed lowered amplitude compared to normals. This was evident even in easy tasks ($90^\circ$ target). Furthermore when normals manifested significantly different $P_3$ amplitude to target/non target, alcoholics did not make that differentiation in their $P_3$ amplitude. This indicates
that alcoholics have difficulty in evaluating the potential significance of a stimulus. These results indicate that the template for making match/mismatch decision is either lost or is not readily available to alcoholics. In either case the study indicates, a memory deficit, such that each incoming stimulus must be evaluated anew. The data suggests that alcoholics manifest two types of brain dysfunction i.e., a delay in $N_2$ latency, which suggests that the template for comparison is not readily accessible, and a low $P_3$ voltage, which suggests that once retrieved, the match/mismatch processes are themselves impaired. 'Context Updating' takes place for both target and nontarget newly at each time leading to decrease $P_3$ amplitude for targets. (Porjesz and Begleiter 1985).

Begleiter and Porjesz and Tenner (1980) determined the relationship between electrophysiological deficits and widened cortical sulci observed in chronic alcoholics. One month abstinent alcoholics were subjected for both CT and ERP ($P_{300}$) on the same day on the basis of presence or absence of cortical atrophy on CT. The patient group were divided into two groups i.e., those with and without cortical atrophy. The groups were matched for age and education. Results showed that $P_{300}$ decrement or absence was related to cortical atrophy which suggest that shrinkage or cortical changes may be responsible for $P_{300}$'s decrement in alcoholics. But both
Positive CT and Negative CT groups had decreased $P_{300}$ amplitude to both targets/non targets, which shows cortical shrinkage alone cannot explain these changes. Animal studies show that alcohol intake results not only in changes within neocortex, but also in other brain areas especially hippocampus (Halgren et al 1980). Often the neocortical deficits are easily assessed and subcortical aberrations are overlooked. A correlative study of widened sulci with hippocampal deficit might throw more light into this deficit.

Section III Electrophysiology and Memory:

ERP studies on memory are being recently undertaken in the field of cognitive psychophysiology. These studies are done using only normals subjects. Studies which comes under this can be summarised along these lines.

1) Sternberg Paradigm
2) Working memory model
3) Encoding

ERP studies with Sternberg Paradigm:

Since early 1970's several cognitive ERP researches have conducted experiments with the purpose of finding out more about memory. All these investigations were carried out within the context of a particular theoretical view of memory process under study. In most cases, both the hypothetical models of memory being tested and the experimental paradigms used in the testing were borrowed from the domain of
experimental psychology. Memory search process in STM has been studied using ERP indices combined with Sternberg paradigm (1969b). Sternberg has shown that by manipulating the number of items in the memory set and measuring the response latency i.e., Reaction time (RT), it was possible to estimate the speed of the search process of memory. ERP research in combination with RT measures have used this model for finding out about memory. Specifically, it has been proposed that P₃ component, can be used to estimate the timing and duration of component process that underlie reaction time.

The P₃ is a wave of positive polarity at the scalp with maximum amplitudes at midline centroparietal location. Although the original discovery of P₃ showed a positive peak with a mean latency around 300 msecs, post stimulus onset, it has been found that P₃ peaks may vary in latency between 300 to 1000 ms with higher latency as a function of task complexity (Kutas and Donchin 1978).

Mulder's et al., (1984) modified the estimates of this Sternberg Paradigm. According to them

1. The slope of the P₃ latency-memory set size function provides an estimate of serial comparison time.
2. The intercept of the P₃₀₀ latency function gives an estimate of stimulus encoding time.
3. The interval between the P300 peak and RT is a measure of the relative timing of response-related processes.

4. The slope of P300 minus RT function is an estimate of the binary decision time.

5. The intercept of the P300 minus RT function reflects the time taken to translate and organise the response.

In conclusion, it appears that a combination of ERP and RT measures provide greater precision than either measure alone in this paradigm.

At best this paradigm has been used to delineate the age related changes in memory (Pfefferbaum et al 1980 and Wickens et al 1987).

ERP'S AND WORKING MEMORY:

Donchin's (1981) proposition that 'the P300 is intimately involved with the process of memory modification' has set the ball rolling in this direction. The most important clue for this comes from experiments where stimulus that elicited larger P3 amplitude was remembered better at the later time. Studies along these lines are:

Karis et al., (1981) made the first attempt to test the relation between P3 amplitude and memory. In an incidental and intentional paradigm, normals were presented with lists of words of which half were dim and the other half were brighter in intensity. This was followed by a recall and
recognition paradigm. Results, suggested that both recalled and recognition words were associated with larger $P_{300}$ on initial presentation than words that were not recalled.

Karis, Fabiani and Donchin (1984) elicited ERP's in a free recall paradigm with certain words isolated in size (i.e., Von Restroff) which makes them novel items. Results again showed that all subjects produced large $P_3$'s to infrequent occurrence of a word typed in smaller or larger size than the other words. Principle component analysis revealed that recalled words had larger $P_{300}$ amplitude on initial presentation with the sequence as follows: Subjects who used rote strategies produced large $P_{300}$ amplitude for words recalled and word isolates. Subjects who used complex mnemonic strategies remembered high percentage of words but did not have $P_{300}$ which could predict later recall, although a broad positive 'slow wave' component with a frontal distribution occurred. Recognition paradigm again showed the same trend of result. Failure to elicit predictive $P_{300}$ in subjects using elaborative strategy could be because, the strategies used would have continued long after the time period reflected by $P_{300}$.

This proposed interaction between $P_{300}$ amplitude, memory and strategy was examined in subsequent studies. Fabiani, Karis and Donchin (1986) evaluated this on a group of 18-31 years old normals from midline electrodes. In order to
equalise rehearsal strategy, the subjects were presented with 'odd ball' name task of male/female with instruction to count male or female names. Recall of names was asked unexpectedly at the end of the task which the authors assumed would curtail elaborative processing automatically. The results showed that there was relationship between P3 and subsequent recall. Though only 16% of the names were recalled, the results indicated some memory related difference. In ERP's elicited by frequent category the memory effect was seen in a range from 400-1100 msecs whereas for rare category the effect was in the range of 800-1100 msecs. The authors discredited these effects stating that this could be due to latency variability. After adjusting for latency jitter, ERP's still showed memory effect i.e., increased positivity at P3 peaks for recalled names compared for non-recalled names. Rare names were characterised by later memory effect. The authors speculated this to be a second P3 which occurs after categorisation. It occurs when the subject relates the stimuli to a known association, thereby increasing the probability to recall. This was again supported by the presence of second P3's only in grand averages of recalled names. This becomes inconsistent with Karis et al (1984) study where elaboration abolished P300. This could be due to limited time window used for P300 in Karis et al's study. Although Fabiani et al (1990) concluded that this data showed evidence for a strong relationship between P300 amplitude and
subsequent recall, they did not provide compelling evidence that it was indeed the P₃ and only the P₃, rather than temporally overlapping process that varied with memory. In next study, Fabiani, Karis and Donchin (1990), directly manipulated subjects' rehearsal strategies by means of Von Restroff paradigm. Rote memory required subjects to repeat words whereas elaboration urged subjects to combine words into images, sentences or stories. Free recall was assessed. Results confirmed with Karis et al (1984) study, i.e., in different rehearsal strategies were associated with different patterns of recall. Overall recall was better for elaborate than rote strategies. Relationship between P₃ amplitude and subsequent recall was more pronounced under rote than elaborate instructions, whereas the relation between later ERP effect and recall was present only under elaborate strategies. Memory ERP effects appeared to be influenced by latency adjustment procedure.

Thus, there does seem to be some relation between working memory and P₃₀₀ that is altered by the nature of rehearsal strategies. Donchin and Coles (1988) hypothesis of "Context Updating" by which he argued that events to be remembered required a restructuring of mental representation i.e., the process of 'Context Updating' reflected in P₃ elicitation enhanced memorability. He argued that context updating is essential to maintain working memory, the temporary storage of information processing.
Although it is not clear that the observed ERP effect can be attributed to modulation of $P_{300}$ component, these data suggest that there is yet a lot of work to be done in this area to get clarity and direction.

**ERP Indexes of Encoding**

Converging evidence for a possible relationship between formation of memory traces and variation in the amplitude of ERP has come from other quarters. Several ERP researchers have attempted to see whether any part of ERP can be a metric of encoding operation. Experiments from this point of view were conducted within the levels of processing framework because it has been one of the influential encoding based theories (Craik and Lockhart 1972; Craik and Tulving 1975).

The studies in this area has been done by Paller's group, though few others have also contributed to this.

Sanquist et al (1980) were the first to conduct studies based on levels of processing approach. The tasks, necessitated yes/no judgements about two pairs of words according to one of three criteria (for example, orthographic similarity, rhyming and synonyms. ERP's were collected to these 3 different orienting task at the time of presentation. This was followed by recognition tasks. Results showed that semantic judgements led to better subsequent recognition than rhyme which was better than orthographic similarity. Also
'same' judgements were followed by better recognition than different judgements except in orthographic condition. ERP's elicited by 'same' judgements were quite similar across all three tasks and characterised by a late positivity whose duration increased steadily from orthographic to semantic, whereas 'different' judgements were characterised by a negativity at 400 msec in all tasks.

Thus, the processing of 'same' and 'different' judgement tasks differ qualitatively in their study. 'Same' judgement tasks show that processing differs quantitatively along the 3 levels, whereas 'different' judgement tasks engage qualitatively distinct operation. So, here judgements seem to create the difference rather than the level of encoding. This data might have revealed more about the relationship among ERP parameters, encoding and memory, had it allowed comparison among the ERP's elicited during each of the orienting tasks averaged as a function of subsequent recognition and same/different judgements. Unfortunately the small number of trials did not permit this.

Paller, Kutas and Mayes (1987) conducted a study within the levels of processing tradition. Two semantic and two nonsemantic tasks were conducted on college going normals with ERP's recorded during initial presentation. Results showed that memory related ERP effect was robust in semantic as opposed to nonsemantic tasks. ERP's elicited by the
semantic task were different from nonsemantic tasks either on morphology or in scalp distribution. Nonsemantic tasks did not elicit any memory related effect. Semantic task elicited a memory related effect i.e., large late positivity. Paller et al concluded that memory related ERP effect could be dissociated from P3. The memory related ERP was a late sustained, positivity and not a peak as P3. Moreover the memory related ERP was maximal at midline leads where as P3 was maximal at Parietal leads. This suggested that the two ERP effects could be independent. The possibility that some aspects of memory could evoke P3 was not ruled out. Paller et al termed the memory related ERP as "Difference Measure (DM)" waveform which was a late positive complex with positivity ranging from 400-800 ms. To avoid prejudging the relationship between the ERP difference and ERP component such as P300 Paller et al (1987) introduced the later term 'DM' to refer to ERP differences based on subsequent memory performance.

Again Paller, Wood and McCarthy (1988) attempted to study the necessary and sufficient condition for elicitation of DM using the same type of tests, retrieval and recording procedures. Subjects viewed words under incidental learning condition in which each word required a two choice decision based on semantic criteria. Again, the results showed that ERP's elicited in response to the original presentation of each word were found to differ as a function of later memory
performance. Items followed by 'yes' evoked a bigger DM wave and were better recognised than 'No' in the 400 - 800 ms latency range.

These studies show that memory processes are reflected in ERP literature. Clarity has not set in these studies, in terms of definiteness in relating to components of processing. ERP studies of memory in alcohol subjects have not been undertaken. The present study is one such attempt in this direction, to integrate memory and cognitive psychophysiology in chronic neurologically intact alcoholics.

DIVISION OF PROCESSING RESOURCES

In order to assess the ability to allocate processing resources for performances of concurrent tasks Wickens et al. (1983) conducted a study on 12 right handed normals using a pursuit step-tracking task as primary task along with a secondary tasks of counting targets in Bernouille series. $P_{300}$ was used as an index of the processing resource available. $P_{300}$ was assessed for the secondary task when administered alone and when administered in conjunction with the pursuit step tracking primary task. Results showed that large $P_{300}$ was elicited by the task when given singly. Introduction of concurrent tracking task led to substantial reduction in $P_{300}$ amplitude. As the resource demands of the tracking task were increased, potentials elicited by the task-defined events increased in amplitude whereas those
elicited by secondary task auditory stimuli decreased. Results provide support for the hypothesis that the reduction in the amplitude of $P_{300}$ elicited by the stimuli of secondary tasks result from a depletion of resources deployed in the service of the secondary task by competition for these resources from the primary task (Israel et al., 1980, Sirevaag et al. 1989). The subroutine reflected by $P_{300}$ amplitude has been suggested to be involved in updating and revising the model of environment maintained in the working memory (Donchin 1981). The resource on which this updating activity depends seems to be limited in their availability and when deployed in the service of one task, their availability to be of service to other task is reduced.

Combining this, with the literature in alcoholics one questions whether the memory deficit seen in alcoholics is due to these reasons. i.e. Is it due to defective information processing or limited information processing resources, or due to inadequate or defective resource allocation strategies.

Summary of the Review:

1. Specific psychometric tests sensitive to tap the memory deficits in chronic alcoholics is lacking.

2. Neuropsychological test show a preponderance of modality specific memory deficit i.e., viscuospatial memory
deficits in chronic alcoholics. The validity of this finding is questionnable as inherent difficulty of viscuospatial tasks seem to be the cause of the deficit rather than the modality specificity.

3. Chronic alcoholics manifest memory deficit in tasks demanding difficult and complex information processing.

4. Process approaches investigating memory show the core deficit to be encoding. Storage approaches lack a definitive trend.

5. Electrophysiological studies on chronic alcoholics using ERP components especially N₂ and P₃₀₀ show and information processing deficit. This has not yet been extended to study memory deficit in chronic alcoholics.

6. ERP studies on memory have been conducted only on normals based on Sternberg's Paradigm, Context Updating Hypothesis and Levels of Processing approach.

7. The ERP component used in Levels of Processing paradigm is DM waveform and LPC. P₃₀₀ is the ERP component studied for memory scanning and Context Updating Hypothesis.

8. P₃₀₀ amplitude has been used to measure the capacity of Processing Resource. The manipulation of P300 amplitude in single and dual task condition has been used to study the limitation in allocation of processing resource in normals.

9. On the whole, the nature of memory deficit in chronic alcoholics is yet to be clearly understood.