# “A Study of Cue Characteristics on Prospective Memory: Exploring the Role of Sleep”

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## DOCTOR OF PHILOSOPHY

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## DECLARATION

I hereby declare that the thesis entitled **"A study of Cue Characteristics on Prospective memory: Exploring the Role of Sleep"** is the result of investigation carried out by me at the Department of Humanities and Social Sciences, Indian Institute of Technology Guwahati, under the supervision of **Dr Naveen Kashyap**. The work has not been submitted either in whole or in part to any other university / institution for a research degree.

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## CERTIFICATE

This is to certify that Ms Tulika Singh has prepared the thesis entitled **"A study of Cue Characteristics on Prospective memory: Exploring the Role of Sleep"** for the degree of Doctor of Philosophy at the Indian Institute of Technology Guwahati. The work was carried out under my supervision and in strict conformity with the rules laid down for the purpose. It is the result of her investigation and has not been submitted either in whole or in part to any other university / institution for a research degree.

IIT Guwahati **Naveen Kashyap**

May 2015 Supervisor



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## *Abstract*

Memories are central to most cognitive processes in humans. Memories are either retrospective (past information) or prospective (future intentions) in origin. Prospective memories combines retrospective knowledge with future intentions [for e.g., remembering to buy milk while crossing the supermarket]. The effectiveness of memory depends on either the nature of the stimuli (component of memory) or the memory process itself (encoding, stabilization, consolidation & retrieval). The present thesis evaluates both the nature of the stimuli and the memory components that form the prospective memory process. Cues (seeing the supermarket), that signal prospective actions (buying milk), are the core component that guarantee the success of prospective memory. The thesis evaluates the role of cue characteristics on the success of prospective memory retrievals. Cue characteristics are manipulated in terms of affect valence, cue encodings and stimulus modality and their effects are studied on prospective memory retrieval accuracy. Besides cue characteristics, variables like retention interval, encoding interference & neural states play a major of retrieval accuracy of prospective memory. The thesis manipulates these factors by studying prospective memory under un-disturbed and sleep deprivation conditions. Results from our thesis suggest that positively valence cues are effective equally under both indirect and direct encodings. Further visual cues are more effective then semantic cues under all conditions. Sleep, as opposed to sleep deprivation, promotes better retrieval accuracies of prospective memory intentions for all cues variations. This is expected as sleep helps in stabilization of cue encodings due to favorable neural states & negligible interference. The outcomes of the thesis can help design systems that minimize prospective memory failures. The thesis also adds theoretical knowledge to the existing literature on prospective memory.



Keywords: Prospective Memory, Intentions, Cue Characteristics, Sleep, Sleep deprivation.





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Forming and retrieving memories is a fundamental ability of most living organism. Memory can be defined as ability by which mind stores and remembers information. Memory functions comprise three major sub processes, i.e., encoding, storage, and retrieval. During encoding, new memory trace of stimuli are formed while during the process of storage, memory traces are gradually stabilized through short and long-term consolidation processes, which helps strengthen and integrate the memory into preexisting knowledge networks. Retrieval is the process where the stored memory is accessed and recalled. There are different types of memories each having their own particular mode of operation, but they all unite together as a process of memorization, and can be seen as three necessary steps in forming a lasting memory. Sensory memory is the shortest-term element of memory which helps in retaining impressions of sensory information from stimuli. Short-term memory, also known as primary or active memory, houses the information we are currently aware of or thinking about. The information found in short term memory comes from paying attention to sensory memories. Most of the information kept in short-term memory is active for approximately 20 to 30 seconds, after which they are lost permanently if rehearsal or active maintenance of the information is prevented. Short-term memory is often used interchangeably with working memory, but the two should be studied separately. Working memory refers to the processes that are used to temporarily store, organize and manipulate information. Short-term memory, on the other hand, refers only to the temporary storage of information in memory. Long-term memory is used for storage of information over long period of time. Our everyday memories are extracted from long term memory because information's related to our past experiences are stored within them.

An important alternative classification of long-term memory used by researchers is based on the temporal direction of the memories. In everyday life we encounter several forms of memory which are generally related either to our past experiences or future intentions. Memory of intentions that we want to complete in future are different from memories of our past experiences as most of them are generated from thoughts, imagination, and anticipation rather than composed of the details that comes from actually performing an activity (Marsh, Cook, & Hicks, 2006). For this reason, researches done on memory have drawn a distinction between retrospective memory for experiences already undertaken and prospective memory for activities


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that we plan to initiate in the future. Although retrospective memory plays its role in prospective memory but this role of retrospective memory in prospective memory is suggested to be minimal, and only helps to access the information required to make plans. According to Einstein & McDaniel (1990) the retrospective memory component of the prospective remembering task refers to the ability to retain the basic information about action and context. Contrary to retrospective memory, prospective memory includes- formation of an intention which needs to be performed in future (intent), what we plan to do (action) & when we want to do (retrieval). However, an important feature of prospective memory tasks is absence of any explicit cue for recall during retrieval. That's why prospective memory is also termed as one's ability of ''remember to remember'' and is distinguished from retrospective memory which is always initiated by some external and explicit cue to recall past events. Although prospective memory is contrary to retrospective memory in some of the aspects, it comprises of both prospective and retrospective component. After having remembered that something needs to be done, one also has to remember ''what'' it is that needs to be done (Meacham, 1977; Zimmerman & Meier, 2006). The "what" content is considered as a part of retrospective component and plays an important role in execution of any prospective memory task.

The term prospective memory was introduced by Meacham and Leiman (1982). Prospective memory represents a form of explicit episodic memory and is defined as completion of planned intention at its appropriate time which is determined by various factors like encoding of intention, its retention, retrieval of the intention and performance. Until about 20 years ago, only a handful of PM papers had been published, most of them were naturalistic studies. This changed when Einstein and McDaniel (1990) published an experimental paradigm that allows repeated measures with well-controlled manipulations. They developed a typical experimental paradigm for controlled laboratory-based studies on prospective memory that follows two stages in the task. In first stage participants are engaged in an ongoing activity (e.g., indicate which of the two numbers presented on the screen is numerically bigger). In the second stage, while they are fully engaged with the ongoing activity, the PM instructions are introduced and participants are asked to try and remember to perform an unrelated action at some pre-specified point in the experiment (e.g., respond differently when both numbers are even). This paradigm allows one to measure performance by the proportion of trials in which participants correctly remembered to


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execute the PM task and the ongoing activity. Many variations of this paradigm were carried out in order to look at the different cognitive processes that form the basis of PM, including, for example, the length of the retention interval, the importance of the tasks and the mechanism underlying prospective memory. The paradigm introduced by Einstien & McDaniel (1990) is widely used in experiments of prospective memory to measure future intentions. These intentions are self-initiated process and determine the successful retrieval of task. Up to some extent the retrieval depends upon the nature of the task (important, pleasant, unpleasant, simple or difficult etc.) which plays their role in initial stage of prospective memory i.e. encoding. Several studies have examined the factors that affect encoding process. The first experimental study on prospective memory conducted by Birinbaum (1930) examined the influence of pleasant, unpleasant and neutral information on prospective memory performance and found that intentions associated to negative emotions (visiting a dentist) are often remembered and tend to postponed or cancelled.

The intentions can be divided in short and long intentions. These delayed intentions can be classified as time based or event based depending on the nature of task during retrieval. Event based intentions rely upon availability of cue and these intentions are executed when they are prompted by some external cue. The time based intentions on the other hand are executed at particular time or after a time period. The major distinction between these two intentions is event based intentions are more prone to external cues whereas time based intentions are based on self-initiated process (Block & Zakay, 2006). The theories concerning event-based memory are more developed, as they are more vigorously studied in laboratories. Less studied forms of PM (in addition to time-based PM) are habitual PM (Meacham & Leiman, 1975), and activity-based PM (Kvavilashvili & Ellis, 1996). Habitual PM tasks are those where the action is performed repeatedly and in a routine manner. For example, remembering to take medicines every day at eight pm. Activity-based PM, on the other hand, requires the intention to be retrieved and executed upon completing some other task. For example, remembering to return a file after dinner.

According to Ellis (1991) there are certain phases of prospective memory that involves formation of intention and action, retention of interval, performance, initiation and execution of action & evaluation of outcome. Encoding phase is concerned with learning the content of


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intention (what we want to do), an intent (something to be done) and retrieval context (when to initiate the action). The second phase is retention interval which refers to the time duration between formation of any intention and its execution. In the third phase i.e. performance interval is the time when we have to perform, for example we have to make a call between 9:00am to 12:00pm, and the performance interval of this intention is 3 hrs. Within this time frame we have to actually initiate and perform action depending upon the retrieval context. The last phase of prospective memory is evaluation of outcome where we make some records of the action completed which is necessary to avoid unnecessary repetitions and to ensure success of performed action.

These intentions follow certain mechanism that allows prospective memories to be retrieved. Several theories have been proposed to explain these mechanisms. The first theory in the series was monitoring theory which argues that strategic, non-automatic preparatory processes must be introduced before the occurrence of a target event if one has to successfully retrieve an intention (Smith, 2003; Guynn, 2003). Consequently, a successful prospective memory intention can only be retrieved if the person monitors for his or her prospective memory cue. Furthermore, because monitoring is non-automatic and capacity-consuming task, successful prospective memory should be associated with costs (slowing or errors) on the ongoing task. Alternatively, spontaneous retrieval theory (Einstein & McDaniel, 1996) argues that the intention retrieval process is much more automatic than the retrieval process described by monitoring theory. The non-automatic preparatory processes that are required to monitor, spontaneous retrieval suggests that the appearance of a target can trigger remembering without incurring a cost on an ongoing task. An intention can be retrieved without keeping the intention in consciousness. Later multi-process theory (McDaniel & Einstein, 2000) was introduced assuming that whether one relies on a monitoring or spontaneous retrieval process depends on the characteristics of the PM task, the ongoing task, and also the individual. Given the prevalence of prospective demands in everyday life, it is adaptive to have a flexible system that can accomplish PM retrieval though several mechanisms. According to the multi-process view, there is a general bias to rely on spontaneous retrieval. It would be maladaptive to depend exclusively on a monitoring process that heavily taxes working memory resources because (a) people often have multiple, simultaneous PM demands and (b) the delays before they can perform intended


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actions are often substantial. Further, the particular method that people use to help them remember to perform actions in the future depends on the characteristics of prospective memory tasks, the ongoing task, the individual and the cue characteristics (McDaniel & Einstein, 2000).

Cue characteristics involve complexity, salience, and familiarity (Mantyla, 1996) which are known to affect retrieval accuracy in both retrospective and prospective memory alike. Because prospective memory tasks are typically embedded in some attention-demanding ongoing cognitive activity, it is likely that the perceptual salience of a prospective memory cue would influence prospective memory performance. Salience in its literal meaning is known as "most noticeable or important". This saliency makes the cue more effective in terms of identification and therefore effect the performance. The more distinct the prospective memory cue is, the less strategic monitoring will be required. The cue characteristics can be manipulated on various grounds like valence, arousal, familiarity, cue pattern, and its presentation. Among all these cue properties, valence had gained the focused attention of many researchers. There has been numerous studies on emotional valence and memory because as memory declines with age, its only emotional experience and emotional regulation that remains intact or even improves across adulthood (Watson &Blanchard-Fields, 1998). A handful of studies have examined the influence of emotion on PM performance, but the findings till date didn't provide any clear understanding of valence effect on prospective memory (Altgassen, Phillips, Henry, Rendell, &Kliegel, 2010; Clark-Foos, Brewer, Marsh, Meeks, & Cook, 2009; Rendell et al., 2011). Several evidences, indicate that prospective memory is susceptible to emotional influences (Martin &Clore,2001). Meacham and Kushner (1980) suggested that the probability to execute an intended uncomfortable action diminishes in comparison to a more neutral situation. However, aversive intentions have been found to enhance memory retrieval but to delay execution. In accordance with this hypothesis, Clark-Foos and colleagues (2009) showed that negative prospective cues compared to positive and neutral cues decrease PM performance. Similarly, Rendell and colleagues (2011) investigating how emotional valence of the stimuli and age influence PM performance showed that young and old adults had better performance on positive than on both negative and neutral PM tasks. Although older compared to younger adults showed generally poorer levels of PM performance they demonstrated greater beneficial effects of positive valence. Furthermore, a study by Altgassen and colleagues (2010) investigated the


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impact of emotional valence on event-based prospective memory performance in depression showed that healthy participants better remember positively valence cues whereas this effect was absent in participants with depression. Both groups tended to be less accurate in response to negative PM cues with respect to positive and neutral cues and no significant difference has been found between them. Another study from the same group of researchers (2010) showed that, generally, emotionally valence cues (positive and negative) increase prospective memory performance of younger and older adults. Unfortunately, methodological differences across these studies, along with limitations in some of the paradigms, prevent a clear understanding of the role of emotion in PM, particularly with respect to the influence that emotion might have on cue saliency.

In relation to presentation of cue it has been observed that prospective memory positively correlates with performance embedded in implicit memory tasks like word-stem completion task (McDaniel and Einstein, 1993), which is an index of implicit memory function. Also using an autonomic measure, Kliegel et al. (2007) found that skin-conductance responses were greater to cues that were undetected than those which were easily detectable for the ongoing task stimuli. However, the mere presence of a salient cue cannot enhance intention recall (Einstein et al., 1998). In addition, it has been suggested that cue identification and intention retrieval are dissociable (Cohen et al., 2001; McDaniel and Einstein, 1992). Also the discrepancy between the ongoing task and a cue, both in terms of the stimuli (McDaniel and Einstein, 1993) and of the processes involved (Marsh et al., 2005), also enhances cue detection. A number of studies have investigated the characteristics of cues that are important for enhancing intention execution but there had been very few studies exploring the effect of cue presentation on prospective memory. Despite of other cue characteristics, cue presentations can also make some distinguishing impact on encoding process which later affects prospective memory performance. The way a cue is presented determines its identification. The presentation of cue can be done in implicit or explicit form which will be preferably called as direct or indirect presentation of stimuli in this thesis because the explicit/implicit terminology is potentially very misleading (Dunn & Kirsner, 1989; Reingold & Merikle, 1990; Richardson-Klavehn & Bjork, 1988). Research conducted on implicit processing suggests priming effects elicit smaller but faster electrophysiological responses compared with overt motor effects, are evoked using unconscious visual words (Dehaene et al., 1998). It has also been found that salient explicit cues can fail to remind of the intention


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(Einstein et al., 1998). Instead, unconscious stimuli (cues) may be non-negligible (Tsushima et al., 2006) and accessible to the maintained intention. In a study, Hashimoto, Umeda & Kojima (2011) used indirect/implicit cues to examine maintained intentions and found that implicit stimuli elicit weak but reliable effects both on behavior and neural activity, without awareness. They found that implicit cues associated with an intention induced a response that was dissociated from irrelevant cues. Matched and non-matched implicit cues yielded different responses during the prospective memory task, although the tasks were explicitly identical. Implicit stimuli yielded subtle but significant effects during the maintenance and execution of delayed intentions. Results from these studies indicate that prospective response can be generated by presenting the cues in indirect mode but there are many questions yet to be explored.

Memory process can be affected at three levels i.e., encoding, retention and retrieval. In the present thesis manipulation are done at the level of encoding (by manipulating cue characteristics) and retention (increasing the retention interval). Brandimonte, Einstien& McDaniel, 1996 described various form of intentions, classified on the basis on time interval (longer &shorter time delay).The time intervals are important as they help in maintaining prospective memory intention until the task is accomplished. For this reason the time duration between encoding and completion of intention becomes very important. This has also been described as "window of opportunity" by Harris and Wilkins (1982) which refers to time gap between formation of intention and its execution. Among all variables affecting the prospective remembering (Marsch & Hicks 1998), the retention intervals, between intention formation and the time an action is to be carried out, has been widely studied (Hicks et al. 2000). Hicks et al. (2000), for instance, found that in an event-based task (i.e. an environmental cue triggers fulfillment of the intention; see for instance Einstein & McDaniel 1990), the prospective memory improved over short (3 min) to long (15 min) delays. With longer delays, participants should retrieve the goal more often, and thus its representation was strengthened. Thus, the prospective memory performance is linked to the goal rehearsal (Hicks et al. 2000) and the processing of cues related to the goal. These aspects would occur during waking period, while they might be reduced during sleep period. It is well-established that sleep induces memory consolidation (Diekelmann & Born 2009). In context of prospective memory also sleep has been proven to


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impact memory resulting in better performance. In a recent study, Scullin and McDaniel (2010) demonstrated a positive sleep effect on goal execution in a prospective memory task. Specifically, in a laboratory setting, the participants executed a prospective memory goal after a short delay (20 min), a 12-h wake delay, ora 12-h sleep delay. However, Scullin and McDaniel (2010) did not report any quantitative and/or qualitative information about the sleep of their participants in their study. Thus, it is unknown whether the prospective performance is related to sleep quantity, or to sleep quality, or to both quantitative and qualitative aspects of sleep.

In recent years, there has been an upsurge of evidence that sleep plays a vital role in the process of memory consolidation of retrospective memories, i.e., memories of past events. Subjects who are allowed to sleep after learning show better memory retention than subjects who spend an equivalent amount of time awake (Diekelmann& Born, 2009). Sleep thereby actively facilitates the consolidation and reorganization of memories for long-term storage rather than merely passively protecting memories against decay and interference (Ellenbogen, Payne & Stickgold, 2006). This active processing of memories during sleep also entails some kind of selection mechanism determining whether or not previously acquired memories will be subjected to sleep dependent consolidation. Although such findings strongly confirm the notion that sleep is critically implicated in processes of memory retention, the role of sleep in maintaining prospective memories is not well understood.

The present thesis aims to examine the role of cue characteristics on prospective memory by modulating retention interval. To conduct these examinations the study was categorized in two sections where section one deals with behavioral experiments manipulating cue characteristics and section two examines the role of retention interval using sleep (minimal interference) and sleep deprivation (interference).In our initial experiments we attempt to examine the role of emotional valence on prospective memory. In experiment one, effect of emotional (positive, negative) and neutral cues on different types of prospective memory (event based, time based and activity based) were examined. As most of the studies in the area of prospective memory examine only event and time based prospective memory, we incorporated the activity based prospective memory which shares characteristics of both event and time based intentions. The activity based intention is a recent addition to prospective memory and less studied compared to other types of prospective memory. The results of the experiment revealed


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significant effect of emotions compared to neutral on prospective memory intentions especially for event based scenarios. In addition the results revealed negligible cue retrievals of the neutral kind when compared to positive and negative cues. Based on these findings we eliminated neutral valence in our further studies as difference we found in our experiment clearly indicates that in comparison to neutral stimuli emotional stimuli facilitates prospective memory. Also, the two prospective memory types (time-based and activity-based) were ruled out in further experiment as they didn't exhibited clear impact of cue characteristics. The next experiment of the thesis (experiment two), explored the role of cue presentation (direct/indirect) and emotional valence (positive/negative) as a function of cue characteristics on event based prospective memory. Manipulation in presenting the emotional cue was done to investigate whether indirect cue presentation effect performance and produce better results. Research on emotions suggest implicit encoding of emotional stimuli to be as effective as explicit encodings. A large volume of research literature supports the unconscious emotion dependent memory modulation. Since the main variable of interest in the present thesis was cue valence, we decided to test whether indirect/implicit/unconscious encoding of valence cue has any effect of cue retrievals on event cued prospective memory. The results from our experiment show clear effect of valence but for the presentation mode (indirect/direct) we didn't found any significant differences. In our third behavioral experiment we manipulated the stimuli type. Previous research on emotion effect on memory suggests that the type of emotional stimuli has a major role to play on such interactions. Since experiments in the thesis till this point used only word stimuli, we decided to vary stimuli format/type in terms of pictures & words. We therefore designed an experiment to investigate the effect of cue presentation across two stimuli type (pictures and words).Results of the experiment clearly indicated picture superiority effect over word stimuli. As expected participants performed better for picture stimuli compared to words. Significant interaction between emotion, cue presentation and stimuli type was also found which reflected the idea that cue characteristics can generate better retrieval of prospective memory intentions when tested in immediate conditions.

To extend our findings, same experiments were repeated to investigate the effect of cue characteristics on prospective memory by modulating the retention interval. The retention interval were: a) resting state (sleep) which not only have optimal neural states that support memory stabilization and consolidation with minimal to no interference; and b) non-resting state


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(sleep deprivation) with increased global and local neural depression that hinder memory stabilization and consolidation and high amounts of interference. Our objective was to examine the effect of sleep on prospective memory retrieval as a function of cue characteristics (experiment 4 & 5). There have been very few studies done on sleep and its effect on prospective memory with their own limitations. Our effort was to explore the effect of different patterns cue characteristics on event based prospective memory across sleep and sleep deprivation condition. In the last experiments we found beneficial effect of sleep over sleep deprivation with sleep enhancing the retrieval of cue in context of emotional valence. The overall result of the thesis revealed better performance in sleep condition compared to sleep deprivation. Improvement in performance was also found in context of emotional cue and stimuli type in behavioral experiments whereas non-significant results were found for presentation style in behavioral as well sleep conditions.

The overall objective of the thesis was to study the impact of cue on enhancement of prospective memory performance. It is well established in retrospective memory studies that cue plays a very important role in retrieval of learned materials but for prospective memory, retrieval is not sufficient in fact performing the action once the intention is retrieved completes the whole process of prospective memory. So the study of cue in depth is essentially required to come across prospective memory failure and to develop strategies that not only remind the intention but could also takes us to perform actions on appropriate time.


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In the late nineteenth and early twentieth century cognitive psychology emerged as an independent discipline which studies all kind of mental processes (attention, perception thinking, problem solving etc.) including memory systems. Memory is the ability of the brain to store, retain, and subsequently recall information. It is the term given to the structures and processes involved in the storage and subsequent retrieval of information. It refers to the processes that are used to acquire, store, retain, and later retrieve information. There are three major processes involved in memory: encoding, storage, and retrieval. In order to form new memories, information must be changed into a usable form, which occurs through the process known as *encoding*. Once the information is successfully encoded, it needs to be *stored* for later use. Much of this stored memory lies outside of our awareness most of the time, except when we actually need to use it. The *retrieval* process allows us to bring stored memories into conscious awareness.

There have been several models proposed to study memory system but the stage model of memory is often used to explain the basic structure and function of memory. Initially proposed in 1968 by Atkinson and Shiffrin, this theory outlines three separate stages of memory: sensory memory, short-term memory and long-term memory.

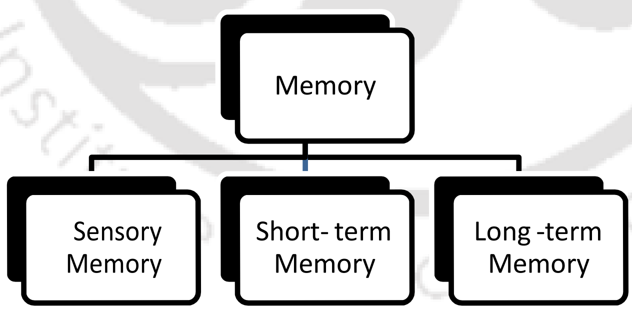


Figure1. Three basic stores of memory system

Sensory memory corresponds approximately to the initial 200–500 milliseconds after an item is perceived. Short-term memory allows recall for a period of several seconds to a minute without rehearsal. Its capacity is also very limited. George A. Miller (1956), when working at Bell Laboratories, conducted experiments showing that the store of short-term memory was 7±2


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items. Modern estimates of the capacity of short-term memory are lower, typically of the order of 4–5 items, however, memory capacity can be increased through a process called chunking.

**2.1 Current Model of Memory:**

The multi-store model proposed by Atkinson's and Shiffrin's (1968) was extremely successful in terms of the amount of research it generated. However, as a result of this research, it became apparent that there were a number of problems with their ideas concerning the characteristics of short-term memory. Building on this research, Baddeley and Hitch (1974) developed an alternative model of short-term memory which they called working memory. They argue that the picture of short-term memory (STM) provided by the Multi-Store Model is far too simple. According to the Multi-Store Model, STM holds limited amounts of information for short periods of time with relatively little processing. It is a unitary system. This means it is a single system (or store) without any subsystems. Working Memory is not a unitary store. Working memory consists of a central executive which controls and co-ordinates the operation of three subsystems: the phonological loop, the visual-spatial sketchpad and episodic buffer.

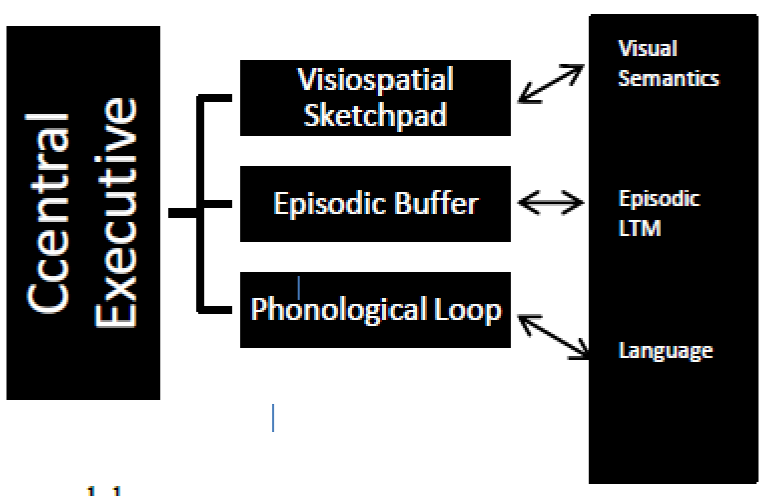


Figure2. Working Memory Model

Information's after being processed in short term memory are transferred to long term memory which is known as permanent store house. Long-term memory stores


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associations among items, as proposed by the dual-store memory model. Theoretically, the capacity of long term memory could be unlimited, the main constraint on recall being accessibility rather than availability. One of the earliest and most influential distinctions for long term memory structure was proposed by Tulving (1972**).** He proposed the existence of declarative and procedural memory. There are mainly two types of long term memory: explicit (declarative) memory and implicit (non-declarative) memory. Explicit memory consists of episodic (biographical events) and semantic (facts & knowledge) subtypes. Implicit memory is expressed through means other than words. This is broken down into four categories which includes skills and habit, simple classical conditioning, priming and non-associative learning

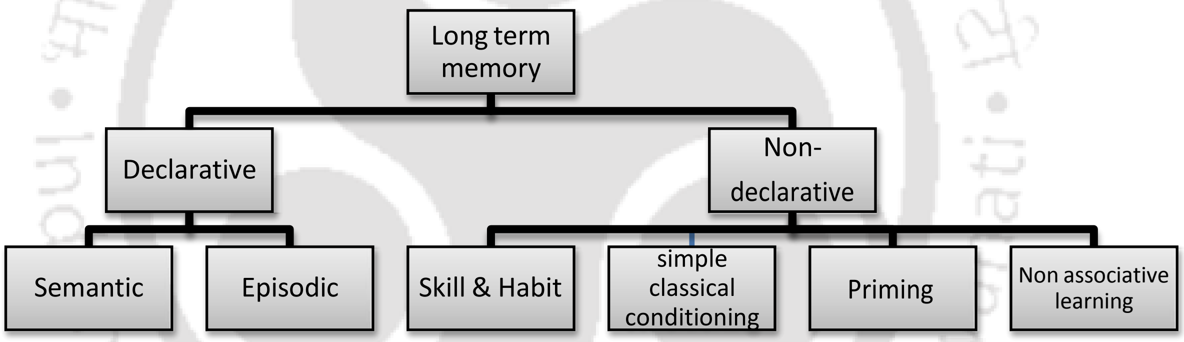


Figure3- Categorization of long term memory

## 2.2 Retrospective and Prospective Memory

Long term memory can be described using various categorizations; one of them being in terms of temporal direction. This temporal direction comprises of two forms of memory which are interrelated to each other. One is retrospective memory where the content to be remembered (people, words, events, etc.) is from the past, i.e. the recollection of past episodes. The other one is prospective memory where the content is to be remembered is in future (fig 4). Prospective memory (PM) can be defined as “remembering to remember” or remembering to perform an intended action at later period of time. It may be either event-based or time-based, often


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triggered by a cue, such as going to the doctor (action) at 4pm (cue), or remembering to post a letter (action) after seeing a mailbox (cue).

**Retrospective memory** refers to memory for people, words, and events encountered or experienced in the past. It includes all other types of memory including episodic, semantic and procedural. It can be either implicit or explicit. In contrast, **Prospective memory** involves remembering something / remembering to do something after a delay, such as buying groceries on the way home from work. It includes forming an intention which includes decision to act in particular way in future (the intent), what we plan to do (the action), and when we plan to do it (retrieval cue). However, it is very closely linked to retrospective memory, since certain aspects of retrospective memory are required for prospective memory.

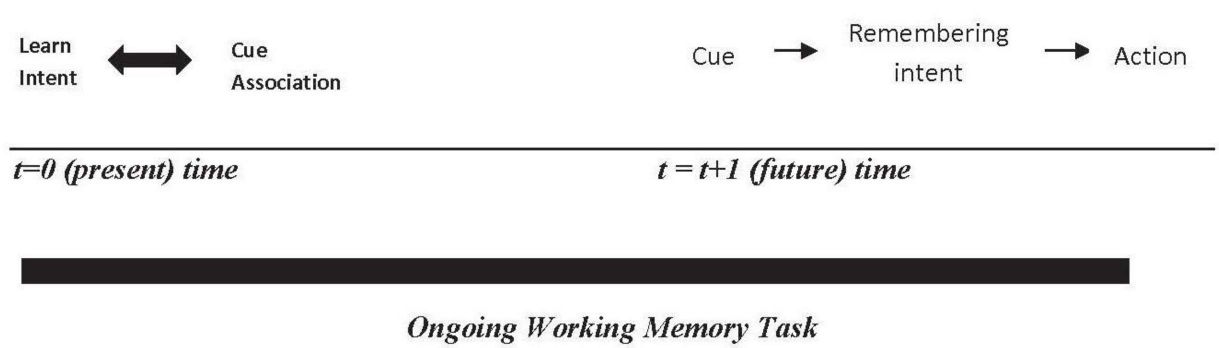


Fig. 4- Mechanism underlying prospective memory

## 2.3 Emergence of Prospective Memory-

Prospective memory initially was considered as distinctive form of episodic memory and suffered with many claims related to its identity. In absence of solid evidence, that prospective memory differs in fundamental way from episodic retrospective memory, it was concluded that prospective memory is a new way of studying retrospective memory (Graf & Uttl, 2001).Early research on prospective memory and retrospective memory has demonstrated that retrospective memory has a role in prospective memory. A review by Burgess and Shallice (1997) described


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studies; where patients had impaired prospective memory but intact retrospective memory and where the impaired retrospective memory caused an impact on prospective memory. The role of retrospective memory in prospective memory is suggested to be minimal, and takes the form of information required to make plans. Einstein & McDaniel (1990) proposed that prospective memory is not a part of retrospective memory instead it's a kind of memory that involves some of the retrospective component into it. Successful prospective memory performance is thought to involve two components: remembering at an appropriate moment that one must do something, and recalling what is to be done (Einstein, Holland, McDaniel, & Guynn 1992). The former is called the prospective component, whereas the latter is referred as the retrospective component. For example, if a person has to remember to give a friend a message, successful prospective memory requires that the appearance of the friend that triggers the memory that a message has to be given (prospective component). Successful prospective memory also requires that the person remember the content of the message (retrospective component). The retrospective component refers to the retention of the action and the target events or the retrieval cue. The prospective component refers to the retrieval of action at appropriate time or in response to appropriate event.

### 2.4 Phases of Prospective Memory:

A prospective memory task can be divided into five stages (Ellis, 1996). For the successful completion of any prospective task, crossing these sequential stages becomes essential

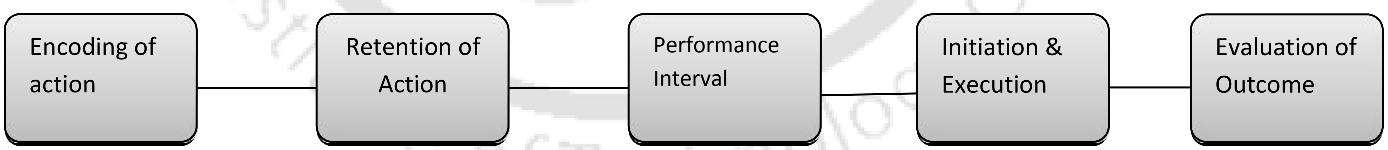


Fig.5- Phases of prospective memory

- Encoding: This is the first phase dealing with formation of intention. It is concerned with the retention of content of delayed intention. More precisely it deals with what type of action is to be performed and when.


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- Retention: This phase is the time period between encoding of the intention and completion of the intention. It varies both in their duration as well as in their content.
- Performance Interval: This phase refers to the retrieval of the intended action. Recognition of the situation (context) where the intention needs to be performed as a part of performance interval.
- Initiation & Execution: As the term suggests, in this phase the action needs to be initiated and executed at its appropriate time. The successful initiation and execution of delayed intention are important to its eventual realization.
- Evaluation of outcome: Once the action is performed, it becomes important to evaluate the outcome of any particular intention which can be based on three different possibilities: a). the goal is fully satisfied, b) Partially satisfied, c) unsatisfied. Full satisfaction is an overlap between content and the outcome. Partial satisfaction is the condition when the intended was retrieved but not performed while the unsatisfied condition is when the intended action is not performed at all.

## 2.5 Theoretical Perspectives of Prospective Memory

There have been several theories proposed to explore the cognitive processes involved in retrieval of prospective memory intentions and discover how the cognitive system enables one to execute intended actions at the appropriate time. Some of the main approaches are as follows:

The earliest theory proposed is **Preparatory Attentional and Memory (PAM)** theory which comprises of two types of processes that are involved in successful prospective memory performance. The first component is monitoring process that begins when any intention is formed and maintained until it is performed. This process involves a capacity-consuming mechanism which is also used during attention maintenance to accomplish the intention to be stored and maintained in memory. The second component comprises of elements of retrospective memory processes. According to this theory, when complete attention is given to the desired task it should result in successful prospective memory performance than when attention is divided among multiple tasks. McDaniel, M. A., Robinson-Riegler, B., & Einstein, G. O. (1998)


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conducted a study where they attempted to prove that prospective memory performance is better on focused tasks compared to those where attention is divided. In their study participants completed a prospective memory task in two conditions, one where full attention was given and second where attention was divided on other tasks. The results found were consistent with the PAM theory, showing that participants' prospective memory performance was better with full attention.

The next theory in the area of prospective memory is **reflexive-associative theory** proposed by Smith & Bayen (2003,2004). This theory states that when any prospective memory intention is created, an association is formed between the target cue and the intended action. Later when the target cue occurs, the automatic associative-memory system triggers the retrieval of the intended action and brings it back into conscious awareness. Therefore, the occurrence of the target cue leads to the retrieval of initiated action and determines the prospective memory. In a study by Reese and Cherry (2002), participants were instructed to form an intention to be completed in future, but were interrupted before acting on their intention when the cue was present. When participants were inquired about their thoughts during interruption, only 2% reported that they were thinking of the original intention. This result claims evidence against the PAM theory, that the associative binding of the target cue and action produce better retrieval of intention rather than conscious monitoring of the intention. Further research conducted by Einstein and McDaniel in 1990, found that subjects during prospective memory tasks reported that their intention often "popped" into mind, instead of being constantly monitored and consciously maintained.

A recent theory proposed by Einstein and McDaniel ( 2005) is **multi-process theory**, which explains the cognitive processes underlying prospective memory performance. This theory emphasizes more on spontaneous retrieval of the action instead of active monitoring (i.e., the occurrence of a cue can cause the intention to be retrieved, even when no preparatory attentional processes are engaged). Because active monitoring requires lots of attentional resources it is difficult to solely rely upon it. It can also interfere with other processes involved in different tasks during retention period. The cue related to the intended action itself prompts the spontaneous retrieval of the action when any of three conditions is met: if the cue and target


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action are highly associated with each other, if the cue is highly salient, or when the other processes performed during the period between cue and action of the prospective memory task direct attention to relevant cue features (e.g., task appropriate processing).

In other researches it has been found that prospective memory tasks being automatic in nature, do involve some amount of processing. Einstein, G. O., McDaniel, M. A., Thomas, R., Mayfield, S., Shank, H., Morrisette, N., et al. (2005) conducted an experiment where they found slow rate of performance in a filler task while running prospective memory task in parallel. Even though some of the participants did not engage in active monitoring, they showed nearly the same rate of success on the task, demonstrating the use of multiple processes for prospective memory performance.

### 2.6 Paradigm of studying Prospective Memory

Earlier experiments of prospective memory can be broadly classified into naturalistic or laboratory based studies. In naturalistic form of studies participants were asked to complete intentions related to their daily life (e.g. post a letter on their way to home) whereas in laboratory experiments they were limited to complete their intentions within the given time frame and situation (Meacham & Singer, 1977). In the current research era laboratory based experiments are used more frequently with many advanced technologies to unravel mechanism underlying varieties of prospective memory. A laboratory study that evoked stimulation for studying prospective memory worldwide got published in 1990 by Einstein and McDaniel. In their study they used a paradigm where members were given directions for an ongoing task, for example, rating the agreeableness of words screening on the monitor. Also the participants were likewise given an extra task with prospective memory embedded into it (for instance, at whatever point they experience a specific word (e.g., apprehension) amid the continuous task they have to perform an extra activity, for example, pressing an uncommon key). Normally the retention interval between the instruction and occurrence of prospective memory target word is around 5-10 minutes. Participants were also asked to recall prospective memory response to check the level of difficulty in recalling the specific response they were supposed to make and the condition for making that response. Although it may seem surprising that participants would


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forget to perform such a simple deferred task, this parallels everyday experience, and error rates in this paradigm are high enough to allow systematic manipulation.

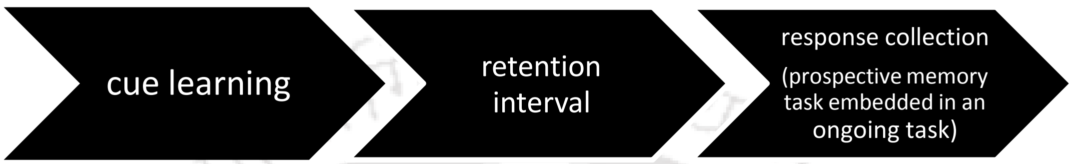


Figure 6. Paradigm of prospective memory experiments in laboratory settings.

### 2.7 Prospective Memory Intentions

Recent advances in prospective memory broadly classify it as event based and time based intention. Event-based prospective memory involves remembering to do a certain action when the specific circumstances are present. For example, driving past the local library cues you to remember that you need to return an overdue book. Time-based prospective memory involves remembering to do an action at a particular point in time. For example, seeing that it is 10:00 PM acts as a cue for you to know that is it time to watch your favorite television show (McDaniel & Einstien, 2007). These two types of prospective memory are the focus of major studies conducted on prospective memory. Sellen, A. J., Louie, G., Harris, J. E., & Wilkins, A. J. (1997) compared event-based and time-based cues on prospective memory tasks. In their experiment they provided participants with a place (event-based) and a time (time-based) cue and instructed them to press a button each time when those cues appeared during the experiment. The result showed that performance on event-based tasks was better than performance on time-based tasks, even when participants took more time to think about their responses. The difference in task performance between the two types of prospective memory suggests that the intended action was better triggered by external cues of the event-based task than internal cues of the time-based task.


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External cues, as opposed to internal cues, act as a prompt for better performance, making it easier to complete event-based tasks.

In some of the recent studies activity based prospective memory has been studied as third type of prospective memory. This type of prospective memory shares characteristics of both event based (end of previous task may act as cue for activity based task) and time based prospective memory (self-initiation of the action). For instance, to purchase grocery items after finishing the dinner is an activity based task, where dinner is one activity that is followed by others activity and acts as a cue to remember purchase grocery which is self-initiated process. As these examples make quite clear, an intention can be formed under any one of the three broad formats identified as types of prospective memory, and the probability of completion could depend on the manner in which the current context interacts with the type of intention formed (Marsh, Hicks & Cook, 2006). The major difference between event-based and time based intention is based on their nature of processing. Event based intentions are cue specific (an intention to give a message to a friend the next time you see her) whereas time-based intentions are time specified(an intention to take cookies out of the oven in 20 minutes). Majority of experimental research so far has been directed to event-based prospective memory, with a modest number of studies exploring time-based prospective memory. The categorization in prospective memory is not limited only to event and time based prospective memory, further categorization has also been done. Time based intentions are categorized by Ellis (1996) as pulse (to be executed at a particular time) and step (to be executed during a more extensive time window). Meacham and Leiman (1976) distinguished ongoing recalling of routinely performed intentions (for example, taking meals at proper time) from episodic recollection of occasional tasks (for example, getting flowers for home)as for both the types one has to structure a different episode for intention(Episodic tasks can be either occasion based or time-based).Beside these intentions Loukopoulos, Dismukes, &Barshi (2009) documented two different circumstances in which people (particularly, pilots) must recall performing proposed activities: recalling resuming an interfered task and recollecting switching consideration between simultaneous tasks. These intentions are considered completed only when they are performed at their specified time or event. Kvavilashvili and Ellis (1996) argue that not all failures to carry out an intention are errors


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of prospective memory. According to them, only situations in which an explicit, episodic intention is formed for a delayed task should be considered prospective memory. Also situations in which individuals absent-mindedly substitute a habitual action for an intended one, for example, going into the bathroom looking for missing eyeglasses and instead brushing one's teeth are also excluded. Understanding the reason why people forget to do what they intend to do are important as they can help avert future prospective memory failures

**2.8 Cue Characteristics of Prospective Memory**

The role of target cue (that prompts the deferred intention) in prospective memory performance has its own importance because it places higher association with the content of the intention stored in memory. Cues eliciting higher correlation with the intention places strong effects on retrieval of same intentions. (McDaniel, Guynn, Einstein, &Breneiser, 2004; Loft & Yeo, 2007). This kind of affiliation is referred in studies where imminent memory activity is to reproduce a particular word when the cue shows up in the succeeding task. For example, if the target is the word shoes, execution will be vastly improved when the intended reaction is to say "socks" than when the reaction is "spoon". Evidently the existing connection in between shoes and the socks expands the level of activation that spreads from the experienced target sign to the related response stored in memory, enhancing retrieval. The things which are profoundly activated are more promptly available and recovered rapidly. One hypothetical viewpoint holds that events related to past experiences activates our memory and supports the recovery of data required for intention execution (Anderson & Lebiere, 1998).

Cues in most cases help in retrieval of information but it is blended with many characteristics. Cues that are distinctive, salient, or unusual produce better prospective remembering than cues that all other cues (Brandimonte & Passolunghi, 1994). The saliency of targets makes the cue more attention driven and therefore facilitates retrieval of more items associated with that cue. For instance, if the words are displayed in capital letters, participants may recognize the change in the target cue and relate it to the activity planned to perform. The nature of the ongoing task also determines the processing of target cue and greatly affects


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prospective remembering. Maylor (1993) conducted a study where she investigated the effect of focal and non-focal cues on prospective memory retrieval. In her experiment participants were given the ongoing task of naming well known individuals presented in a series of photos and then to press a certain key when the name John is distinguished (in one condition) as a part of prospective memory task or pressing other key when a man with a funnel is recognized (in another condition). Result of the study revealed better performance in the first condition, on the grounds that the engrossment in continuous task made members concentrates more on the identification of target cue. In the first condition target cue is said to be focal as it was part of ongoing task while in second condition the ongoing task requires the participants to consider whether the persons in the photos have funnels, which shares the characteristics of non-focal task (Focal cues are directly initiated by ongoing task while non-focal cues are not activated by ongoing task).

Few situations itself bolster the planned activity based on the background as well as the nature of ongoing task (Cook, Marsh, & Hicks, 2004; Nowinski & Dismukes, 2005). Recalling to perform postponed tasks becomes simpler when the target cue is strongly associated with the ongoing task opposed to the task that is not part of our ongoing activity. Thus, an individual would be more inclined to recall an intention relating his work space when the message need to be conveyed to an associate when the partner is present in office, than when the associate is met at a supermarket. An essential exemption to the common results with intensely demanding ongoing tasks happens when the target cue is exceedingly remarkable (Einstein, McDaniel, Manzi, Cochran, & Baker, 2000) or correlated with the prospective memory intention (McDaniel, Guynn, Einstein, &Breneiser, 2004). In these two circumstances planned intention is not hindered actually when the continuous task places heavy demands on executive processes.

### 2.9 Role of Emotion in Memory

Emotional events are frequently recalled with more precision and distinctiveness (however these two attributes don't generally go together) than events without an emotional component into it (Reisberg & Hertel, 2005). Various studies have demonstrated that the most distinctive autobiographical memories have a tendency to be of emotional in nature, which are


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liable to be reviewed more frequently and with more clarity compared to neutral events. Memories of our experiences are described by representations replayed through neuronal action. Activity that takes places within a system of neurons delivers a code for experiences (e.g. birthday party). At a later time when the system is initiated by some cue (which triggers a re-experience of that occasion) we are reminded of the experience (birthday get-together). This upgraded memory for emotional experiences has been credited to associations between the amygdala and other neural regions (for example, the hippocampus and prefrontal cortex, PFC) (Cahill &McGaugh, 1996). The amygdala is dynamic during experience of any emotional event, and this action impacts the encoding and consolidation of the memory related to emotional experiences (LaBar&Cabeza, 2006; Phelps, 2004). According to Buchanan (2007), these impacts on the "front end" of memory (attention, encoding, and the early phases of consolidation) have been well reported, yet the impact of emotion and amygdala activity on memory retrieval is hard to illustrate.

Collaborations between the amygdala and hippocampus are essential for the recovery of emotional memories. The hippocampus and amygdala are intensely interconnected (Pitkänen, 2000), and their collaboration in the encoding and combining of emotional memories has been well established (Packard & Cahill, 2001; Phelps, 2004). Seidenbecher, Laxmi, Stork, and Pape (2003) analyzed the functional network in mice conditioning of fear by recording neuronal activity from the amygdala and the hippocampus during the retrieval of fear memory. They discovered significant synchronization of action between the two structures during the presentation of the fear instigating cue (CS+ initially combined with stun) and during re exposure of the training setting. The amygdala and hippocampus likewise demonstrated proclaimed synchronization during the retrieval of both conditioned fear (through introduction to the first cue) and contextual fear (through exposure to the original testing environment), proposing that these structures collaborate in the retrieval of fear memories (Seidenbecher T, Laxmi TR, Stork O, Pape HC. 2003). The role of amygdale in emotional memory encoding gets further support by the functional neuroimaging studies of the human amygdala. Cahill, L., Haier ,R.J., Fallon, J., Alkire, M.T., Tang, C., Keator ,D., Wu, J., & McGaugh, J.L. (1996) reported that, the recollection benefits are greater when activity takes place in right amygdala while watching an


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emotional video. For instance, in a study by Dolcos, F., LaBar, K.S., &Cabeza, R. (2004) it was reported that during the successful encoding of emotional scenes, activation of amygdala and anterior hippocampus occurs simultaneously in context of later remembering. The amygdala and hippocampus co-enactment happens during emotional memory encoding which has been accounted by several researchers, (Canli, T., Zhao, Z., Brewer, J.B., Gabrieli, J.D.E., & Cahill, L. (2000); Dolcos, F., LaBar, K.S., &Cabeza, R. (2004);) and the degree of functional network involvement while learning could help in the prediction of strong (postponed) memory maintenance (Ritchey,M., Dolcos. F., & Cabeza, R. 2008). Behavioral and neuroimaging findings together show the effects of emotional arousal on memory formation which includes collaboration between the amygdale and medial temporal lobe, with the additional involvement of focal and peripheral neuro-hormonal structures.

Various related findings have proposed that emotion will facilitate cue saliency, as studies have demonstrated that emotional targets are, a) recognized quicker than neutral targets (Öhman, Flykt, & Esteves, 2001), b) improvises visual processing (Phelps, Ling, & Carrasco, 2006), and also c) recollection of emotional materials are found be higher in accuracy compared to neutral materials (Buchanan & Adolphs, 2004; Cahill & McGaugh, 1995). Conway, M. A., Anderson, S. J., Larsen, S., Donnely, C. M., McDaniel, M. A., McClelland, A. G. R., et al. (1994)examined autobiographical memory and discovered that people are more inclined to recollect those events that were sentimental in nature. Therefore it can be concluded that emotions are not uni-dimensional, in fact they have been measured along two separate dimensions: Arousal (magnitude and intensity of emotion) and Valence (the degree being from positive to negative (Labar & Cabeza, 2006; Lang, Greenwald, Bradley, & Hamm, 1993). Research evidences suggest the arousal and valence, as dimensions of emotion, have distinctive information encoding. Kensinger (2004) has reported that even the low arousal cues with either positive or negative emotional valence gives better consequence of retention when contrasted with neutral events. He additionally reported that this improvement may not rely on upon amygdala activation. Kensinger & Corkin (2003), reported the existence of dissociable components for encoding of emotional stimuli across valence and arousal. Negative words with high arousal level show greater activity in amygdala compared to neutral words. Also, negative


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words with lower arousal were found to enhance memory encoding and activate hippocampus and a posterior region of the lateral inferior prefrontal cortex. Consequently, distinctive cognitive and neural impacts help in the development of emotional memories which relies on upon the involvement of arousal and valence quality and direction.

It has been well documented in the studies of memory that even the emotional tone of a word has been found to be related to how well one remembers it; stimuli with strong valence are recalled more frequently than neutral stimuli. This better memory for emotional stimuli has been termed the emotionally enhanced memory effect (Denburg, Buchanan, Tranel, &Adolphs, 2003; Talmi, Schimmack, Paterson &Moscovitch, 2007). Emotional cues can benefit spontaneous-retrieval processes. Previous research has shown that salient or distinctive PM cues lead to above avergae PM performance (Brandimonte & Passolunghi, 1994; Cherry, K. E., Martin, R. C., Simmons-D'Gerolamo, S. S., Pinkston, J. B., Griffing, A., & Gouvier, W. D. (2001);), and that this high performance can occur with no evidence of monitoring (Harrison & Einstein, 2010). If emotion operates to boost the saliency of PM targets, one would expect that emotion, like other cue manipulations (e.g., perceptual distinctiveness), would reduce the demand for deliberate monitoring and stimulate retrieval via spontaneous-retrieval processes. If this were the case, the benefits of emotional prospective memory cues should be accompanied by no increases in monitoring, and perhaps by decreases. These views have been difficult to evaluate in previous research because no previous work on PM and emotion has examined the consequences of emotional PM cues on monitoring.

In a study, Clark-Foos, A., Brewer, G.A., Marsh, R.L., Meeks, J. T., & Cook, G.I. (2009) used neutral cues embedded in either neutral or emotional contexts. Participants in the study read sentences (e.g., "Those who got diarrhea had eaten oysters") and were instructed to press a key whenever they encountered a food item ("oysters"). The results from this study showed that neutral PM cues embedded in neutral contexts were detected more often than neutral PM cues embedded in emotional contexts. Because emotion was associated with the context (e.g., "diarrhea") rather than with the PM cue ("oysters"), it was not possible to determine the influence of emotion on cue saliency. Furthermore, related research has demonstrated that emotion heightens memory for central or intrinsic features of a stimulus or event but impairs


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memory for peripheral or extrinsic features (Christianson, 1992; Christianson, Loftus, Hoffman, & Loftus, 1991; Heuer & Reisberg, 1990; Kensinger, 2007; Kensinger, Garoff-Eaton, & Schacter, 2007; Loftus, 1979) for example, people who view a picture of a snake in the forest show strong memory for the snake itself, but not for its surroundings, presumably because attention is devoted to the snake at a cost to the surrounding context. Thus, it is not surprising that neutral targets embedded in emotional contexts led to poorer PM, as attention was likely diverted from the neutral items to the emotional context. Some evidence has spoken more directly to the prospect that performance is better for emotional than for neutral cues in event-based PM tasks (Altgassen, M.,Philips, L., Henry, J., Rendell, P., &Kliegel, M. (2010); Rendell, P.G., Phillips, L.H., Henry, J.D., Brumby-Rendell, T., Piedad Garcia, X., Altgassen , M., &Kliegel, M (2011). Altgassen et al (2010) demonstrated better PM for emotional than for neutral PM targets, although this finding was reliable for older but not younger adults. In addition, Rendell et al. (2011) found significantly better PM for positive than for neutral cues for both younger and older adults, but the difference between negative and neutral cues was not reliable. Both studies indeed suggested that emotional PM cues may be more salient than neutral cues, at least under some circumstances, but the methodologies across these studies limited any strong conclusions that could be drawn about PM and emotion. For example, only four stimuli (two positive and two negative) were used to assess the influence of emotion on performance in the former study. Furthermore, in both the studies, the emotional PM cues were no more arousing than the neutral PM cues. As arousal plays a key role in the impact of emotion on cognitive performance (Ochsner, 2000; Reisberg, Heuer, MacLean, & O'Shaughnessy, 1988; Thomas &LaBar, 2005), the use of non-arousing emotional cues in those studies may have resulted in a smaller effect of emotion on prospective memory. Thus, although these results were suggestive that further research is necessary before we can conclude with confidence that emotional cues benefit PM. There are three previous studies that inspected the effect of valence on prospective memory tasks. The effect of cue valence and age on prospective memory performance was examined by Altgassen, Phillips, Henry, Rendell and Kliegel (2010). In the study positive, negative, or neutral pictures were presented and participants were asked to recollect if the picture was presented stimulus beforehand. The prospective memory task was to remember to push a key when one of 6 (2 positive, 2 negative, 2 neutral) pictures occurred. It


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was found that prospective memory performance was better for positive or negative than for the neutral pictures. Another study on prospective memory and cue valence involved a color-matching task where participants pointed out whether the color of a random word matched the color of previously displayed squares. The PM task was to remember to press the space bar if certain target words appeared. Results showed no significant effect of valence for younger adults but a stronger effect of positive valence words for older adults (Schnitzspahn, Horn, Bayen, & Kliegel, 2012). Another classic study on prospective memory and cue valence was conducted by Rendell et.al. (2011) where participants played a virtual game meant to mirror execution of daily tasks in real life. The prospective memory task included carrying out specified daily tasks that had a positive, negative or neutral valence (Rendell et al., 2011). Findings of the study indicated that only positive valence tasks lead to better prospective memory performance than neutral task. No significant difference between neutral and negative task performance was observed.

The elementary principle behind these prospective memory studies on cue valence is that emotionally charged stimuli are more distinct than neutral stimuli, and distinct stimuli promote spontaneous retrieval, or automatic recovery of prospective memory intentions. Both perceptual and semantic distinctiveness were manipulated in the previous studies of distinctiveness in the prospective memory literature. For example, one study on perceptual distinctiveness demonstrated members in the non-distinct cue condition were presented all stimuli (counting the PM target) in lowercase content, while the participants in distinct cue condition were presented all stimuli in lowercase with the exception of the PM target which was in uppercase content. The result of the study revealed that with all other stimuli displayed in lowercase text, an uppercase (distinct) target word led to better PM performance than a lowercase target word (Einstein, Harrison, Mullet, Addington, & Ousterhout, 2011). It is believed that emotional PM cues can improve PM retrievals either by encouraging monitoring or by enhancing spontaneous-retrieval processes. For example, to the extent that emotional cues are highly salient and arousing, they could foster greater interest and focus on the PM task and increase monitoring (McDaniel & Einstein, 1993). That’s why better prospective memory performance is expected from cues with a strong valence if they are more distinct than neutral ones. The present thesis seeks to confirm existing findings through a typical prospective memory paradigm. Two different stimuli type


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will be included to further expand the existing research on valence in order to determine if emotionally laden words or pictures produce different behavioral pattern.

**2.10 Prospective Memory and Stimuli Type**

One significant issue in cognitive psychology is concerned with the storage and accessibility of conceptual representations of objects in response to both pictures and words in the human brain. Two classes of models have been proposed to study stimulus modality, dual framework model affirms that the visual and verbal data modalities have separate representation (Paivio, 1986; 1991) whereas a single semantic framework model recommends that all processing routes merge on a single arrangement of conceptual representations (Caramazza, Hillis, Rapp & Romani, 1990). The two speculations give diverse expectations about the results that ought to be acquired when one looks at picture and word processing and searches for communications between them. A lot of information has been accumulated from behavioral investigations of both ordinary and neuropsychological participants (Job & Tenconi, 2002; Cooper-Pye & Leadbetter, 2006). Prevailing studies in this area have used pictures to display effects from differential processing in category specific effects of modalities. Results of few studies strongly recommend that category-specific deficits effect modality specific structures but the result of these studies are found to contradict each other. Farah, McMullen & Meyer, 1991 have found that category specific effects might just be exhibit in the picture processing, others demonstrated that they can be additionally specifically seen in the word modality (McCarthy & Warrington, 1988).

The beneficial effects of pictures over words have been well established for retrospective memory but only handfuls of studies are available for showing the same effect in the area of prospective memory. Understanding if pictures lead to better prospective memory than words has the theoretical benefit of increasing our understanding of what particular factors lead to spontaneous retrieval and the practical benefit of informing the design of memory aids. Nicole Fink (2013) examined if there are differences in ongoing task and prospective memory task performance between age groups (old and young) and under different loads of attention (non-divided and divided). Results of the study demonstrated that a picture superiority effect does


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exist for prospective memory tasks. Participants who were exposed to picture stimuli performed better than those who were presented with word stimuli. In another study (Emmanuelle. V.,Gil Gonen-Yaacovi. G, Costello.A.L.,Gilbert. S.J, and Burgess.P., 2011) patients with lesion in their pre frontal cortex were examined to determine regions that are necessary for prospective memory performance, using the human lesion approach. In their study they used both word and picture stimuli and found same region to be involved using both words and pictures, suggesting that right rostral PFC plays a material nonspecific role in prospective memory. There are contrasting result found with effect of words and pictures in prospective memory, so studying this aspect of cue becomes important to generalize the results of retrospective memory on prospective memory for which more studies are required to be conducted in in same line of research. Pictures are believed to be more salient to activate emotional responses (Carr, McCauley, Sperber, &Parmlee, 1982). In this light, for pictures, the effect of emotion might be in evidence immediately and might be evoked relatively automatically, whereas activation of emotional responses for word stimuli may require more in depth and controlled processing. So in the present thesis we compared the two different stimuli type (words and the pictures) and measured its effect on prospective memory by manipulating the cue presentation of the stimuli type.

Though stimulus type (pictures and words) can be one factor to distinguish performance on the level of retrieval, but the way of presenting stimuli can also determine the processing of stimuli and memory performance. A stimuli can be presented in direct or indirect ways which is termed as explicit or implicit presentation respectively but to specify implicit presentation is difficult as we might run into controversies related to subliminal presentations, so for avoiding complications of terminology altogether, we have presented our stimuli in direct and indirect mode to examine whether both these presentation mode brings change in prospective memory performance.

**2.11 Prospective Memory and Presentation Mode**

Classification of memory tasks as direct or indirect mode dependent is identical to a classification based on distinction between explicit and implicit measures of memory (Graf & Schacter, 1985; Schacter, 1987). We prefer memory task distinction as direct and indirect


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because the explicit/implicit terminology is potentially very misleading (Dunn & Kirsner, 1989; Reingold & Merikle, 1990; Richardson-Klavehn & Bjork, 1988). Specifically, the terms implicit and explicit have been used to classify both memory processes and memory tasks. The dual meaning of the terms has blurred the distinction between theoretical constructs and empirical measures. On the other hand, the direct/indirect distinction is based solely on task instructions and does not require any speculation as to either underlying memory processes or possible phenomenal experiences (e.g., awareness, intentionality) correlated with the different types of tasks. It is precisely for this reason that many researchers (Hintzman, 1990; Reingold & Merikle, 1990; Richardson-Klavehn & Bjork, 1988) have suggested that the use of terms direct and indirect rather than explicit / implicit are better labels for these two classes of memory tasks. We follow the above suggestions in the present thesis because the environment for stimuli with high informational value is pre-attentively monitored and is followed by the implicit processes and hence has a beneficial value. Threat-related and reward- or safety-related cues are perhaps one of the most important classes of stimuli to monitor. Research in the field of lie detection indicates that personally significant information may be implicitly processed. In one such demonstration, participants enacted mock crime scenarios and were later given the task of distinguishing between two arbitrary, experimenter-defined classes of stimuli (Farwell & Donchin, 1991). Embedded within the stimuli were items related to participants' "crime." Event-related brain potential (ERP) responses differentiated crime related and crime-irrelevant material, suggesting that even though participants were performing an unrelated classification task, they were nevertheless implicitly processing stimuli in terms of its relation to their guilt (Rosenfeld, Agnell, Johnson, &Qian, 1991).

Existing research contains a range of evidence suggesting that items in our environment can be implicitly evaluated (Murphy &Zajonc, 1993; Niedenthal, 1990; Pratto& John, 1991).Research in cognitive psychology (Balota, 1983; Marcel, 1983), suggests that implicit perception of meaningful verbal stimuli influences ongoing perceptual and cognitive processes. Affective reactions can also be influenced by nonverbal cues. A classic example of nonverbal affective information is facial expression of emotion. Facial expression of emotion is one of the most powerful, and least ambiguous, types of nonverbal affective information (Izard,


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1977).However, the meaning of facial expressions have considerable cross cultural agreement (Ekman, P., Friesen, W. V., O'Sullivan, M., Chan, A., Diacoyanni-Tarlatzis, I., Heider, K., . . . Tzavaras, A, 1987). Infants possess a well-developed capacity to discriminate among emotional expressions (Schwartz, Izard, & Ansul, 1985). Therefore, the claim that individuals are extremely efficient at processing human faces has been reliably supported by the research findings (Homa, Haver, & Schwartz, 1976), and also that they are particularly skilled at processing faces expressing emotion (Hansen & Hansen, 1988).

Implicit perception of nonverbal affective information has not been distinctively considered by research, even though; some recent research has demonstrated implicit perception of the affective meaning of verbal information (Greenwald, A. G., Klinger, M. R., & Liu, T. J., 1989). A positive or negative word (prime) to subjects' non-dominant eye was presented by Greenwald and his colleagues. By the simultaneous presentation of a pattern mask to the dominant eye, the prime was rendered undetectable (this procedure is called simultaneous dichotic pattern masking).In this method participants were asked to report whether the target word referred to something good or something bad. Results indicated valence of the prime influenced the speed with which subjects could report the affective nature of the target word was. When prime and target were inconsistent in affective meaning, response latencies were significantly longer than when prime and target were affectively consistent. This suggests that the affective meaning of the prime had been implicitly perceived and that this processing interfered with the requirements of processing information of a different affective tone (Fazio, Powell, & Herr, 1983). Also using an autonomic measure, Kliegel, M., Guynn, M.J., Zimmer, H. (2007) found that skin-conductance responses were greater to cues that were undetected than those which were easily detectable for the ongoing task stimuli. Covert motor priming effects, which elicit smaller but faster electrophysiological responses compared with overt motor effects, are evoked using unconscious visual words (Dehaene, S., Naccache, L., Le Clec'H, G., Koechlin, E., Mueller, M., Dehaene-Lambertz, G., van de Moortele, P., Le Bihan, D. (1998).

In the present thesis, manipulation in presenting the emotional cue was done to investigate whether indirect cue presentation effect PM performance and produce better results. In relation to presentation of cue it has been observed that prospective memory positively


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correlates with performance embedded in implicit memory tasks like word-stem completion task (McDaniel and Einstein, 1993), which is an index of implicit memory function. In their study they have presented two views about how recollection of an intended action can take place without any explicit request to retrieve information's which serves as an interesting feature of prospective memory. The first view emphasize on deliberately searching for the cue that triggers the intention while the second view focus upon relying more on environmental cues with less monitoring and processing it more automatically. They also displayed information supporting both perspectives and contend that individuals use multiple approaches to deal with problems related to retrieval of intention after delay. In context of prospective memory it has also been found that salient explicit cues can fail to remind of the intention (Einstein, G., McDaniel, M., Smith, R., & Shaw, P, 1998). Instead, unconscious stimuli may be non-negligible (Tsushima, Y., Sasaki, Y., Watanabe, T., 2006) and accessible to the maintained intention. In their study Tsushima, Y., Sasaki, Y., Watanabe, T (2006) has shown considerable evidences that suggest that stimuli which are out of awareness can influence brain activity and effect behavioral performances. They found that a task-irrelevant sub-threshold coherent motion led to a stronger disturbance in task performance than did supra-threshold motion. With the sub-threshold motion, activity in the visual cortex measured by functional magnetic resonance imaging was higher, but activity in the lateral prefrontal cortex was lower, than with supra-threshold motion. These results suggest that subthreshold irrelevant signals are not subject to effective inhibitory control. In another study conducted by, Hashimoto, Umeda & Kojima (2011) it was reported that unconscious processing of stimuli can affect prospective memory performance. They used indirect/implicit cues to examine maintained intentions and found that implicit stimuli elicit weak but reliable effects both on behavior and neural activity, without awareness. Functional magnetic resonance imaging was used to examine the maintenance of intentions during an ongoing task involving implicit cues. Participants were required to detect target words while engaging in the ongoing task. Cues matched to the target category and cues matched to the action for targets were presented implicitly during the ongoing task. Implicit categorical target cues were found to enhance prospective memory performance, and implicit action cues accelerated responses more than irrelevant implicit cues in the prospective memory task. Although the results of the study clearly indicate that indirect processing influence prospective memory


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performances but still there are very few studies available to demonstrate effect of indirect cuing on prospective memory. Hence it becomes important to find out whether prospective memory can be enhanced by indirect cue presentation. The present thesis attempts to explore the difference of direct and indirect cueing on prospective memory and come up with some clear understanding of the factors that can enhance prospective remembering.

**2.12 Sleep**

Sleep is defined as a naturally repetitive state marked by changed consciousness, relatively subdued sensory activity, and inhibition of almost all voluntary muscles activity (Macmillan Dictionary for Students, 2009). There are two types of sleep documented in literatures: REM (rapid eye-movement) and NREM (non- rapid eye-movement). These two sleep types are further divided into stages depicting the relative depth of sleep. These stages are characterized by various features such as variations in brain wave patterns, muscle tone and eye movements.

**NREM and REM sleep Cycles**

The whole sleep cycle undergoes NREM and REM sleep alternatively. The sleep episode starts with stage 1 of NREM sleep continuing to stage 2 and then going through stage 3 and 4, ending up at REM sleep. This whole cycle is repeated throughout the night. Nocturnal sleep comprises of 75-80% NREM and 20-25% REM episodes. According to Carskadon (2005), the average length of the first NREM-REM sleep cycle is 70-100 minutes. The second, and later, cycles lasts for about 90-120 minutes. In normal adults, REM sleep increases as the night progresses and in the last one-third of the sleep episode, it is the longest.

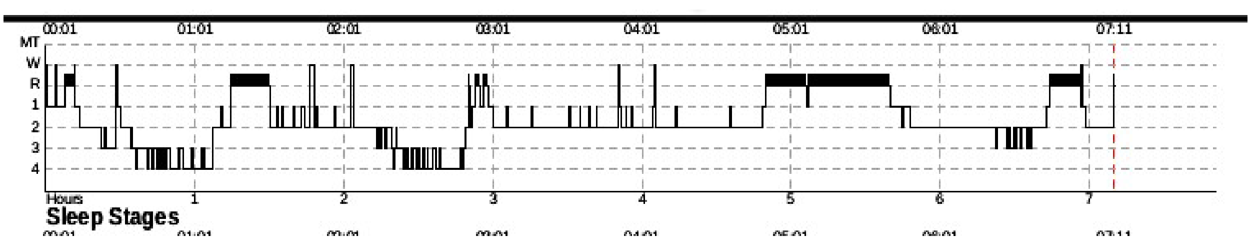


figure7. Represents sleep stages

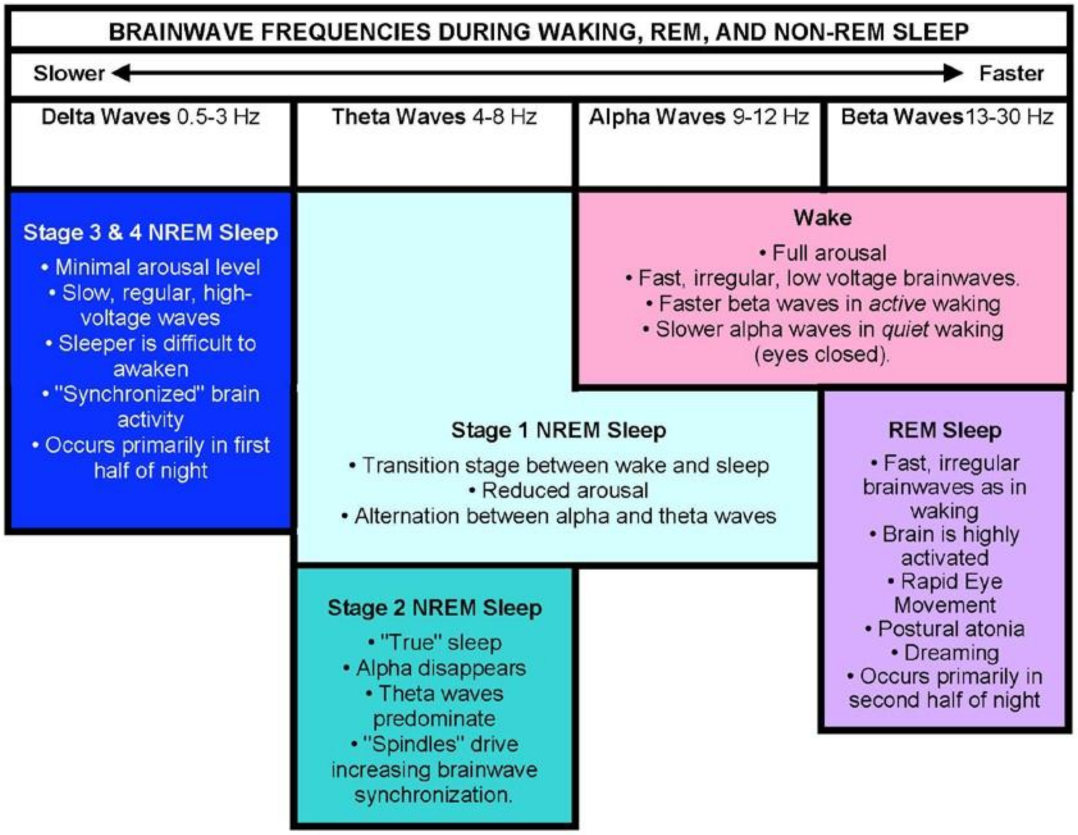


Figure8. Sleep stage specifications.

### 2.13. Sleep and Memory: A General Overview

Many recent studies reported the impacts of lack of sleep on declarative memory encoding. Harison& Horne (2000) explored the effects of 36hrs of sleep deprivation on a neuropsychological test of temporal memory. The task comprised color photographs of unknown faces and had two components: recognition memory (distinction between previously presented and novel faces), and recency discrimination (temporal memory: when a previously shown face was presented). The result of their study revealed that sleep deprivation impairs temporal memory (i.e.recency). Neuroimaging reports have also investigated the neural basis of these


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effects using similar periods of sleep deprivation. Drummond, S. P. A., Brown, G. G., Gillin, J. C., Stricker, J. L., Wong, E. C., & Buxton, R. B (2000) used functional magnetic resonance imaging to measure the effects of 35 hours of sleep deprivation on cerebral activation during verbal learning in normal young volunteers. They found prefrontal cortex (PFC) being more responsive after one night of sleep deprivation than after normal sleep. Although sleep deprivation significantly impaired free recall compared with the rested state, better free recall in sleep-deprived subjects was associated with greater parietal lobe activation. These findings show that there are dynamic, compensatory changes in cerebral activation during verbal learning after sleep deprivation and implicate the PFC and parietal lobes in this compensation.

Earlier examination of sleep and memory in humans was mostly dedicated to declarative learning tasks and therefore provided mixed conclusions. For example, significant increases in post training REMafter concentrated foreign language learning correlated highly with the degree of successful learning (De Koninck, J., Lorrain, D., Christ, G., Proulx, G., Coulombe, D 1989). This demonstrates that REM sleep is primary source for memory consolidation and that post training it helps to combat increased demands for such consolidation and maintains homeostasis. In other studies also similar results for sleep after learning a verbal memory task have been reported. In a recent study improvement on a word-pair task after appropriate sleep in context of time has been demonstrated and effect of modification in post training sleep rich in SWSwas also observed (Born, 2010).

The role of sleep in declarative memory consolidation rather than being absolute, might depend on more precise phases of the consolidation task, such as the degree of semantic association. Ellenbogen and colleagues (Ellenbogen, J. M., Hulbert, J. C., Stickgold, R., Dinges, D. F., Thompson-Schill, S. L. 2006a) have recently examined the extent of sleep's ability to protect declarative memories to reveal the effect of experimentally learned material. Subjects first learned unrelated word-paired associates using AB-AC paradigm and found influence of sleep on declarative memory. After a night filled sleep or awake during the day the participants were divided in two groups. Each group learned a new, interfering list containing a new associate paired with the first word, designated as list A-C before being tested on the original A-B list. In the other group participants were simply



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being trained and tested on list A-B. Results indicated a beneficial effect of sleep on memory recognition. However, in the group with interference list (list A-C), improvement on memory recognition was evident only when they were allowed to sleep. Thus, memories tested after a night of sleep were significantly more resistant to interference, whereas across a waking day, memories were far more susceptible to this antagonistic learning challenge. Although the true benefits of sleep was evident in the case where interference list was used—a similar benefit would not necessarily be evident in standard study-test memory paradigm.

Recent studies have explored more varied measures of memory, for example, it has been shown that REM sleep provides a brain state in which access to weak associations is selectively facilitated and in which flexible, creative processing of new information is enhanced (Stickgold, R., Scott, L., Rittenhouse, C., & Hobson, J. A., 1999; Walker, M. P., Brakefield, T., Morgan, A., Hobson, J. A., Stickgold, R, 2002).It has likewise been exhibited that sleep can promote insight the next morning in the case of problem solving tasks. It has been observed that in a numeric sequence problem solving task execution procedure of the problem improvised the next morning after a sleep filled night (Wagner, U., Gais, S., Haider, H., Verleger, R., and Born, J., 2004). Also a recent study revealed that sleep not only improvises the memories for items itself but also strengthens their association (Ellenbogen, J., Hu, P., Payne, J.D., Titone, D. & Walker, M.P.,2007) therefore, the main objective of sleep lies in not only enhancing the memory of single items but also to integrate them in a schema and encourage the methodology that structures the premise of summed up learning. Sleep-dependent plasticity is also measured by comparing patterns of brain activation before and after a night of sleep. This method aims to determine whether next-day learning improvements are associated with an overnight, sleep- dependent restructuring of the neural representation of the memory rather than just measure changes in functional activity during sleep. A recent fMRI study investigated the differences between patterns of brain activation before and after sleep using a sleep-dependent motor skill



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task (Walker, 2005). Result show that following a night of sleep, and relative to an equivalent intervening period of wake, increased activation in motor control structures of the right primary motor cortex and left cerebellum was observed. Medial prefrontal lobe and hippocampus structures are recently identified as supporting improved sequencing of motor movements. On the contrary, decreased performance by post sleep activity was identified bilaterally in the parietal cortices that indicate a reduced need for conscious spatial monitoring as a result of improved task automation. Also regions of signal decrease throughout the limbic system were observed indicating a decreased emotional task burden. Together these findings propose that sleep related motor learning is connected with an expansive scale plastic revamping of memory all through various brain region, allowing skilled motor movements to be executed more rapidly, more precisely, and more consequently after sleep. In sensory perceptual system too, overnight reorganization of memory has comparably been evinced using the sleep dependent visual discrimination task (Walker, 2005). Significantly greater activation was found in the areas of primary visual cortex corresponding to the visual target location after a sleep period. Several other regions of increased post sleep activity were also observed, however both the ventral object recognition and dorsal object location pathways show corresponding decreases in the right temporal pole, a region involved in emotional visual processing. Therefore a sleep filled night not only modulates the representation of visual memories but also enhances the identification of both the stimulus form and its location in space.

It has been reported across a range of phylogeny that sleep after learning helps in successive memory consolidation (Walker & Stickgold, 2004, 2006). Studies on animal models support that sleep plays role in the consolidation of both circumstantial fear and shock avoidance tasks which is dependent on intact hippocampal function (Smith, 1985; Walker &Stickgold, 2004). Alterations in sleep-stage characteristics are triggered by daytime training of the tasks, especially in REM sleep (Ambrosini, M. V., Mariucci, G., Colarieti, L., Bruschelli, G., Carobi, C., &Giuditta, A.,1993) which probably reflects homeostatic demands of the REM sleep-dependent mechanisms of consolidation. Alternatively, disruption of consolidation and impairment



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in next day memory retention is reported if sleep deprivation takes place after learning of tasks (Smith, 1985; Walker & Stickgold, 2004). Furthermore, these effects are

apparent following selective REM sleep deprivation, rather than total sleep deprivation (Beaulieu & Godbout, 2000).Interestingly, the important factor is the time at which sleep deprivation occurs. For example, Graves, L. A., Heller, E. A., Pack, A. I., Abel, T. (2003) have reported that sleep deprivation of 0–5 hour post-training selectively impairs consolidation of contextual fear conditioning compared to a post 24 hour retest. These outcomes put forward that the consolidation of memory occurs soon after learning, possibly during subtle brain-state time windows. In case of humans, sleeps plays role in declarative memory consolidation. Instead of being absolute, here the information being learned depends on more intricate aspects like novelty, meaning to extract, and also the affective salience of the material. There are many evidences signifying that emotions experienced by humans are better remembered than neutral ones (Cahill, 2000; McGaugh, 2004; Phelps, 2004). This clarifies the possible influence of sleep in episodic memory processing.

In general, long-term memory consolidation is seemed to involve interactions among multiple brain systems, which are modulated by assorted neurotransmitters and neuro-hormones. It has been proposed that the characteristics of dreams can be best understood when the context of this neuro-modulatory impact on the brain systems is involved in memory consolidation. The hypothesis which suggests that increased learning is proportional to increased memory consolidation and hence requiring more REM sleep time, is the basis of the idea that REM sleep duration should increase with learning. Smith (Smith, 1985, 1986) has closely examined the issue of REM sleep increase after learning. Immediate increase in REM sleep after training was seen in some experiments. It was seen in some cases that increase in REM sleep occurs more frequently with some delay, when training was given for 36 hours or more. The increase of REM sleep was seen from 1 to 4 hours, 9 to 12 hours, and 21 to 24 hours after training, in one of the avoidance task, but was not observed at other times. More than 15 days “REM sleep window” was said to have lasted more than 15 days, in some of the other studies. Studies were also conducted on humans to examine the REM sleep enhancement. Sleep recordings of students after a rigorous exam period exhibited no variation in REM sleep time but instead an increase in



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density of REM sleep eye movements. These finding were in contrast with that of the increased REM sleep time in most learning studies on rats (Smith, 1985). In recent years there has been a resurgence of interest in the effect of sleep on memory. Interestingly, the idea that sleep could benefit memory is millennia old and the history of recorded sleep-related memory benefits is as old as the empirical study of memory. In his seminal study, Ebbinghaus (1885) observed a reduction in forgetting from 9 hrs to 24 hrs (2.1%), which can be compared to the forgetting rate from 1 hr to 9 hrs (8.4%) and from 24 hrs to 48 hrs (6.1%). The reduced forgetting rate was observed during an interval that included the first night of sleep following learning, In a classic study, Jenkins and Dallenbach (1924) examined memory for nonsense syllables across sleep and wake retention intervals of 1 to 8 hrs. Not only was recall greater following sleep delays (59%) than wake delays (26%), but recall was actually better following an 8-hr sleep delay (56.5%) than a 1-hr wake delay (46%). These results led Jenkins and Dallenbach(1924) to conclude that sleep serves to protect against "the interference, inhibition, or obliteration of the old by the new". In other words, sleep (passively) protects against retroactive interference (Wixted, 2004). Another general account for sleep-related memory benefits contends that memories are reactivated and restructured during sleep, and thereby (actively) consolidated (Mograss, Guillem, & Godbout, 2008; Rasch, Buchel, Gais, & Born, 2007; Sejnowski & Destexhe, 2000). It has been demonstrated that memories can be selectively reactivated during sleep and therefore enhanced. Participants learned a visuo spatial object-location task (the game "Concentration") that involved recalling the location of card pairs following a sleep or wake interval. Importantly, during learning, a rose scent (or an odorless control) was repeatedly presented and participants were re-exposed to the rose scent (or control) while they slept. Performance on the memory task following sleep demonstrated that memory was enhanced when the rose scent (relative to the odorless control) was presented both during learning and sleep (specifically, the slow-wave-sleep). In contrast, no memory enhancement was observed if the rose scent was presented at learning and again during a wake interval. In addition, functional magnetic resonance imaging (fMRI), demonstrated that rose scent re-exposure led to greater hippocampal area activation (an area that is critical to memory encoding and retrieval) during sleep than while awake (Rasch, B., Buchel, C., Gais, S., &



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Born, J., 2007). Thus, behavioral and neurophysiological evidence powerfully demonstrated that, beyond simply protecting against retroactive interference (Jenkins & Dallenbach, 1924; Wixted, 2004), sleep might also enhance memory by reactivating and strengthening associative links. In addition to Rasch et al.'s (2007) evidence for sleep-dependent memory consolidation, other researchers have demonstrated that sleep preferentially benefits associative memory (Barrett & Ekstrand, 1972; Fowler, Sullivan, & Ekstrand, 1973; Talamani, Nieuwenhuis, Takashima, & Jensen, 2008; Yaroush, Sullivan, & Ekstrand, 1971). More specifically, sleep has been demonstrated to cause weak associations to become stronger (Diekelmann, S., Wilhelm, I. & Born, J., 2009) and memory representations to become more elaborated (Mograss, M. A., Guillem, F., & Godbout, R., 2008; Charlton & Andras, 2009). Stickgold, Scott, Rittenhouse, and Hobson (1999) gave participants a semantic priming task that consisted of weak and strong primes before and after sleep. Their results demonstrated that weak primes led to more priming than even strong primes following a sleep interval (that contained dreaming). The effect of sleep on weak associations has also been observed in cued recall and recognition memory tasks. Using an A-B, A-C paired associate learning paradigm. Drosopoulos, Schulze, Fischer, and Born (2007) demonstrated a sleep-related benefit for the A-B list over the A-C list. The authors reasoned that, even though learning the second list (A-C) initially weakened the associative strength of first list pairs (A-B) (via retroactive interference), sleep re-strengthened these weak associations. Mograss, M. A., Guillem, F., & Godbout, R. (2008) examined event-related potentials to provide converging evidence that sleep affects the structure of a memory via strengthening associative links. In their recognition memory study, they examined the medial-temporal-lobe generated late-positive- component (LPC) effects on old items (compared to new items) in sleep and wake conditions.

### 2.14. Sleep and Emotional Memory

The impact of sleep deprivation on declarative memory encoding of both emotional and non-emotional material were studied in a recent study where 10 individuals were subjected either to sleep deprivation for 36 hours or permitted to sleep normally before learning sets of emotionally negative, positive, and neutral words. Overall, 40% reduction in memory retention



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was shown by subjects who had the sleep deprivation relative to subjects who had slept normally prior to encoding—outcomes that represent a remarkable weakening of declarative memory formation under conditions of sleep deprivation. These data were separated into the three emotional categories (positive, negative, or neutral).

Recent data on pre-learning sleep in human episodic memories agrees well with earlier sleep dependent memory data on post learning sleep. Few of the initial studies on sleep deprivation and human memory encoding focusing on neutral forms of learning indicated that temporal memory (memory for when events occur) was significantly disrupted due to a night of sleep deprivation prior to pre training (Harrison & Horne, 2000; Morris, Williams, & Lubin, 1960). The role of pre-training sleep for the formation of emotional and neutral memories has been investigated more recently (Walker, M. P., &Tharani, A., 2009). A learning session composed of emotionally negative, positive and neutral words was preceded either by sleep deprivation of 36 hrs or a normal sleep to the subjects. Latter the subjects were tested after two nights of sleep for recovery in both groups and recollection was tested. A 40% decrease in memory encoding was observed in subjects who were sleep deprived as compared to those who had slept normally prior to learning (the results were averaged across all memory categories). In contrast, both positive and negative stimuli showed better retention levels as compared to the neutral condition and selective dissociation became apparent when these data were separated in to the emotional categories. A significant decrease in encoding and retention was observed for



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neutral and more importantly positive emotional memories as compared to the control condition when subjects were sleep deprived. Memory related to the negative emotions showed resistance to sleep deprivation as impairment of retrieval was small and insignificant.

Many reports describe decrease in forgetting of emotional information as compared to neutral which may appear to persist and also improve when containing a night of sleep (Kleinsmith& Kaplan, 1963; LaBar& Phelps, 1998; Levonian, 1972; Sharot& Phelps, 2004; Walker & Tarte, 1963). Others have directly studied the time duration of sleep which preferentially modulates these effects. Now the researches are being focused to examine a selective REM sleep-dependent hypothesis of affective human memory consolidation based on the equivalent neurophysiology, where the REM sleep offers the neurobiological necessities of emotional memory processing (Cahill, 2000;McGaugh, 2004). Hu, Stylos-Allen, & Walker, 2006 studied the comparison between the consolidation of emotionally arousing and non-arousing picture-stimuli which were followed by a period of 12 hrs across a day / night of sleep. Benefit of emotional memory which followed sleep was observed but not across an equivalent time awake. It has been examined by Atienza and Cantero that impairment of emotional as well as neutral visual stimuli takes place due to total sleep deprivation on one week later retention task (Atienza & Cantero, 2008). Surprisingly, the difference reported for neutral was more as compared to emotional items. Such a difference may emphasize on emotional items being more resistant to the impact of sleep deprivation at first night than successive post-deprivation recovery sleep which is more accomplished of recovering consolidation of emotional as compared to neutral memories. It has been shown in study of Wagner and colleagues (Wagner, Gais, & Born, 2001) that sleep is only beneficial for retention of previously learned emotional texts comparative to neutral texts, depending upon time period of sleep (a time period rich in REM sleep). Similar type of result was found in continuation study performed after four years describing the effect of REM sleep on affective stimuli (Wagner, U., Hallschmid, M., Rasch, B., & Born, J. 2006). In another study significant improvement was revealed in distinguishing emotional face expressions presented prior to sleep and this benefit was positively correlated with the amount of prevailing REM sleep (Wagner, Kashyap, Diekelmann, & Born, 2007).



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Sleep has been known to target the consolidation of definite aspects of emotional experiences and to facilitate the elimination of human fear memories. Payne, Stickgold, Swanberg, & Kensinger, 2008 have confirmed that sleep can target the establishment of negative emotional objects in a scene, but not the peripheral background by experimentally changing the foreground and background elements of emotional picture stimuli. In contrast, awakening till the same time period didn't make any differences to emotional object memory (or the background scene). These results indicate that sleep-dependent processing can selectively distinguish episodic experience into component parts, specially consolidating the memories with affective salience. Using a conditioning paradigm in humans Pace-Schott and colleagues investigated the impacts of sleep and wake on fear extinction and its generalization (Pace-Schott, E. F., Milad, M. R., Orr, S. P., Rauch, S. L., Stickgold, R., Pitman, R. K., 2009). In their study fear conditioning was done for two different stimuli and was followed by targeted extinction of any one of the stimuli. The participants were then categorized in two groups for further testing: in one group participants were given 12hrs of wake at night while in the other group participants slept for 12hrs. Generalization of extinction from the target stimuli to the non-targeted stimuli occurred in the condition where 12hrs of sleep was given but the results were not same in wake condition. Hence, sleep is known not just for balancing the learned emotional relationship between two stimuli, it likewise effectively generalizes the associational values across related contexts. In a recent study it has been reported that according to neurophysiology of REM sleep the association benefit could be speculated using nap paradigm (Nishida, Pearsall, Buckner, & Walker, 2009). In the study participants performed in two sessions in which they learned emotional and neutral items respectively before they administered a recognition test. The learning sessions were given before 15min and before 4hrs after which participants were given nap for 90mins. The other group of participants remained awake for the same time period. Hence, things from the initial (4hrs) study sessions transitioned through diverse mind states in each group before testing, containing sleep in the Nap group and no sleep in the No-Nap group. There was no change found in no nap group for emotional as well, as neutral items, whereas in the nap group participants shown an enhancement in their performance for both emotional and neutral stimuli with the degree that was related with the measure of REM sleep, and depending upon the latency of REM



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sleep. The spectral analysis of the EEG demonstrated that the magnitude of right-dominant

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prefrontal theta power during REM sleep (activity in the frequency range of 4.0–7.0 Hz) which exhibited a significant and positive relationship with the amount of emotional memory improvement

These findings demonstrate that sleep plays a beneficial role in enhancing emotional memory and suggests that both the quality and the quantity of REM sleep is positively associated with improvement of emotional memory. Because of its unique biology, REM sleep represents a brain-state particularly amenable to emotional memory consolidation and that had already been hypothesized in previous studies verifying its correlation with emotional memory (Hu, P., Stylos-Allen, M., & Walker, M. P. 2006; Walker, 2009). It has also been evinced that the neurochemical levels of limbic and forebrain acetylcholine are extraordinarily raised during REM sleep (Vazquez &Baghdoyan, 2001), supposedly four-fold during NREM and two-fold in calm waking (Marrosu, F., Portas, C., Mascia, M. S., Casu, M. A., Fa, M., Giagheddu, M., et al. 1995). Considering the known significance of acetylcholine in the long term consolidation of emotional learning (McGaugh, 2004), the pro-cholinergic REM sleep state may advance the specific effect of emotional memory similar to the effect of acetylcholine while using experimental manipulations (Power, 2004). Neuro-physiologically, theta oscillations have been proposed as a carrier frequency, allowing disparate brain regions that initially encode information to selectively interact offline, in a coupled relationship. By doing so, REM sleep theta may afford the ability to strengthen distributed aspects of specific memory representations across related but different anatomical networks (Buzsaki, 2002; Jones & Wilson, 2005).

These outcomes exhibit that brain state containing sleep, particularly REM sleep, may offer a neurobiological state that is particularly appropriate for the enhancement of emotional processing. It ought to be noted, on the other hand, that most of the studies have primarily utilized negative and stimulating emotional stimuli. In future studies positive stimuli can be used to measure the distinctive arousal extents in such ideal models, offering an undeniably refined comprehension of the collaboration between valence asymmetry and sleep dependent emotional memory



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## 2.15. Sleep & Prospective Memory:

Researches done on prospective memory revealed many factors that affect the retrieval of prospective memory intention. Out of all the factors which affect prospective memory, the most studied factor is the retention interval between the formation of the intention and the time when it has to be carried out (Hicks, J. L., Marsh, R. L., & Russell, E. J., 2000). It was reported in a study that an event based intention was carried out with help of environmental cue, and the prospective memory was found to be improve over a delay of 15 min than when the delay was of 3 min (Einstein & McDaniel 1990). It proves that when the time duration between the intention and action has longer delay the traces of the intention gets strengthen and the goal is retrieved more frequently. In this manner, the prospective memory execution is connected to the objective rehearsal and the processing of related cues (Hicks, J. L., Marsh, R. L., & Russell, E. J., 2000). This process of goal as well as cue rehearsal could be hampered during sleep as this is done while being in the state of awareness which is not possible during sleep, while during wake it becomes easy to rehearse the cue and the goal for completion of any intended action. On the other hand, it has also been stated that sleep actuates memory consolidation (Diekelmann& Born 2009). To demonstrate the role of sleep in prospective memory a recent study by Scullin and McDaniel (2010) exhibited a positive impact of sleep on intention execution in a prospective memory task. In the study participants completed a prospective memory task after a short defer (20 min), a 12-h wake deferral, or a 12-h sleep delay. A very simple event based task was administered where participants were instructed to press a specific key when they saw a cue that will appear in between the ongoing task. The performance of the participants were found to be impaired after awake delay of 12 hours and clear benefits of sleep was visible as participants performed much better in sleep condition compared to wake as well as short delay of 20 min. The results show direct evidence of sleep promoting event based prospective memory in accord with general thought that sleep advances memory consolidation (Diekelmann & Born 2009). Scullin and McDaniel (2010) have reported positive sleep effect on prospective memory, beyond the well-documented sleep effect on retrospective memory. The only drawback of the study was that Scullin and McDaniel (2010) did not report any quantitative and/or qualitative data about the sleep of participants in the study. Therefore, it is obscure whether the intention execution is



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identified with sleep amount, or to sleep quality, or to both quantitative and qualitative effects of sleep.

A study by Grundgeiger, Bayen& Horn (2014) investigated the impact of sleep deprivation (25 hours of sleep deprivation vs. no sleep deprivation) on prospective-memory performance in more resource-demanding and less resource-demanding prospective-memory tasks. The result of the study revealed impairment in performance after sleep deprivation with a more resource-demanding prospective-memory task. According to the researchers the results support the view that sleep deprivation affects cognition more globally and demonstrate that sleep deprivation increases failures to carry out intended actions, which may have severe consequences in safety-critical situations. Another study on sleep and prospective memory investigated the relationship between sleep and prospective memory, comparing the performance of "good" and "bad" sleepers in a naturalistic prospective memory task (to remember to press the event-marker button of acti-graph at wake-up time). The "good" and "bad" sleepers were defined according to following sleep parameters: Sleep Onset Latency(SOL), Total Sleep Time (TST), Wake After Sleep Onset (WASO), Sleep Efficiency (SE), and Number of Awakenings (NA > 5). The results showed that the good sleepers performed the prospective memory task better than the bad sleepers. Specifically, the performance of prospective memory task at wake-up time was influenced by the quantity (TST) and the quality (WASO, SE%, and NA > 5) of the sleep (Fabbri,M., Tonetti,L., Martoni, M., &Natale,V.,2013).

According to Diekelmann & Born(2013) sleep improves the ability to execute intended actions after a delay of two days; and this improvement specifically depends on slow wave sleep rather than rapid eye movement (REM) sleep. Sleep thereby enhances both components of prospective memory, (i) to remember that something has to be done and (ii) to remember what has to be done. Moreover, the facilitative effect of sleep on prospective memory is particularly evident under conditions of reduced attentional resources at retrieval, suggesting that sleep favors the additional recruitment of spontaneous-associative retrieval processes. Together, these findings indicate that sleep-dependent consolidation processes strengthen intentional memory representations that support spontaneous-associative retrieval processes to remember the



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intention at the appropriate time. There have been very few studies done on sleep and its effect

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on prospective memory with their own limitations. Our effort in the present thesis is to explore the effect of emotional valence across two different patterns of cue presentation and stimuli type on event cued prospective memory during sleep and wake conditions.

From the review of literature on prospective memory and the various factors which affect it as well as its outcome, the following research questions were framed and the present research attempted to answer them -

1. Whether valence of stimuli as cue characteristic feature has any effect on prospective memory?
2. Do emotion effects all three types (event, time and activity) of prospective memory performance?
3. Whether positive and negative affect cue have differential effect on event cued prospective memory performance?
4. What is the effect of manipulating cue presentation style (direct/indirect) on prospective memory performance?
5. Do types of emotional stimuli (words/ pictures) effect prospective memory differently?
6. Whether emotional valence of different stimuli across presentation mode has significant effect on prospective memory?
7. Whether sleep filled retention interval modulates event cued prospective memory?
8. a) Does cue valence (positive/ negative) have differential impact on prospective memory across sleep and sleep deprivation condition?

b) Whether sleep modulates cue retrieval for emotional valence cues presented under direct/indirect presentation mode.

9. a) Whether sleep modulates cue retrieval for emotional valence cue as a function of stimuli type?



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b) Whether cue valence, stimuli type and presentation mode as a function of cue characteristics differentially modulates prospective memory performance across sleep/sleep deprivation?

**2.16. Rationale of the Thesis:**

The rationale for the present research can be found in the unexamined questions that emerged out of the literature review. As prospective memory is new and a growing field of research, there are several process (encoding and retrieval) related variables that needs examination.

- Failures of prospective memory typically occur when we form an intention to do something later, become engaged with various other tasks, and lose focus on the thing we originally intended to do. Despite the name, prospective memory actually depends on several cognitive processes, including planning, attention, and task management. Common in everyday life, these memory lapses are mostly annoying, but can have tragic consequences. Existing studies suggests emotional variable as measure to overcome prospective memory failure. This is because wide variety of cognitive resources decline with age, only emotional experience and emotional regulation remains intact. This is one reason we selected emotional valence as major variable to study prospective memory. Secondly, discrepancies in findings across studies, along with limitations in some of the paradigms, prevent a clear understanding of the role of emotion valence in PM

- The three tasks described in literature (event- based, time based and activity based) differ in terms of underlying processes. There are several studies that have investigated the differences between event based and time based prospective memory but very few studies have focused on comparing all three tasks together. On the basis of literature it is proved that activity based task shares characteristics of both time based and event based tasks and it plays major role in everyday activities. This study attempts to compare all three tasks and find out which task is benefitted most by emotional saliency.

- Research suggests that unconscious stimuli elicit weak but reliable effects on both



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behavioral and neural activity. However, there are very few studies available that have

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examined the effect of indirect presentation of cue on prospective memory. In this study we will investigate whether manipulating presentation style of cue can facilitate prospective memory performance?

- Several theories have been put forth to explain the picture superiority effect, however most of the studies in prospective memory have used words as stimuli to examine prospective memory performance. We found only handful of studies that reveals effect of pictures and its effects on prospective memory performance. So the present study aims to examine differential effect of words and picture stimuli on prospective memory performance.

- In recent years, there has been an upsurge of evidence that sleep plays a vital role in the modulating retrospective memory processes, i.e., memories of past events. Subjects who are allowed to sleep after learning show better memory retention than subjects who spend an equivalent amount of time awake. Sleep thereby actively facilitates the consolidation and reorganization of memories for long-term storage rather than merely passively protecting memories against decay and interference. Although such findings strongly confirm the notion that sleep is critically implicated in processes of memory retention, the role of sleep in maintaining prospective memories is not well understood as very few studies have been conducted in this area. So the overall aim of the study will be to examine the role of sleep on prospective memory performance as a function of cue distinctiveness.



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## Behavioral Studies

### 3.1: Experiment1- Effect of emotional valence on prospective memory types.

Previous research strongly suggests that emotional valence effect memory processes especially retrieval of retrospective and prospective memory. The present experiment attempts to examine the effect of emotional valence (positive, negative and neutral) on prospective memory intentions. Till date studies have emphasized the effect of emotional valence mainly on event based and time based intentions. The present study incorporates activity based intention which is a recent addition to prospective memory types and examine whether emotional saliency effect only intentions that are more cue dependent or it produces similar effects on intentions that are more relied upon self-initiated processes.

#### 3.1.1. Objectives:

The present experiment has two fold objectives:

a) To evaluate the effect of valence (positive/ negative & neutral) on prospective memory.

b) To evaluate the role of emotional cue valences on types (event, time & activity) of prospective memory intentions.

The tasks used for measuring prospective memory in the present experiment were designed in house and were based on standardized tasks meant to measure the three types of prospective memory.

**3.1.2.** Hypothesis:

a) We hypothesize that performance on emotional cues will be better compared to neutral cues.

Rationale: The enhanced memory for emotional events has been attributed to interactions between the amygdala and other neural areas such as the hippocampus and prefrontal cortex (PFC). The amygdala is active during emotional cue encodings in addition to the hippocampus, and this enhanced activity of the amygdala influences the encoding and consolidation of the memory trace for the emotional event.


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b) It is hypothesized that retrieval accuracy will differ significantly across time/event/activity based prospective memory.

Rationale: The nature and mechanism underlying prospective memory intentions differ at the level of encoding as well as at retrieval (for example, event based prospective memory relies more upon external cue and hence it has greater effect of emotional valence compared to time and activity based prospective memory which rely more on self and activity termination initiated cuing) . Hence, it is predicted that all three prospective memory intentions will differ in the cue retrieval accuracy (which is an indirect measure of prospective memory performance).

**3.1.3. Variables:**

- Independent variables- Emotional valence, Prospective memory types
- Dependent variables- Accuracy scores for time, event and activity cued prospective memory tasks. (We believe that retrieval accuracy for cue retrieval is the single most factors that signals the actual onset of the prospective memory task completion – pressing a specific key on the appearance of pre-learned cue while being engaged on the working memory task).

**3.1.4. Methodology**

**3.1.4.1 Participants:**

Undergraduate students (mean age= 25.6 ± 3.18) from Indian Institute of Technology Guwahati volunteered in exchange for partial credit toward a course requirement. Each participant was tested individually in sessions that lasted approximately 15 min. Participants (N=40) were randomly assigned equally to both positive and negative emotional group. Each participant completed a personal data form (including demographic details), inform consent sheet, mood questionnaire, and positive and negative affect schedule (PANAS; Watson et al., 1988).

**3.1.4.2 Definitions of tasks used in the experiment**

a) Ongoing task: At the beginning of the experiment participants read the instruction for lexical decision task in which both prospective memory tasks (event-based & time-based) were embedded. In the lexical decision task the participants were shown words on the screen for 5


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seconds. The participants had to categorize the words as abstract or concrete words. This task is thought to place relatively heavy demands on working memory and information processing resources. Participants were instructed to press “a” to indicate abstract words & “c” to indicate concrete words.

b) Event- based prospective memory task- This task was to remember pressing “s” whenever any six letter word appears on the screen. In total 20 targets appeared during the ongoing task. All participants were made familiar with the 20 targets in an earlier session spaced well before the actual experiment. Every hit on the target key that occurred within 5s after the presentation of the target was scored as success.

c) Time-based prospective memory task- This task was to remember press “1” as target key at 30s interval from the start of ongoing task as accurately as possible. To analyze time based prospective memory performance, we set a target window of 30 s (± 5s). Every hit on the target key within this time window was scored as success.

d) Activity based prospective memory task- For this task, the participants were given a questionnaire which comprised of questions related to their experience during the experiment. Participants were asked to recall the words they seen during the ongoing task of the experiment in the questionnaire. They were told to fill the questionnaire at home and drop it in the drop box kept at certain place in the department (Kliegel & Jager, 2006a,b). In addition they were instructed to write date, day & time of returning on the right top of the questionnaire. Based on their returning time, score of 1 was assigned if participant posted the questionnaire exactly after the session. A score of 1 was assigned if participants returned the questionnaire on an incorrect day and a score of 0 if participant failed to return the questionnaire back. Additional score of 1 was given if participant remembered to write date, day and time according to the instructions given to them.

**3.1.4.3. Material and Procedure:**

The prospective memory task was embedded in working memory task. There were 100 trails, with equal number of emotional (positive & negative) and neutral words. These words were selected from ANEW (Affective Norms for English Words) prepared by Bradley & Lang (1999).


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The selections were based on valence, arousal, word frequency & length of words. The range of valence for positive words was 6-9 and for negative words 0-3. The words were presented using E-prime software (ver. 2.0).The two groups of participants (negative & positive) were exposed to all the prospective memory tests in a pre - defined study design. Data obtained from the tests were recorded and scored according to the demands of the prospective memory involved.

### 3.1.5. Results

#### 3.1.5.1. Emotional valence and prospective memory types:

a) Events cued prospective memory: Hits on event cued prospective memory task was successfully identifying the target cues (six letter words) from the learning session and pressing the “s” key as response during the ongoing task. The maximum number of hits was 20 (10 valence / 10 neutral) cues.

b) Time cued prospective memory: Hit on the time cued prospective memory task was retrieving the intention to act every 60 seconds from the start of the ongoing task and then responding accordingly by pressing the “1” key as response. The maximum score any participant gets on this task was approximately 35 (the ongoing task lasted for about 35 minutes).

c) Activity cued prospective memory: Every successful return of the questionnaire one day after termination of the experimental session and up to a maximum of two days, was considered success and was assigned score 1. However, failure to return the questionnaire was scored 0. Additional score of 1 was given if participant remembered to write date, day and time according to the instructions given to them. The maximum score any participant can achieve in this task was 2 (1 for questionnaire return + 1 for date and time impressions).

Statistical Analysis:

Mixed model 2 x 3 ANOVA with valence (positive, negative) between group & prospective memory type (event, time, activity) within group repeated on all factors, was used to test the effects of emotional valence on prospective memory. The dependent variable for event & time cued prospective memory were accuracy scores while scores (as explained above) was dependent measure for activity cued prospective memory. Significant main effects for prospective memory


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type [F (1, 38) = 70.59, $p < 0.01$, mean (8.1, 2.7, 0.45), $\eta 2 = 0.547$] suggested irrespective of valence (positive / negative) prospective memory performance differs across prospective memory types. This would suggest that emotional valence did not differentially affect all prospective types significantly. All other effects turned out to be non-significant.

**3.1.5.2. Positive vs. Neutral cue effects on prospective memory Scoring**

a) Events cued prospective memory: Hits on event cued prospective memory task was successfully identifying the target cues (positive / neutral six letter words) from the learning session and pressing the "s" key as response during the ongoing task. The maximum number of hits was 20 (10 positive / 10 neutral cues)

b) Time cued prospective memory: Hit on the time cued prospective memory task was number of successful responses recorded as press of the "1" key after 60 seconds following the occurrence of the positive / neutral cues in the ongoing task. The maximum score in this task was 20 key presses (10 positive / 10 neutral cues)

c) Activity cued prospective memory: The number of successful positive and neutral cue words retrieved on the activity questionnaire, among the ongoing task retrievals were scored as hit. The maximum score here was 20 (10 positive / 10 neutral) cue word retrievals.

Statistical Analysis:

Repeated measure 2 x 3 (ANOVA) with valence (positive, neutral) between group & prospective memory type (event, time, activity) within group (repeated on all measures), and accuracy scores (as mentioned above) as dependent measures was applied to the data. Significant main effects for valence [F (1, 19) = 5.039, $p = 0.037$, mean (positive = 3.87. neutral = 2.1) $\eta 2 = 0.21$], prospective memory type [F (1, 19) = 38.027, $p = 0.001$, mean (event = 6.4, time = 2.17, activity = 0.4) $\eta 2 = 0.67$] & significant interaction effects (valence x task) [F (1, 19) = 6.07, $p = 0.005$, $\eta 2 = 0.24$] were obtained. Interaction effects were followed up by computing simple mean effects (LSD) which revealed smaller accuracy scores for the neutral stimuli than emotional stimuli ($p < 0.001$) and that positive stimuli group revealed better accuracy scores on all prospective memory types while in the neutral group only event based prospective memory revealed better accuracy results (fig3).


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**3.1.5.3. Negative vs. Neutral cue effects on prospective memory.**

a) Events cued prospective memory: Hits on event cued prospective memory task was successfully identifying the target cues (negative / neutral six letter words) from the learning session and pressing the “s” key as response during the ongoing task. The maximum number of hits was 20 (10 negative / 10 neutral cues)

b) Time cued prospective memory: Hit on the time cued prospective memory task was number of successful responses recorded as press of the “1” key after 60 seconds following the occurrence of the negative / neutral cues in the ongoing task. The maximum score in this task was 20 key presses (10 positive / 10 neutral cues)

c) Activity cued prospective memory: The number of successful negative and neutral cue words retrieved on the activity questionnaire, among the ongoing task retrievals were scored as hit. The maximum score here was 20 (10 negative / 10 neutral) cue word retrievals.

Statistical Analysis:

Repeated measure 2 x 3 (ANOVA) with valence (negative, neutral) between group & prospective memory type (event, time, activity) within group (repeated on all measures), and accuracy scores (as mentioned above) as dependent measures was applied to the data. Significant main effects for valence [$F(1, 19) = 8.67$, $p = 0.008$, mean (negative = 3.71, neutral = 2.13), $\eta2 = 0.31$], prospective memory type [$F(1, 19) = 30.881$, $p = 0.001$, mean (event = 5.78, time = 2.5, activity = 0.45), $\eta2 = 0.62$], & significant interaction effects (valence x task) [$F(1, 19) = 4.92$, $p = 0.013$, $\eta2 = 0.20$] were obtained. Interaction effects were followed up by computing simple mean effects (LSD) which revealed smaller accuracy scores for the neutral stimuli than emotional stimuli ($p < 0.001$) and that positive stimuli group revealed better accuracy scores on all prospective memory types while in the neutral group only event & time based prospective memory revealed better accuracy results


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#### 3.1.5.4. PANAS and Mood Scores:

Positive and Negative Affective Schedule and Mood questionnaire were administered to rule out the existence of extreme positivity / negativity among the participants. PANAS scores obtained from the participants on the positive / negative scales across the groups were subject to t-test [positive scale: $t(1, 38) = 0.312$, $p < 0.5$; negative scale: $t(1, 38) = -0.421$, $p<0.5$], revealed no significant differences between the groups. Similarly mood questionnaires were included to monitor extreme mood shifts while participating in the experiment. Scores on the mood questionnaire were subjected to t-test [$t(1, 38) = 0.523$, $p <0.5$], revealed non-significant difference between the positive and negative group.

### 3.1.6 Conclusion:

In conclusion, the data reported in this study suggests that in line with previous studies, emotion is relevant in understanding prospective memory functions. Further, our data indicate, better effect of positive and negative emotions as compared to neutral across all prospective memory types. Lower significant difference found in positive and negative emotion needs further experimentation. The activity based task results were not very satisfactory and should be tested using newer efficient designs in future studies. This study added evidence to the fact that the association between emotional variable and prospective memory performance might be reversed in everyday life relative to the laboratory situation. However, further research is clearly necessary to replicate these findings on a larger sample.


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**3.2: Experiment 2- Effect presentation mode (indirect / indirect) for valence cues on event cued prospective memory performance**

In experiment one (1), we have examined the effect of emotional valence (positive, negative and neutral) on prospective memory tasks and found significant difference between emotional and neutral cue. The mean scores revealed that emotional cues when compared to neutral cues generate better response on all prospective memory tasks (event, time and activity). The result of the experiment 1 directly indicates the beneficial effect of emotional cues over neutral cue on prospective memory cue retrievals. In our next experiment, we manipulate cue saliency in terms of cue presentation modes (direct / indirect) and try to gauge its effect on cue retrieval accuracy for valence cues.

**3.2.1. Objective:**

The present experiment attempts to evaluate the role played by presentation mode (direct and indirect) and valence (positive and negative) as a measure of cue distinctiveness on event based prospective memory task.

**3.2.2. Hypothesis:**

a) We hypothesize that there will be significant difference in cue retrieval accuracy between direct and indirect modes of presentation with better accuracies for indirect presentation mode.

Rationale: In relation to presentation of cue it has been observed that prospective memory positively correlates with performance embedded on implicit memory tasks like word-stem completion task (McDaniel and Einstein, 1993). Also presentation of implicit cues influences the intention without the requirement of explicitly remembering the intention (Hashimoto, Umeda & Kojima, 2011). Based on these results we assume that there will be better performance for emotional stimuli under indirect mode of encoding.

b) It is hypothesized that positive cues will foster more cue retrieval and this trend will be evident across both the presentation modes


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Rationale: There have been numerous studies on emotional valence and memory that reported emotional valence as function of cue saliency determining better performance on memory tasks. Across age also, only emotional experience and emotional regulation that remains intact or even improves across adulthood (Watson &Blanchard-Fiels, 1998). Previous studies on emotional valence have reported significant differences among performances across valence cues with slightly better results for positive cues. The reason for the results has been largely ambiguous. Based on our previous result we expect that positive valence will influence the event based tasks more than negative valence.

**3.2.3. Variables:**

- Independent variable- emotional valence, cue presentation style (direct/indirect)
- Dependent variable: accuracy scores on event based prospective memory task.

**3.2.4. Methodology**

**3.2.4.1. Participants:**

Undergraduate students (mean age= 25.6 & SD= 3.18) from Indian Institute of technology Guwahati volunteered in exchange for partial credit toward a course requirement. Each participant was tested individually in sessions that lasted approximately 25-30 min. Thirty participants were randomly assigned to one of two conditions: positive and negative

**3.2.4.2. Design:**

A 2 valence (positive, negative) x 2 mode of presentation (implicit, explicit) mixed design was used with repetition on second factor.

**3.2.4.3. Materials and procedure:**

Participants completed the following set of questionnaires: biographical information sheet (including questions about age, gender eyesight etc.), inform consent sheet, mood questionnaire, and positive and negative affect schedule (PANAS). There were two phases in the experiment:


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***Phase one:***

In phase one, subjects were presented the prospective memory cues and were instructed to be attentive with minimum eye blinks. Subjects were required to view stimulus being presented on the screen for very brief periods on time.

***Stimuli presentation:***

Twenty valence words (10 emotional, 10 neutral) acted as cues and were presented during phase one to all groups. Cue words were randomly assigned to two categories as follows:

- Implicit presentation: The words were presented at frequency of 120 millisecond / word. All implicit words were presented in Arial style with font size 8 written in grey color on black background. The standard decided for subliminal presentation of words was based on subjective response of 40 subjects being exposed to several frequencies and color shades.
- Explicit presentation: The words were presented at frequency of 250millisec / word. All explicit words were presented in Arial style with font size 8 written in white color on black background

***Phase two:***

In the second phase subjects were given instruction about the lexical decision task that they had to perform. In the lexical decision task the participants were shown emotional words on the screen. The participants were required to count the number of vowels present in the each word and press the digit key accordingly. In addition they had to also press a separate key (p) if any word (cue) from phase one appears on the screen. After the instruction (oral and written) subjects were introduced to the cue learning (phase one) task. Following a thirty minutes distraction task (mathematical puzzle), the ongoing task was introduced in which prospective memory tasks (event-based) was embedded. Subjects were required to make responses for both the ongoing and prospective memory task. There were 160 trails in these phase with equal number of emotional (positive & negative) and neutral words. These words were selected from ANEW (Affective Norms for English Words) [Bradley & Lang (1999)]. The selections of words were based on valence, word frequency & length of words. The range of valence for positive words was 6-9 and


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for negative words 0-3. Thus there was large difference in the valence range between positive and negative words. The present study used E-prime software (2.0 versions) to conduct the experiment. Data collected from the experiment was entered into SPSS for further analysis. Result Accuracy of cue retrieval during the ongoing task was considered success in event based prospective memory task.

### 3.2.5. Results

Statistical analysis: Accuracy of cue retrieval during the ongoing task was considered success in prospective memory and served as the dependent variable. Since the accuracy of neutral cue retrieval was negligible when compared to valence cues we dropped the neutral cue accuracy from further analysis. With the remaining data on cue valence and cue mode accuracy we performed a mixed model; within 2 [valence (positive, negative)] x between 2 [mode (implicit, explicit)] repeated on factor 2 analysis of variance (ANOVA).

#### 3.2.5.1. Cue valence and prospective memory performance

Between group test results for valence reported significant main effects for valence $F(1, 28) = 8.5$, $p = 0.05$, $\eta2 = 0.23$ mean accuracy [positive = 9.2 ± 4.0, negative = 6.7 ± 2.4]. This result reveals that there was clear difference among the positive and negative valence groups on prospective memory cue retrievals.

#### 3.2.5.2 Cue mode and prospective memory performance

There was no significant differences ($F(1, 28) = 0.06$, $p > 0.05$, mean accuracy [explicit = 7.9 ± 1.69, implicit = 8.0 ± 1.8]) for prospective memory accuracy as a function of cue presentation mode. Thus, prospective memory was not significantly affected by manipulation of presentation style. However we found significant interaction between condition and presentation style ($F(1, 28) = 9.08$, $p < 0.05$), $\eta2= .24$), which reveals a different pattern of response across conditions for both direct & indirect cue presentation. Interaction effects were followed up by computing simple mean effects (LSD) which revealed large accuracy differences between positive and negative groups for the implicit mode of presentation ($p < 0.05$), however no such difference was reported in the explicit mode of presentation ($p > 0.05$). This interaction effect clearly indicate that although there is no main effect of cue presentation on prospective memory,


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cue valence and cue presentation can together bring changes in performance on prospective memory tasks. All other effects turned out non-significant. Although interaction effects revealed large accuracy differences between positive and negative groups for the indirect mode of presentation ($p < 0.05$), however no such difference was reported in the direct mode of presentation ($p > 0.05$) after computing simple mean effects (LSD). This interaction effect clearly indicate that although there is no main effect of cue presentation on prospective memory, cue valence and cue presentation can together bring changes in performance on prospective memory tasks.

### 3.2.6. Conclusion:

The results of analysis of variance suggest non-significant main effects of presentation modes. However, we find significant effects of interaction between presentation modes and valence. Further analysis of interaction effects points to an implicit dominated enriched processing for certain levels of cue valence. This indicates that emotional information's are also processed through implicit presentation of words. Responses to emotional stimuli in implicit presentation were more effective with positive valence words compared to negative valence words. In the case of explicit presentation no such difference were found in both the conditions. This effectiveness of implicit presentation is evidence that affective processing can occur without any conscious awareness.


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**3.3: Experiment 3- Effect of nature of stimuli (picture / word) used as valence cue presented across different modes on event cued prospective memory performance**

In our previous experiments effect of valence and presentation mode was examined on prospective memory intentions using single stimuli (words) and mixed results were reported. There are numerous ways in which data can be encoded, however these systems for the most part depend on either visualizations (recalling data as pictures), or verbalization (recollecting data as words). Most studies on prospective memory have utilized words or pictures as stimuli to determine performance in terms of retrieval of intention. Since picture superiority effect (better retrieval of picture stimuli) has not been established in prospective memory studies, we aimed at testing picture superiority over words for event based prospective memory retrieval. Retrospective memory studies explain the beneficial effect of pictures over words in retrieval memory tasks as pictures have both a verbal and spatial code, while words have just a verbal code. Thus while words carry just semantic meaning, pictures have an additional imaginable quality associated with them as well as their semantic meaning which leads to better retrieval on memory tests.

**3.3.1. Objective:**

In the present experiment we examined if emotional valence cues (positive/negative)presented in different format (words/pictures) and presentation mode (direct/indirect) effects event based prospective memory performance.

**3.3.2. Hypothesis:**

It is predicted that pictures will promote better prospective memory performance compared to words across both direct and indirect presentation.

Rationale: Pictures are believed to be more salient, and to activate emotional responses more easily than words (Carr, McCauley, Sperber, & Parmlee, 1982). In this light for pictures, the effect of emotion gets evoked immediately and relatively automatically, whereas activation of emotional responses for word stimuli may require more depth and controlled processing.


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**3.3.3. Variables:**

- Independent variable- emotional valence (positive/negative), cue presentation style (direct/indirect), stimuli type (words/pictures)
- Dependent variable: accuracy scores on event based prospective memory task.

**3.3.4. Methodology**

**3.3.4.1. Participants:**

Undergraduate students (mean age = 25.6 ± 3.18) from Indian Institute of Technology Guwahati volunteered in exchange for partial credit toward a course requirement. Each participant was tested individually in sessions that lasted approximately 25-30minutes. Forty Participants were randomly assigned to one of two conditions: positive and negative

**3.3.4.2 Design:**

2 valence (positive, negative) x 2 mode of presentation (implicit, explicit) x 2 stimuli type (words/stimuli) mixed design was used with repetition on second and third factor.

**3.3.4.3. Material & Procedure:**

Participants completed the following set of questionnaires: biographical information sheet including questions about age, gender eyesight etc. along with inform consent sheet, a mood questionnaire, and positive and negative affect schedule (PANAS). There were two phases in the experiment for both the conditions.

*Phase one:*

In phase 1, subjects were presented the emotional cues of both modality (words/pictures) with instructions to be attentive by keeping eyes blink to minimum. They were told that there will be some presentations on the screen for very brief period of time. They were not required to respond in any way, simply to pay attention and focus on the screen.


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*Stimulus presentation:*

There were 4 words and 4 pictures [2 emotional (positive and negative) & 2 neutral] cues that were presented in phase 1 of both the conditions. Cues were randomly assigned to two categories as follows:

- Implicit presentation: The words& pictures were presented at frequency of 120ms / word. All indirect presentation was done in Arial style with font size 8 written in grey color on black background. The standard decided for indirect presentation of stimuli's was based on subjective response of 40 subjects being exposed to several frequencies and color shades.

- Explicit presentation: The words& pictures were presented at frequency of 250ms / word. All explicit presentations were done in Arial style with font size 8 written in white color on black background.

*Phase two:*

In the 2nd phase subjects were given instruction about the lexical decision task that they had to perform. There were 160 trails, with equal number of emotional (positive & negative) and neutral cues (words and pictures). The emotional words used in the experiment were selected from ANEW (Affective Norms for English Words) prepared by Bradley & Lang (1999) and the picture stimuli were taken from International Affective Picture System (IAPS) (Lang et al., 1997, 2008). The selections of stimuli were based on valence and the range of valence for positive words/pictures was 6-9 and for negative words/pictures 0-3. Thus there was large difference in the valence range between positive and negative words. The present study used E-prime software (2.0.11 versions) to conduct the experiment.

After the instruction (oral and written) subjects were given a trail of experimental task. After a 30 minutes distraction task (mathematical puzzle), the ongoing task was introduced in which prospective memory tasks (event-based) was embedded. In the lexical decision task the participants were shown emotional words/pictures on the screen. The participants had to count the number of vowels present in the each word and press the digit key accordingly. They had to also press a separate key (p) if any word (cue) from phase 1 appears on the screen.


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### 3.3.5. Results

#### 3.3.5.1. Cue valence & Stimuli type

As found in other previous studies, main effect of valence was found [F (1, 19) =4.0, p=0.03, $\eta 2$ = 0.13]. Significant effect of stimuli type was also found [F (1, 19) =3.1, p=0.004, $\eta 2$ = 0.24] which suggests that pictures are remembered better than words. Significant interaction effects (valence x task) [F (1, 19) = 4.92, p= 0.002, $\eta 2$ = 0.20] were obtained. Interaction effects were followed up by computing simple mean effects (LSD) which better accuracy scores for positive emotions ($p < 0.05$) for both type stimuli (words and pictures).

#### 3.3.5.2. Cue valence & Presentation mode

For presentation mode also, significant effect was found [F (1, 19) =2.4, p=0.02, $\eta 2$=0.21] which indicates clear differences between both type of presentation. We also found significant interaction between condition and stimuli type [F (1, 19) =5.92, p=0.02, $\eta 2$=0.32]; condition, presentation and stimuli type [F(1, 19) =15.44,p=0.002, $\eta 2$= 0.12]. Significant interactions effects were found for presentation mode, stimuli type and valence [F(1, 19) =6.77,p=0.001, $\eta 2$= 0.09] for which simple mean effects (LSD) was computed showing better accuracy scores for positively valence pictures ($p < 0.05$) in both presentation modes (direct and indirect).

### 3.3.6. Conclusion:

By manipulating the style and forms of cue presentation, the present study aimed at investigating the effect of indirect/direct presented emotional stimuli across two type of stimulus on event based prospective memory performance. The results indicates reliably greater prospective memory success for positive valence compared to negative valence which reveals that cues associated with positive emotions are beneficial for prospective memory. Similar results were found in our previous experiment also, so this result is validation of our previous findings. Also, significant difference is found while comparing the stimuli type (words, pictures) which shows that both stimuli type differ in their nature of processing. This study in line with previous findings also indicated better prospective memory performances for pictures compared to words independent of valence. Significant result was also found with presentation mode along


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with significant interaction between emotion, stimuli type and presentation mode. In our next set of experiments we will be examining the role of sleep on event based prospective memory with our selected variables serving as cue characteristics (valence, presentation mode, stimuli type).


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## Studies based on polysomnography

Polysomnography (PSG) is a multi-parametric test used in the study of sleep. Polysomnography is a comprehensive recording of the bio physiological changes that occur during sleep. The PSG monitors many body functions including brain(EEG), eyemovements (EOG), muscle activity or skeletal muscle activation (EMG) and heart rhythm (ECG) during sleep.

### 3.4: Experiment 4- Effect of emotional valence and presentation mode across sleep and sleep deprivation.

The previous sets of experiments were designed to evaluate the role of cue characteristics (emotional valence, cue presentation mode, stimuli format) on prospective memory using behavioral analysis. In the present experiment we will incorporate sleep as our main independent variable to explore its role in enhancing prospective memory retrieval. Sleep is known to facilitate the consolidation of memories for past events. While this beneficial impact of sleep for memories of the past is well established, its role for prospective memory is less well understood. Recent research provides initial evidence that consolidation processes during sleep target preferentially those memories that are relevant for future behavior, such as memories for which participants expect a retrieval test. In the present experiment we had examined the effect of sleep on event based prospective memory across presentation mode and emotional valence.

#### 3.4.1. Objective:

In the present study we aim to examine

- Comparisons of event based prospective memory performance across sleep and sleep deprivation condition.
- Effect of sleep on event based prospective memory across emotional valence.
- Difference in consolidation of direct and indirect encoded differentially valence cues across nights of sleep.


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**3.4.2. Hypothesis:**

The hypotheses formulated for the experiment are as follows:

a) Sleep will promote event cued prospective memory performance when compared to sleep deprivation.

Rationale: Certain sleep stages are noted to improve an individual's memory, although this is task specific. Generally, declarative memories are enhanced by slow-wave sleep, while non-declarative memories are enhanced by rapid eye movement (REM) sleep, although there are some inconsistencies among experimental results. Also, sleep plays a very important role in homeostatic restoration, thermoregulation, tissue repair, immune control and memory processing (Walker, 2008). Hence it is expected that sleep will have beneficial effect on event cued prospective memory

b) Sleep will facilitate consolidation of emotional cue compared to neutral.

Rationale: As functional neuroimaging studies suggest the critical role of the amygdala in facilitating emotional memory encoding, it is expected that emotional items will be better encoded that neutral items. Cahill *et al.* have reported greater activity in the right amygdala while viewing emotional versus neutral films and the same pattern of amygdala activity being repeated during sleep in subject undergoing his experiment. This greater activity is a direct measure of emotional memory consolidation across sleep measured in terms of greater recollections of at retrieval tests (Cahill, *et al.*, 1996).

c) Sleep will have beneficial effect on indirect cue presentation

Rationale: There is substantial evidence to indicate that rapid-eye movement (REM) sleep would be involved in consolidation of implicit (or non-declarative) memory (Plihal & Born, 1999a). Nevertheless, there are few studies which reported discrepant results in favor of a beneficial role of both SWS and REM sleep in episodic as well as in implicit memory consolidation (Gais, Plihal, Wagner & Born, 2000; Stickgold *et al.*, 2000).


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### 3.4.3. Variables:

- Independent variable- sleep and sleep deprivation condition, cue presentation during encoding phase (direct/indirect), emotional valence ( positive / negative)
- Dependent variable: Accuracy scores for event cued prospective memory performance

### 3.4.4. Methodology

#### 3.4.4.1. Participants:

Sixteen (16) young, right handed adults (all male, mean age = 20.5 ± 1.5 years) participated in the study. All subjects were screened to insure that there was no history of psychiatric, neurological or mental illness or a history of substance abuse which could compromise cognitive functions.

#### 3.4.4.2 Material and procedure:

Prior to the experiments, subjects were accustomed to sleeping under laboratory conditions during an adaptation night, including attachment of electrodes for polysomnographic recordings. Sleep scale was also administered to check the level of sleepiness in participants and data's were ruled out accordingly. On experimental days they were required to get up at 0700 h and not to consume caffeine or alcohol. Each subject was tested for emotion reactivity using 20 items self-administered positive and negative affect scale (PANAS; Watson, Clarke & Tellegen, 1988). All participants scored within normal limits (i.e. average T scores) on these measures. Each participant gave informed consent in accordance with the Institute Human Ethics Board (IIT Guwahati, India).

The study was a within subject design with the order of conditions ('sleep' and 'no-sleep') balanced across participants, and wait of at least two weeks before consecutive testing. Subjects reported to the laboratory at 2100 h after which they provided the informed consent and PANAS questionnaire. On sleep nights subjects were attached sleep recording electrodes and were made to perform the memory task designated for learning phase of the study from 2130 to 2245 h.


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Subject then retried to the sleep laboratory where they slept with continuous sleep recordings till 0700 h the next day. Upon waking subject again performed the memory task designated for the retrieval phase. On the no-sleep night subjects after completing the preliminary form performed on the memory task (learning) from 2130 to 2245. Following this they were kept awake in the presence of the experimenter till 0700 h the next day. The subjects were not allowed to drink caffeine, watch/read emotional materials and nap but were allowed to eat light snacks, drink water and take walks to keeping them awake. At 0700 h subjects completed the memory task (retrieval) and were allowed to leave the laboratory.

*Learning and recall testing:*

There were two phases in the experiment for both the conditions. In phase 1, subjects were presented the prospective memory cues with instructions to be attentive keep eyes blink to minimum. They were told that there will be some presentations on the screen for very brief period of time. They were not required to respond in any way, simple to pay attention and focus on the screen.

In the 2$^{nd}$ phase subjects were given instruction about the lexical decision task that they had to perform. There were 100 trails, with equal number of emotional (positive & negative) cue presentations. The words were selected from ANEW (Affective Norms for English Words) prepared by Bradley & Lang (1999) and the picture stimuli were taken from International Affective Picture System (IAPS) (Lang et al., 1997, 2008). The selections of stimuli were based on valence and the range of valence for positive words was 6-9 and for negative words 0-3. Thus there was large difference in the valence range between positive and negative words. The present study used E-prime software (2.0 versions) to conduct the experiment.

After the instruction (oral and written) subjects were given a trail of experimental task. After a 30 minutes distraction task (mathematical puzzle), the ongoing task was introduced in which prospective memory tasks (event-based) was embedded. In the lexical decision task the participants were shown emotional words/pictures on the screen. The participants had count the number of vowels present in the each word and press the digit key accordingly. They had to also press a separate key (p) if any word (cue) from phase 1 appears on the screen.


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*Sleep signal acquisition*

For standard polysomnography, the electroencephalographic (EEG) activity was continuously recorded with (Ag/Agcl) electrodes from C3 and C4 referenced to linked electrodes attached to the mastoids. In addition, horizontal and vertical electrooculography (EOG) and electromyography (EMG) data were recorded. Data were amplified by Nihon Khoden Amplifiers (Nihon-Khoden, Japan) and continuously digitized at a rate of 250 Hz. Sleep recordings were scored off-line according to standardized criteria (Rechtschaffen& Kales, 1968). Total sleep time (TST, in min) and time spent in the different sleep stages (wake, sleep stage 1, 2, 3, 4; SWS; REM in min and in percentage of TST) was calculated

**3.4.5. Results**

**3.4.5.1. Sleep stages & retrieval accuracy**

Analysis of sleep data revealed the prevalence of stage 2 sleep in most subjects on experimental nights as compared to adaptation nights. The average time spent in each sleep stage in minutes were [stage 1 = 20.98 ± 1.8, stage 2 = 52.59 ± 2.1, stage 3 = 15.53 ± 2.8, stage 4 = 4.18 ± 1.6, stage rem = 9.93 ± 2.6]. Correlation between sleep stages and recognition accuracy index turned out to be significant only in case of REM sleep ($p = 0.05$).

**3.4.5.2. Sleep & cue valence**

Results indicated significant main effect of emotional valence (positive/negative) [$F(1, 14) = 15.71$, $p = 0.001$, $\eta 2 = 0.52$] on event based prospective memory which confirms our previous results that compared to neutral cues emotional valence enhances prospective memory performances. There was significant difference found across experimental conditions (sleep/ sleep deprivation) [$F(1, 14) = 48.0$, $p = 0.00$, $\eta 2 = 0.7$].

**3.4.5.3. Sleep & cue presentation**

In the case of effect of cue presentation, no significant difference was found for the encoding mode (direct/indirect) [$F(1, 14) = 0.28$, $p = 0.17$, $\eta 2 = 0.02$]. This indicates that although there is no difference in prospective memory performances, indirect cues can equally produce effective responses as direct cues. There was significant interaction found between


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presentation mode and emotion [F (1, 14) =13.7, p = 0.00, η2 = 0.49] and sleep condition and presentation mode [F (1, 14) =5.8, p = 0.03, η2= 0.29]. Simple mean effects (LSD) was computed to check the level of significance for each variable which revealed better accuracy scores for positive valence cues when presented directly ($p < 0.05$) as well as indirectly across sleep condition. Other interaction effects turned out to be non-significant.

### 3.4.6. Conclusion

The result of the study showed beneficial effect of sleep over sleep deprivation across valence, cue presentation and stimuli type. This benefit of sleep can be attributed to increased associative binding and enhance memory retrieval. Many previous findings have indicated that sleep plays vital role in memory consolidation, it seems like prospective memory might not be very much different from other types of memory. Our thesis reports similar findings as in the study of Scullin and McDaniel (2010) which indicated the positive sleep effect on prospective memory, beyond the well-documented sleep effect on retrospective memory.


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**3.5: Experiment 5- Effect of various cue characteristics (emotional valence, stimuli type and presentation mode) across sleep and sleep deprivation.**

In the last experiment the results indicated beneficial effect of sleep over sleep deprivation across emotional valence. It was found that sleep plays an important role in intention retrieval as a result of consolidation and stabilization of PM cues as compared to sleep deprivation. The experiment was conducted using stimuli of only one type (valence cue words) for exploring the role played by sleep and its interaction with emotional valence and cue presentation. In the present experiment the participants were presented valence cues in form of pictures and words under direct and indirect presentation mode. The major goal of the study was to replicate the results of the behavioral experiment three (3) under longer, less noisy retention interval provided by sleep.

**3.5.1. Objective:**

The aim of the present experiment was:

a) To compare the effect of sleep and sleep deprivation on event based prospective memory as a function of stimuli type (words/pictures).
b) To examine whether cue valence, stimuli type and presentation mode as a function of cue characteristics differentially modulates event cued prospective memory performance across sleep/sleep deprivation

**3.5.2. Hypothesis:**

The hypotheses formulated for the present study states that sleep will facilitate prospective memory across cue characteristics.

Rationale: As Rapid eye movement (REM) sleep has been repeatedly proposed to support the superior retention of emotional memories it is expected that when emotional cues will be combined with other cue characteristics (stimuli type & presentation mode) they will produce better prospective memory performance under sleep as compared to sleep deprivation.


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### 3.5.3. Variables:

- Independent variable- sleep and sleep deprivation condition, stimuli type (pictures/ words), emotional valence (positive/negative) & presentation mode (direct/indirect)

- Dependent variable: Accuracy scores for event cued prospective memory retrievals

### 3.5.4. Methodology

#### 3.5.4.1. Participants:

Sixteen (16) young, right handed adults (all male, mean age = 20.5 ± 1.5 years) participated in the study. All subjects were screened to insure that there was no history of psychiatric, neurological or mental illness or a history of substance abuse which could compromise cognitive functions.

#### 3.4.4.2 Material and Procedure:

Prior to the experiments, subjects were accustomed to sleeping under laboratory conditions during an adaptation night, including attachment of electrodes for polysomnographic recordings. Sleep scale was also administered to check the level of sleepiness in participants and data's were ruled out accordingly. On experimental days they were required to get up at 0700 h and not to consume caffeine or alcohol. Each subject was tested for emotion reactivity using 20 items self-administered positive and negative affect scale (PANAS; Watson, Clarke & Tellegen, 1988). All participants scored within normal limits (i.e. average T scores) on these measures. Each participant gave informed consent in accordance with the Institute Human Ethics Board (IIT Guwahati, India).

The study was a within subject design with the order of conditions ('sleep' and 'no-sleep') balanced across participants, and wait of at least two weeks before consecutive testing. Subjects reported to the laboratory at 2100 h after which they provided the informed consent and PANAS questionnaire. On sleep nights subjects were attached sleep recording electrodes and were made to perform the memory task designated for learning phase of the study from 2130 to 2245 h. Subject then retried to the sleep laboratory where they slept with continuous sleep recordings till 0700 h the next day. Upon waking subject again performed the memory task designated for the


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retrieval phase. On the no-sleep night subjects after completing the preliminary form performed on the memory task (learning) from 2130 to 2245. Following this they were kept awake in the presence of the experimenter till 0700 h the next day. The subjects were not allowed to drink caffeine, watch/read emotional materials and nap but were allowed to eat light snacks, drink water and take walks to keeping them awake. At 0700 h subjects completed the memory task (retrieval) and were allowed to leave the laboratory.

*Learning and recall testing:*

There were two phases in the experiment for both the conditions. In phase 1, subjects were presented the prospective memory cues with instructions to be attentive keep eyes blink to minimum. They were told that there will be some presentations on the screen for very brief period of time. They were not required to respond in any way, simple to pay attention and focus on the screen.

In the 2$^{nd}$ phase subjects were given instruction about the lexical decision task that they had to perform. There were 100 trails, with equal number of emotional (positive & negative) cue presentations. The words were selected from ANEW (Affective Norms for English Words) prepared by Bradley & Lang (1999) and the picture stimuli were taken from International Affective Picture System (IAPS) (Lang et al., 1997, 2008). The selections of stimuli were based on valence and the range of valence for positive words/pictures was 6-9 and for negative words/pictures 0-3. Thus there was large difference in the valence range between positive and negative words. The present study used E-prime software (2.0 versions) to conduct the experiment.

After the instruction (oral and written) subjects were given a trail of experimental task. After a 30 minutes distraction task (mathematical puzzle), the ongoing task was introduced in which prospective memory tasks (event-based) was embedded. In the lexical decision task the participants were shown emotional words/pictures on the screen. The participants had count the number of vowels present in the each word and press the digit key accordingly. They had to also press a separate key (p) if any word (cue) from phase 1 appears on the screen.


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*Sleep signal acquisition*

For standard polysomnography, the electroencephalographic (EEG) activity was continuously recorded with (Ag/Agcl) electrodes from C3 and C4 referenced to linked electrodes attached to the mastoids. In addition, horizontal and vertical electrooculography (EOG) and electromyography (EMG) data were recorded. Data were amplified by Nihon Khoden Amplifiers (Nihon-Khoden, Japan) and continuously digitized at a rate of 250 Hz. Sleep recordings were scored off-line according to standardized criteria (Rechtschaffen & Kales, 1968). Total sleep time (TST, in min) and time spent in the different sleep stages (wake, sleep stage 1, 2, 3, 4; SWS; REM in min and in percentage of TST) was calculated

**3.5.5. Results**

*Sleep & Emotional valence*: Results indicated significant main effect of emotional valence (positive/negative) [$F (1, 14) = 15.71$, $p = 0.001$, $\eta2 = 0.52$] on event based prospective memory which confirms our previous results that compared to neutral cues emotional valence enhances prospective memory performances.

**3.5.5.1 Sleep & Stimuli type**

There was non-significant effect found for stimuli type [$F (1, 14) =2.09$, $p = 0.17$, $\eta2 = 0.13$] but there was significant interaction found between stimuli type and emotion [$F (1, 14) =13.7$, $p = 0.02$, $\eta2 = 0.49$]; and sleep conditions, stimuli type and emotions [$F (1, 14) =5.2$, $p = 0.03$, $\eta2 = 0.27$]. All other results turned out to be non-significant.

**3.5.5.2. Sleep & Cue characteristics**

Although cue characteristics in terms of valence were found to be significant, other cue characteristics (stimuli type & presentation mode) were found to be non-significant. The result of the experiment revealed that interaction of sleep with valence & stimuli is significant but the overall interaction of variables (sleep/sleep deprivation, stimuli type, emotional valence & presentation mode) turned out to be non-significant [$F (1, 14) = 0.22$, $p = 0.6$, $\eta2 = 0.01$].


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### 3.5.6. Conclusion:

Results of the present experiment clearly indicated beneficial effect of sleep over sleep deprivation where accuracy score were highly correlated with REM sleep. We found that a period of sleep following prospective memory instruction generally improved the ability to implement the intended behavior at appropriate time. Although there was non-significant result found for stimuli type, it was observed that sleep benefited both the word and picture stimuli when interacted with emotional valence. The same pattern of result appeared in context of presentation mode. The effect of emotional valence was again found to be significant which reveals that sleep not only had beneficial effect on remembering intentions but it also enhances emotional aspect of cue encoding.


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# Experimental Design

# Tables and Figures


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**Experiment 1: Effect of emotional valence on prospective memory types.**

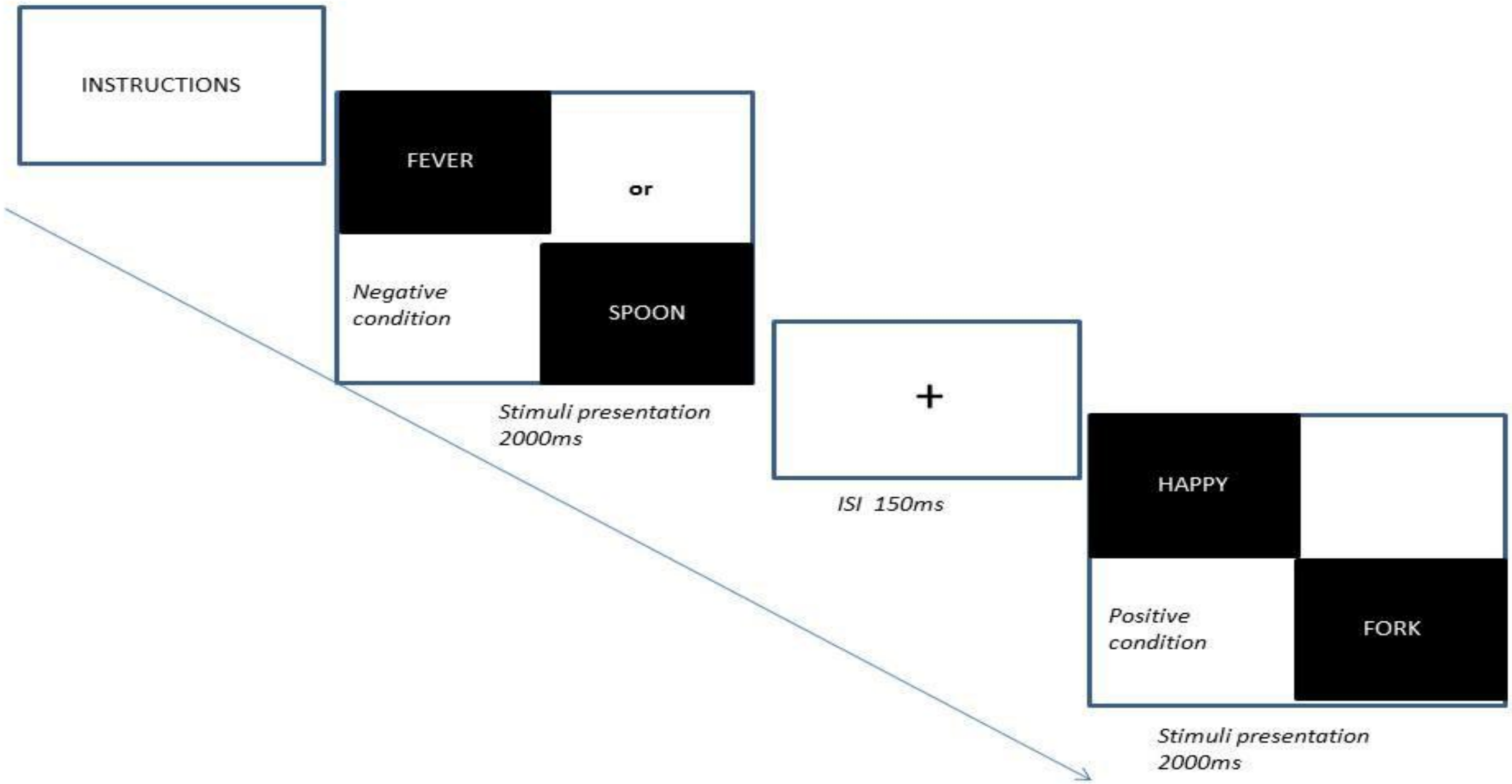


*Fig (1) Represent procedural design were participants were categorized in two conditions (positive and negative). In both the conditions participants were presented with emotional and neutral stimuli for which they provided three prospective memory responses: Event based- press "s" for six letter word. Time based- press "t" at every 50 seconds", activity based- after completion of ongoing task drop the questionnaire in specified drop box.*

**Experiment 2: Effect presentation mode (indirect / indirect) for valence cues on event cued prospective memory performance**

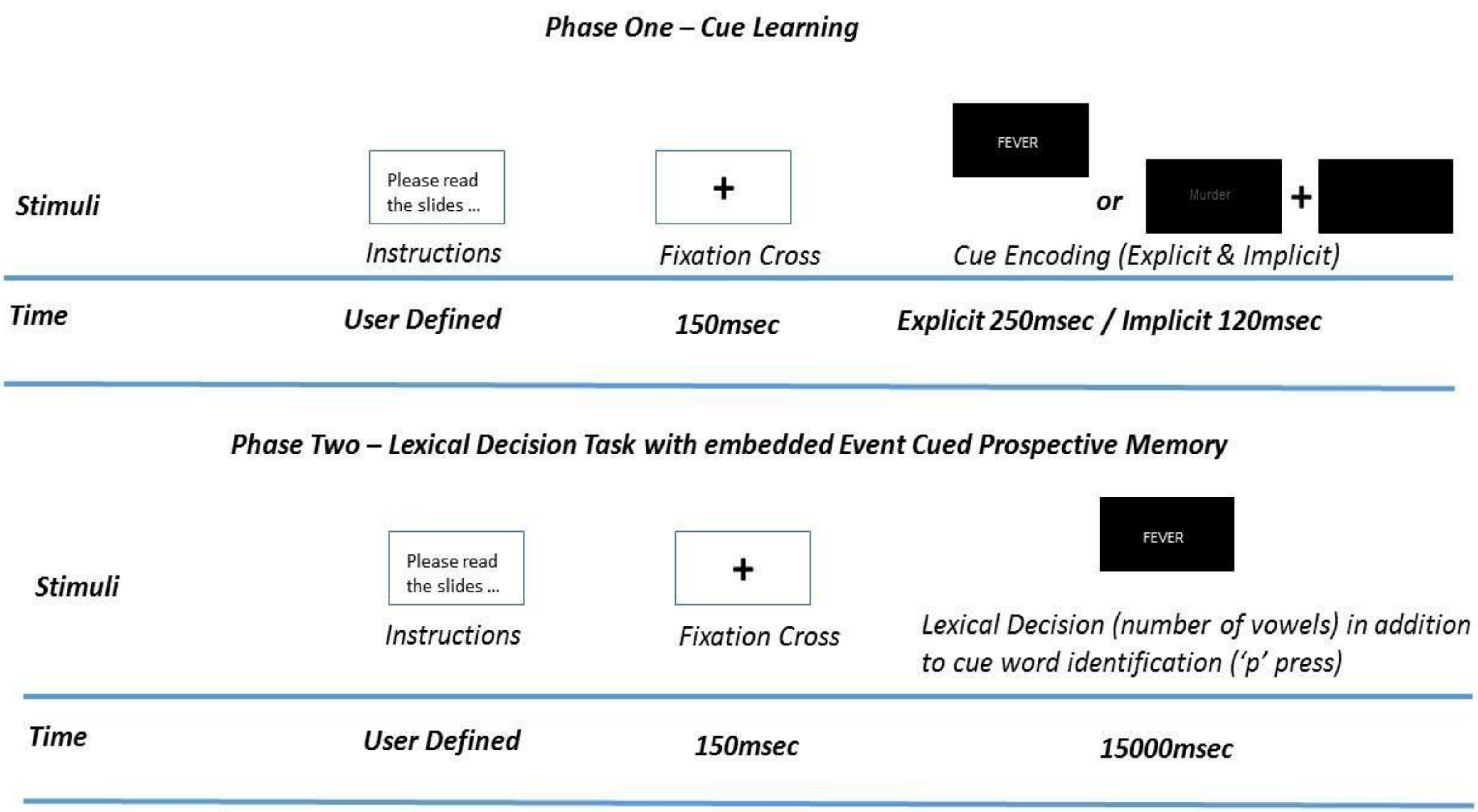


*Fig (2) represents procedural design of experiment two. There were two phases in the experiment. Phase one – cue learning during which subjects encoded the (positive / negative ) cues in explicit & implicit mode followed by mathematical distraction task; Phase two – lexical decision embedded with event cued prospective memory*

**Experiment 3: Effect of nature of stimuli (picture / word) used as valence cue presented across different modes on event cued prospective memory performance**

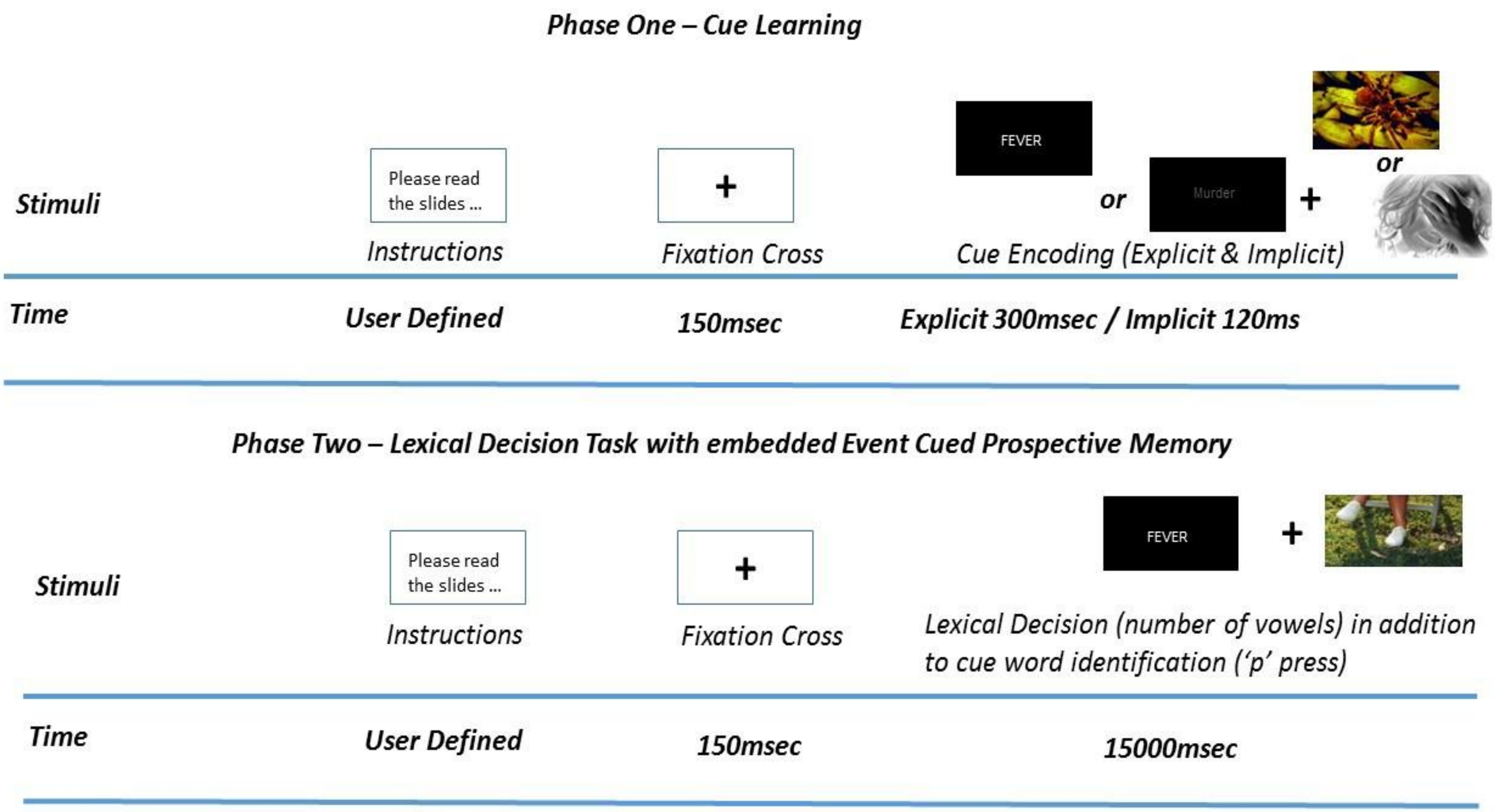


*Fig (3) Phase one – cue learning during which subjects encoded the (positive / negative ) cues in explicit & implicit mode with two type pf stimuli (words/pictures) followed by mathematical distraction task; Phase two – lexical decision embedded with event cued prospective memory task.*


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**Experiment 4: Effect of emotional valence and presentation mode across sleep and sleep deprivation.**

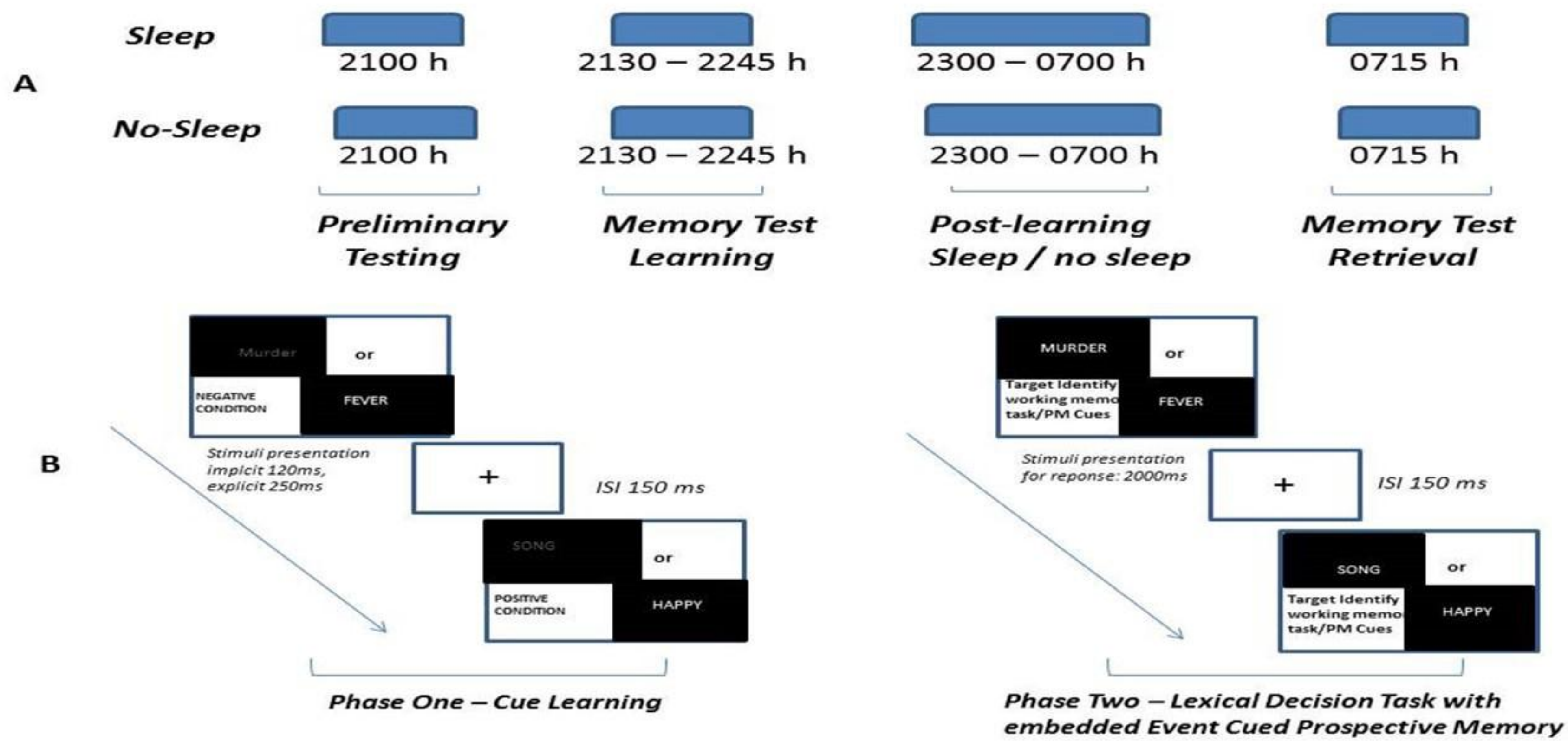


Figure 4. Procedural design used in experiment 4: a) depicts the flow of procedures followed by each subject on the two experimental nights. Each subjects finished preliminary testing and memory test phase before starting post learning sleep / sleep deprivation. Memory retrieval test followed the next morning; b) prospective memory task design used in the experiment


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**Experiment 5: Effect of various cue characteristics (emotional valence, stimuli type and presentation mode) across sleep and sleep deprivation.**

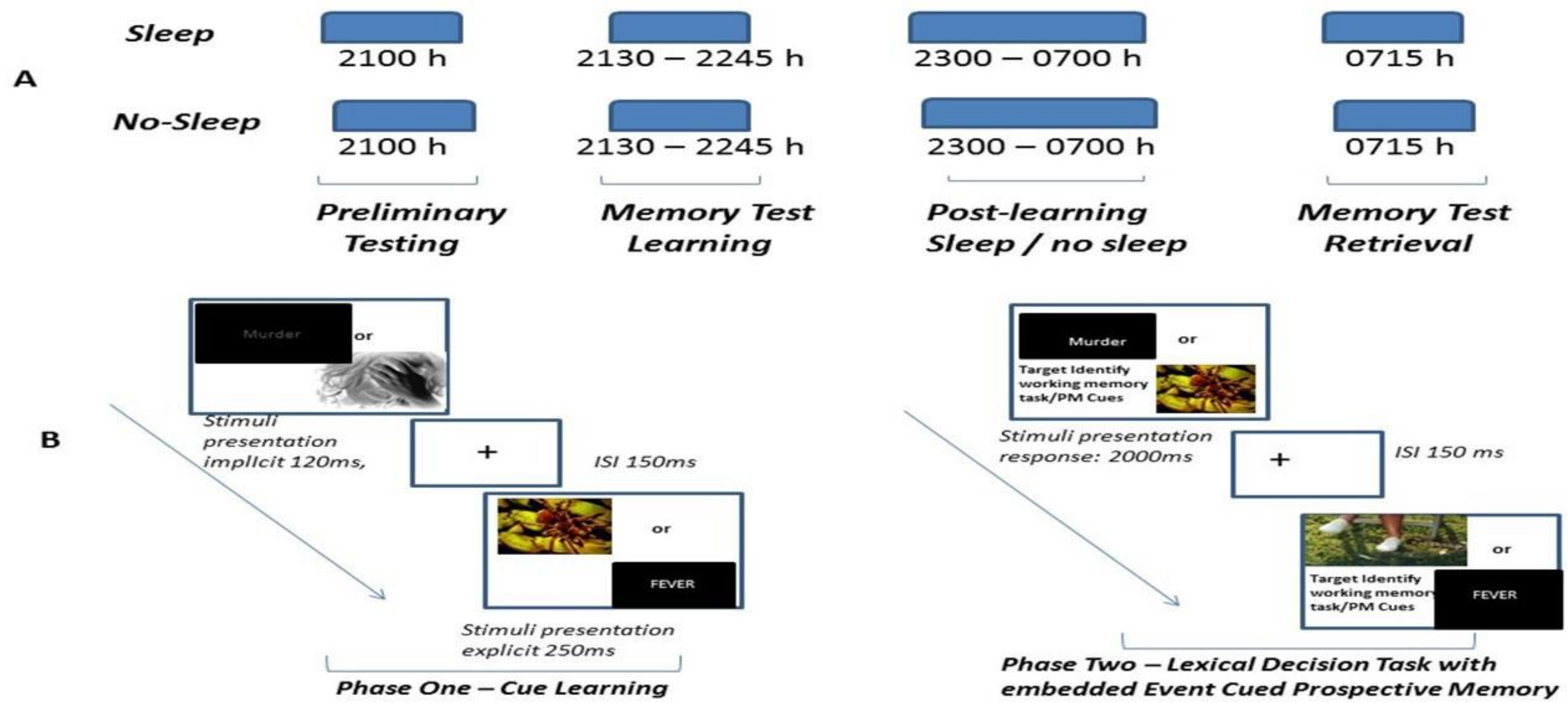


Figure 5. Procedural design used in experiment 5: a) depicts the flow of procedures followed by each subject on the two experimental nights. Each subjects finished preliminary testing and memory test phase before starting post learning sleep / sleep deprivation. Memory retrieval test followed the next morning; b) prospective memory task design used in the experiment had both words and pictures in implicit and explicit formats


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## Experiment 1: Effect of Emotional Valance on Prospective Memory types

**Table 1. Descriptive statistics for 2 valence (positive, negative) X 3(prospective memory types: event, time activity based prospective memory**

| | Emotions | Mean | Std. Deviation | N |
|---|---|---|---|---|
| event | 1.00 | 7.5000 | 5.00000 | 20 |
| | 2.00 | 8.8500 | 6.53150 | 20 |
| time | 1.00 | 3.0500 | 3.23590 | 20 |
| | 2.00 | 2.3500 | 2.99605 | 20 |
| activity | 1.00 | .5000 | .88852 | 20 |
| | 2.00 | .4000 | .68056 | 20 |

**Table2: A X B Anova Summary Table (Repeated On B)**
**Design: 2 (emotional, neutral) X 3(prospective memory types: event, time activity based prospective memory.**

| Source | SS | *df* | MS | F | Significance |
|---|---|---|---|---|---|
| Total | 1710.075 | 1 | 1710.075 | 102.618 | **.00** |
| Between-Subjects | 634.25 | 39 | | | |
| A(Emotion) | 1.008 | 1 | 1.008 | .061 | **.80** |
| Error(Between) | 633.25 | 38 | 16.664 | | |
| Within-Subjects | 1846.49 | 40 | | | |
| B(prospective memory type) | 1193.512 | 1 | 1193.512 | 70.592 | **.00** |
| AB | 10.512 | 1 | 10.512 | .622 | **.43** |
| Error (Within) | 642.47 | 38 | 16.90 | | |


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**Table3: AXB Anova Summary Table (Repeated On B)**
**Design: 2(positive, neutral) X 2 (event, time and activity based) prospective memory task**

| Source | SS | *df* | MS | F | Significance | $\eta^2$ |
|---|---|---|---|---|---|---|
| **A(emotional valence)** | 90.13 | 1 | 90.13 | 5.03 | **.03** | .21 |
| **Error(Within)** | 339.86 | 19 | 17.88 | | | |
| **Within-Subjects** | 1370.84 | 31.75 | | | | |
| **B(Task)** | 766.85 | 2 | 383.42 | 38.02 | **.00** | .67 |
| **Error (Within)** | 383.15 | 25.83 | 14.83 | | | |
| **AB** | 146.31 | 2 | 73.15 | 6.07 | **.00** | .24 |
| **Error (Within)** | 457.68 | 27.75 | 16.48 | | | |

**Table 4: AXB Anova Summary Table (Repeated On B)**

**Design: 2 valence (negative, neutral) X 2 prospective memory task**

**(event, time and activity based**

| Source | SS | *df* | MS | F | Significance | $\eta^2$ |
|---|---|---|---|---|---|---|
| **A(emotional valence)** | 75.208 | 1 | 75.208 | 8.66 | **.00** | .31 |
| **Error(Within)** | 164.95 | 19 | 8.68 | | | |
| **Within-Subjects** | 881.87 | 42 | | | | |
| **B(Task)** | 575.55 | 2 | 287.77 | 30.88 | **.00** | .61 |
| **Error (Within)** | 354.11 | 38 | 9.31 | | | |
| **AB** | 63.01 | 2 | 31.50 | 4.92 | **.01** | .20 |
| **Error (Within)** | 243.31 | 38 | 6.40 | | | |


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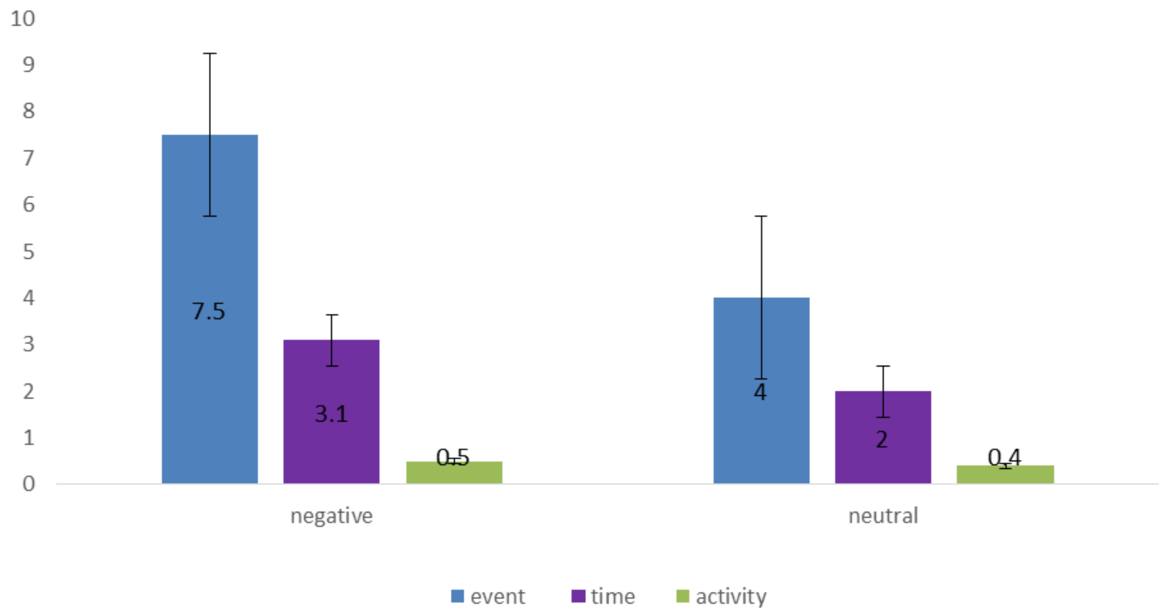


figure2. represents mean scores of prospective memory intentions across emotional valence.

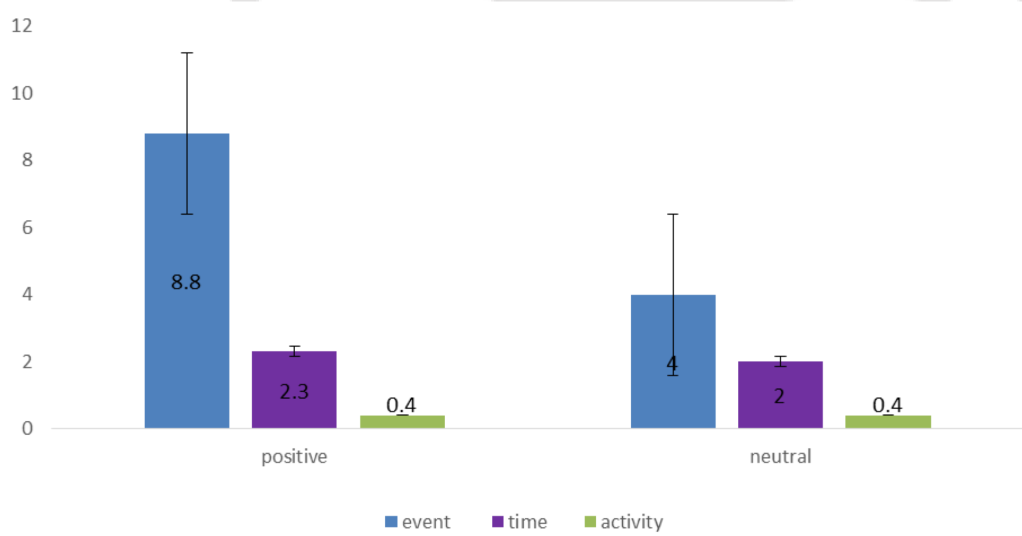


figure1. represents mean scores of prospective memory intentions across positive and neutral cues


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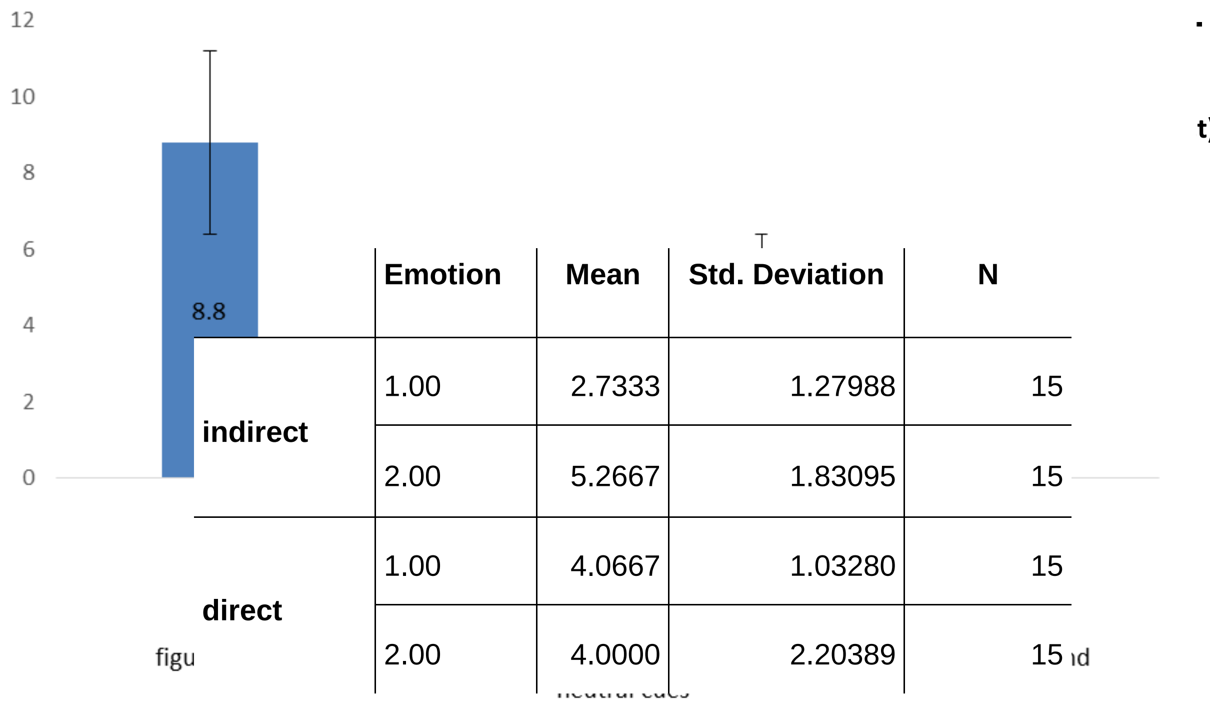


| | Emotion | Mean | Std. Deviation | N |
|---|---|---|---|---|
| indirect | 1.00 | 2.7333 | 1.27988 | 15 |
| | 2.00 | 5.2667 | 1.83095 | 15 |
| direct | 1.00 | 4.0667 | 1.03280 | 15 |
| | 2.00 | 4.0000 | 2.20389 | 15 |

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**Table 6: AXB Anova Summary Table (Repeated On B)**

**Design: 2 valence (positive, negative) X 2 presentation mode (direct, indirect)**

| Source | SS | *df* | MS | F | Significance | $\eta^2$ |
|---|---|---|---|---|---|---|
| **A(emotional valence)** | 11.40 | 1 | 11.40 | 8.556 | **.00** | .23 |
| **Error(Between)** | 37.33 | 28 | 1.33 | | | |
| **Within-Subjects** | 103.49 | 30 | | | | |
| **B(presentation style)** | .017 | 1 | .017 | .006 | **.93** | .00 |
| **AB** | 25.35 | 1 | 25.35 | 9.08 | **.00** | .24 |
| **Error (Within)** | 78.13 | 28 | 2.79 | | | |

event time activity

figure2. represents mean scores of prospective memory intentions across emotional valence.

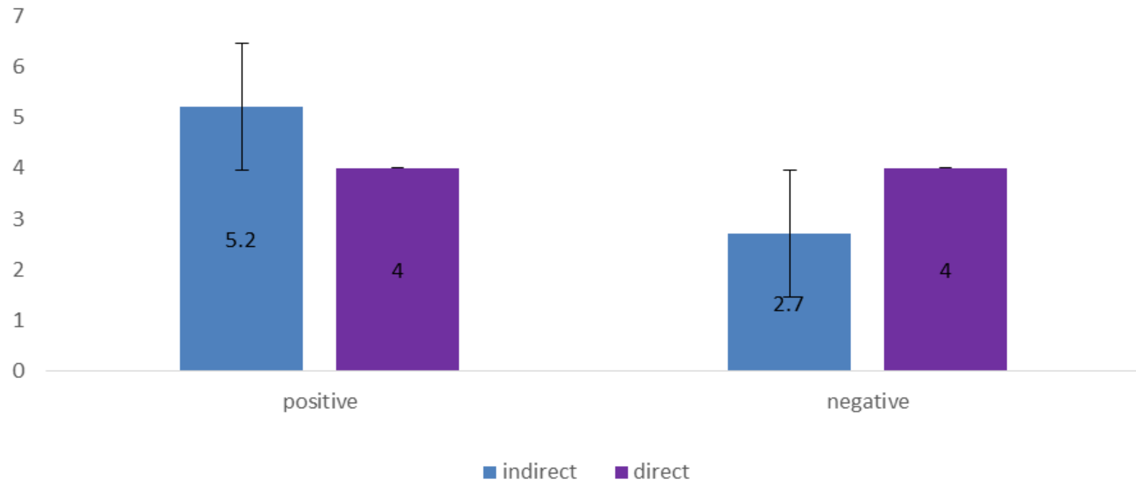


figure 3. represents mean accuracy scores for two presentation style across condition.

## Experiment 3: Effect of nature of stimuli (picture / word) used as valence cue presented across different modes on event cued prospective memory performance

**Table 7: Descriptive Statistics for 2valence (positive, negative) X2presentation mode (direct, indirect) X 2 Stimuli Type (words, pictures).**

| | group | Mean | Std. Deviation | N |
|---|---|---|---|---|
| indirect | 1.00 | 2.7333 | 1.27988 | 15 |
| | 2.00 | 5.2667 | 1.83095 | 15 |
| direct | 1.00 | 4.0667 | 1.03280 | 15 |
| | 2.00 | 4.0000 | 2.20389 | 15 |

**Table 8: AXBXC ANOVA Summary Table (Repeated on B & C)**

**Design: 2valence (positive, negative) X2presentation mode (direct, indirect) X 2 Stimuli Type (words, pictures).**

| Source | SS | *df* | MS | F | Significance | $\eta^2$ |
|---|---|---|---|---|---|---|
| **Total** | 464.13 | 1 | 464.13 | 619.33 | **.00** | .95 |
| **Between-Subjects** | 26.61 | 29 | | | | |
| **A(Emotion)** | 5.63 | 1 | 5.63 | 7.51 | **.01** | .21 |
| **Error(Within)** | 20.98 | 28 | .74 | | | |
| **B(Presentation Mode)** | 4.80 | 1 | 4.80 | 4.40 | **.05** | .07 |
| **Error (Within)** | 64.00 | 28 | 2.28 | | | |
| **AB** | 1.20 | 1 | 1.20 | .52 | **.47** | .01 |
| **C(Stimuli Type)** | 17.63 | 1 | 17.63 | 8.35 | **.00** | .23 |
| **Error(Within)** | 59.06 | 28 | 2.11 | | | |
| **AC** | 24.30 | 1 | 24.30 | 11.51 | **.00** | .29 |
| **BC** | 7.50 | 1 | 7.50 | 2.88 | **.10** | .09 |
| **Error(Within)** | 72.86 | 28 | 2.60 | | | |
| **ABC** | 17.63 | 1 | 17.63 | 6.77 | **.01** | .19 |


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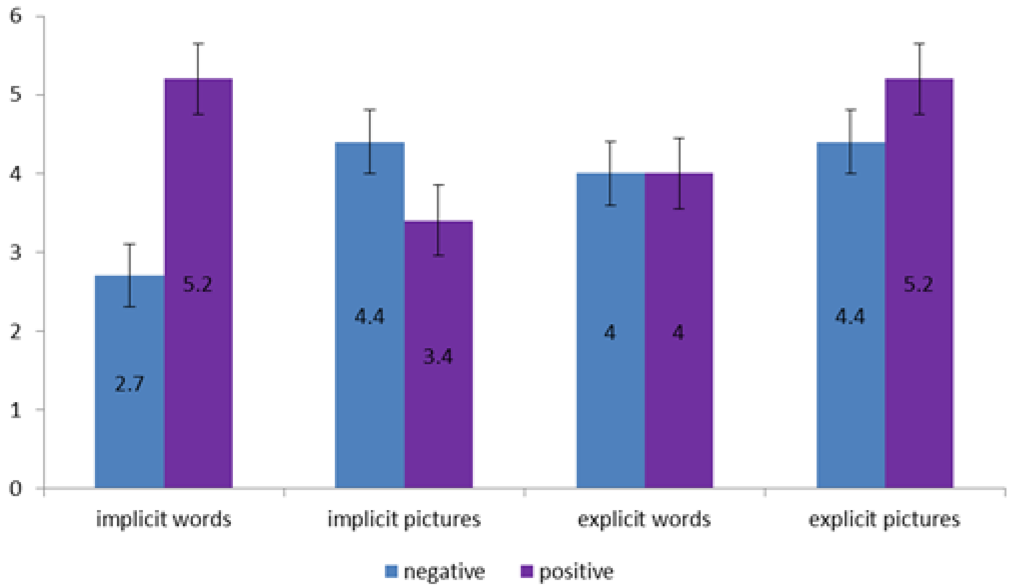


figure4. Mean scores of presentation mode across valence

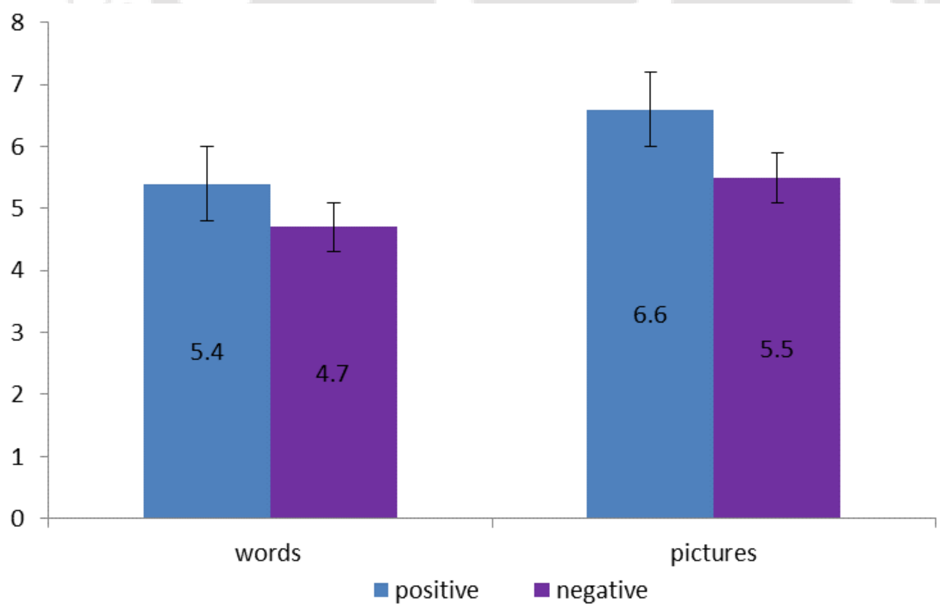


figure5. Mean score for stimuli type across both the valence


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## Experiment 4&5 Effect of cue characteristics (emotional valence, presentation mode and stimuli type)on event cued Prospective Memory across Sleep/ Sleep Deprivation

**Table 9: Descriptive Statistics for 2 valence (positive, negative) X condition (sleep/sleep deprivation) X 2 Stimuli Type (words, pictures) X 2 presentation mode (direct, indirect).**

| | Emotion | Mean | Std. Deviation | N |
|---|---|---|---|---|
| **Direct sleep pic** | 1.00 | 7.13 | 1.642 | 8 |
| | 2.00 | 8.00 | 1.069 | 8 |
| **Indirect sleep pic** | 1.00 | 6.3750 | 1.76777 | 8 |
| | 2.00 | 8.2500 | .88641 | 8 |
| **Direct sleep words** | 1.00 | 6.0000 | 2.50713 | 8 |
| | 2.00 | 8.1250 | 1.45774 | 8 |
| **Indirect sleep words** | 1.00 | 4.3750 | 2.06588 | 8 |
| | 2.00 | 8.2500 | 1.03510 | 8 |
| **Direct wake pic** | 1.00 | 3.8750 | 2.10017 | 8 |
| | 2.00 | 4.8750 | 1.95941 | 8 |
| **Indirect wake pic** | 1.00 | 3.8750 | 1.45774 | 8 |
| | 2.00 | 7.0000 | 1.51186 | 8 |
| **Direct wake words** | 1.00 | 4.5000 | 1.41421 | 8 |
| | 2.00 | 4.3750 | 2.19984 | 8 |
| **Indirect wake words** | 1.00 | 3.8750 | 1.12599 | 8 |
| | 2.00 | 5.8750 | 2.16712 | 8 |


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**Table 10: AXBXCXD ANOVA Summary Table (Repeated on B, C & D)**

**Design: 2 valence (positive, negative) X condition (sleep/sleep deprivation) X 2 Stimuli Type (words, pictures) X 2 presentation mode (direct, indirect).**

| Source | SS | *df* | MS | F | Significance | $\eta^2$ |
|---|---|---|---|---|---|---|
| **Total** | 464.13 | 1 | 464.13 | 619.33 | **.00** | .95 |
| **Between-Subjects** | 26.61 | 29 | | | | |
| **A(Emotion)** | 5.63 | 1 | 5.63 | 7.51 | **.01** | .21 |
| **Error(Within)** | 20.98 | 28 | .74 | | | |
| **B(Condition)** | 166.53 | 1 | 166.53 | 48.89 | **.00** | .77 |
| **Error (Within)** | 47.68 | 14 | 3.40 | | | |
| **AB** | 3.78 | 1 | 3.78 | 1.11 | **.31** | .07 |
| **C(Stimuli)** | 8.0 | 1 | 8.0 | 2.09 | **.17** | .13 |
| **Error(Within)** | 53.50 | 14 | 3.82 | | | |
| **AC** | .50 | 1 | .50 | .13 | **.72** | .00 |
| **D(Mode)** | .50 | 1 | .50 | .28 | **.60** | .02 |
| **Error(Within)** | 25.00 | 14 | 1.78 | | | |
| **AD** | 24.50 | 1 | 24.50 | 13.72 | **.00** | .49 |
| **BC** | 2.00 | 1 | 2.00 | .693 | **.41** | .04 |
| **Error(Within)** | 40.37 | 14 | 2.88 | | | |
| **BD** | 12.50 | 1 | 12.50 | 5.8 | **.03** | .29 |


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| | | | | | | |
|---|---|---|---|---|---|---|
| **Error(Within)** | 29.87 | 14 | 2.13 | | | |
| **CD** | 2.53 | 1 | 2.53 | 2.00 | **.17** | .12 |
| **Error(Within)** | 17.68 | 14 | 1.26 | | | |
| **ABC** | 15.12 | 1 | 15.12 | 5.24 | **.03** | .27 |
| **ABD** | 1.12 | 1 | 1.125 | .52 | **.48** | .03 |
| **ACD** | .281 | 1 | .281 | .22 | **.64** | .01 |
| **BCD** | .03 | 1 | .03 | .02 | **.87** | .00 |
| **Error(Within)** | 17.68 | 14 | 1.26 | | | |
| **ABCD** | .281 | 1 | .281 | .223 | **.64** | .01 |

**Table 11. Mean and S.D for scores obtained on questionnaires used in experimental task across positive and negative condition.**

| **Condition** | | **ESS (Epworth Sleepiness Scale)** | **DAST-10 (Drug Use Questionnaire)** | **MMSE (Mini Mental State Examination** |
|---|---|---|---|---|
| **Positive** | Mean | 19.87333 | 23.625 | 1 |
| | S.D | 1.669046 | 5.853875 | 0.534522 |
| **Negative** | Mean | 8.125 | 24.5 | 0.625 |
| | S.D | 4.882549 | 2.56348 | 0.744024 |


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## Experiment 4: Effect of emotional valence and presentation mode across sleep and sleep deprivation.

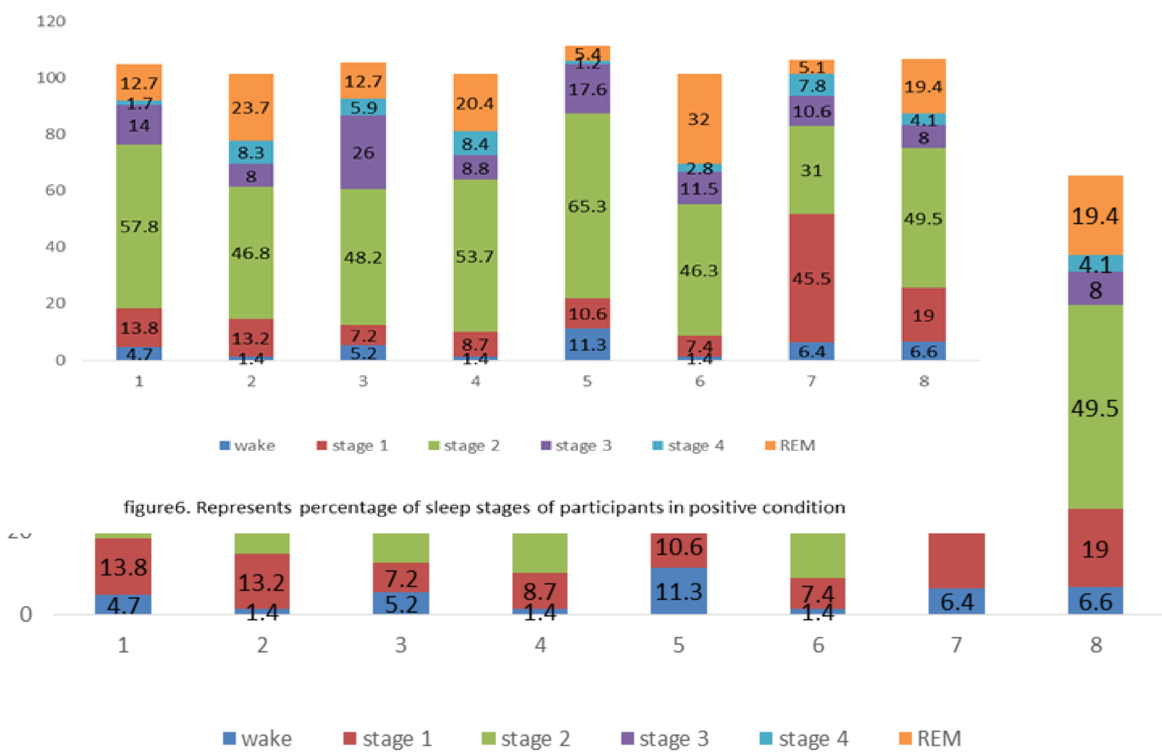


figure6. Represents percentage of sleep stages of participants in positive condition

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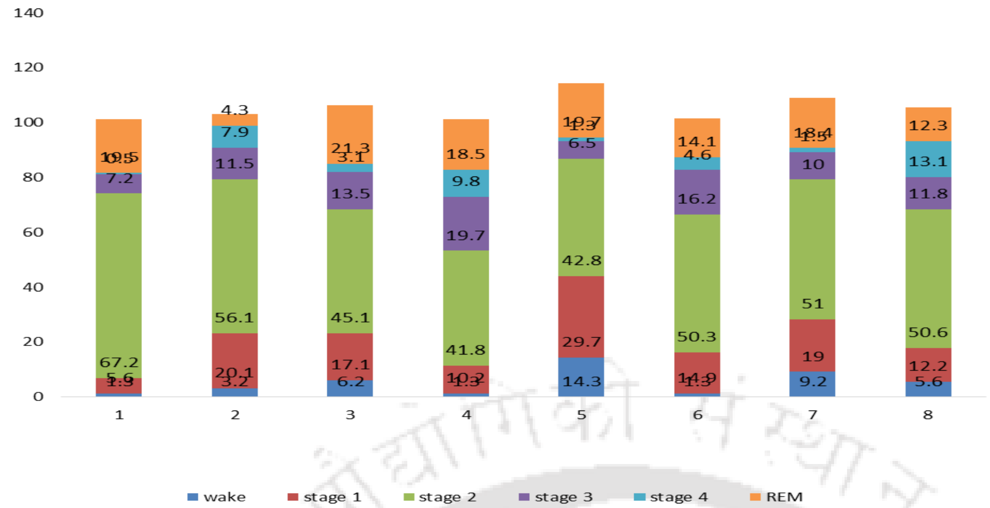


figure7. Represents percentage of sleep stages of participants in negative condition

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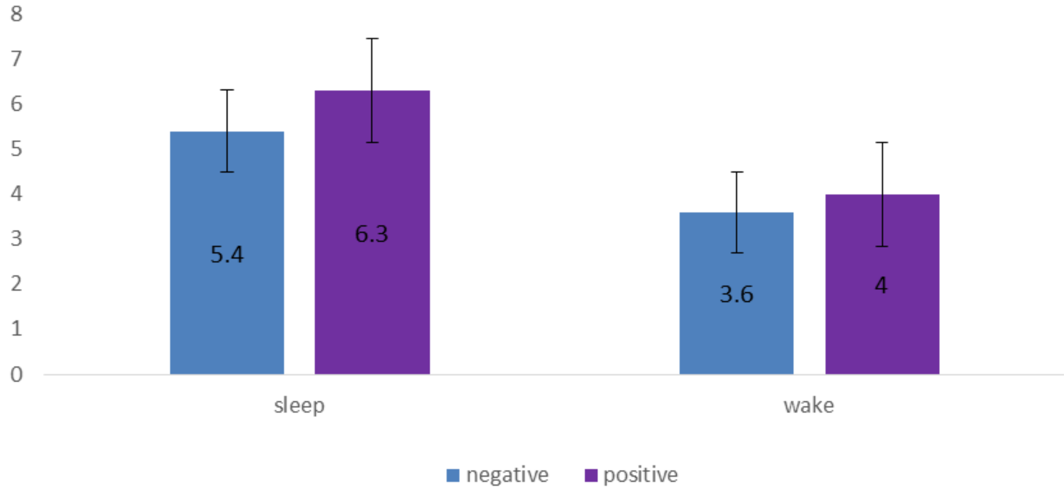


figure8. represents mean accuracy scores of positive and negative emotion across sleep and wake condition

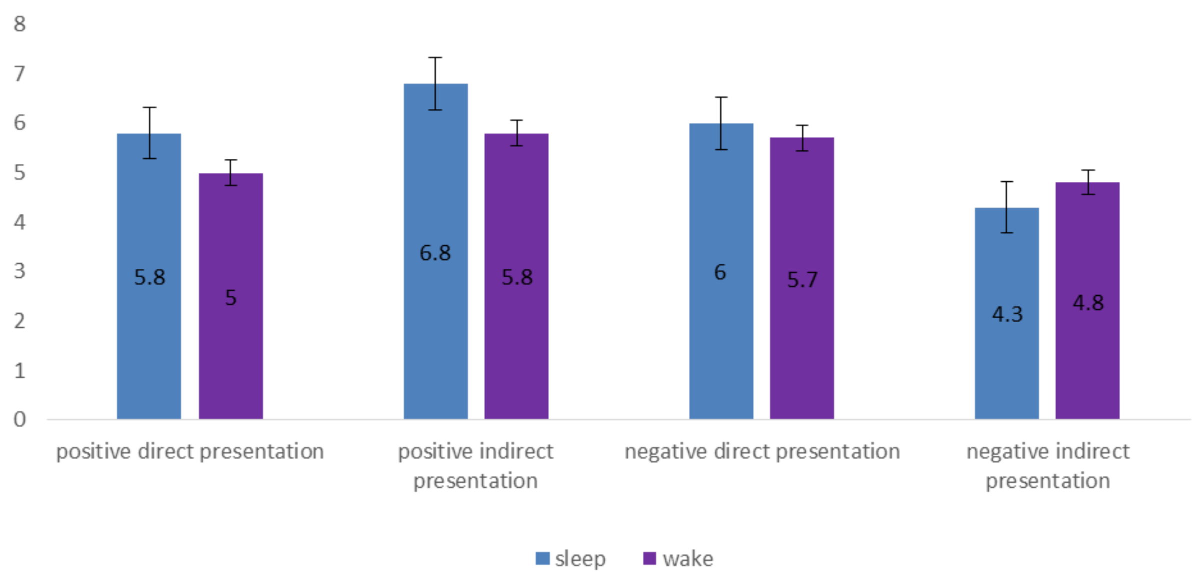


figure9. represents mean scores of presentation mode in both positive and negative emotions across sleep and wake condition


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## Experiment 5: Effect of various cue characteristics (emotional valence, stimuli type and presentation mode) across sleep and sleep deprivation.

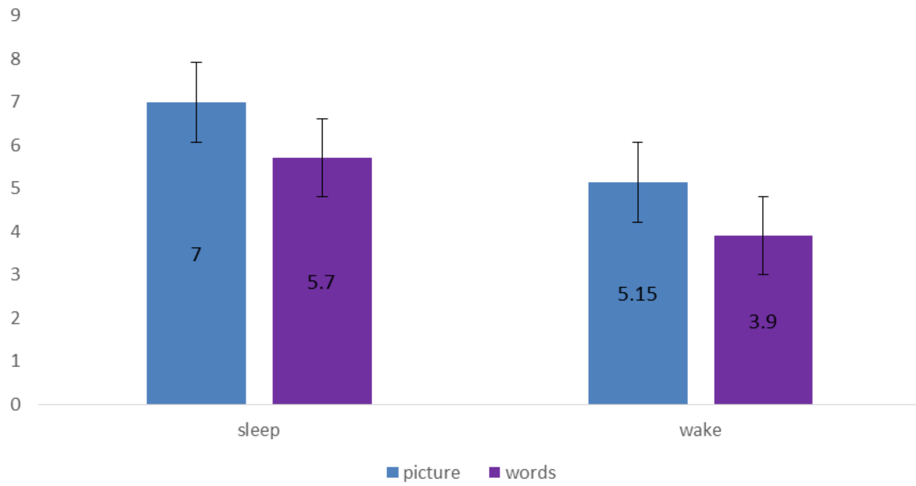


figure10. represents mean accuracy score of stmuli type across sleep and wake condition

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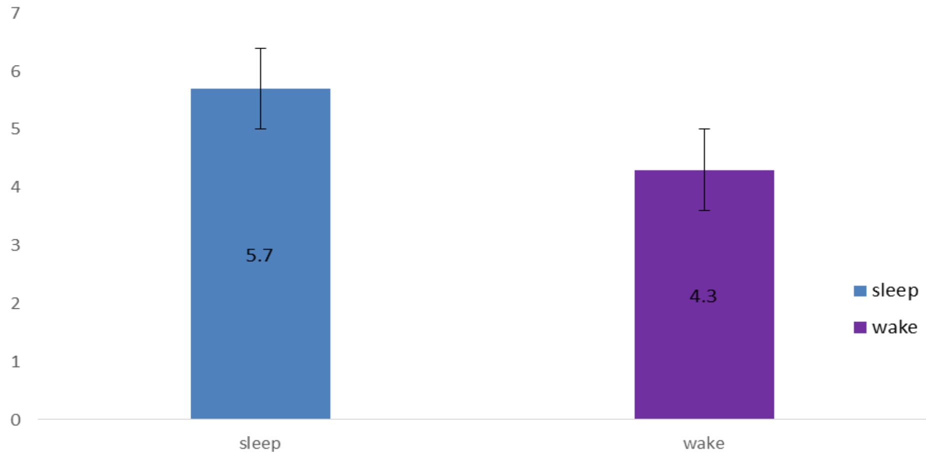


figure11. represents mean scores of prospective memory task across sleep and wake condition


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**4.1. Answers to the overall research questions:**

The present thesis aims to explore the role of sleep in modulating cue characteristics (emotional valence, stimuli type & presentation mode) and its effect on prospective memory performance. There were five experiments conducted to answer the overall research questions. In the first three experiments, cues were modified in terms of valence (positive/negative), presentation (direct/indirect) and format (pictures/words) during encoding to examine the effects of cue characteristics on prospective memory retrieval. The last two experiments of the thesis examined the effect of sleep over sleep deprivation on prospective memory retrieval caused by manipulating various cue characteristics. The first research question was whether valence of stimuli as cue characteristic feature has any effect on prospective memory. To address this question in experiment one effect of cue valence was measured prospective memory performance using valence words as cue stimuli. The valence words were selected from ANEW (Affective Norms for English Words) prepared by Bradley & Lang (1999) using pre-determined criteria. It was hypothesized that cue retrievals (performance) of emotional cues will be better compared to neutral cues. The experiment had two groups of subjects (positive and negative)and subjects in each group were presented with the valence and neutral cues specific to their groupings (e.g., positive group subjects received positive and neutral cues only).Results of the study revealed significant differences in within group comparisons (positive/neutral; negative/neutral) but non-significant differences between group comparisons (positive/negative). The second research question was designed to test whether significant results from experiment one can be extended over all types (event, time & activity) of prospective memories. To answer this question we repeated experiment one with three types of prospective memories. The dependent variable for event, time& activity cued prospective memory were accuracy scores (cue retrievals for event & time and successful completion of pre-defined activities for activity; see method section for details). In accordance with previous research findings, it was expected that performance will differ significantly across time/event/activity based prospective memory. The result indicated significant main effect of valence over neutral cues across prospective memory types and suggests that irrespective of valence (positive/negative) prospective memory performance differs across prospective memory types. For both the research questions our hypothesis was accepted showing that emotional cues enhance prospective memory


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performances across all prospective memory type in comparison with neutral cues. But among three prospective types event based task were found to be most affected by cue saliency as it is only one prospective memory type that relies heavily on external cues.The third question of the thesis was whether positive and negative affect cue have differential effect on event cued prospective memory performance. In our previous experiment we compared emotional and neutral valence and found significant difference between them difference between positive and negative valence didn't found to be significant. So in experiment two only positive and negative cues were used excluding the neutral cues to examine clear difference between two valence separately. In terms of retrieval accuracy it was expected that positive cues will foster cue retrieval and there will be difference in performance across positive and negative condition. The result confirmed our hypothesis indicating significant main effect of valence. There was clear difference found among the positive and negative valence groups on prospective memory cue retrievals. This result shown that memory for positive emotion is better remembered compared to negative. The fourth research question was to study the effect of manipulating cue presentation mode (direct/indirect) on event cued prospective memory performance. The hypothesis formulated for this question was that there will be significant difference between modes of presentation with indirect cue presentation facilitating relatively better prospective memory performance. The result of the experiment revealed non-significant difference for prospective memory cue retrieval accuracy as a function of cue presentation mode. Thus, hypothesis formulated for this question was rejected as prospective memory was not significantly affected by manipulation of presentation style. The fifth research question was concerned with studying the effect of types of emotional stimuli (words/ pictures) on prospective memory. It was expected that pictures would result in more accurate prospective memory retrievals as compared to words. Participants were presented valence cue in two formats (words/pictures) under direct and indirect presentation mode (experiment 3). The results of our experiment confirmed our hypothesis that picture when compared to words will better prospective memory retrievals pertaining to picture superiority effect. The sixth research question was whether differentially valence (positive/negative) cues (picture/words) when presented across varying modes (direct/indirect) has significant effect on prospective memory. The result revealed significant interaction of cue valence, stimuli type and presentation mode. This result indicates that valence


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cues when presented in picture format under different presentation mode can generate better prospective memory response.

The seventh research question was whether sleep filled retention interval modulates event cued prospective memory. To address this question in experiment four participants were invited to sleep laboratory for three nights (adaption night, experimental (sleep) night and control (sleep deprivation) night). Participants were shown cues before sleep and were tested the following morning with a prospective memory task embedded in an ongoing task. It was hypothesized that sleep will enhance prospective memory performance compared to sleep deprivation. Results of the experiment confirmed our hypothesis showing performance to be better in sleep condition compared to sleep deprivation. The eighth question comprised of two parts. The first section of the question was to examine whether cue valence (positive/ negative) have differential impact on prospective memory across sleep and sleep deprivation condition. To examine this question the experiment was categorized in two conditions: emotional and neutral where the cues presented in experiment four were emotional and neutral respectively under two presentation modes (direct/indirect). Based on our previous findings it was hypothesized that sleep will facilitate consolidation of emotional cue compared to neutral. Results indicated significant main effect of cue valence (positive/negative) on event based prospective memory which confirms our previous results that compared to neutral cues emotional valence enhances prospective memory performances. The second section of question eighth was whether sleep modulates cue retrieval for emotional valence cues presented under direct/indirect presentation mode. The previous findings of the thesis displayed insignificant results in context of presentation mode. It was expected that sleep will modulate the effect of presentation mode and performance will be better for indirect presentation of cues. Results indicated non-significant difference for cue presentation mode (direct/indirect). This indicates that although there is no difference in prospective memory performances, indirect cues are as effective as direct cues on cue retrievals. There was significant interaction found between presentation mode and cue valence as well as between sleep, valence and presentation mode. The last research question was whether sleep modulates cue retrieval for emotional valence cue as a function of cue characteristics. In our previous findings, picture superiority effect was found so it was expected that sleep will facilitate prospective memory across stimuli type. The experiment was conducted using word stimuli to explore the role played


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by sleep and its interaction with emotional valence and cue presentation. In the experiment the participants were categorized in two groups (sleep and sleep deprivation) and were presented valence cues in form of pictures and words cue under direct and indirect presentation mode (experiment 5). Result revealed non-significant effect found for stimuli type (picture/word)but there was significant interaction found between stimuli type and emotion; sleep, stimuli type and emotions. All other results turned out to be non-significant.

### 4.2. The Findings in relation to previous research

#### 4.2.1. Emotional Valence and Prospective Memory Intentions:

Prospective memory is essential for everyday functioning and it is important to identify factors moderating prospective memory performance. Previous research implies that besides cognitive factors, emotions play an important role in prospective memory. The first evidence that prospective memory performance is influenced by emotions comes from findings that time-based prospective memory of clinically depressed adults is impaired (Rude, Hertel, Jarrold, Covich, & Hedlund, 1999). Further support comes from recent findings that clinical depression also results in impaired event based prospective memory, but only with non-focal prospective memory cues (Altgassen, Kliegel, & Martin, 2009). The present thesis reports beneficial effects of valence on event based prospective memory which can be explained conceptually through the predictions from the multi-process framework (McDaniel & Einstein, 2000) which maintains that emotionally salient cues facilitated prospective memory performance. The beneficial effect of cue valence on event cued prospective memory could also be attributed to the fact that emotionally salient information are more likely to be recalled and attended to than emotionally neutral information (Murphy & Isaacowitz, 2008).

Consistent with many previous studies, the results in the experiments indicated emotional valence as major variable that fosters prospective memory performance. The thesis attempts to evaluate the effect of emotional valence on different types of prospective memory. In context of performance on prospective memory tasks, significant difference was found among all three prospective memory types. This result suggests that different processes are involved in different types of prospective memory intentions which have been reported in previous studies. Event-based PM requires fewer executive resources than time-based as event based prospective


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memory task has to be executed at occurrence of specific cue whereas time-based prospective memory relies more heavily on internal control mechanisms and the self-initiated reactivation of one's intention, given that no external cues are available (Einstein, G. O., Mcdaniel, M. A., Thomas, R., Mayfield, S., Shank, H., Morrisette, N., et al., 1995). Activity based prospective task is executed after completion of some other activity (e.g., the timer going off) which itself serves as a cue, and automatically reactivates one's prior intention. Kliegel, Ramuschkat, and Martin (2003) report that both event and time based prospective memory tasks rely on different executive processes, with event based tasks requiring inhibition and time based task requiring shifting. The executive functions of inhibition and shifting explain the ability to flexibly switch between tasks, when a reconfiguration of memory is required, by disengaging from previous goals or task sets (Mayr and Keele, 2000). Monsell and colleagues (2000) have demonstrated that reaction time depends on the preparation to task changes, namely mean reaction time is longer (and error rate usually greater) when the task changes (shifting) than when the same task is performed as on the previous trial. Different from event based and time based, in activity based tasks no interruption of the ongoing task is required to retrieve the intention and execute the PM task (Kvavilashvili & Ellis, 1996). Because of this reason, we expected to have better result for activity cued prospective memory task. But the results revealed lesser accuracy scores in activity based task compared to other two prospective memory task. Such results can be attributed to the fact that activity based task are followed by other activities and the end of one task acts as less salient cue than the typical event-based cue that often occurs in the focus of attention (Hicks, Cook & Marsh, 2005). Compared to event based prospective memory task, which is an independent kind of task being retrieved by some external cue, activity based tasks are performed at the end of other activities which means that retention period for this task is filled with other intentions and which can lead to failure of activity based tasks. However, if one has learned to perform the activity-based intention at critical junctures in a variety of different circumstances, then cognitive load will not have the same deleterious consequences that have been observed in this thesis. This means that practice also have an effect on execution of prospective memory tasks. Other than these, there can be variations among prospective memory intentions, depending on the characteristics of the prospective memory task (i.e., target cue distinctiveness, associative strength between the target cue and the intended action, level of


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emphasis given to the PM task, length of the PM retention interval), the nature and demands of the ongoing task (i.e., focal processing of the target, degree of engagement, and demands of the ongoing task), and the characteristics of the individuals. Okuda, J., Fujii, T., Ohtake, H., Tsukiura, T., Yamadori, A., Frith, C. D. (2007) conducted a positron emission tomography study on young adults to examine event based and time based prospective memory. They found that different sub regions of the rostral prefrontal cortex were involved in event based and time based, and reported additional activation of several frontal, parietal, and temporal cortices, as well as the cerebellum in the time based prospective memory task, suggesting the engagement of additional processes in time based prospective memory. The identification of distinct neural substrates for the two tasks supports the idea that different cognitive processes are involved in event based and time based prospective memory. Another important finding that the study indicates is impact of emotions on all prospective memory tasks. Compared to neutral cues participants performed better with emotional cues across all three task types and conditions (positive, negative). The data is consistent with the notion that emotional items are more distinctive or salient than neutral items, and that they may spontaneously trigger the PM intention and reduce the need for deliberate processing. Our results show nearly equal facilitation for both negative and positive stimuli but significantly better facilitation as compared to neutral stimuli. Eviatar & Zaidel (1991) in study have reported facilitation effects for emotional (positive, negative) words over neutral words. Since the study used a mixed design with both positive and negative words, specific facilitation in terms of positive and negative over neutral words cannot be safely deduced. Similar results were also reported by Challis & Crane (1988) and Kanske & Kotz (2007). Previous studies more directly explain the idea that performance is better for emotional than for neutral cues in event-based PM tasks (Altgassen et al., 2010; Rendell et al., 2011). Altgassen et. al.,(2010) demonstrated better PM for emotional than for neutral PM targets, although this finding was reliable for older but not younger adults. In addition, Rendell et al. 2011 found significantly better PM for positive than for neutral cues for both younger and older adults, but the difference between negative and neutral cues was not reliable. Both studies indeed suggested that emotional PM cues may be more salient than neutral cues, at least in some circumstances, but the methodologies across these studies limited any strong conclusions that could be drawn about PM and emotion. In all our experiments, there is a


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common finding that positive valence cues have better effects on prospective memory performance compared to negative and neutral cues for event based tasks. One possible reason for the pattern of results we have obtained in our study can be drawn from research on processing of positive and negative stimuli. Studies using negative and positive stimuli have reported that although negative stimuli are encoded at the same speed as positive stimuli, negative stimuli hold attentional processes longer than positive / neutral stimuli (Fox, Russo, Bowles, & Dutton, 2001). This leads to slow processing for negative stimuli which in turn leads to slower responses to negative valence stimuli in cognitive tasks not employing explicit evaluative judgments (Algom, Chajut, & Lev, 2004; Estes & Verges, 2008). This temporary slowdown in processing of negative stimuli has been attributed to the innate defense mechanisms that freeze all ongoing activity (Algom, Chajut, & Lev, 2004). Our results based on mean scores report better response for positive valence compared to negative valence cue which shows similar pattern of results to Rendell et al., 2011. However, the effect found is not significant enough to prove differential effect of both positive and negative valence on prospective memory tasks. Another plausible explanation for this effect can be shared neural regions that are involved in the regulating positive and negative emotions. The regulation of positive and negative emotions commonly involved the left superior and lateral frontal regions (BA8/9) (Mak et. al., 2009). Another study on prospective memory reported that positive cues improved the prospective component, while negative cues improved the retrospective component in old people but valence has no significant main effect on younger adults on an overt accuracy measure of prospective memory (Schnitzspahn, Horn, Bayen, & Kliegel, 2012). For younger adults, amygdala activation during picture encoding is associated with superior memory compared to old people for emotionally positive and negative information (Cahill, L., Haier, R. J., Fallon, J., Alkire, M. T., Tang, C., Keator, D., Wu, J., & McGaugh, J. L., 1996). This implies that processes underlying emotional effects on prospective memory may differ depending on valence and age. But still the issue of emotional valence in context of prospective memory remains unraveled because of existing discrepancies in results due to methodological limitations which require further researches in the area to implicate clear understanding about emotional valence and its effect on prospective memory. The three types of prospective memory have different monitoring requirements. Research suggests that time cued prospective memory requires more self-initiated


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processing to complete, thereby also requiring greater attentional demands. Event cued prospective memory on the other hand is external cue dependent and this requires environmental monitoring for appropriate cues that signal the successful intention to act. Activity cued prospective memory, the most recent and neglected, requires monitoring the environments for certain activities that cue the execution of intentions. A broad look at the monitoring demands suggest that attentional resource allocation should be highest for time cued followed by event and activity cued prospective memory. This is expected as time monitoring is very specific requiring undivided utilization of the default brain network. On the other hand event cued prospective memory requires monitoring of specific cues to signal intent based action and thus uses lesser attentional resources. Activity cued prospective memory uses the least attentional resources as they can be initiated by varied environment cues that signal the intent based PM act. We believe that since time cued intentions requires the most attentional resources, facilitatory effects of stimuli valence is the least here than in event and activity cued prospective memory.

**4.2.2. Cue characteristics and event based prospective memory intention:**

It has been well documented in prospective memory studies that cue saliency plays vital role in enhancing prospective memory remembrance. The present thesis attempted to extend the previous findings and explore whether cue salience in terms of valence alone or in combination with other factors like presentation mode & format can equally modulate prospective memory performance. For this reason the present thesis investigated the role of cue distinctiveness (in terms of cue valence & cue presentation mode) on event cued prospective memory. Participants were presented emotional words in both direct and indirect modes. After a distraction task they were tested for prospective memory performance.

**4.2.2.1. Cue characteristics as emotional valence**

In terms of valence, the results indicated reliably greater prospective memory success for positive and over negative valence cues. Results indicate better performance of participants in positive condition across both presentation modes, preferentially when stimuli are presented in implicit mode. The plausible reason for this could be negative cues are processed more deeply than positive cues taking more time to encode (Clark-Foos et.al. 2009). This can result in lesser cue detection rates thereby lowering the response for negative cue. Research on emotions and


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prospective memory support negative dominated cue retrievals however, in the present study we find the opposite effect. The positive domination of cue retrievals may result from the small cue presentation times which would cause incomplete negative cue processing (negative cues require more processing time) thereby signaling better encoding and consolidation of positive over negative cues. Another explanation for such response can be frequent occurrence of negative situational thoughts that are generated more automatically for negatively valence material and interfere with event based prospective memory task. Experimenting with valence and age, previous studies have suggested positive event based prospective memory task being performed more accurately relative to both negative and neutral tasks (Rendell et al., 2011). Algassen et al., (2010) found that older adults exhibited significant impairment while performing with neutral cues in prospective memory task. Despite all the findings, it is still unclear how the emotion processing is manipulated by neural mechanisms. More work from various aspects and different technological approaches are needed to understand the role of valence in context of presentation mode on prospective memory performance.

#### 4.2.2.2. Cue characteristics as presentation mode

In the present study, for both type of presentation modes (direct/indirect) the cue valence was found to influence the accuracy of carrying out intended action (prospective memory accuracy).Presentation mode variation was achieved by varying the presentation time and foreground background contrast of the stimuli. The results of analysis of variance suggest non-significant main effects of presentation modes. However, we find significant effects of interaction between presentation modes and valence. Further analysis of interaction effects points to an implicit dominated enriched processing for certain levels of cue valence. This indicates that emotional information's are also processed through implicit presentation of words. Responses to emotional stimuli in implicit presentation were more effective with positive valence words compared to negative valence words. In the case of explicit presentation no such difference were found in both the conditions. This effectiveness of implicit presentation is evidence that affective processing can occur without any conscious awareness. A study by LeDoux (1989) justifies this result as it argues that the core of the emotional system is a brain mechanism which computes the affective significance of a stimulus. It gives rise to the conscious experience of emotion, and that it necessarily operates outside of conscious awareness. Evidences are also available suggesting


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that conditioning can occur without conscious awareness, as indexed by brain responses Wong, P., Bernat, E., Bunce, S., & Shevrin, H., 1997), EMG responses (Bunce, S. C., Bernat, E.,Wong, P. S., & Shevrin, H., 1999), and skin conductance (Ohman, A., Esteves, F., & Soares, J. J. F., 1995). Apart from these studies, Bernat, Shevrin and Snodgrass (2001) present evidence that subliminal stimuli produce a P300 response. This study clearly suggests that these processes can emerge within 100 ms, and can change from pleasant to unpleasant valence within seconds to randomly presented valence words. The use of semantic stimuli in the study also demonstrates that pictorial stimuli, considered more biologically prepared than words, are not required. These evidences support the notion that a substantial range of affective processes can occur without benefit of consciousness. In context of prospective memory also implicit stimuli were found to have indirect but significant effect during maintenance and execution of delayed intention (Hashimoto, Umeda & Kojima, 2011). The results demonstrate the effectiveness of implicit cues for examining the maintenance of intention. Overall, it has been found that implicit target cues can facilitate prospective memory performance, and implicit action cues can accelerate responses.

**4.2.2.3. Cue Characteristics as Stimuli Type**

Other than presentation modes there are many ways in which information can be encoded but these methods generally rely on either visualizations (remembering information as images), or verbalization (remembering information as words). Picture–word studies (Smith & Magee, 1980) have shown a naming advantage for word processing but a picture advantage when problem-solving tasks or text-processing tasks were used. Potter (1976) in her study found that, pictures were detected better than printed words while studying short-term memory for pictures. According to Theios & Amrhein (1989), there are well-recognized differences in encoding stimuli across these two formats (and it is generally acknowledged that comprehension of instructional materials is enhanced when illustrations appear together with textual material (Glenberg & Langston, 1992; Larkin & Simon, 1987). Studies depicting better performance for pictures compared to words in retrospective memory studies reveal that picture superiority effect in memory applies to both recall and recognition (Madigan, 1983; Paivio, 1991). The evidence for such results come from study by Standing, Conezio, & Haber (1970), where participants studied over 2000 pictures at a rate of 10 seconds each, and shown accuracy up to 90% in


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recognition test several days later. Because the surface features of pictures are generally more varied and distinctive than those of words, it has often been hypothesized that the memory effect can be ascribed to those perceptual features (Jacoby, 1983). Nearly all studies in prospective memory have used words or pictures as a cue, carrying dimensions that make it more accessible during retrieval of intention. Surprisingly, there are very few studies that compared the difference of encoding of words and pictures and its effect on prospective memory. One of the previous study (experiment 2, Mc Daniel et al., 1998) examined the picture superiority effect in prospective memory using a factorial design to manipulate encoding format (picture or word), retrieval format (picture or word), and environment where encoding and retrieval occurred. Results indicated a robust picture superiority effect, with prospective memory performance significantly higher in the picture encoding conditions, than the word encoding conditions. Another study by Fink (2013), demonstrated that a picture superiority effect does exist for prospective memory tasks. Participants viewing all picture stimuli not only remembered to perform the prospective memory task more often than participants who viewed all word stimuli; they also performed the ongoing categorization task faster. The result of the present thesis in line with previous findings also indicated better prospective memory performances for pictures compared to words independent of valence. The reason why pictures produce better performance compared to words comes from Paivio's Dual Coding Hypothesis (Paivio 1969, 1971, 1986, & 1991). It suggests that pictures are remembered better than words (i.e. the picture superiority effect) because pictures have both a verbal and spatial code, while words have just a verbal code. That is, while words carry just semantic meaning, pictures have an additional imaginal quality associated with them as well as their semantic meaning. Pavio (1986) also suggests that the imaginal code itself is inherently mnemonically superior to verbal code, although the exact reason why remains unclear.

**4.2.3. Sleep effects on event based prospective memory:**

In retrospective memory studies it has been evinced that sleep places enhancing impacts on memory process. Ebbinghaus (1885) in his initial studies showed that sleep filled retention interval reduces forgetting whereas others (Patrick, 1896) reported impairment in memory


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performances due to sleep deprivation. This proves that sleep has been studied as a variable influencing memory processes since a long time. Recent studies on sleep and retrospective memory have claimed that sleep enhances verbal memory by aiding resistance to interference (Ellenbogen, 2009). In their study, they compared memory recall after sleep, with and without interference before testing and found that recall performance for verbal memory was greater after sleep than after wakefulness. In the condition where interference testing was introduced they found the difference to be more pronounced. By introducing interference after sleep, their study confirms an experimental paradigm that demonstrates the active role of sleep in consolidating memory, and unmasks the large magnitude of that benefit. Because memory is an essential factor that is involved in all cognitive function, it is important to strengthen and stabilize new acquired memories before sleep (Maquet, 2001). It has been documented that sleep actively promotes the reprocessing of fresh memories as well as their integration into the pre-existing network of long-term memories (Diekelmann and Born, 2009). Apart from its beneficial effect on the consolidation of previously learned memories, sleep also benefits the subsequent acquisition of new learning material (Van Der Werf, Y. D., Altena, E., Schoonheim, M. M., Sanz-Arigita, E. J., Vis, J. C., De Rijke, W., and Van Someren, E. J. 2009). Not only along span of sleep but even a short period of sleep prior to learning can enhance the capacity to encode new information (Mander, B. A., Santhanam, S., Saletin, J. M., & Walker, M. P. 2011).

In the present thesis learned intention were retrieved after one night filled with undisturbed sleep/sleep deprivation. The result of the experimental manipulation resulted in higher accuracy for cue (manipulated in terms of valence, presentation mode & stimuli type) retention post sleep. The results could be supported by two main theories which have been proposed to explain the beneficial effect of sleep for learning and memory. According to the active system consolidation theory, new memories become reactivated and reorganized on the system-level during sleep, with selected neuronal representations being potentiated and thereby strengthened (Lewis and Durrant, 2011; Inostroza, M., Binder, S., Born, J. 2013a b; Rasch and Born, 2013). While the other theory i.e., synaptic homeostasis hypothesis assumes that synaptic connections become widely de-potentiated during sleep, whereby selected memory representations are de-potentiated less or are spared from de-potentiation so that these memories come out relatively stronger (Tononi and Cirelli, 2014). Based on these notions it could be stated


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that sleep impact memory by consolidating and strengthening the learned material for better retrieval. Although the nature of learned material could contribute in retrieval success but sleep anyway helps in strong binding of association among stimuli. In context of emotional memory, studies suggest that the associations between emotion and sleep are complex and bidirectional. That is, poor sleep may adversely affect emotional well-being, and conversely, certain emotions may lead to compromised sleep (Kahn, Sheppes & Sadeh, 2013). Studies have repeatedly shown that in both real life as well as in laboratory emotionally arousing stimuli are found to be remembered better than neutral ones (Walker, 2009). Few recent studies have produced evidence demonstrating that during sleep memories are altered in ways that are emotionally adaptive. Results from studies examining sleep's role in the consolidation of emotional episodic memories suggest that the sleeping brain "unbinds" objects from their background to consolidate only the emotionally salient and perhaps adaptive emotional element (Payne and Kensinger, 2010). Also a positive association has been found between REM sleep and a consolidation bias towards negative features of complex scenes. Furthermore, the extent of this consolidation bias seems to be effected by the timing of sleep, and is maximized when sleep follows soon after learning (Payne, J. D., Chambers, A. M., Kensinger, E. A. 2012).In line with the previous research results, the present thesis also indicates beneficial effect of sleep over sleep deprivation which is supported by a many studies that suggest beneficial impact of sleep on emotional memories. For instance, in a study conducted by Walker and Tharani (2009) sleep deprivation was found to impair the encoding of neutral and especially positive emotional memories, whereas negative emotional stimuli were not significantly affected by lack of sleep. Hence, sleep deprivation may negatively affect the individual's emotional state and sleep appears to selectively influence the encoding of new memories, thus enhancing the emotional memories (Walker and van der Helm, 2009).Although we didn't found any significant difference between stimuli type, it can be assumed that processing of both word and picture stimuli undergo similar process during sleep which restrains from interference resulting in similar outcomes. But surprisingly in the case of presentation mode, the results of the thesis suggested significant interactions between presentation mode, emotional valence and sleep which indicate that emotional stimuli when presented in indirect mode can produce better remembrance of prospective memory intentions in context of sleep. The difference between implicit and explicit stimuli was not significant enough


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but the performance for both the presentation mode was found to be at same level. This indicates that implicit processing of stimuli can generate responses similar to explicit processing and gives a scope of manipulating and adding more characteristics to stimuli presentation to come across better retrieval of prospective memory intention. There is substantial evidence to indicate that rapid-eye movement (REM) sleep would be involved in consolidation of implicit (or non-declarative) memory (Plihal & Born, 1999a,b). Nevertheless, there are few studies which reported discrepant results in favor of a beneficial role of both SWS and REM sleep in episodic as well as in implicit memory consolidation (Gais, Plihal,Wagner & Born, 2000; Stickgold, R., James, L., and Hobson, J. A., 2000a). Assessment of implicit memory mainly concerns with the phenomenon whereby the mere presentation of a stimulus will modify (and usually facilitate) the subsequent processing of this item or of an item close to it, despite the absence of any conscious recollection of a preliminary encounter with it (Tulving & Schacter,1990).

In the area of prospective memory also sleep has been proven to accelerate success of intention retrieval when compared to sleep deprivation. In recent study Scullin and McDaniel (2010), examined the effect of retention interval on later remembering. The results of their study demonstrated a large decline in prospective memory performance after a long wake period compared to short delays. The result of the present thesis also revealed better impact of sleep over sleep deprivation while retrieving event based prospective memory intention which adds evidence to previous studies exploring the role of sleep on prospective memory. In the thesis, we attempt to examine the effect of long retention interval with interference (sleep deprivation) and with minimal interference (sleep) and found that in case of valence, sleep show enhancing effect on retrieval of prospective memory intention. Although sleep could not benefit the processing of stimuli type and presentation mode but significant interactions reveal that prospective memory intentions could be better remembered when cue encoding as function of cue characteristics interrelates with sleep. The results of the thesis are supported by another study conducted on sleep and prospective memory comparing the performance of “good” and “bad” sleepers in a naturalistic prospective memory task. The results showed that the good sleepers performed the prospective memory task better than the bad sleepers. Specifically, the performance of prospective memory task post wake was influenced by the quantity and the quality of the sleep (Fabbri,M., Tonetti,L., Martoni, M., & Natale,V., 2014).Diekelmann, Wilhelm,Wagner & Born


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(2013) conducted a study where they applied a laboratory prospective memory task in which subjects were required to detect cues (i.e., specific cue words) and perform associated actions (i.e., recall associated second words) in an ongoing task. Subjects were instructed to press as fast and as accurately as possible the right key (on a keyboard) for correct words and the left key for non-words. In their study they found that a period of sleep following prospective memory instruction generally improved the ability to implement the intended behavior at the appropriate time after two days. Sleep not only enhanced the overall ability to remember the intention, but benefited both the prospective component of prospective memory to remember *that* something has to be done and the retrospective component of prospective memory to remember what has to be done. The prospective component thereby specifically benefited from sleep under conditions of reduced attentional resources, suggesting that sleep supported the consolidation of prospective memories in an associative memory network favoring spontaneous-associative retrieval processes. Together, these findings indicate that sleep-dependent consolidation processes strengthen intentional memory representations that support spontaneous-associative retrieval processes to remember the intention at the appropriate time.

In essence, the topic of prospective memory remains as enigmatic as ever. Knowing the importance of prospective memory in daily life, results from our research becomes essential in informing the fields of cognitive psychology to prepare new methods of overcoming memory failures in laboratory as well as naturalistic studies.


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# Chapter 5 Conclusion

In order to lead a productive life independent from others, one must develop the ability to remember carrying out one's intentions. But this ability may decline because of various factors like age, cognitive and attention load, stress and pressure. Previous findings in this area had reported several mechanisms to improve prospective memory; one of the most prominent factors that help in remembrance of future intentions is cue saliency. It has been found in many studies that salient cues benefits prospective memory performance (McDaniel & Einstien, 2000). But cue saliency plays its major role in event based prospective memory where the intention is associated with cue and appearance of that cue helps in retrieval of the intention. Cue saliency can be measured using cue familiarity and cue distinctiveness. In the present study, cue distinctiveness has been manipulated in terms of emotional valence, modes of presentation and stimuli type. Emotions are known to play vital role in retrieving prospective memory intentions. Similarly, presentation mode (direct/indirect) and stimuli type (words/pictures) are two other variables through which the role of cue characteristics and its effect on prospective memory can be explored.

## 5.1. Implications & Contribution of the Study

The implication of present study has been categorized under three section which are described below-

### 5.1.1. Theoretical implication:

The present study added evidence to other previous studies that emotional valence helps in remembrance of future intentions. The significance of valence in all our studies clearly indicates the role of emotional valence in retrieval of prospective memory. Compared to neutral, valence cue produces better prospective memory performance. While comparing the two valences (positive/negative), in the thesis we found positive valence producing better results compared to negative.

There are very few studies conducted on presentation mode and its effect on prospective memory. Till the knowledge of researcher this is one of the first behavioral study to compare the effect of two presentation mode on prospective memory performance. The results of the study


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suggest that there is no difference between performance for both direct and indirect mode of presentation, but indirect presentation of stimuli can produce similar results as direct cues and in some cases (with positive cue) can even produce better results compared to direct cues. So, the study helps clarifying the role of presentation mode in the area of prospective memory.

Most of the studies in prospective memory have focused on strategies of overcoming memory failures using different type of stimuli. This study has compared two different types of stimuli and helped establishing the role of stimuli type on prospective memory performances. The question of whether word or picture cues support better prospective memory is important when it comes to the design of memory aids. If pictures do indeed support better prospective memory than words, the relatively simple design change of reminders from text to images may help reduce instances of forgetting both the prospective component (i.e., remembering to perform an intention at the appropriate moment) and the retrospective component (i.e., remembering the contents of the intention) of a prospective memory task. It is well-established that sleep induces memory consolidation (Diekelmann & Born 2009). Understanding the role of sleep for memory, the present thesis had compared sleep and sleeps deprivation across valence, presentation mode and stimuli type and established significant effect of valence across sleep and sleep deprivation. A positive sleep effect on goal execution in a prospective memory task has been found.

**5.1.2. Methodological implications:**

Contribution at the methodological level by this study is that the researcher developed three sets of experiments using E-prime (version 2.0) which can be used to measure effect of valence across difference stimuli type, effect of presentation mode across emotional valence, comparison of face and scenes across valence. The experiments may be used in future research in the area of prospective memory.

In addition the study design lets us compare valence and neutral cue effects on prospective memory within the same group (group 1 = positive + neutral cues, group 2 = negative + neutral cues). Most study designs used till date use three group comparisons (positive, negative & neutral). With our design we have been able to show a clear benefit of valence (positive & negative) over neutral cues [prospective memory successes of neutral cues were negligible as


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compared to valence cue]

### 5.1.3. Practical implication of prospective memory:

Neglecting to finish expectations can be irritating (neglecting to pack a toothbrush before leaving for the airplane terminal), and can have negative outcomes (neglecting to take drugs). In this way, we ought to be keen on whether we can enhance planned memory. Our everyday lives are immersed with imminent memory assignments, and forthcoming memory disappointment which can adversely influence our own wellbeing, monetary, or social life. The viable importance of this thesis lies in adding more information's related to cues characteristics which can potentially lead to enhance memory issues (Fink & Pak, 2010) by utilizing cues which are candidly loaded with differential pictorial examples with varieties in shading, brightness or text styles. Although today numerous mechanical gadgets are accessible that can be useful as updates, however they are truly costly and are not feasible for all population. These cues either as pictures or words can be reasonable approach to recall future plans.

Alongside these cues in combination with sleep can furthermore help overcome prospective memory failures. While this advantageous impact of sleep for memories of the past is well established, the part of sleep for planned memory is less well comprehended (Diekelmann, 2014). This examination includes proof that combining courses of action sleep target specially those memories that are important for future behavior. The facilitative impact of sleep over prospective memory recommends that it supports the additional recruitment of spontaneous-associative retrieval processes (Diekelmann, 2014). Together, these findings indicate that sleep-dependent consolidation processes strengthen intentional memory representations to remember the intention at the appropriate time

## 5.2. Limitations of the Study and Future Directions:

Researchers of any scientific study try their best to avoid limitations of the study, yet every scientific study carries its own limitations. Limitations of the present study are as follows:


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- The first limitation of the study is that the study had focused only on single dimension of emotions i.e. valence, in future studies other dimensions especially arousal alone or arousal and valence together could be studied as an independent variable and examine its effect on prospective memory.

- As with all experiments, there are a number of methodological shortcomings that should be considered when the quality of the results is evaluated. For instance, the sample used in the current work consisted entirely of college students, mostly freshmen and the sample was quite small. So, the findings might not be generalizable to the wider population and demographics at large, but maybe to the concentrated group of college students.

- In the present thesis the manipulations were done only at the level of encoding and retention, future studies can manipulate retrieval process and examine its effect on prospective memory retrieval.

- Experiments conducted on mode of presentation can be extended by adding more manipulations in brightness, fonts & colors. In this study, we didn't found significant difference between modes of presentations but future studies can explore the differences in pattern of the stimuli or can use animated pictures as cue to recall prospective memory intentions.

- In sleep experiments, EEG has been recorded to study the impact of sleep patterns on prospective memory and attempted to compare the result with sleep deprivation condition. Future studies could incorporate the wake condition and compare the results among three conditions (sleep, sleep deprivation & wake). ERP measures could also be taken to better understand the processing between a stimulus and a response, making it possible to determine which stage(s) are being affected by a specific experimental manipulation during prospective memory.


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# Appendix A.

# Questionnaires used in the Thesis

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# The Epworth Sleepiness Scale (ESS)

How likely are you to doze off or fall asleep in the following situations, in contrast to feeling just tired? This refers to your usual way of life in recent times. Even if you have not done some of these things recently try to work out how they would have affected you. Use the following scale to choose the **most appropriate number** for each situation:

0 = would **never** doze
1 = **slight chance** of dozing
2 = **moderate chance** of dozing
3 = **high chance** of dozing

| SITUATION | CHANCE OF DOZING (0–3) |
|---|---|
| Sitting and reading | |
| Watching television | |
| Sitting inactive in a public place (e.g. a theater or meeting) | |
| As a passenger in a car for an hour without a break | |
| Lying down to rest in the afternoon when circumstances permit | |
| Sitting and talking to someone | |
| Sitting quietly after a lunch without alcohol | |
| In a car, while stopped for a few minutes in the traffic | |
| **TOTAL SCORE** | |

**SCORE RESULTS:**

| | |
|---|---|
| 1-6 | Congratulations, you are getting enough sleep! |
| 7-8 | Your score is average |
| 9 and up | Very sleepy and should seek medical advice |

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# Consent Sheet for Subjects Participation

**I voluntarily take the responsibility as a test subject in the present experiment and am offered a token reimbursement of______INR**

**The experiment will be investigating the relation between "*Emotional Cues and Prospective Memory"* across nights filled with sleep and wakefulness**

**No invasive interferences would be made in the present experiment (no blood acceptance, no medicine dose administration). I understand the risks in volunteering for the study and voluntarily agree for participation, limiting to the conditions mentioned below:**

- **I was informed comprehensively about the test sequence, and my questions were sufficiently answered by the experimenters. The experimenters kept the indicated test conditions.**
- **I voluntarily agree to the publication of results emerging from the data collected from my participation, limiting to complete anonymity of my credentials.**
- **I can break the experiment off at any time; ask for partial / complete removal of my data / credentials without any explanations to experimental group.**

**IIT Guwahati**

________________________________________

**(Signature)**

**For Laboratory Records**

**Name:**

**House Number:**

**Tel (for reference):**

**Account Number:**
**Bank Name:**

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## General Questionnaire

**Age:_________years**

**Gender: M / F**

**Occupation/Academic: ____________**

**Handedness: Left / Right**

**Spectacles: Yes / No**

**Non Smoker: Yes / No**

**At what time in the evening do you normally go to bed?**

**How many hours of sleep in the night do you have normally?**

**Do you sleep during the day? (If yes when, how many hours)**

**Do you suffer from Chronic illness**

**Allergies?**

**Do you suffer from any clinical sleep disorder at present or in the past?**

**Do you suffer from any endocrinological, neurological or psychiatric illness at present or in the past?**

**Have you been a subject in a sleep experiment? (If yes when and with whom)**

**Do you have partial health restriction? (If yes, what)**

**Do you take any medications/Drugs?**

**Have you worked during the night 6 weeks prior to this day? (If yes When and how much)**

**Did you take cola or coffee today afternoon? (If yes when and how much)**

**Have been you undergoing special stress? (If yes, which and what exact)**

**What time did you awake today Morning?**

**Did you sleep today in the afternoon? (If yes when and what length)**

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# Mood Questionnaire

**Subject code: ________**

**Age: _______________**

**Clock Time: _________**

**Report as according to your present feeling**

**I feel the following way now ………….**

| | Not at all | | | | Very much |
|---|---|---|---|---|---|
| Sleepy | | | | | |
| Active | | | | | |
| Tense | | | | | |
| Tired | | | | | |
| Bored | | | | | |
| Motivated | | | | | |
| Concentrated | | | | | |

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# Folstein Mini-Mental State Exam

| | | |
|---|---|---|
| I. **ORIENTATION** (Ask the following questions; correct = 0) | **Record Each Answer:** | (Maximum Score = 10) |
| What is today's date? | Date (eg, May 21) | 1 0 |
| What is today's year? | Year | 1 0 |
| What is the month? | Month | 1 0 |
| What day is today? | Day (eg, Monday) | 1 0 |
| Can you also tell me what season it is? | Season | 1 0 |
| Can you also tell me the name of this hospital/clinic? | Hospital/Clinic | 1 0 |
| What floor are we on? | Floor | 1 0 |
| What city are we in? | City | 1 0 |
| What county are we in? | County | 1 0 |
| What state are we in? | State | 1 0 |
| **II. IMMEDIATE RECALL** | (correct = 0 ) | (Maximum Score = 3) |
| Ask the subject if you may test his/her memory. Say "ball, "flag," "tree" clearly and slowly, about one second for each. Then ask the subject to repeat them. Check the box at right for each correct response. The first repetition determines the score. If he/she does not repeat all three correctly, keep saying them up to six tries until he/she can repeat them | Ball | 1 0 |
| | Flag | 1 0 |
| | Tree | 1 0 |
| | | NUMBER OF TRIALS: |
| III. **ATTENTION AND CALCULATION** | | |
| **A. Counting Backwards Test** | (Record each response, correct = 0 ) | (Maximum Score = 5) |
| Ask the subject to begin with 100 and count backwards by 7. Record each response. Check one box at right for each correct response. Any response 7 or less than the previous response is a correct response. The score is the number of correct subtractions. For example, 93, 86, 80, 72, 65 is a score of 4; 93, 86, 78 70, 62, is 2; 92, 87, 78, 70, 65 is 0. | 93 | 1 0 |
| | 86 | 1 0 |
| | 79 | 1 0 |
| | 72 | 1 0 |
| | 65 | 1 0 |
| **B. Spelling Backwards Test** | | |
| Ask the subject to spell the word "WORLD" backwards. Record each response. Use the instructions to determine which are correct responses, and check one box at right fore each correct response. | D | 1 0 |
| | L | 1 0 |
| | R | 1 0 |
| **C. Final Score** | O | 1 0 |
| Compare the scores of the Counting Backwards and Spelling Backwards tests. Write the greater of the two socres in the box labeled FINAL SCORE at right, and use it in deriving the **TOTAL SCORE**. | W | 1 0 |
| | | **FINAL SCORE** (Max of 5 or Greater of the two Scores) |

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| | | |
|---|---|---|
| IV. **RECALL** | (correct = O ) | (Maximum Score = 3) |
| Ask the subject to recall the three words you previously asked him/her to remember. Check the Box at right for each correct response. | Ball | 1 O |
| | Flag | 1 O |
| | Tree | 1 O |
| **V. Language** | (correct = O ) | (Maximum Score = 9) |
| **Naming** | Watch | 1 O |
| Show the subject a wrist watch and ask him/her what it is. Repeat for a pencil. | Pencil | 1 O |
| **Repetition** | | |
| Ask the subject to repeat "No, ifs, ands, or buts." | Repetition | 1 O |
| **Three -Stage Command** | | |
| Establish the subject's dominant hand. Give the subject a sheet of blank paper and say, "Take the paper in your right/left hand, fold it in half and put it on the floor." | Takes paper in hand | 1 O |
| | Folds paper in half | 1 O |
| | Puts paper on floor | 1 O |
| **Reading** | | |
| Hold up the card that reads, "Close your eyes." So the subject can see it clearly. Ask him/her to read it and do what it says. Check the box at right only if he/she actually closes his/her eyes. | Closes eyes | 1 O |
| **Writing** | | |
| Give the subject a sheet of blank paper and ask him/her to write a sentence. It is to be written sponataneously. If the sentence contains a subject and a verb, and is sensible, check the box at right. Correct grammar and punctuation are not necessary. | Writes sentence | 1 O |
| **Copying** | | |
| Show the subject the drawing of the intersecting pentagons. Ask him/her to draw the pentagons (about one inch each side) on the paper provided. If ten angles are present and two intersect, check the box at right. Ignore tremor and rotation. | Copies pentagons | 1 O |

| **DERIVING THE TOTAL SCORE** | |
|---|---|
| Add the number of correct responses. The maximum is 30. | TOTAL SCORE |
| 23-30 = Normal / 19-23 = Borderline / <19 = Impaired | Up to Grade 8 Level |

**Folstein MF, Folstein SE, and McHugh PR, 1975**

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**NAME:** ____________________ **DATE:** ______________

DRUG USE QUESTIONNAIRE (DAST - 20)

The following questions concern information about your potential involvement with drugs not including alcoholic beverages during the past 12 months. Carefully read each statement and decide if your answer is "Yes" or "No". Then, circle the appropriate response beside the question. In the statements "drug abuse" refers to (1) the use of prescribed or over the counter drugs in excess of the directions and (2) any non-medical use of drugs. The various classes of drugs may include: cannabis (e.g. marijuana, hash), solvents, tranquillizers (e.g. Valium), barbiturates, cocaine, stimulants (e.g. speed), hallucinogens (e.g. LSD) or narcotics (e.g. heroin). Remember that the questions **do not** include alcoholic beverages.

Please answer every question. If you have difficulty with a statement, then choose the response that is mostly right.

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## Adult Version

| These questions refer to the past 12 months. | Circle Your Response | |
|---|---|---|
| 1. Have you used drugs other than those required for medical reasons? | Yes | No |
| 2. Have you abused prescription drugs? | Yes | No |
| 3. Do you abuse more than one drug at a time? | Yes | No |
| 4. Can you get through the week without using drugs? | Yes | No |
| 5. Are you always able to stop using drugs when you want to? | Yes | No |
| 6. Have you had "blackouts" or "flashbacks" as a result or drug use? | Yes | No |
| 7. Do you every feel bad or guilty about your drug use? | Yes | No |
| 8. Does your spouse (or parents) ever complain about your involvement with drugs? | Yes | No |
| 9. Has drug abuse created problems between you and your spouse or your parents? | Yes | No |
| 10. Have you lost friends because of your use of drugs? | Yes | No |
| 11. Have you neglected your family because of your use of drugs? | Yes | No |
| 12. Have you been in trouble at work (or school) because of drug abuse? | Yes | No |
| 13. Have you lost your job because of drug abuse? | Yes | No |
| 14. Have you gotten into fights when under the influence of drugs? | Yes | No |
| 15. Have you engaged in illegal activities in order to obtain drugs? | Yes | No |
| 16. Have you been arrested for possession of illegal drugs? | Yes | No |
| 17. Have you ever experienced withdrawal symptoms (felt sick) when you stopped taking drugs? | Yes | No |
| 18. Have you had medical problems as a result of your drug use (e.g. memory loss, hepatitis, convulsions, bleeding, etc.)? | Yes | No |
| 19. Have you gone to anyone for help for drug problem? | Yes | No |
| 20. Have you been involved in a treatment program specifically related to drug use? | Yes | No |

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**PANAS-X**

This scale consists of a number of words and phrases that describe different feelings and emotions. Read each item and then mark the appropriate answer in the space next to that word. Indicate to what extent you feel this way *right now*. Use the following scale to record your answers:

| **1** | **2** | **3** | **4** | **5** |
|---|---|---|---|---|
| very slightly or not at all | a little | moderately | quite a bit | extremely |

1. ______cheerful
2. ______disgusted
3. ______attentive
4. ______bashful
5. ______sluggish
6. ______daring
7. ______surprised
8. ______strong
9. ______scornful
10. ______relaxed
11. ______irritable
12. ______delighted
13. ______inspired
14. ______fearless
15. ______disgusted with self
16. ______sad
17. ______calm
18. ______afraid
19. ______tired
20. ______amazed
21. ______shaky
22. ______happy
23. ______timid
24. ______alone
25. ______alert
26. ______upset
27. ______angry
28. ______bold
29. ______blue
30. ______shy
31. ______active
32. ______guilty
33. ______joyful
34. ______nervous

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35. ______lonely

36. ______sleepy

37. ______excited

38. ______hostile

39. ______proud

40. ______jittery

41. ______lively

42. ______ashamed

43. ______at ease

44. ______scared

45. ______drowsy

46. ______angry at self

47. ______enthusiastic

48. ______downhearted

49. ______sheepish

50. ______distressed

51. ______blameworthy

52. ______determined

53. ______frightened

54. ______astonished

55. ______interested

56. ______loathing

57. ______confident

58. ______energetic

59. ______concentrating

60. ______dissatisfied with self

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**Scales**

General Positive Emotion:= (p31 + p25 + p3 + p52 + p47 + p37 + p13 + p55 + p39 + p8)

General Negative Emotion:= (p18 + p44 + p34 + p40 + p11 + p38 + p32 + p42 + p26 + p50)

fear:= (p18 + p44 + p53 + p34 + p40 + p21)

hostility:= (p37 + p38 + p11 + p9 + p2 + p56)

guilt:= (p32 + p42 + p51 + p46 + p15 + p60)

sadness:= (p16 + p29 + p48 + p24 + p35)

joviality:= (p22 + p33 + p12 + p1 + p37 + p47 + p41 + p58)

self_assurance:= (p39 + p3 + p57 + p28 + p6 + p14)

attentiveness:= (p25 + p3 + p59 + p52)

shyness:= (p30 + p4 + p49 + p23)

fatigue:= (p36 + p19 + p5 + p45)

serenity:= (p17 + p10 + p43)

surprise:= (p20 + p7 + p54)

basic positive affect:= (joviality+self_assurance+attentiveness)/3

basic negative affect:= (sadness+guilt+hostility+fear)/4

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# Appendix B.

# Equipments Specification

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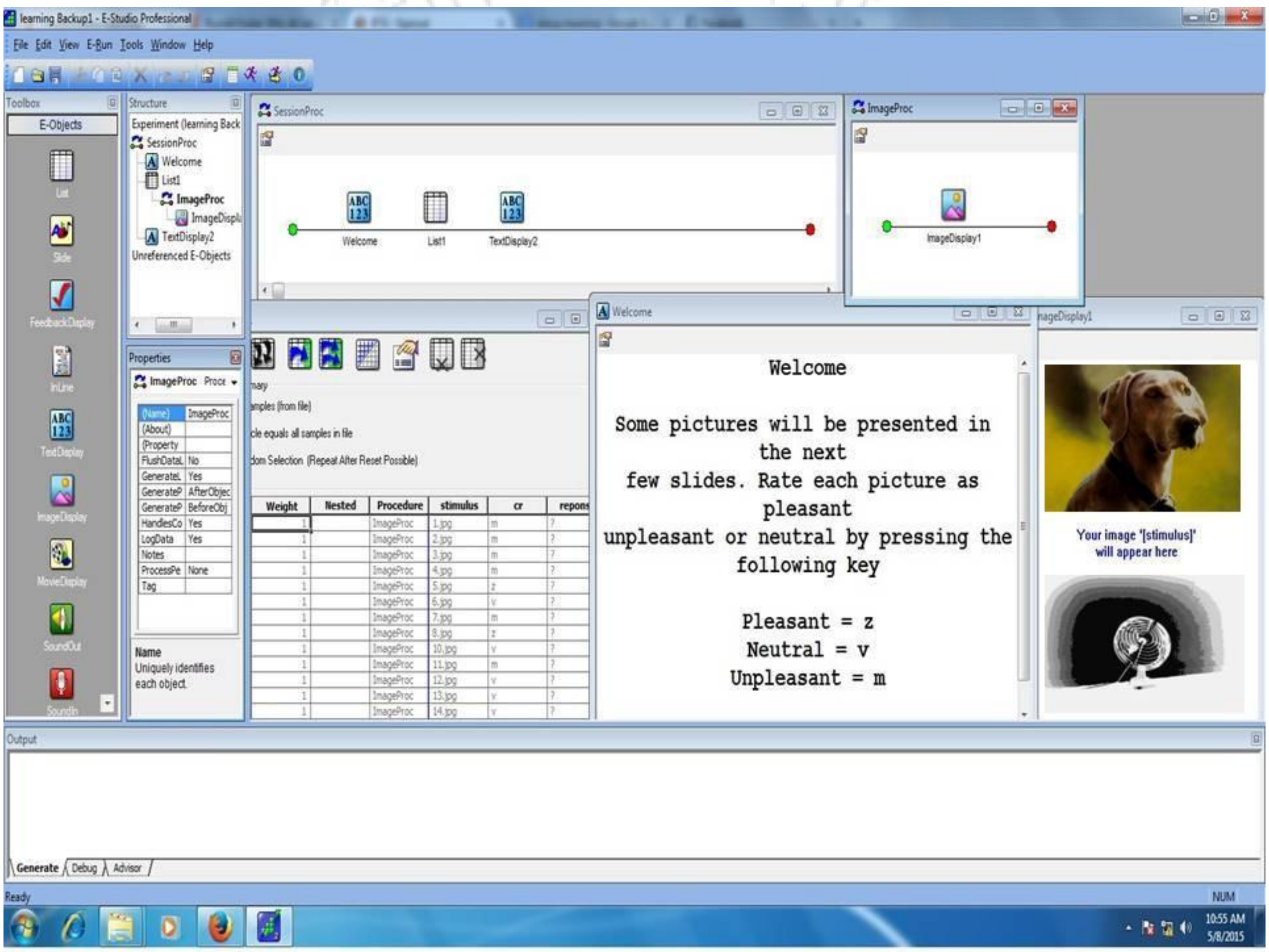
## Specification of Instruments:

1. E-prime 2.0 for designing experiment:

This set of applications is used for computerized experiment design, data collection and analysis. It provides millisecond precision timing to ensure the accuracy the data. E-Prime's flexibility to create simple to complex experiments is ideal for both novice and advanced users.



2. 40 channel Nihon-Khoden polysomnography system:

This system serves as a digital electroencephalogram (EEG) and polygraph. With up to 44 channels (20 EEG/PSG inputs, 14 bipolar inputs, 10 DC inputs, and integrated SpO2 adapter connection) it is the ideal alternative for polysomnographic diagnostic recording. The scope of functions can be easily extended with optional add-ons, such as the latest generation of synchronous video recording. With integrated frequency and amplitude mapping, even the comprehensive standard software of our Neurofax series provides a range of functions which greatly exceeds the normal standard. The optional Polysmith™ software enables powerful, automated sleep analysis with report functionality.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# Appendix C.

# Sleep Reports

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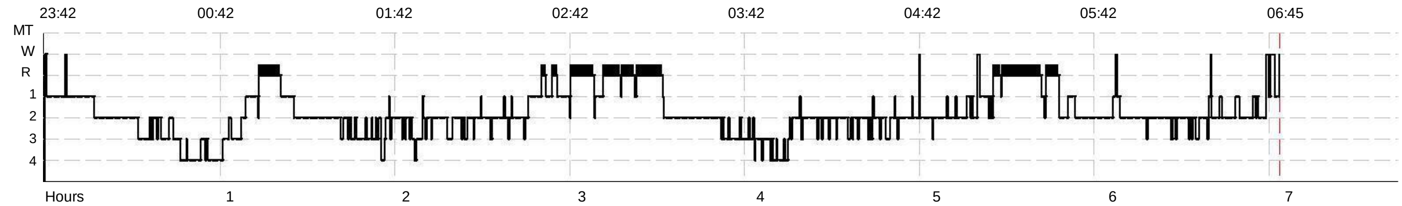
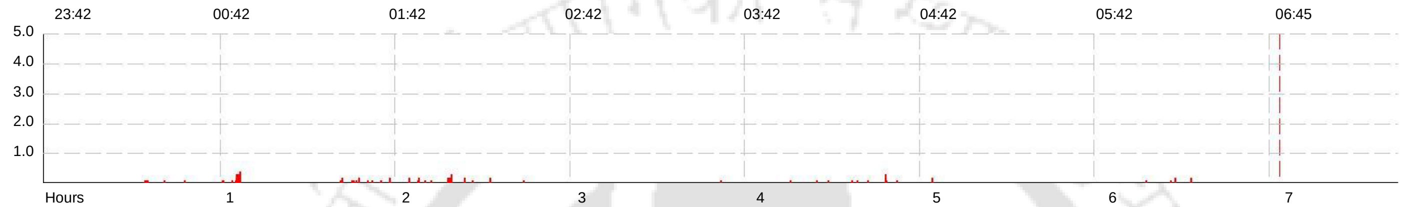
Name: Subject 13

Patient ID: 0013

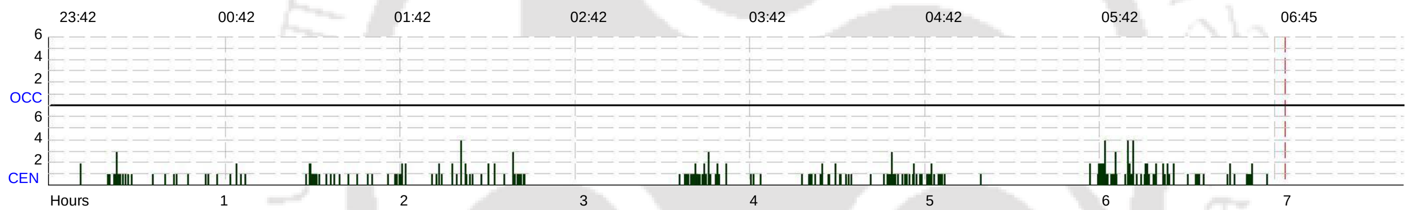
Date: Sun, Feb 09, 2014



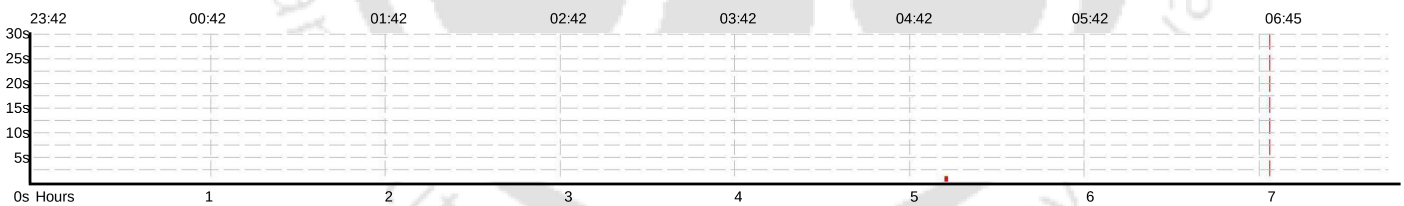

## Sleep Stages



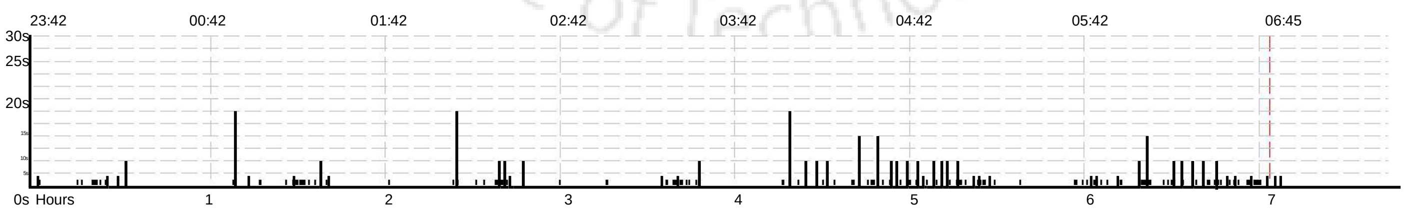

## Alpha/Delta



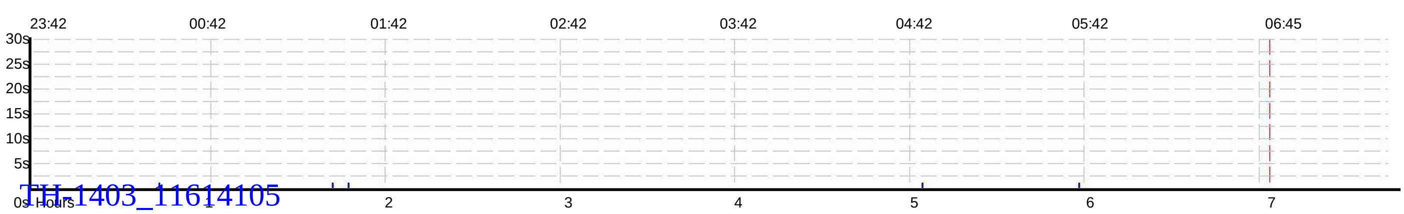

## Spindle count per epoch (EEG1 and EEG2)




## Beta time (s) per epoch




## Delta time (s) per epoch



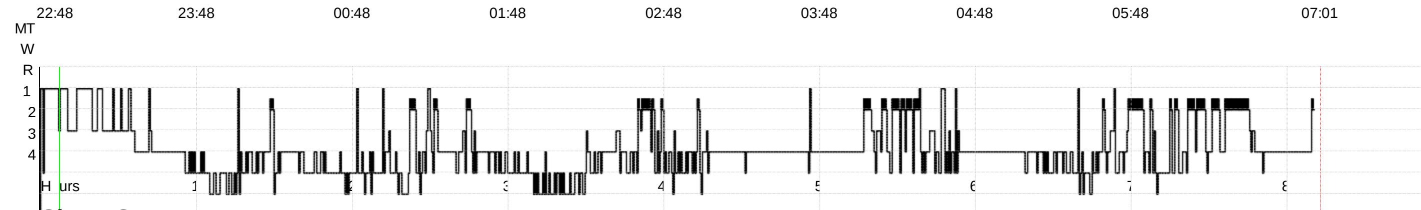

TH-1403_11614105

## Theta time (s) per epoch

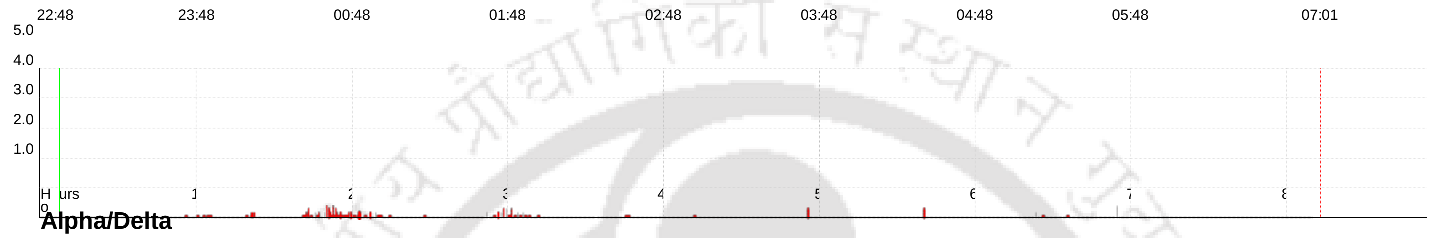
Name: Subject 7

Patient ID: 007

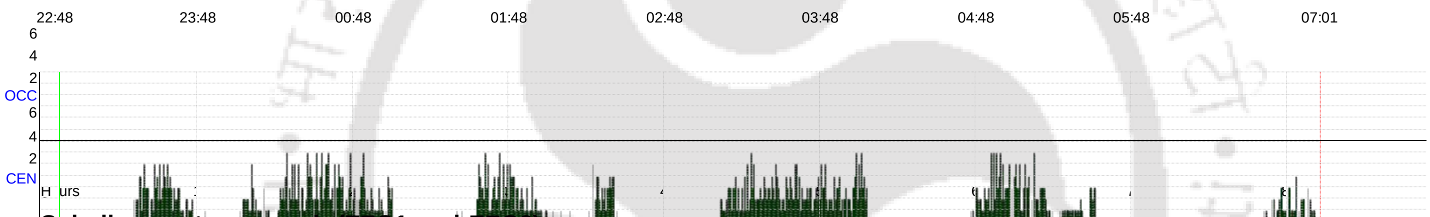
Date: Mon, Mar 31, 2014



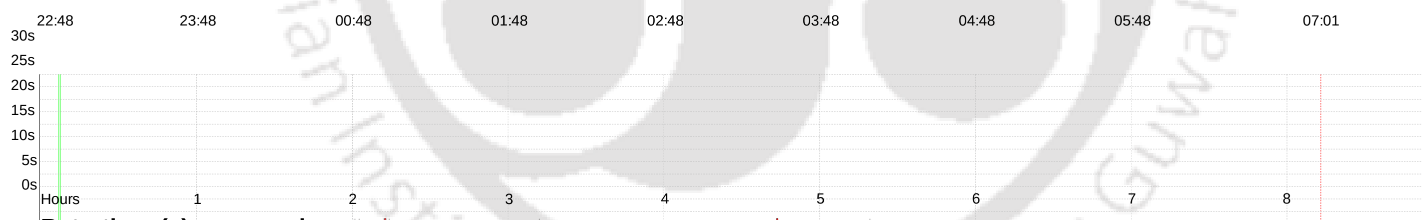

Sleep Stages



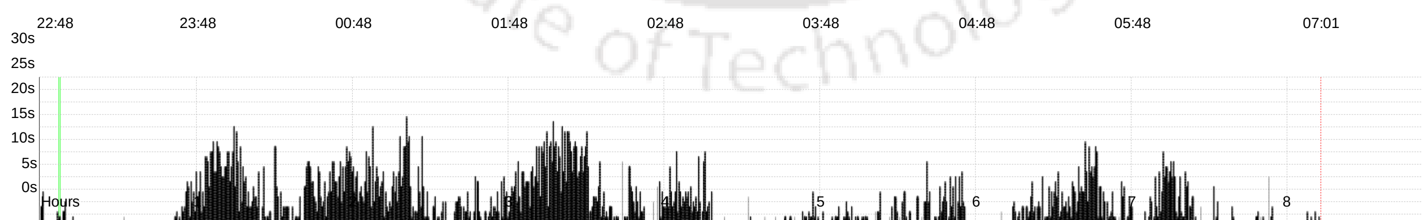

Alpha/Delta



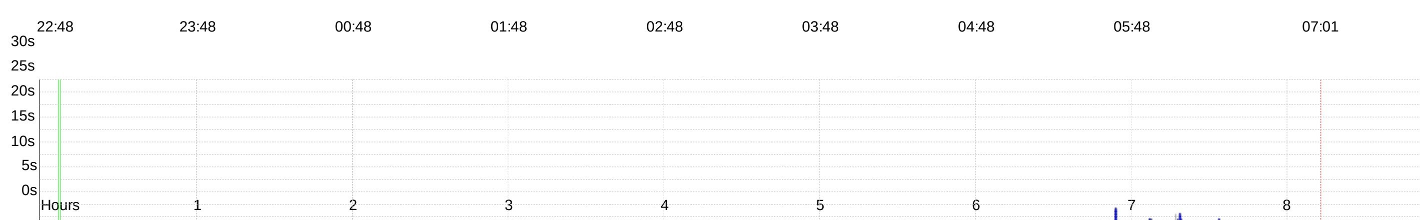

Spindle count per epoch (EEG1 and EEG2)




Beta time (s) per epoch




Delta time (s) per epoch




Theta time (s) per epoch

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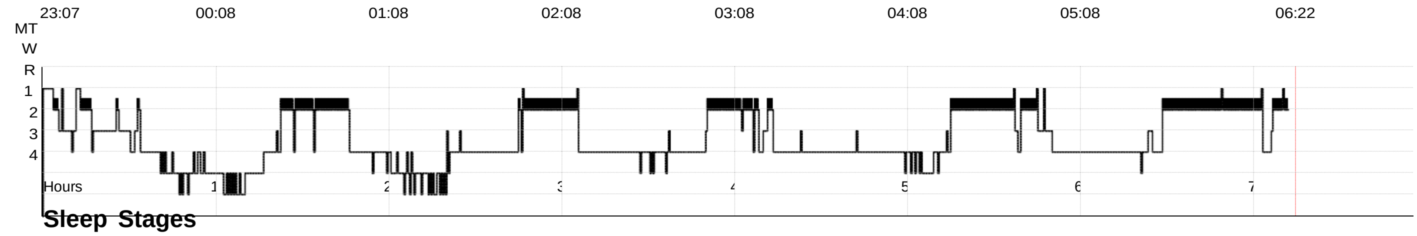
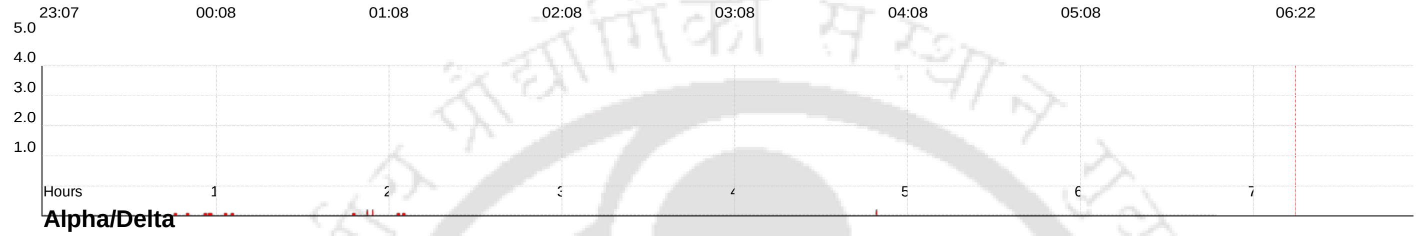
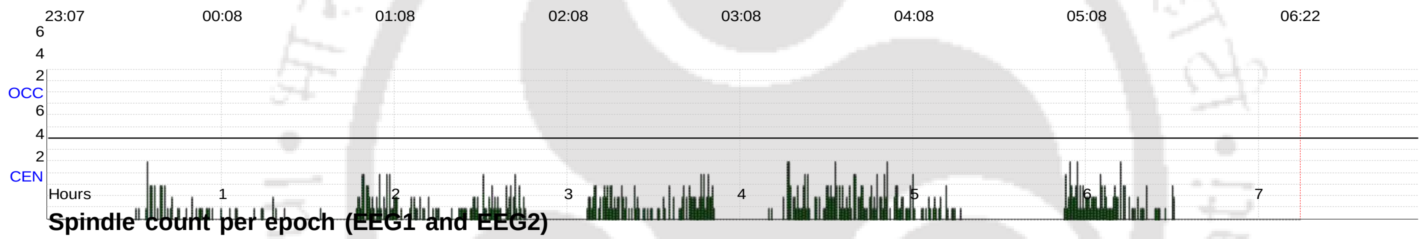
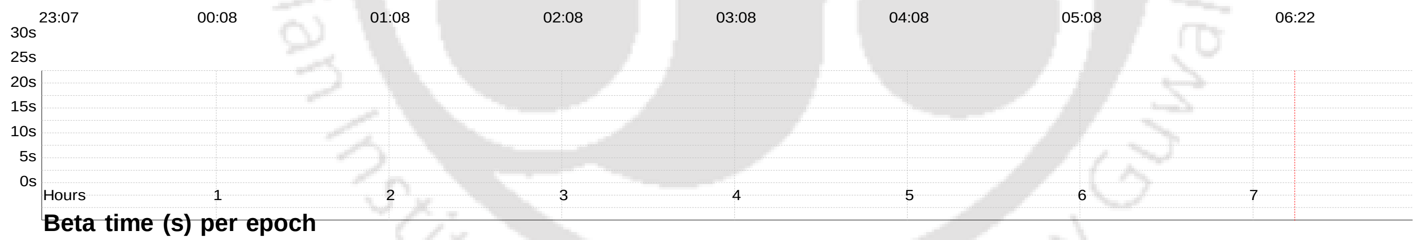
Name: Subject 6 Patient ID: 006

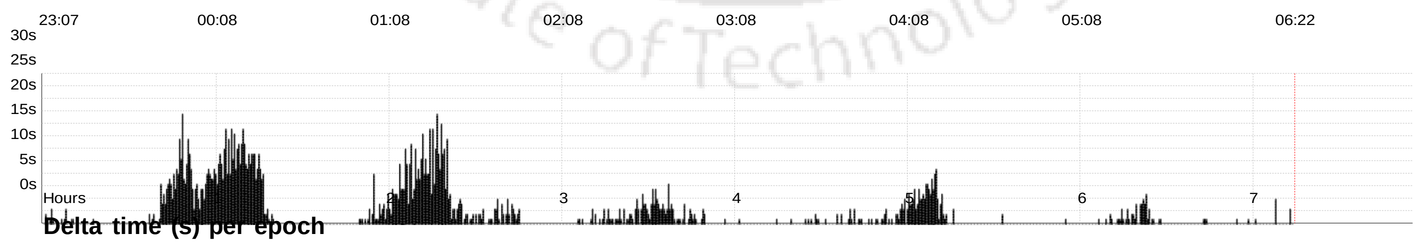
Date: Tue, Apr 01, 2014

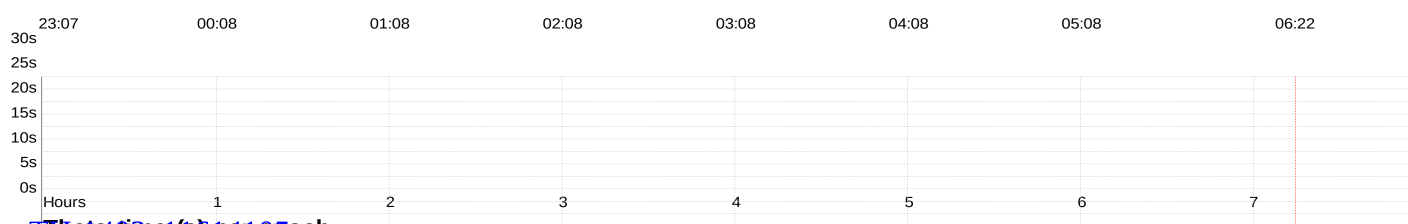
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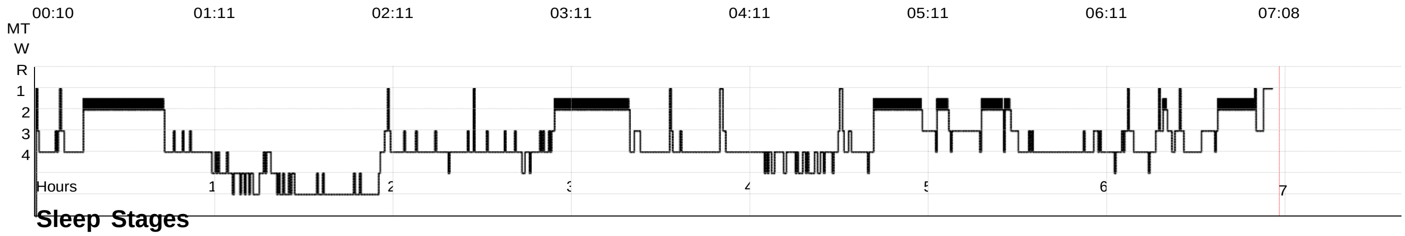
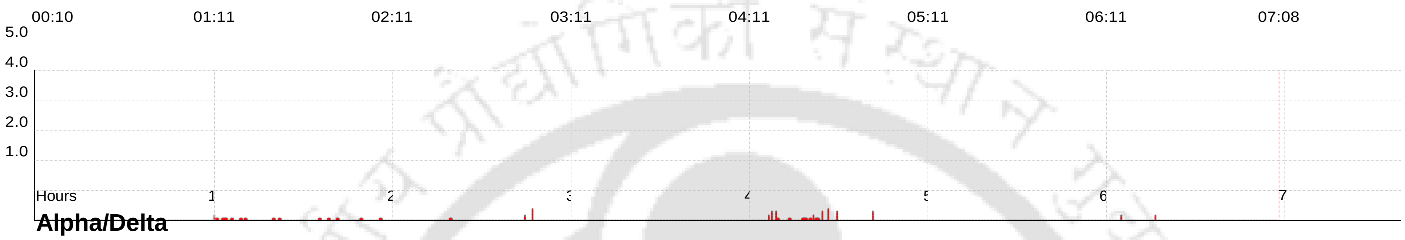
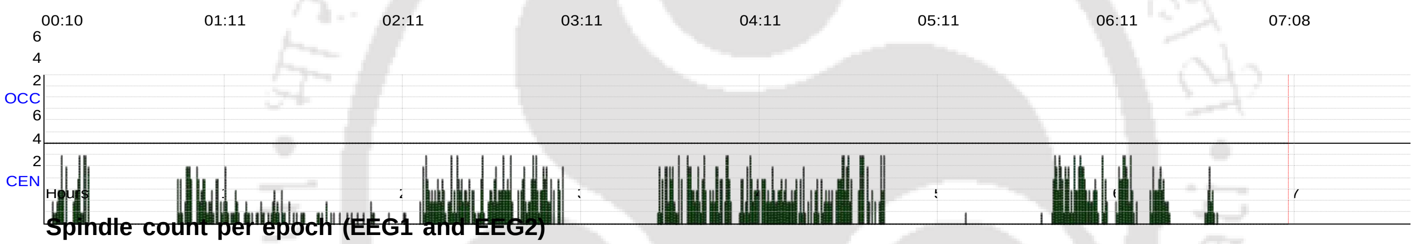
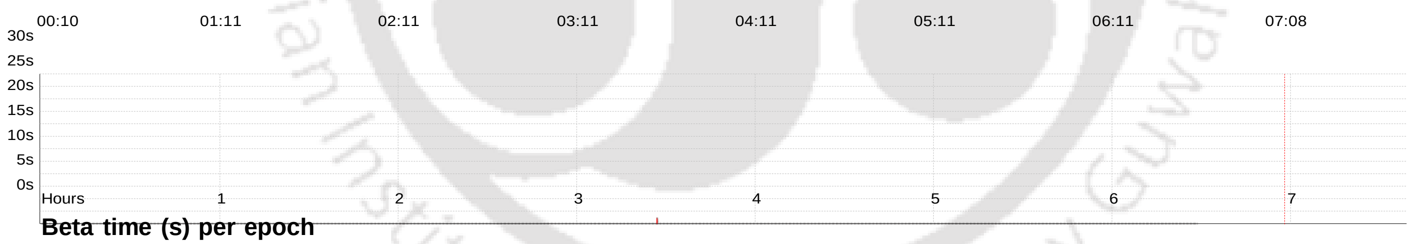
Name: Subject 5 Patient ID: 005

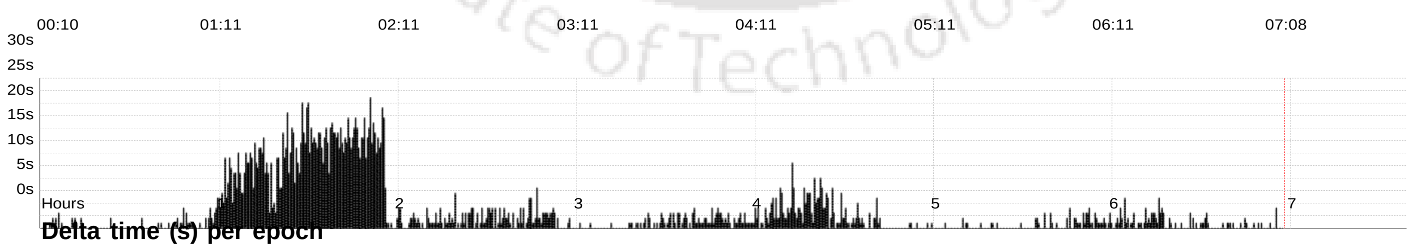
Date: Thu, Apr 03, 2014

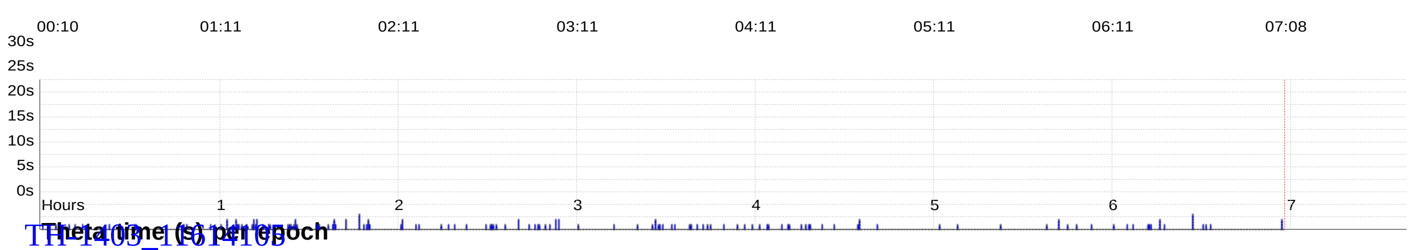
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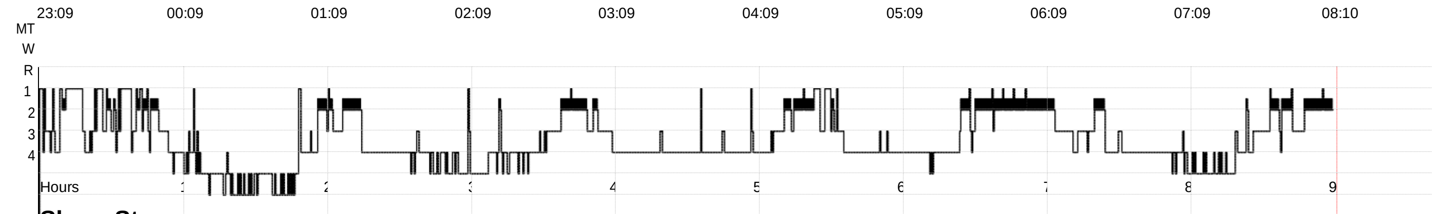
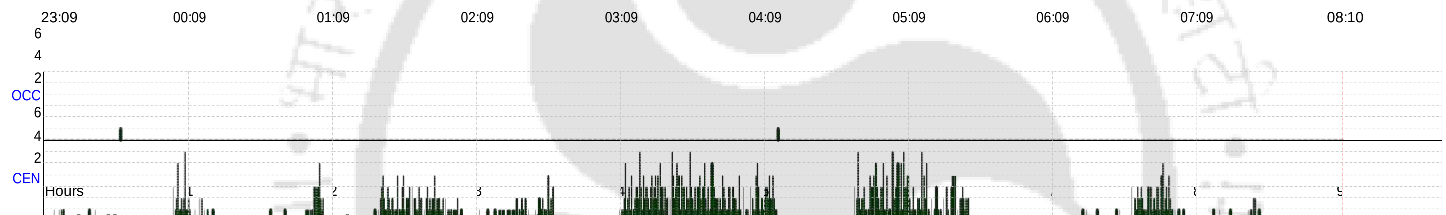
Name: Subject 4 Patient ID: 004

Date: Fri, Apr 04, 2014

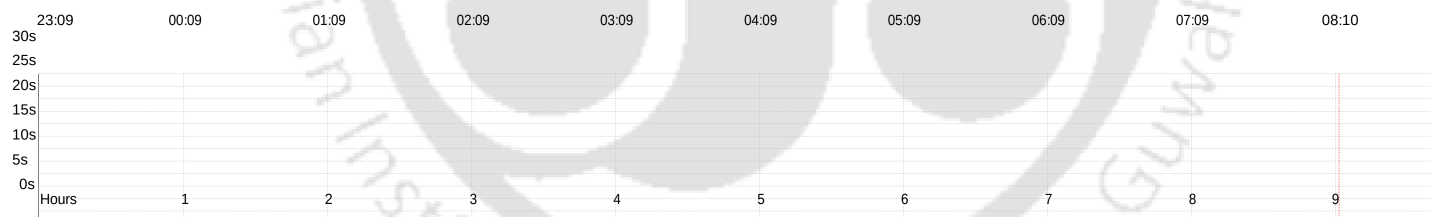



Sleep Stages

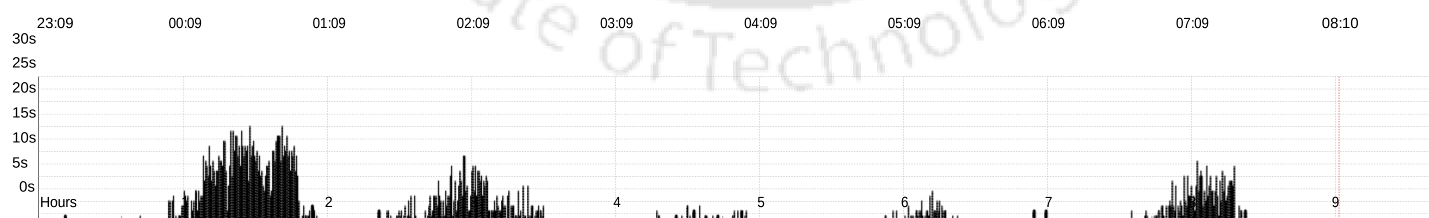

Alpha/Delta



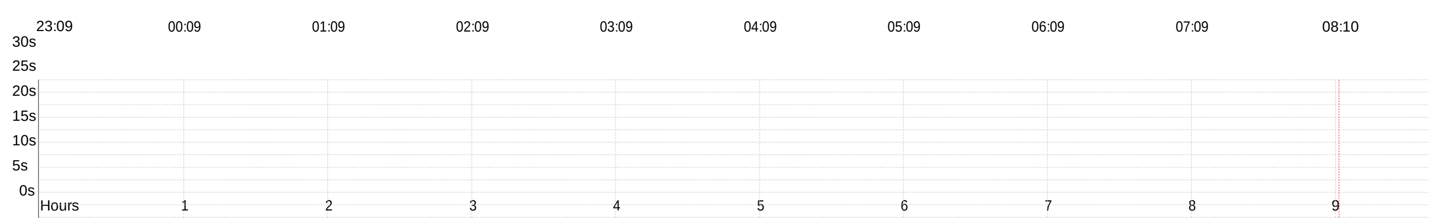

Spindle count per epoch (EEG1 and EEG2)




Beta time (s) per epoch




Delta time (s) per epoch



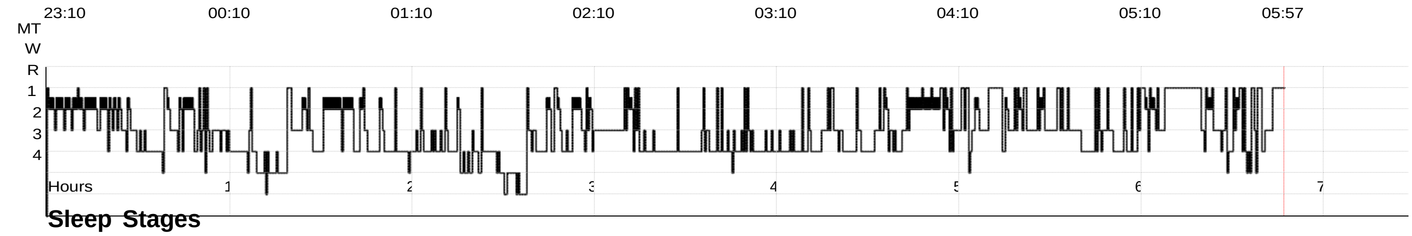

Theta time (s) per epoch

TH-1403_11614105

Name: Subject 3

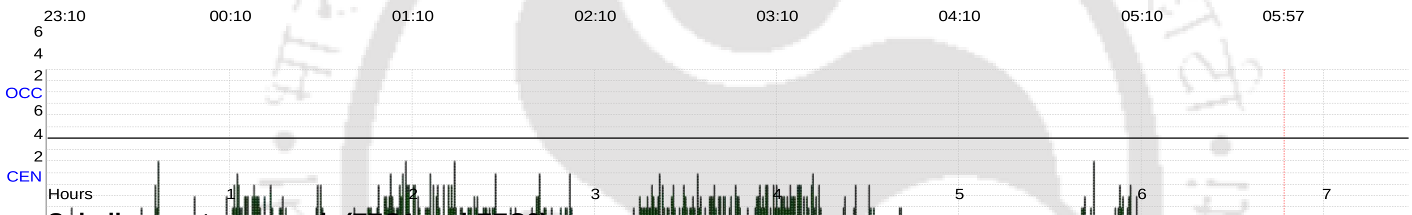
Patient ID: 003

Date: Sun, Apr 06, 2014

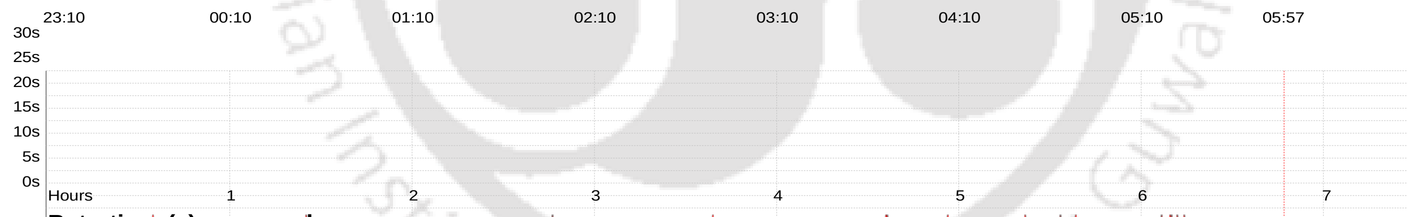



Sleep Stages


Alpha/Delta

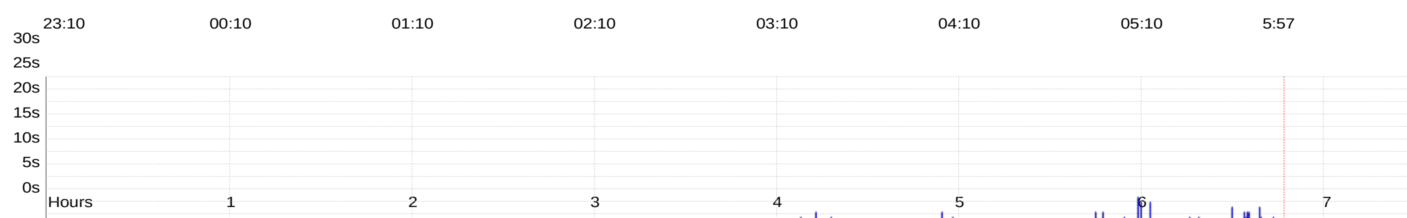



Spindle count per epoch (EEG1 and EEG2)




Beta time (s) per epoch


Delta time (s) per epoch

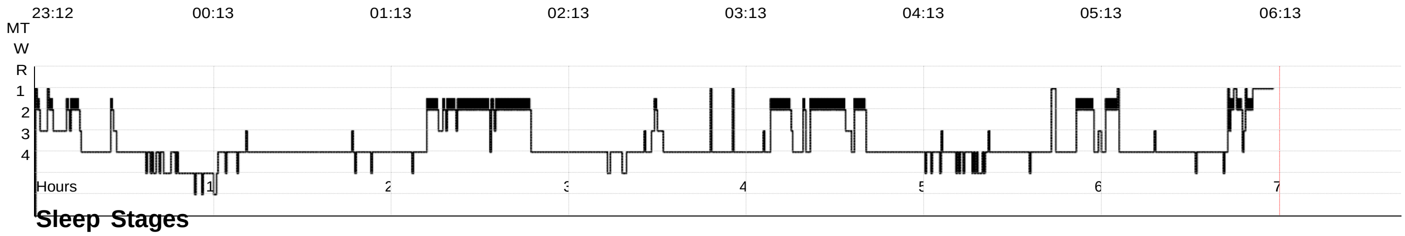



Theta time (s) per epoch

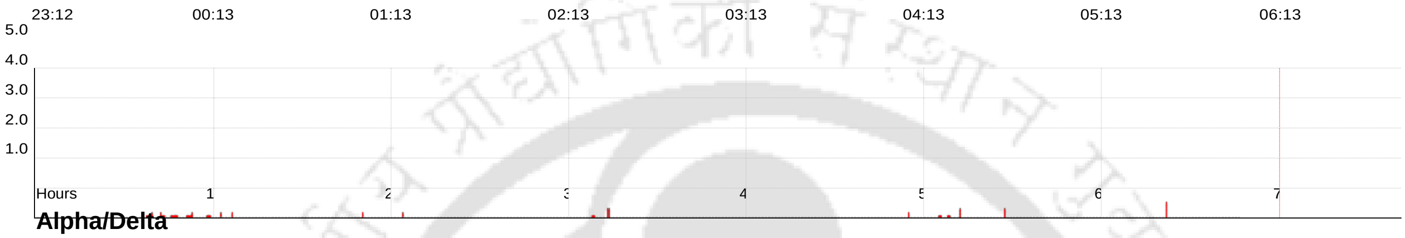
TH-1403_11614105

Name: Subject 2 Patient ID: 002

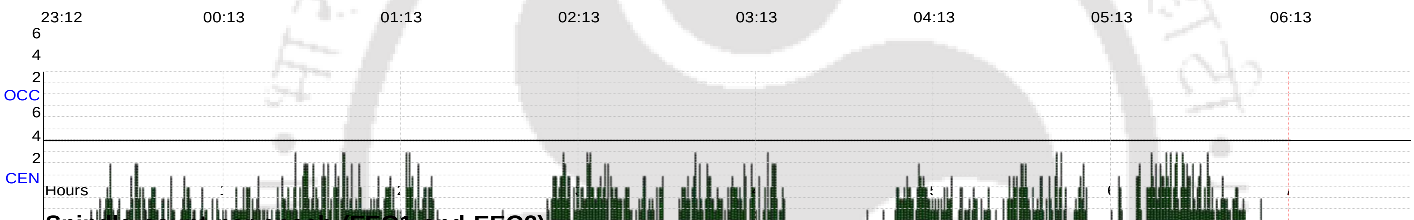
Date: Wed, Apr 09, 2014



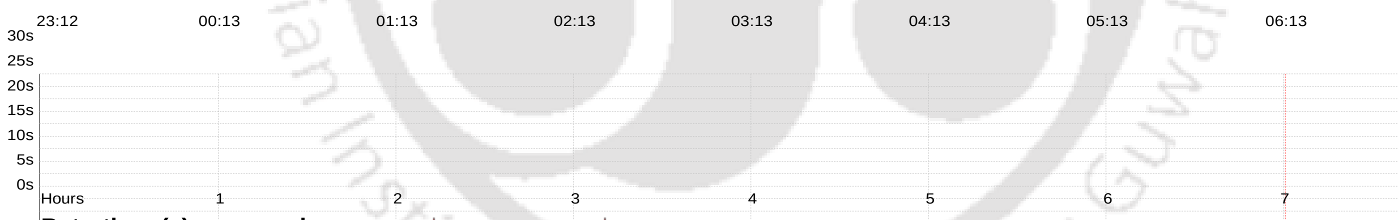

**Sleep Stages**



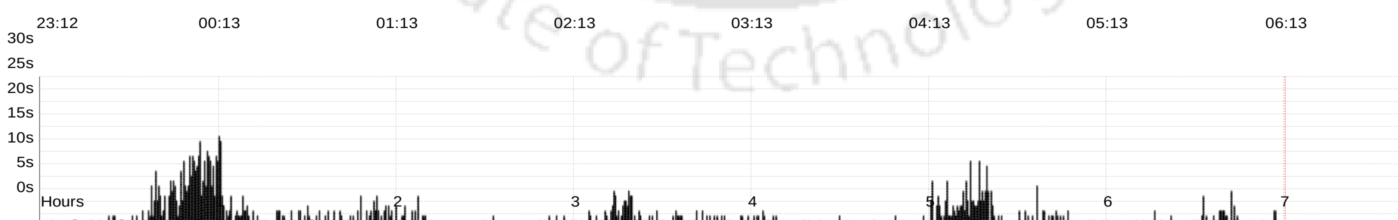

**Alpha/Delta**



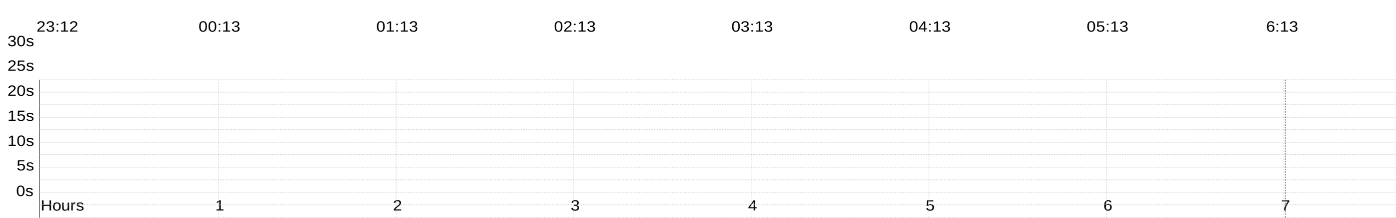

**Spindle count per epoch (EEG1 and EEG2)**




**Beta time (s) per epoch**




**Delta time (s) per epoch**



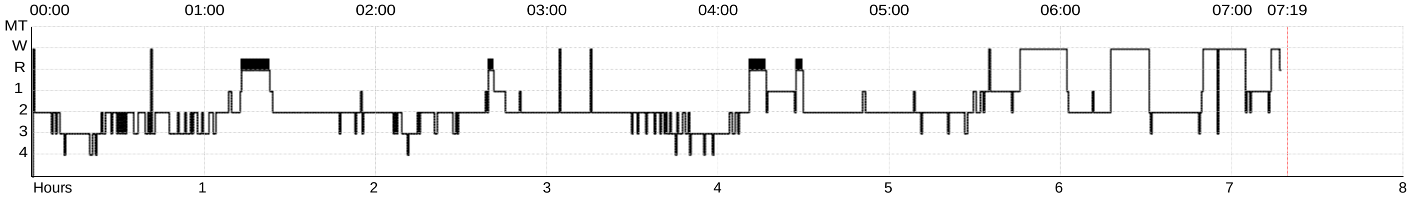

**Theta time (s) per epoch**

TH-1403_11614105

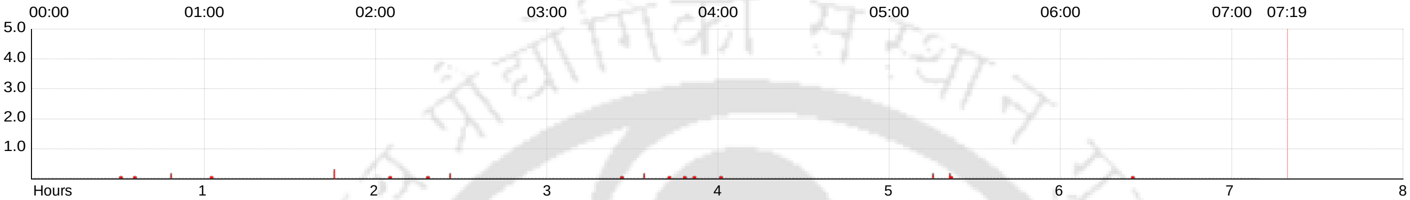
Name: Subject1

Date: Sat, Apr 12, 2014

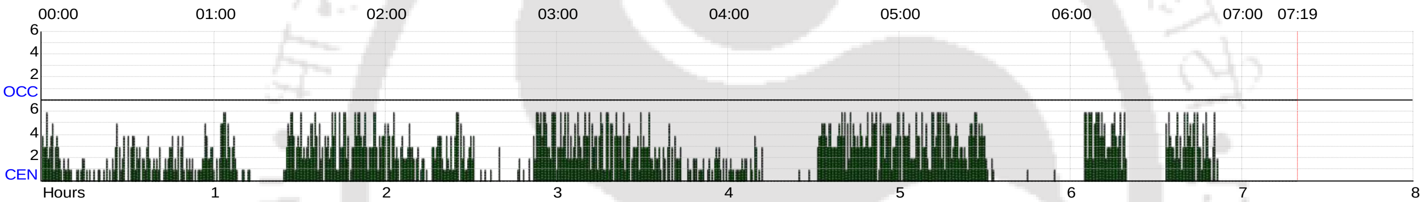
Patient ID: 001



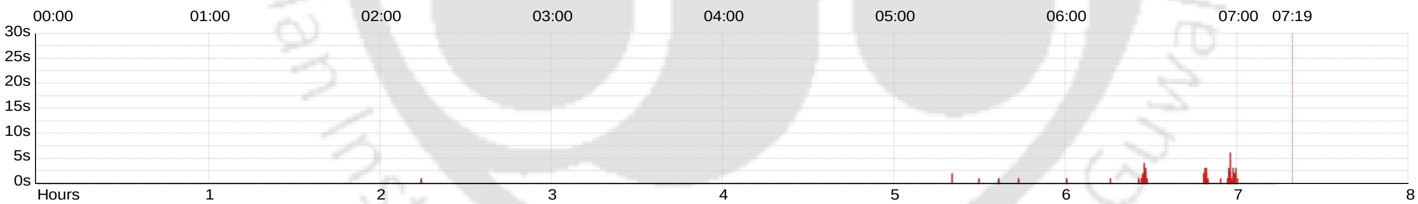

**Sleep Stages**



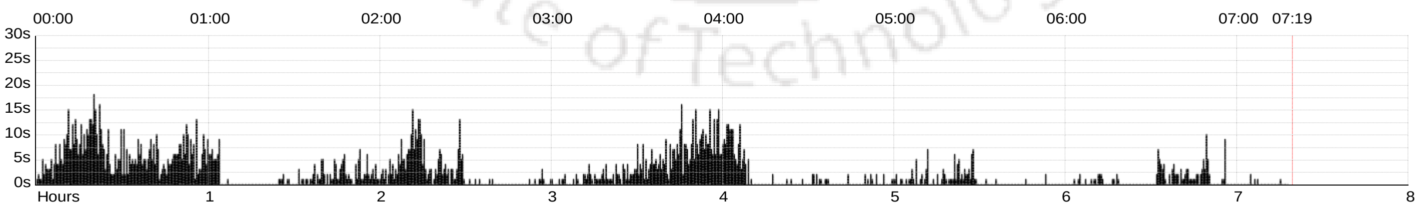

**Alpha/Delta**



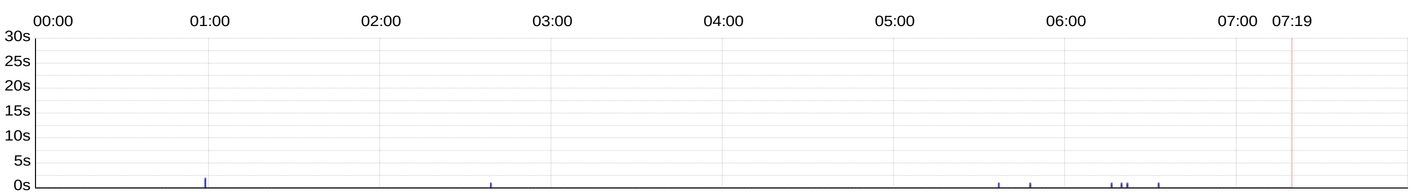

**Spindle count per epoch (EEG1 and EEG2)**




**Beta time (s) per epoch**




**Delta time (s) per epoch**



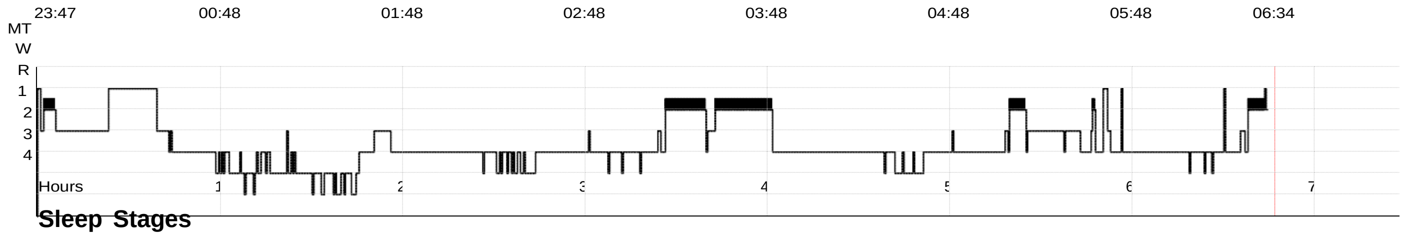

**Theta time (s) per epoch**

TH-1403_11614105

Name: Subject 12

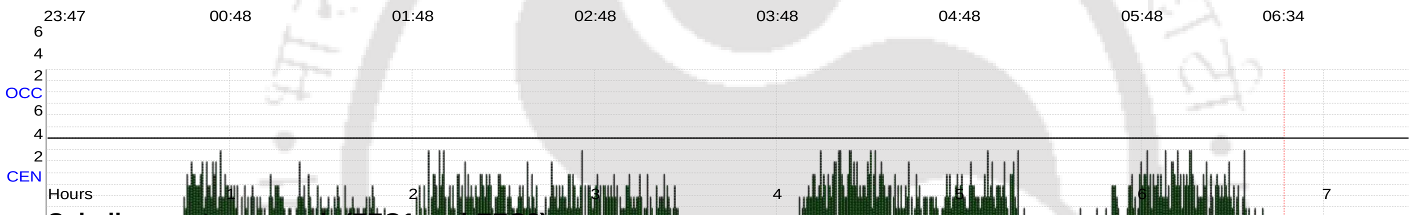
Patient ID: 0012

Date: Sat, Mar 08, 2014

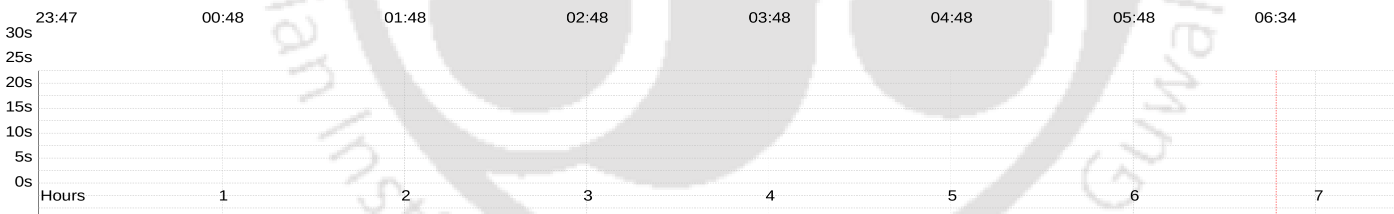



Sleep Stages

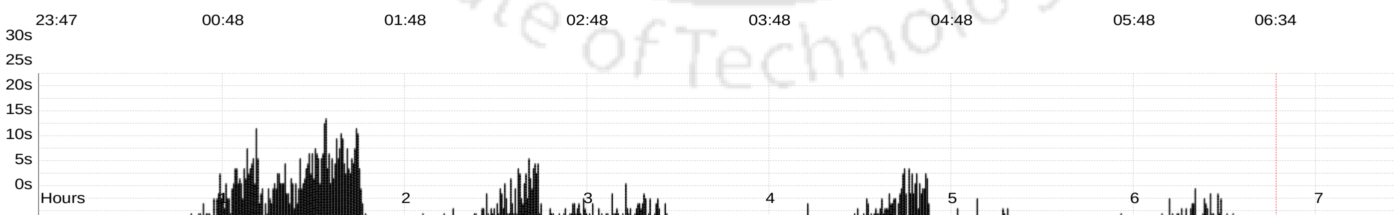

Alpha/Delta



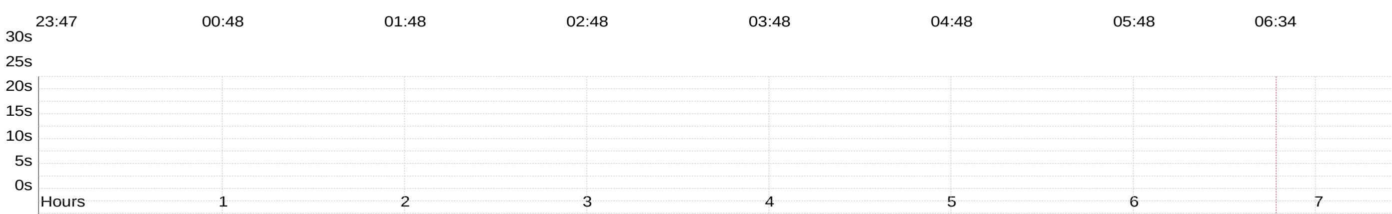

Spindle count per epoch (EEG1 and EEG2)




Beta time (s) per epoch




Delta time (s) per epoch




Theta time (s) per epoch

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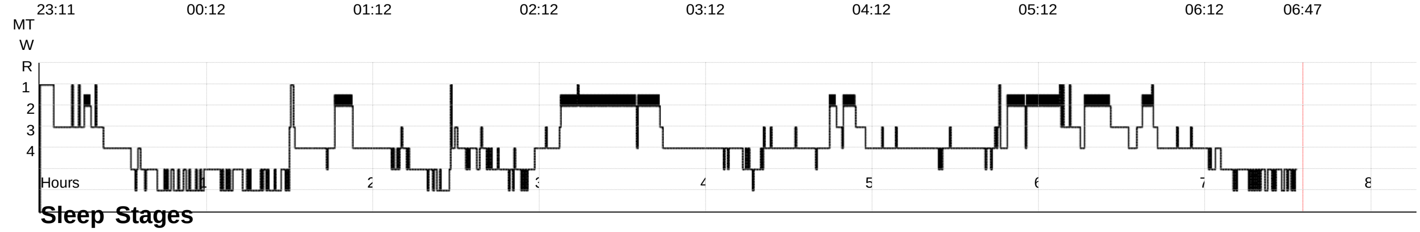
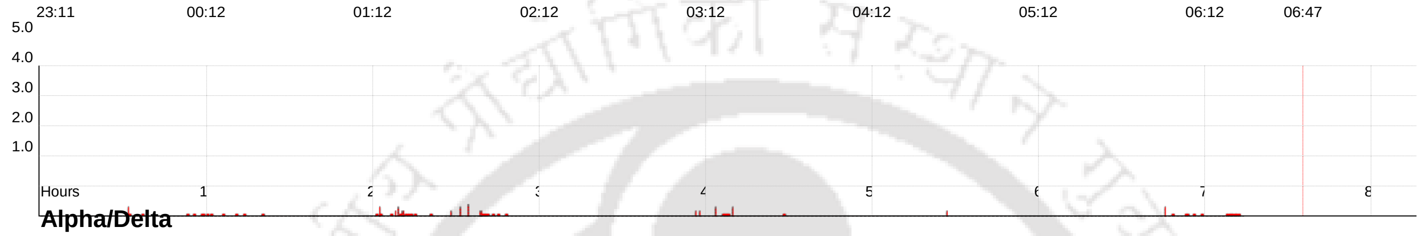
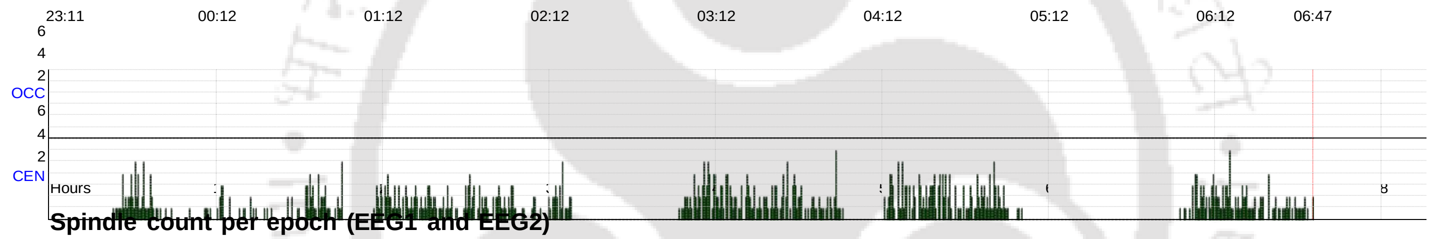
Indian Institute of Technology Guwahati

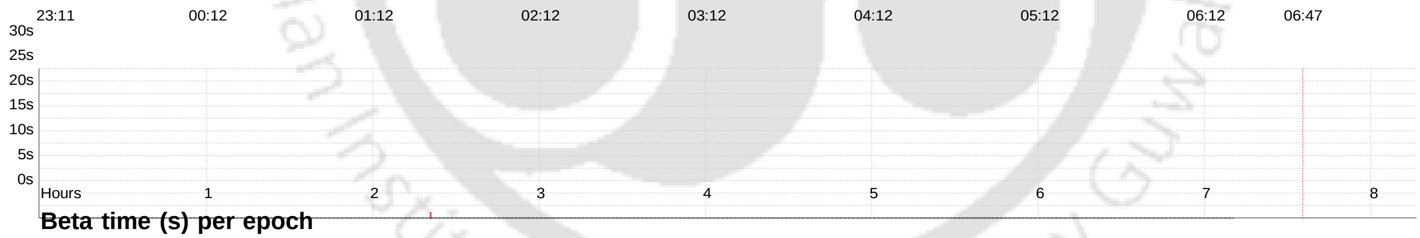
Name: Subject 11 Patient ID: 0011

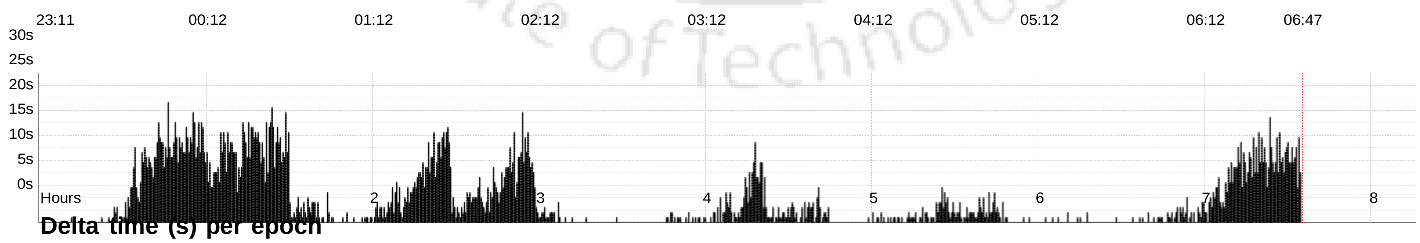
Date: Sun, Mar 09, 2014

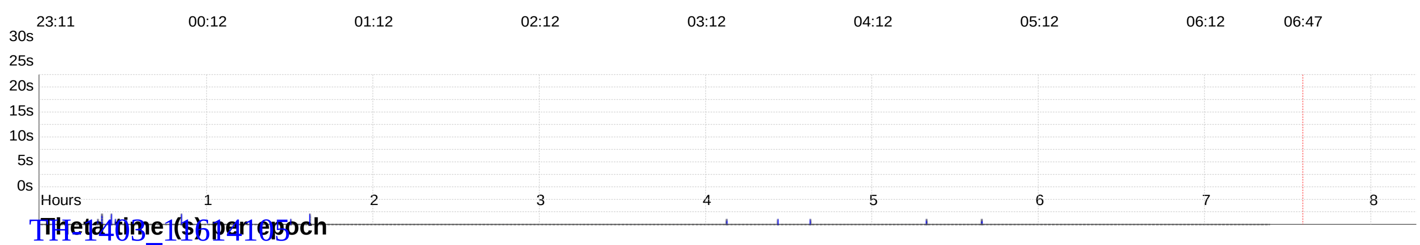


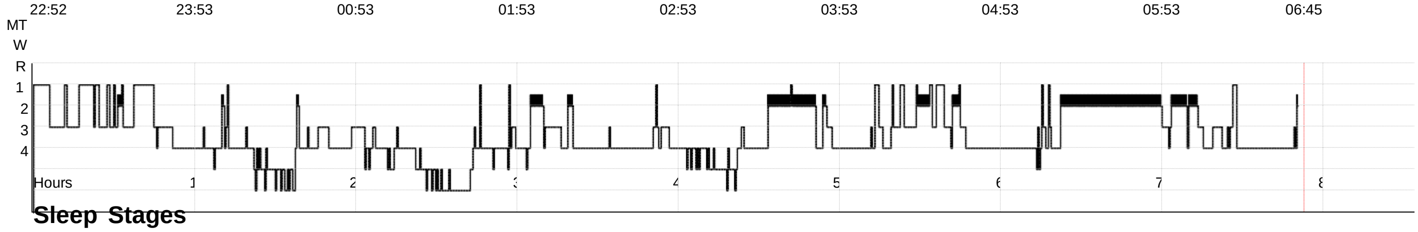



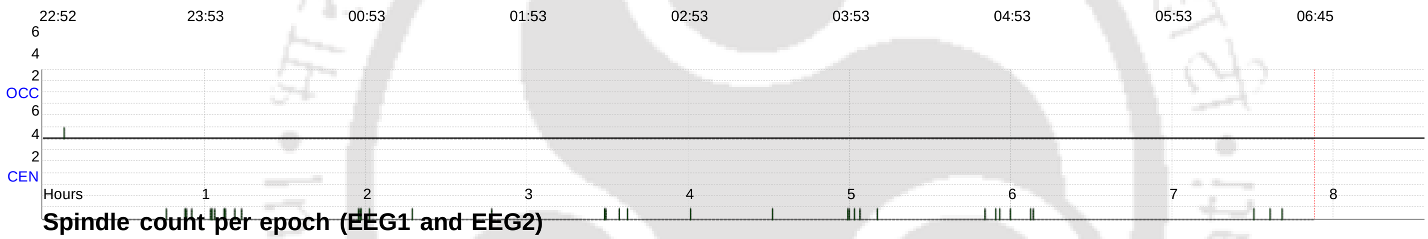



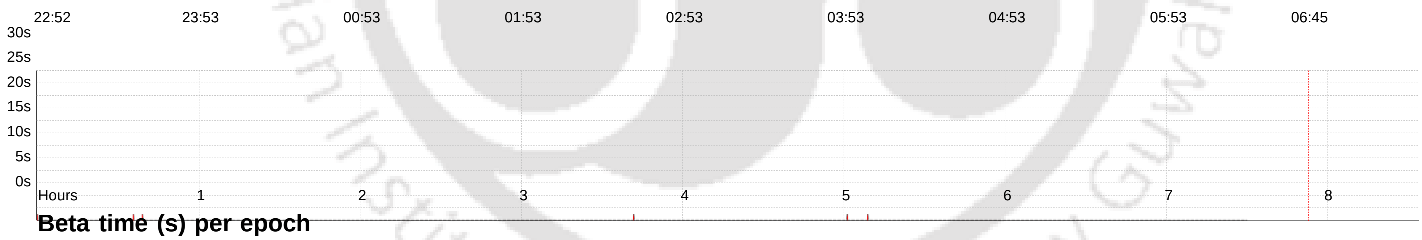
Name: Subject 10 Patient ID: 0010

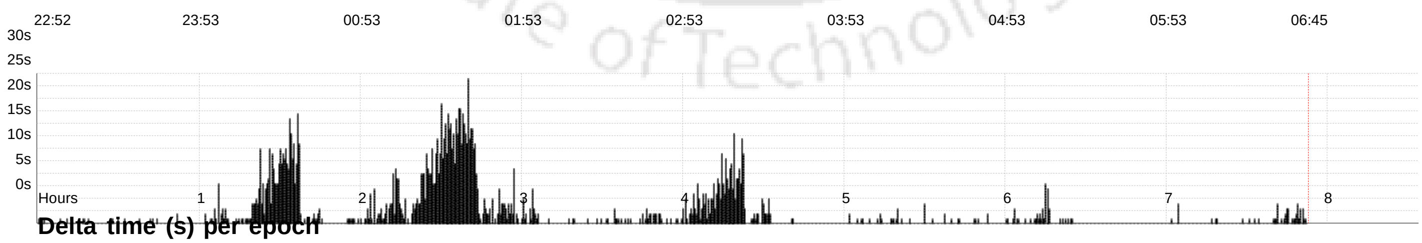
Date: Tue, Mar 11, 2014

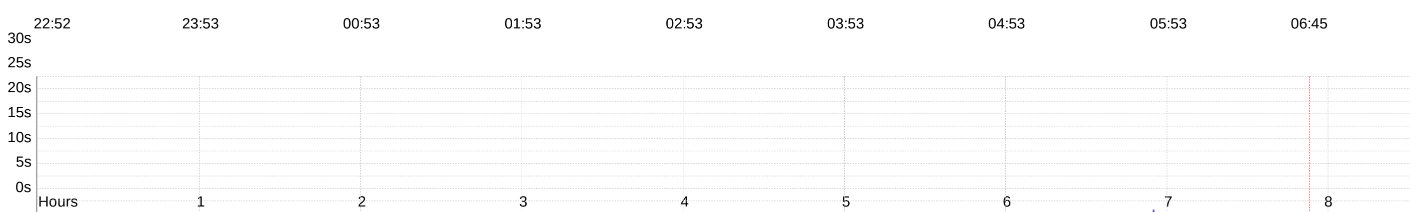






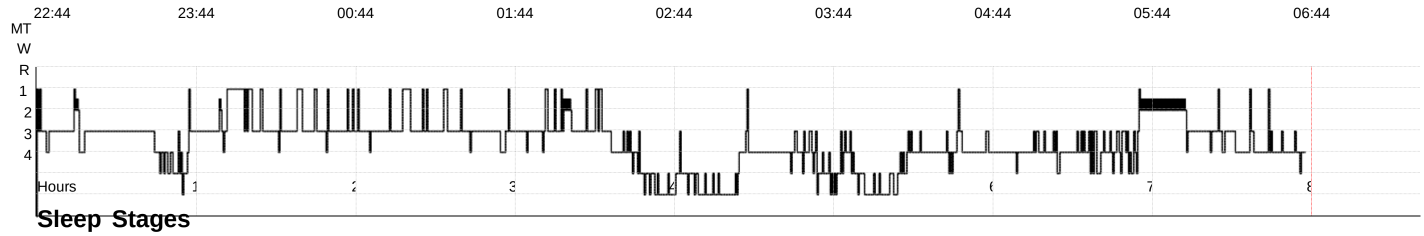



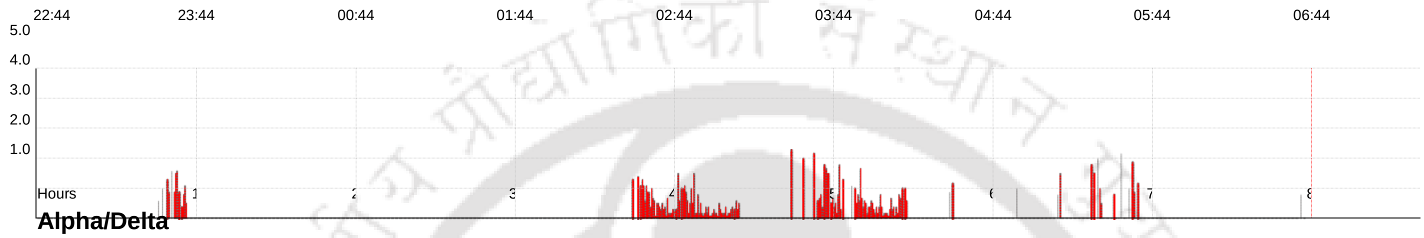

TH-1403_116141105

Name: Subject 9 Patient ID: 009

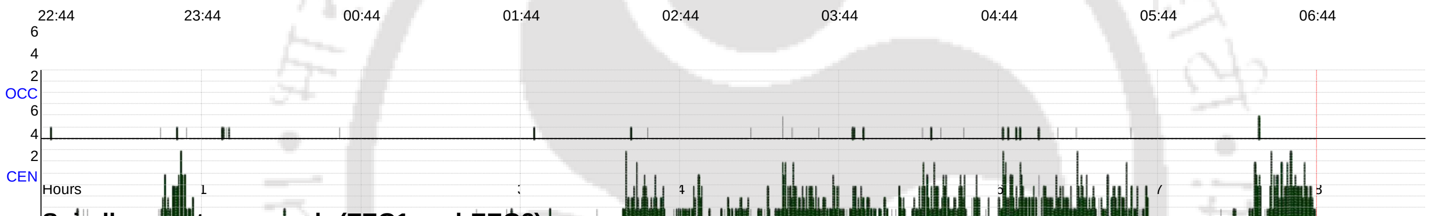
Date: Thu, Mar 13, 2014



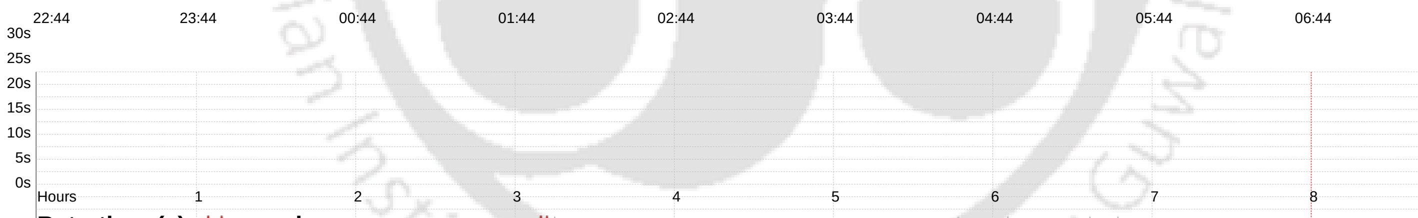

Sleep Stages



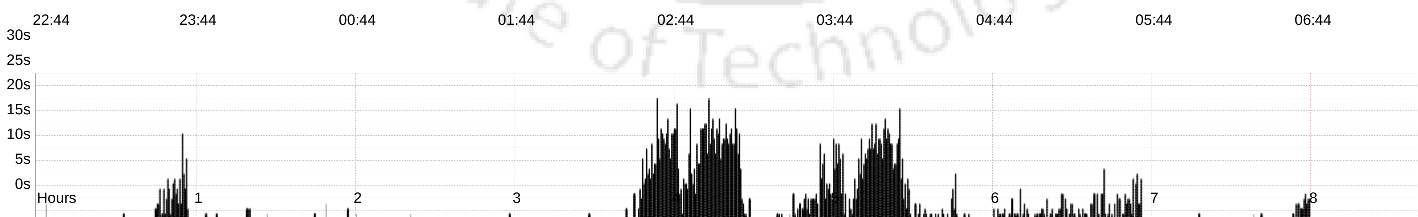

Alpha/Delta



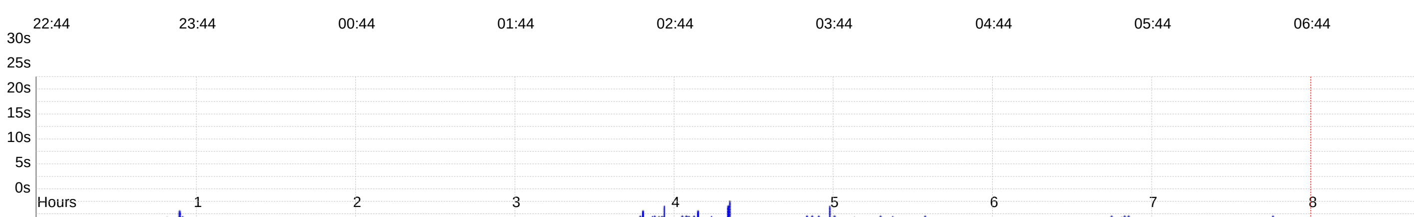

Spindle count per epoch (EEG1 and EEG2)




Beta time (s) per epoch




Delta time (s) per epoch




Theta time (s) per epoch

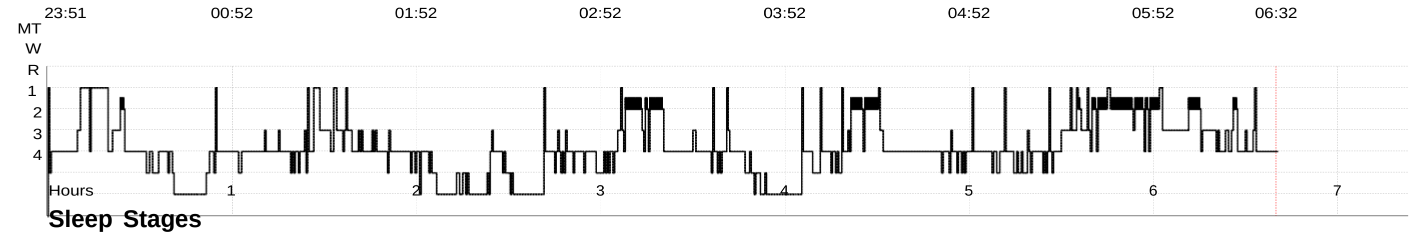
Indian Institute of Technology Guwahati

TH-1403_10614105

Name: Subject 8

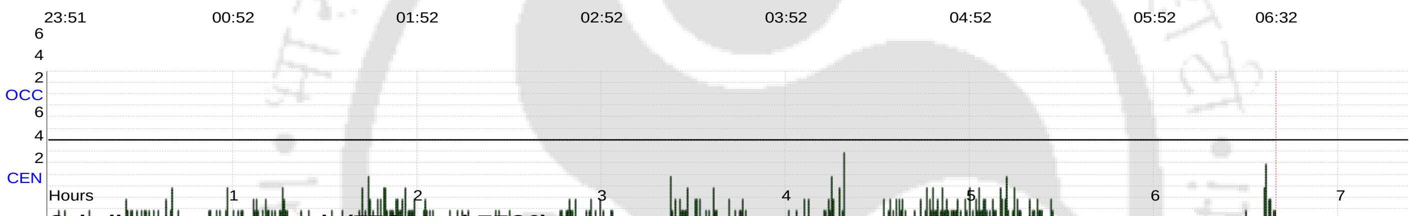
Patient ID: 008

Date: Fri, Mar 14, 2014

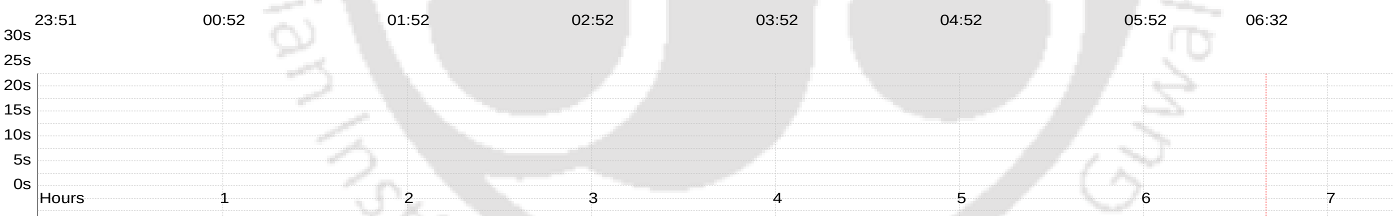



Sleep Stages

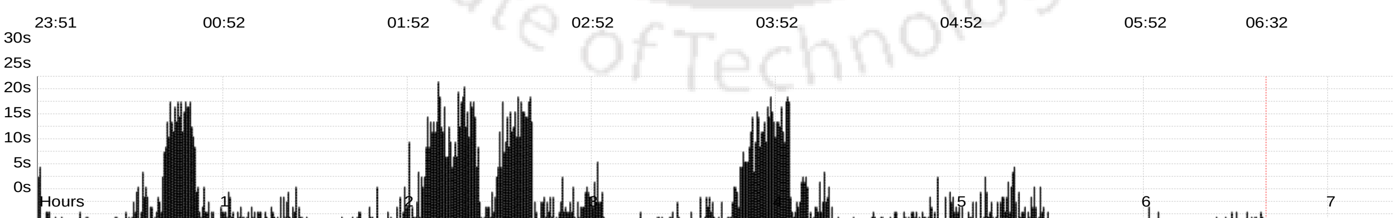

Alpha/Delta



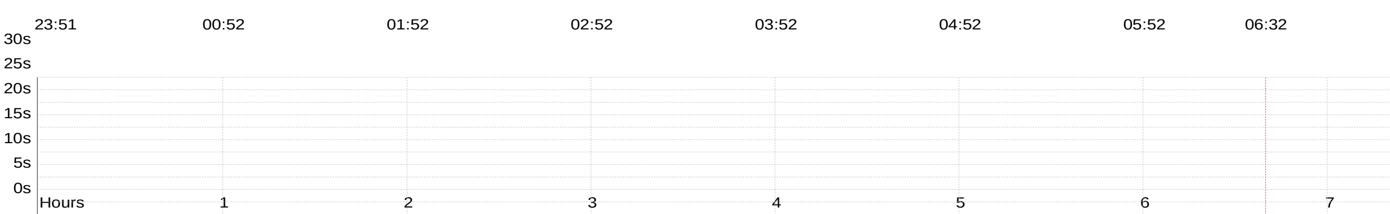

Spindle count per epoch (EEG1 and EEG2)




Beta time (s) per epoch




Delta time (s) per epoch




Theta time (s) per epoch

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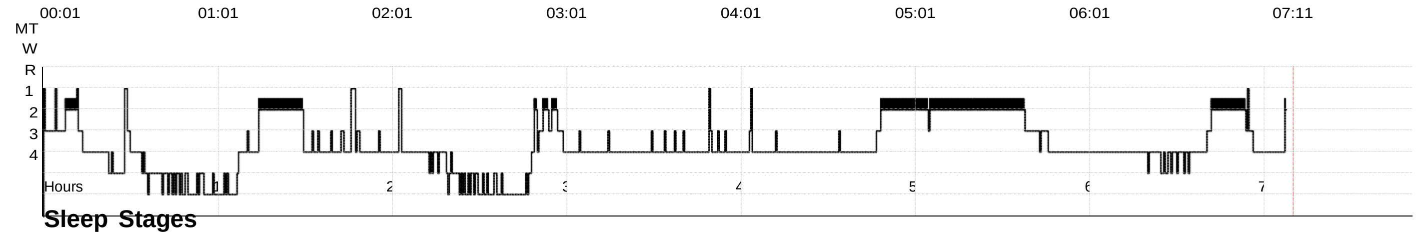
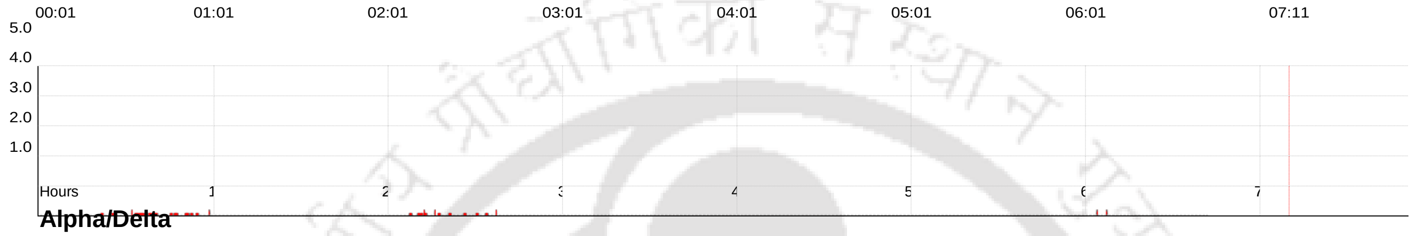
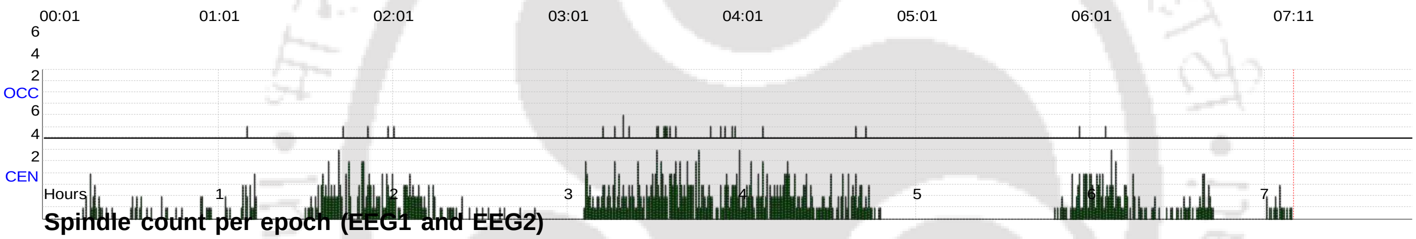
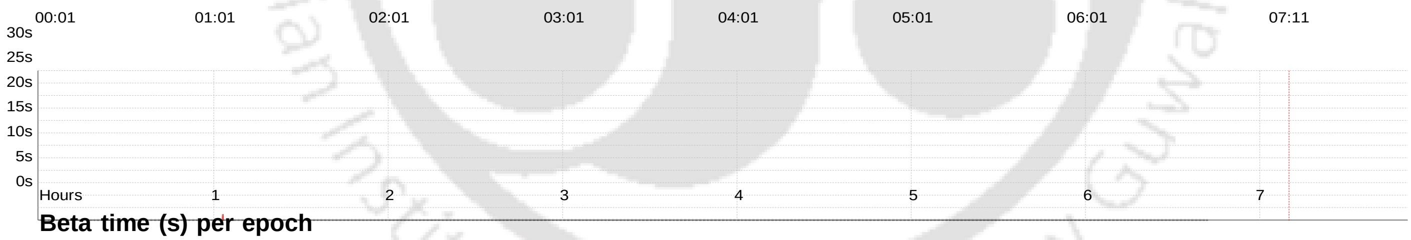
Name: Subject 14 Patient ID: 0014

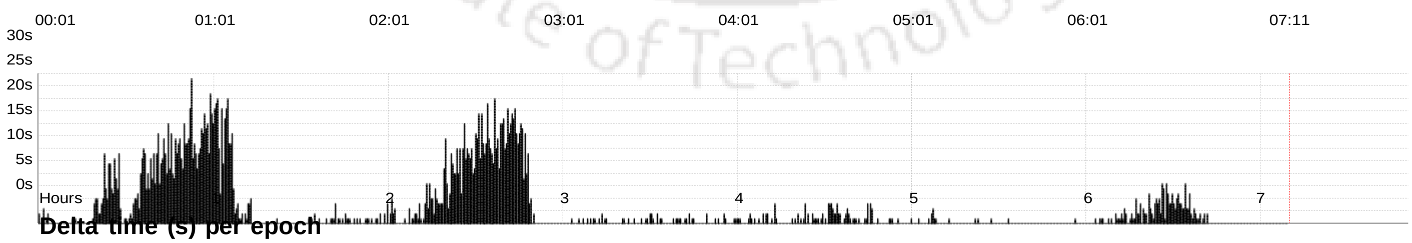
Date: Sat, Feb 08, 2014

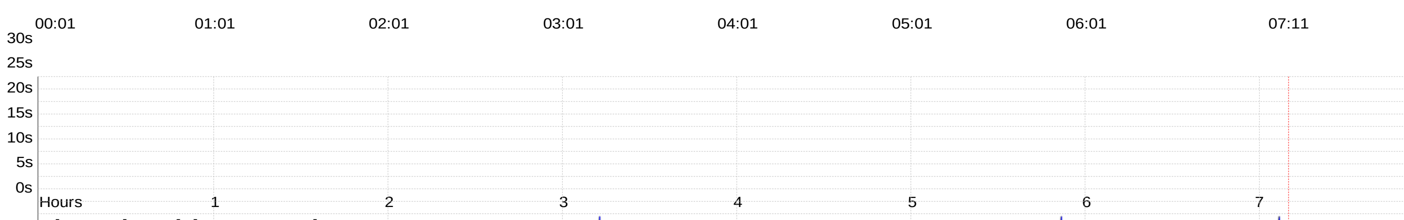



TH-1403_11614105

general assessment series

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Best Practices in Nursing Care to Older Adults

From The Hartford Institute for Geriatric Nursing, New York University, College of Nursing

Issue Number 6.2, Revised 2012

Series Editor: Marie Boltz, PhD, GNP-BC
Series Co-Editor: Sherry A. Greenberg, MSN, GNP-BC
New York University College of Nursing

# The Epworth Sleepiness Scale (ESS)

*By: Carole Smyth MSN, APRN, BC, ANP/GNP, Montefiore Medical Center*

**WHY**: Sleep at night is essential for good health. Sleepiness during the day can be an antecedent to falls, declining quality of life, and less functional recovery in older adults. Sleepiness during the day may also be an indicator that hypertension and diabetes are not well controlled (Cuellar & Ratcliffe, 2008; Goldstein, Ancoli-Israel, Shapiro, 2004). Assessment of daytime sleepiness enables the nurse to intervene by implementing interventions with the client, or by referring the client for further assessment.

**BEST TOOL**: The Epworth Sleepiness Scale (ESS) is an effective instrument used to measure average daytime sleepiness. The ESS differentiates between average sleepiness and excessive daytime sleepiness that requires intervention. The client self-rates on how likely it is that he/she would doze in eight different situations. Scoring of the answers is 0-3, with 0 being "would never doze" and 3 being "high chance of dozing". A sum of 10 or more from the eight individual scores reflects above normal daytime sleepiness and need for further evaluation (Johns,1992).

**TARGET POPULATION**: The ESS may be used for both initial assessment and ongoing comparative measurements with older adults across the health care continuum. The ESS is not an appropriate tool for measuring changes in sleep over a period of hours.

**VALIDITY AND RELIABILITY**: There is a high level of internal consistency between the eight items in the ESS as measured by Cronbach's alpha, ranging from 0.74 to 0.88. Numerous studies using the ESS have supported high validity and reliability.

**STRENGTHS AND LIMITATIONS**: The ESS is a subjective measure of sleepiness. Self reporting by clients though empowering and revealing, may reflect inaccurate information if the client has difficulty understanding what is written, or cannot see or physically write out responses. The ESS has been translated into Spanish, Portuguese, Italian, German, Swedish, Finnish, Greek, French, Mandarin, Japanese and Turkish. The tool has not been validated for phone interviews.

**MORE ON THE TOPIC**:

Best practice information on care of older adults: www.ConsultGeriRN.org.
Johns, M.W. The Epworth Sleepiness Scale: The Official Website of the Epworth Sleepiness Scale: http://epworthsleepinessscale.com/about-epworth-sleepiness/.
Antic, N.A., Buchan, C., Esterman, A., Hensley, M., Naughton, M.T., Rowland, S., Williamson, B., Windler, S., Eckerman, S., & McEvoy, R.D. (2009). A randomized controlled trial of nurse-led care for symptomatic moderate-severe obstructive sleep apnea. *American Journal of Respiratory and Critical Care Medicine, 179*, 501-508.
Cuellar, N.G., & Ratcliffe, S.J. (2008). A comparison of glycemic control, fatigue, and depression in Type 2 diabetes with and without restless legs syndrome. *Journal of Clinical Sleep Medicine, 4*(1), 50-56.
Goldstein, I.B., Ancoli-Israel,S., Shapiro, D.(2004). Relationship between daytime sleepiness and blood pressure in healthy older adults. *Am J Hypertension 17*,787-792.
Johns, M.W. (1991). A new method for measuring daytime sleepiness: The Epworth sleepiness scale. *Sleep, 14,* 540-545.
Johns, M.W. (1992). Reliability and factor analysis of the Epworth Sleepiness Scale. *Sleep, 15,* 376-381.
Johns, M.W. (1994). Sleepiness in different situations measured by the Epworth Sleepiness Scale. *Sleep, 17,* 703-710.
Silva, G.E., Ming-Wen, A, Goodwin, J.L., Shahar,E., Redline, S., Resnick, H., Baldwin, C.M., & Quan, S.F. Longitudinal evaluation of sleep-disordered breathing and sleep symptoms with change in quality of life: The sleep heart health study (SHHS). *Sleep, 32*(8), 1049-1057.

TH-1403_11614105

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# The Epworth Sleepiness Scale (ESS)

How likely are you to doze off or fall asleep in the following situations, in contrast to feeling just tired? This refers to your usual way of life in recent times. Even if you have not done some of these things recently try to work out how they would have affected you. Use the following scale to choose the **most appropriate number** for each situation:

0 = would **never** doze
1 = **slight chance** of dozing
2 = **moderate chance** of dozing
3 = **high chance** of dozing

| SITUATION | CHANCE OF DOZING (0–3) |
|---|---|
| Sitting and reading | |
| Watching television | |
| Sitting inactive in a public place (e.g. a theater or meeting) | |
| As a passenger in a car for an hour without a break | |
| Lying down to rest in the afternoon when circumstances permit | |
| Sitting and talking to someone | |
| Sitting quietly after a lunch without alcohol | |
| In a car, while stopped for a few minutes in the traffic | |
| **TOTAL SCORE** | |

**SCORE RESULTS:**

| | |
|---|---|
| 1-6 | Congratulations, you are getting enough sleep! |
| 7-8 | Your score is average |
| 9 and up | Very sleepy and should seek medical advice |

Johns, M.W. (1991). A new method for measuring daytime sleepiness: The Epworth sleepiness scale. *Sleep*, *14*, 540-545.

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TH-1403_11614105

## Consent Sheet for Subjects Participation

**I voluntarily take the responsibility as a test subject in the present experiment and am offered a token reimbursement of______INR**

**The experiment will be investigating the relation between "*Emotional Cues and Prospective Memory"* across nights filled with sleep and wakefulness**

**No invasive interferences would be made in the present experiment (no blood acceptance, no medicine dose administration). I understand the risks in volunteering for the study and voluntarily agree for participation, limiting to the conditions mentioned below:**

- **I was informed comprehensively about the test sequence, and my questions were sufficiently answered by the experimenters. The experimenters kept the indicated test conditions.**
- **I voluntarily agree to the publication of results emerging from the data collected from my participation, limiting to complete anonymity of my credentials.**
- **I can break the experiment off at any time; ask for partial / complete removal of my data / credentials without any explanations to experimental group.**

**IIT Guwahati**

________________________________________
**(Signature)**

**For Laboratory Records**

**Name:**

**House Number:**

**Tel (for reference):**

**Account Number:**
**Bank Name:**

TH-1403_11614105

## General Questionnaire

**Age:_________years**

**Gender: M / F**

**Occupation/Academic: ____________**

**Handedness:  Left / Right**

**Spectacles: Yes / No**

**Non Smoker: Yes / No**

**At what time in the evening do you normally go to bed?**

**How many hours of sleep in the night do you have normally?**

**Do you sleep during the day? (If yes when, how many hours)**

**Do you suffer from Chronic illness**

**Allergies?___**

**Do you suffer from any clinical sleep disorder at present or in the past?**

**Do you suffer from any endocrinological, neurological or psychiatric illness at present or in the past?**

**Have you been a subject in a sleep experiment? (If yes when and with whom)**

**Do you have partial health restriction? (If yes, what)**

**Do you take any medications/Drugs?**

**Have you worked during the night 6 weeks prior to this day? (If yes When and how much)**

**Did you take cola or coffee today afternoon? (If yes when and how much)**

**Have been you undergoing special stress? (If yes, which and what exact)**

**What time did you awake today Morning?**

**Did you sleep today in the afternoon? (If yes when and what length)**

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# Mood Questionnaire

**Subject code: _________**

**Age: ________________**

**Clock Time: __________**

**Report as according to your present feeling**

**I feel the following way now ………….**

| | Not at all | | | | Very much |
|---|---|---|---|---|---|
| Sleepy | | | | | |
| Active | | | | | |
| Tense | | | | | |
| Tired | | | | | |
| Bored | | | | | |
| Motivated | | | | | |
| Concentrated | | | | | |

Indian Institute of Technology Guwahati

# Folstein Mini-Mental State Exam

| | | |
|---|---|---|
| I. **ORIENTATION** (Ask the following questions; correct = 0 ) | **Record Each Answer:** | (Maximum Score = 10) |
| What is today's date? | Date (eg, May 21) | 1 0 |
| What is today's year? | Year | 1 0 |
| What is the month? | Month | 1 0 |
| What day is today? | Day (eg, Monday) | 1 0 |
| Can you also tell me what season it is? | Season | 1 0 |
| Can you also tell me the name of this hospital/clinic? | Hospital/Clinic | 1 0 |
| What floor are we on? | Floor | 1 0 |
| What city are we in? | City | 1 0 |
| What county are we in? | County | 1 0 |
| What state are we in? | State | 1 0 |
| **II. IMMEDIATE RECALL** | (correct = 0 ) | (Maximum Score = 3) |
| Ask the subject if you may test his/her memory. Say "ball, "flag," "tree" clearly and slowly, about one second for each. Then ask the subject to repeat them. Check the box at right for each correct response. The first repetition determines the score. If he/she does not repeat all three correctly, keep saying them up to six tries until he/she can repeat them | Ball | 1 0 |
| | Flag | 1 0 |
| | Tree | 1 0 |
| | | NUMBER OF TRIALS: |
| III. **ATTENTION AND CALCULATION** | | |
| **A. Counting Backwards Test** | (Record each response, correct = 0 ) | (Maximum Score = 5) |
| Ask the subject to begin with 100 and count backwards by 7. Record each response. Check one box at right for each correct response. Any response 7 or less than the previous response is a correct response. The score is the number of correct subtractions. For example, 93, 86, 80, 72, 65 is a score of 4; 93, 86, 78 70, 62, is 2; 92, 87, 78, 70, 65 is 0. | 93 | 1 0 |
| | 86 | 1 0 |
| | 79 | 1 0 |
| | 72 | 1 0 |
| | 65 | 1 0 |
| **B. Spelling Backwards Test** | | |
| Ask the subject to spell the word "WORLD" backwards. Record each response. Use the instructions to determine which are correct responses, and check one box at right fore each correct response. | D | 1 0 |
| | L | 1 0 |
| | R | 1 0 |
| **C. Final Score** | O | 1 0 |
| Compare the scores of the Counting Backwards and Spelling Backwards tests. Write the greater of the two socres in the box labeled FINAL SCORE at right, and use it in deriving the **TOTAL SCORE**. | W | 1 0 |
| | | **FINAL SCORE** (Max of 5 or Greater of the two Scores) |

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| | | |
|---|---|---|
| IV. **RECALL** | (correct = 0 ) | (Maximum Score = 3) |
| Ask the subject to recall the three words you previously asked him/her to remember. Check the Box at right for each correct response. | Ball | 1 0 |
| | Flag | 1 0 |
| | Tree | 1 0 |
| **V. Language** | (correct = 0 ) | (Maximum Score = 9) |
| **Naming** | Watch | 1 0 |
| Show the subject a wrist watch and ask him/her what it is. Repeat for a pencil. | Pencil | 1 0 |
| **Repetition** | | |
| Ask the subject to repeat "No, ifs, ands, or buts." | Repetition | 1 0 |
| **Three -Stage Command** | | |
| Establish the subject's dominant hand. Give the subject a sheet of blank paper and say, "Take the paper in your right/left hand, fold it in half and put it on the floor." | Takes paper in hand | 1 0 |
| | Folds paper in half | 1 0 |
| | Puts paper on floor | 1 0 |
| **Reading** | | |
| Hold up the card that reads, "Close your eyes." So the subject can see it clearly. Ask him/her to read it and do what it says. Check the box at right only if he/she actually closes his/her eyes. | Closes eyes | 1 0 |
| **Writing** | | |
| Give the subject a sheet of blank paper and ask him/her to write a sentence. It is to be written sponataneously. If the sentence contains a subject and a verb, and is sensible, check the box at right. Correct grammar and punctuation are not necessary. | Writes sentence | 1 0 |
| **Copying** | | |
| Show the subject the drawing of the intersecting pentagons. Ask him/her to draw the pentagons (about one inch each side) on the paper provided. If ten angles are present and two intersect, check the box at right. Ignore tremor and rotation. | Copies pentagons | 1 0 |

| **DERIVING THE TOTAL SCORE** | |
|---|---|
| Add the number of correct responses. The maximum is 30. | TOTAL SCORE |
| 23-30 = Normal / 19-23 = Borderline / <19 = Impaired | Up to Grade 8 Level |

**Folstein MF, Folstein SE, and McHugh PR, 1975**

**NAME: ___________________ __** **DATE: _____________**

DRUG USE QUESTIONNAIRE (DAST - 20)

The following questions concern information about your potential involvement with drugs not including alcoholic beverages during the past 12 months. Carefully read each statement and decide if your answer is "Yes" or "No". Then, circle the appropriate response beside the question. In the statements "drug abuse" refers to (1) the use of prescribed or over the counter drugs in excess of the directions and (2) any non-medical use of drugs. The various classes of drugs may include: cannabis (e.g. marijuana, hash), solvents, tranquillizers (e.g. Valium), barbiturates, cocaine, stimulants (e.g. speed), hallucinogens (e.g. LSD) or narcotics (e.g. heroin). Remember that the questions **do not** include alcoholic beverages.

Please answer every question. If you have difficulty with a statement, then choose the response that is mostly right.

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## Adult Version

| **These questions refer to the past 12 months.** | **Circle Your Response** | |
|---|---|---|
| 1. Have you used drugs other than those required for medical reasons? | Yes | No |
| 2. Have you abused prescription drugs? | Yes | No |
| 3. Do you abuse more than one drug at a time? | Yes | No |
| 4. Can you get through the week without using drugs? | Yes | No |
| 5. Are you always able to stop using drugs when you want to? | Yes | No |
| 6. Have you had "blackouts" or "flashbacks" as a result or drug use? | Yes | No |
| 7. Do you every feel bad or guilty about your drug use? | Yes | No |
| 8. Does your spouse (or parents) ever complain about your involvement with drugs? | Yes | No |
| 9. Has drug abuse created problems between you and your spouse or your parents? | Yes | No |
| 10. Have you lost friends because of your use of drugs? | Yes | No |
| 11. Have you neglected your family because of your use of drugs? | Yes | No |
| 12. Have you been in trouble at work (or school) because of drug abuse? | Yes | No |
| 13. Have you lost your job because of drug abuse? | Yes | No |
| 14. Have you gotten into fights when under the influence of drugs? | Yes | No |
| 15. Have you engaged in illegal activities in order to obtain drugs? | Yes | No |
| 16. Have you been arrested for possession of illegal drugs? | Yes | No |
| 17. Have you ever experienced withdrawal symptoms (felt sick) when you stopped taking drugs? | Yes | No |
| 18. Have you had medical problems as a result of your drug use (e.g. memory loss, hepatitis, convulsions, bleeding, etc.)? | Yes | No |
| 19. Have you gone to anyone for help for drug problem? | Yes | No |
| 20. Have you been involved in a treatment program specifically related to drug use? | Yes | No |

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**PANAS-X**

This scale consists of a number of words and phrases that describe different feelings and emotions. Read each item and then mark the appropriate answer in the space next to that word. Indicate to what extent you feel this way *right now*. Use the following scale to record your answers:

| **1** | **2** | **3** | **4** | **5** |
|---|---|---|---|---|
| very slightly or not at all | a little | moderately | quite a bit | extremely |

1. ______cheerful
2. ______disgusted
3. ______attentive
4. ______bashful
5. ______sluggish
6. ______daring
7. ______surprised
8. ______strong
9. ______scornful
10. ______relaxed
11. ______irritable
12. ______delighted
13. ______inspired
14. ______fearless
15. ______disgusted with self
16. ______sad
17. ______calm
18. ______afraid
19. ______tired
20. ______amazed
21. ______shaky
22. ______happy
23. ______timid
24. ______alone
25. ______alert
26. ______upset
27. ______angry
28. ______bold
29. ______blue
30. ______shy
31. ______active
32. ______guilty
33. ______joyful
34. ______nervous

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35. ______lonely
36. ______sleepy
37. ______excited
38. ______hostile
39. ______proud
40. ______jittery
41. ______lively
42. ______ashamed
43. ______at ease
44. ______scared
45. ______drowsy
46. ______angry at self
47. ______enthusiastic
48. ______downhearted
49. ______sheepish
50. ______distressed
51. ______blameworthy
52. ______determined
53. ______frightened
54. ______astonished
55. ______interested
56. ______loathing
57. ______confident
58. ______energetic
59. ______concentrating
60. ______dissatisfied with self

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**Scales**

General Positive Emotion:= (p31 + p25 + p3 + p52 + p47 + p37 + p13 + p55 + p39 + p8)

General Negative Emotion:= (p18 + p44 + p34 + p40 + p11 + p38 + p32 + p42 + p26 + p50)

fear:= (p18 + p44 + p53 + p34 + p40 + p21)

hostility:= (p37 + p38 + p11 + p9 + p2 + p56)

guilt:= (p32 + p42 + p51 + p46 + p15 + p60)

sadness:= (p16 + p29 + p48 + p24 + p35)

joviality:= (p22 + p33 + p12 + p1 + p37 + p47 + p41 + p58)

self_assurance:= (p39 + p3 + p57 + p28 + p6 + p14)

attentiveness:= (p25 + p3 + p59 + p52)

shyness:= (p30 + p4 + p49 + p23)

fatigue:= (p36 + p19 + p5 + p45)

serenity:= (p17 + p10 + p43)

surprise:= (p20 + p7 + p54)

basic positive affect:= (joviality+self_assurance+attentiveness)/3

basic negative affect:= (sadness+guilt+hostility+fear)/4

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