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Experiential Knowledge of Event-based VS Learning through Repetition of Information-Based Memory

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Abstract: When stimuli are learned by repetition, they are remembered better and retained for a longer time and so when it comes repetition learning part they lack in the medial temporal lobe of the brain region, and cortical regions are involved in the learning effect when subjects retrieve associative memory, and whether their activations differentially change over time due to learning experience. On the other hand, Memory consolidation is a time-dependent process by which recently learned experiences are being transformed into long term memory. It stabilizes the memory trace after the initial acquisition, neurologically, the process of consolidation utilizes a phenomenon called long-term potentiation, which allows a synapse to increase in strength as increasing numbers of signals are transmitted between the two neurons. Lobes of the cerebral cortex: While memory is created and stored throughout the brain, some regions are associated with specific types of memory. The temporal lobe is important for sensory memory, while the frontal lobe is associated with both short- and long-term memory. Repetition of information and the retrieval of the incident that took place with an individual affects the mindset of an individual. Eventually, it solidifies the connections which are used to recall memory and also helps to emphasize a feeling or idea, create rhythm, and also helps in developing a sense of urgency. The motive of memory repetition is to bring attention to an idea. However, that learning is different from the experiential knowledge of an individual due to participation in an event. To study the memory and its related issues neuropsychological tests were used to measure memory and Brain Electrical Oscillations Signature (BEOS) profiling was used to measure the difference between the Experiential Knowledge (EK) produced because of repetition of information as compared to event-related memory. A total of 30 individuals were randomly selected after taking an interview for BEOS recording. BEOS recording was done for both repetitions of information based EKs and Event-based EK's. The results were compared using a paired sample t-test along with Mean & Standard Deviation of Episodic Memory & Repetitive Memory which has been discussed in the paper in detail.

Index Terms - ***Repetition of Information, Experiential Knowledge, Event-Based memory, BEOS Recording, Neuropsychological Assessment.***

I. INTRODUCTION

Understanding the human brain concerning different experiences acquired by them is a very complex phenomenon. Our brain is stored with so many experiences, right from the time we have started making sensory-motor contacts with the world, which are labeled as memories of life. After more than a century of research on episodic memory, there is still little agreement on mechanisms that underlie the effects of repetition. Repetition generally improves performance in standard recall and recognition-memory experiments, so to explain performances in these tasks, the cumulative-strength versus multiple-trace distinction may not much matter. Researchers investigating this issue have therefore turned to tasks that require other kinds of memory judgments. Judgments of recency (JOR) have played an especially important role in this work. There are two basic JOR procedures. In the forced-choice JOR or recency discrimination task, the experimental subjects choose the member of a test set (usually two items) that seems more recent. In the numerical JOR or absolute-judgment task, the subjects judge the number of items that intervened since a single test item was last presented. Data from both JOR tasks suggest that apparent recency approximately follows a logarithmic function of time or actual recency (e.g., Hinrichs, 1970; Yntema & Trask, 1963). Repetition creates a pattern and familiarity, which gets our attention. It can also lead to understanding. We have to repeat things more than once to finally sink into our minds. Rehearsing over and over again improves something. As they say, practice makes perfect. The principle of exercise states that those things most often repeated are best remembered. It is the basis of drill and practice. It has been proven that people learn best and retain information longer when they have meaningful practice and repetition. The key here is that the practice must be meaningful. Practice leads to improvement only when it is followed by positive feedback. For people to move information into their long-term memory for later use, they will need to rehearse the learning. Rehearsing learning may involve the work of tying imagery to concepts, word definitions, or phenomena. Visual rehearsal may involve the creation and memorization of visual imagery that reflects certain information, with these images held in a visual “buffer” until they are moved into the long-term memory. There are two main benefits of endless repetition. The first one is that repetition creates habits. Repetition causes actions or processes that require your conscious attention to become automatic habits controlled by the subconscious. During encoding, multiple learning leads to decreased activation in stimulus-related cortical regions and the hippocampus when compared to learning once (for reviews, Grill-Spector et al., 2006; Segaert et al., 2013). The repetition suppression in the hippocampus is confirmed when the single stimuli (e.g., pictures, Suzuki et al., 2011; Manelis et al., 2013) and stimulus associations are repeatedly presented (e.g., face-name pairs, Rand-Giovannetti et al., 2006; Vannini et al., 2013; face-scene pairs, Kremers et al., 2014 and object pairs, Zeithamova et al., 2016). During retrieval, studies which focus on implicit retrieval suggested that the hippocampal activation increases when subjects retrieve repeated items (vs. new items) by explicit strategy (e.g., Schacter and Buckner, 1998; for reviews, see Segaert et al., 2013; Kim, 2017), but those studies did not directly manipulate retrieval processes to explore the role of the hippocampus for the learning effect.

Repetition of Information (Repetitive Memory)

Repetition of Information is a condition in relational information where the values of one attribute are determined by the values of another attribute in the same relation, and both values are repeated throughout the relation. Sir John Eccles found that repetitive stimulation of nerves going to the "spinal cord" led to an increase in the size of the electrical response elicited in “postsynaptic neurons” in the spinal cord. (LeDoux, 137). Repetition creates long term memory by eliciting or enacting strong chemical interactions at the synapse of your neuron (where neurons connect to other neurons). Repetition is critical to most types of learning in most cases. People learn by repeating things. They learn by being repeatedly exposed to information, or by repeatedly making an effort to try out a movement or to find their way from point A to point B. Once information is remembered correctly, it still needs to be reviewed regularly, but at gradually lengthening intervals. This repetition results in reinforcement of the neuronal connections along the lengths of “axons” and “dendrites” and across the “synapses.” The more the neural connections are activated by the stimulation that practice brings, the more dendrites grow to strengthen the connections between the neurons. When the brain perceives information repeated in multiple ways, there is a “priming” process that makes “encoding” of that information more efficient. (Willis, 29). An individual will remember an event (a “stimulus”) as a function of the number of repetitions (of the event). If you give one stimulus, you have a “short-term memory.” If you give five pieces of training or more, you produce “long-term memory.” (Kandel Brain and Mind, 5) If you

stimulate repeatedly, you release more “serotonin” and that activates “genes” in the “sensory neurons,” which ultimately give rise to the growth of new "synaptic connections." This step requires new “protein synthesis.” (Kandel Brain and Mind, 6). The cerebellum, or hindbrain, handles fine motor movements, balance, and posture. It helps us to perform quick and repetitive movements. The brainstem is in front of the cerebellum and is connected to the spinal cord. Its job is to pass signals between the cerebral cortex and the rest of the body. Repetition is ubiquitous because of itself. It's a popular and well-understood method for improving memory simply because we've all been repeating the act of repetition for most of our lives. Repetition works well because it helps your brain solidify connections that are used to recall memories

Does Repetition of Information Improves our Memory

Repetition has been a part of our repertoire of memorization skills since childhood. You could say that repetition has been repetitious throughout our lives – and it would be true! All through school we study for tests and exams, cramming all of the information into our brains through one main technique: repetition. Reading the same notes over and over again, bouncing study information back and forth with your study partner – these things are good examples of repetition. Those who aren’t in school any more still do it – how many times have you caught yourself repeating a phone number or a grocery list over in your head in the hope that you won’t forget it? Repetition certainly works, when you learn something new, your brain instantly attempts to associate it with something that you already know through a process of assimilation. This association process is the brain building a new connection between a new idea and a previously understood idea. This new connection can be observed physically, as well. When your brain makes a new connection, your neurons create new neural pathways to accommodate the new information. While you won’t be able to trace a path between a brain cell storing a memory about apples and one holding onto a memory of apple pie, the new synapses will improve your ability to think. These new connections allow for a higher level of communication between the different areas of your brain, which can improve your memory recall in general.

Repetition helps in Remembering

There are several everyday things that repetition can help you with. Some of these things you may already know and use repetition for unconsciously.

1. You can use repetition to remember people’s names. Have you ever been introduced to someone at a party and had them repeat your name to you three or four times? This is a very effective form of repetition, and almost a full-proof way to remember someone’s name.
2. You can use repetition to remember numbers. Many people use this technique for remembering phone numbers, by repeating the number until they’re able to reach a keypad and punch it in. You can also combine the chunking technique with repetition. If you break a number into smaller components, then repeat each of the individual components to yourself instead of the entire number, you’re more likely to remember all the numbers.

Event-Based Memory

Event-based prospective memory involves remembering to perform certain actions when specific circumstances occur. For example, driving past the local library cues the remembrance of the need to return an overdue book. Time-based prospective memory involves remembering to act at a particular point in time. There have been several studies using neuroimaging, electrophysiological, and neuropsychological tests for establishing the involvement of the prefrontal cortex, and temporal lobes in various aspects of writing into and retrieval from memory. Recall from memory takes place for, using the recalled information for the identification of external objects, entities, and words, and using the recalled knowledge for interpreting relationships among concepts, entities, objects, etc., and for remembrance of past events in life. Shallice et al. [29] found in a study using PET imaging that encoding and acquisition were associated with activity in the left prefrontal cortex and retrosplenial area, whereas retrieval of the encoded information was associated with activity in the right prefrontal cortex and precuneus. Shallice et al. [29] and Fletcher et al. [30] studied normal subjects with verbal encoding and retrieval tasks and found activation of the left prefrontal cortex and retrospinal area of the cingulated cortex during the encoding stage, and activation of the right prefrontal cortex and bilateral activation of the precuneus during the retrieval stage. They concluded that separate brain systems

are engaged during the encoding and retrieval phases of episodic auditory-verbal memory. Several neuroimaging studies on normal subjects have documented evidence for a "hemispheric encoding/ retrieval asymmetry (HERA)" [13,30-33]. A theory of memory system with multiple memory traces representing different episodic memories acquired by the individual over the lifetime. The model "Multiple Memory Trace" theory distinguished between episodic and semantic memories, which were not done in the traditional memory postulations [34]. Factors that contribute to autobiographical recall and its association with the areas activated using event-related fMRI. They used a measure of recollective quality using measures of details recalled their emotional or personal significance and regency. There are several studies, which have been differentiated knowing from remembering. The difference between knowing and remembrance was first proposed by Mandler [2]. In the dorsolateral prefrontal cortex, activation was obtained during remembrance. Studies by Tulving [13], Le Page et al. [35,36], Henson et al. [37,38], and Fletcher and Henson [39] have shown anterior prefrontal cortex activation in mental tasks involving remembrance. Similar findings have been reported in a recall of autographical information in recent studies by Giloba et al. [8], Cabeza et al. [7], and Umeda et al. [5]. Autographical remembrance is a recall of experiences, which may be composed of awareness of experiences consisting of sensations, proprioceptive, sensations, emotions, and visual and other forms of mental imageries. Examples of autobiographical recall of individuals that we have examined in a study, which were also independently verified from sources other than the subject past events in their life, followed by an inquiry into what they truly remember, which makes them think the remembrance was true [23]. Accuracy of remembrance depends on several factors and awareness of the time of experiencing is one of them, which helps to support the veracity of the experience. Time estimation is one of them, which helps to support the veracity of the experience. Time estimation is one of them, which helps to support the veracity of the experience [23].

Experiential Knowledge on Event-Based (Autobiographical Episodes)

In-memory systems, 'remembering' is more attributed to 'experiential knowledge' (EK), while 'knowing' is related to mere recognition. Brain signature(s) specific to remembering as distinct from knowing will have enormous applied value including its forensic use. Information is retrieved from memory during recognition as well as a remembrance of past personal episodes. Recognition of familiarity requires retrieval of information acquired in the past, which forms a major spectrum of neural activities related to perception. Retrieval of past personal events, often called remembrance of autobiographical episodes, may take place intentionally and when cued by stimuli. In perception, the retrieved information facilitates the recognition of entities of the external world (1), whereas, in remembrance, the individual becomes aware of the retrieved information. All learning contributes to the knowledge bank, and retrieval from this source facilitates not only the recognition of entities but also understanding of different aspects of relationships among entities across temporal and spatial dimensions. Mandler (2) differentiated between 'knowing' and 'remembrance' as two memory systems; and Tulving (3,4) further substantiated multiple memory systems. Functional neuroimaging studies have shown that brain activation during a remembrance of autobiographical episodes is distinctly different from that seen in 'knowing'. Studies report extensive ventral brain activation, including that of anterior cingulate cortex, orbitofrontal cortex, and medial temporal cortex during remembrance; while 'knowing' correlated mainly with smaller activation patterns in dorso frontal prefrontal cortex (5-15). These studies have shown that 'knowing', especially that leading to recognition may engage minimal brain resources in comparison with a remembrance of personal past events, which may have temporal and spatial references, sensory and motor mental imageries, and emotional experiences, which require extensive neural participation. Source memory provides the contextual, temporal, and spatial references required to correctly identify or locate the autobiographical episode for retrieval. Source memory has a different neural localization compared to the main autobiographical episode, as shown in various neuroimaging studies (16-28). Remembrance of an experience is almost like reliving the same experience when all its original components are recalled (29). Remembrance may, therefore, include the recreation of sensory mental imageries (30-36), and motor mental imageries (37-43). As seen in these studies transcoded verbal details of the episode may be used for the recreation of the original mental imageries. Remembrance constitutes neural building of the earlier experience, which may be a recreation of the mental imageries of the sensory-motor contacts of the experience, as well as the revoking of emotional effects of the experience. Thus, taking part in an activity as well as witnessing an activity constitutes experiences of different dimensions, though both could create emotional effects in the participating as well as witnessing person. Autobiographical episodes that have an emotional significance to the individual are only remembered for a long. Hence both emotional and personal significance of episodes is therefore of crucial importance for their later, when the same emotions may be

recreated in varying degrees in the individual remembering the episode. Remembrance of an earlier episode takes place when its memory is triggered or cued by a related piece of information. The cueing effect is present only in those who have taken part in the experience or episode, whereas the process of remembrance cannot occur at all when one has not had the primary experience. When one has an earlier experience, its cueing by external reference words or objects would bring about its remembrance in an automatic and mandatory manner [21-23]. Experiencing emotions during a remembrance of personal episodes is well known in day-to-day life for everyone. Retrieved emotions may almost equal the same original experience. Its intensity and duration may vary based on the personal significance of the original experience. Significant differences in the intensity, vividness, and components may exist from one remembrance to another in the same individual. Quality of remembrance of a shared experience or event witnessed may differ from individual to individual. The triggering of the remembrance may not be uniformly time-locked to the cueing stimulus across stimuli, occasions, and individuals. There are frequent instances when one remembers a name or details of a personal event much later after receiving a triggering cue. None of these factors can be differentially known or predicted presently from outside by a measuring system. Remembrance is indeed a complex neurocognitive process unlike other cognitive processes such as arousal of attention, attentional allocation, recognition, and anticipation. Neuroimaging can indicate the brain areas activated during remembrance but it cannot be considered to reflect the subjective quality of remembrance. Similarly, a surface EEG recording is only a reflection of widespread neural activity within the brain and the changes that accompany processing related to cognitive and motor events. Remembrance of autobiographical episodes may be considered one of the complex cognitive states, as complex as experiencing itself, requiring extensive neural participation.

Brain Electrical Oscillation Signature Profiling (BEOS)

At the very onset, certain things that are needed to be cleared regarding BEOS is that it is not a deception detection test. It has nothing similar to Guilty Knowledge tests or measuring the psychophysiological changes during arousal of guilty knowledge. BEOS is a memory-based test, and its scientific base is derived from the differences between the two memory systems, one responsible for ‘knowing’ and the other for ‘remembrance’ which was originally stated by [2]. Knowing is a process of acquisition or sharing knowledge or information with others. On the other hand, remembrance is that of autobiographic episodes, and episodes are encountered in life by each, which is called experience. Several neuroimaging studies have distinguished between the neural activation patterns in ‘knowing’ and ‘remembering’ [3-15]. Several of these studies have reported that remembering is associated with extensive activation of the ventral brain, anterior cingulated cortex, orbitofrontal cortex, and medial temporal cortex. Knowing requires brain engagement mainly from the dorso frontal cortex, which is a much smaller engagement of the brain for knowing and retrieving information. This may involve mainly the process of recognition of the external signals or proprioceptive sensations, and their later retrieval for recognition of the same signal. Knowing is essentially a conceptual process, as it allows us to build a knowledge base in the brain. Knowledge is shared with others, or acquired from multiple external sources like books, lectures, videos, etc. On the other hand, experiencing occurs while participating in an activity and the knowledge acquired through such participation has been termed “Experiential Knowledge”. Remembrance is triggered in BEOS by presenting cues to a subject in the form of short verbal statements called the probes. The electrophysiological changes taking place when retrieval is triggered by the cue are measured from the multiple channels of electrical oscillations of the brain. Multiple channels of EEG are analysed to extract the significant changes that occur in the brain EEG while listening to each probe. As the subject is not expected to give any response to the probe head, only change evoked by listening to a probe is recorded as a remembrance. Remembrance of experience may be triggered by a probe only if the person has personally acquired the experience and stored the information. The analysis program looks for changes in the electrical activity, which indicates remembrance of autobiographical episodes or experiential knowledge. The EEG frequency and the time domain changes associated with different stages of cognitive processing in remembrances such as semantic processing of the probe, a shift in attention, episodic memory, and neutral binding effects [23,24] are extracted if present, and the significant changes are interpreted by the program. BEOS profiling is carried by using EEG with 30 cephalic channels and 2 eye movement channels. The hardware and the software for data acquisition and analyses were developed by Axxonet System Technologies.

Principle

The human brain receives millions of arrays of signals in different modalities, all through the waking periods. These signals are classified and stored in terms of their relationship perceived as a function of experience and available knowledge base of an individual, as well as new relationships produced through sequential processing. The process of encoding happens primarily when the individual directly participates in an activity or experiences it. It is considered secondary, when the information is obtained from a secondary source viz. books, conversations, hearsay, etc. in which there is no primary experiential component and the brain deals mainly with conceptual aspects. Primary encoding is deep-seated and has specific source memory in terms of time and space of occurrence of experience, as the individual himself/herself has shared or participated in the experience/act/event at a certain time in his/her life at a certain place. It is found that when the brain of an individual is activated by a piece of information of an event in which he/she has taken part, the brain of the individual will respond differently from that of a person who has received the same information from secondary sources (non-experiential). BEOSP is based on this principle, thereby intending to demonstrate that the suspect who has primary encoded information of those who have participated in the suspected events will show responses indicating first hand (personally acquired) knowledge of the event.

Repetition & Its Relation with Brain

When stimuli are repeated, neural activity is usually reduced. This neural repetition effect has been reported at multiple spatial scales, from the level of individual cortical neurons in monkeys [1–3] to the level of hemodynamic changes (measuring the pooled activation of millions of neurons) in humans using functional magnetic resonance imaging (e.g. fMRI [4–10]). Repetition-related reductions also occur at multiple temporal scales, both in their longevity – from milliseconds [3] to minutes [9] and days [11] – and in the latency of their expression [12,13]. The phenomenon also occurs in multiple brain regions, and across an impressively large number of experimental conditions. This stimulus-specific reduction in neural activity has been referred to as adaptation [14–16], mnemonic filtering [17], repetition suppression [18], decremental responses [19], and neural priming [20]. We will use ‘repetition suppression’ (RS) to refer to decreased neural responses following stimulus repetition. As will be apparent below, it is important to distinguish the scale at which RS arises, because the correspondence across scales (e.g. neural firing and hemodynamic responses) might not be simple. Interest in repetition effects has recently intensified, for two main reasons. First, repetition effects have proved useful for inferring the nature of representations across different stages of a processing stream. This approach has been used behaviourally (e.g. using visual aftereffects to infer the nature of orientation tuning [21] or face representation [22,23]), with single-cell recording [24], and more recently has become popular with fMRI, particularly given claims that it enables improved spatial resolution [7]. The second reason for the heightened interest is the possibility that RS might be the neural correlate of priming [25–27]. Priming refers to improved processing of a repeated stimulus according to some behavioural measure (e.g. greater accuracy in identifying the stimulus, or faster response times to decide it), and often occurs under the same experimental conditions as RS. Nevertheless, it is important to note that, under certain conditions, priming can be associated with increased activity, rather than reduction (for discussion of repetition enhancement effects and changes in frontal cortices that might contribute to priming, see [27,28]). The purpose of this review is to consider several kinds of neural models that have been proposed to account for repetition suppression (RS). We focus primarily on studies using visually presented objects and their effects on the ventral object processing stream, to maximize the overlap between monkey and human studies. We evaluate the neural models in terms of their ability to account for the main properties of RS as measured with single-cell recordings, fMRI, and electroencephalogram/magnetoencephalogram (EEG/MEG), discuss implications of these models for interpreting experimental results and propose directions for distinguishing between the models.

Objective

1. The objective of the research was to elicit the evidence for supporting that during the remembrance of the particular event/incident the presence of Experiential Knowledge (EK) can be detected by the Neuro Signature System which can be further used in the forensic investigative purpose as well.
2. To compare b/w Experiential Knowledge of any event is more significant as compared with the learning through repetition of information-based memory.
3. Also doing certain Neuropsychological Assessments we may able to find whether the individual possesses any sort of Memory Impairment or not.

Methods & Materials

A total of 30 samples were selected through purposive random sampling that was willing to share their personal experience and on the other side one standard script was given to memorize the entire incident. Before going through the BEOS Profiling the subjects were undergone through certain neuropsychological assessments to see whether is there any memory impairment or not. The samples were between 20-25 years of age.

Inclusion Criteria

1. Individuals who are above 19 years and below 26 years old.
2. Individuals who were willing to share their personal experiences.
3. Individuals who gave consent to sit for N.S.S. recording.

Exclusion Criteria

1. Individuals who do not share their personal experiences.
2. Individuals below 18 years old and above 26 years of age.
3. Individuals who didn't give consent to sit for N.S.S. recording.

Hypothesis

1. Experiential Knowledge can be detected by the Neuro Signature System when the individual experiences any event/incident & repetition of any information won't show any Experiential Knowledge in the Neuro Signature System.

2. Through certain neuropsychological assessments, an individual has memory impairment or not can be identified.

Instrument

BEOS Profiling was conducted in the study. BEOS profiling is a technique primarily developed as a forensic tool for deception detection in suspects which was developed and tested by Dr. C. R. Mukundan. Analyzing the electrophysiological data recorded from the scalp of a subject; the test is expected to provide information on the presence of "experiential knowledge" of participation in any activity. The scientific basis of the test uses the distinction between recognition using familiarity or knowledge and remembrance of experience from the autobiographical memory of the individual.

Procedure

The objective of the study was to elicit the experiential knowledge on the event which the individual has experienced instead of that event/incident in which the individual has just memorize it. The procedure was divided into 5 phases which are described below: -

Phase I - Memory Tests.

As the first part of the study, a series of psychological tests were conducted for each participant to identify any possible memory deficits that may be present. The primary instrument used in the study (BEOS) is based heavily on the individual's ability to recognize and remember and impaired memories may act as a confounding variable and interfere with results. Participants displaying any signs of memory impairment were taken care not to be included in the remaining procedure. The instruments from the PGI Memory Scale and few tests from the book 'The Brain Experience' authored by C.R Mukundan were used.

Remote Memory Test - This was done by asking the patient about historical or verifiable personal events of the past. Remote memory typically refers to memory for the distant past, measured on the order of years or even decades. Following, the digit span test was conducted to assess the individual's attention/concentration or working memory. The participant is asked to repeat a series of numbers that increase with each turn for up to 6 digits, forwards and backward. Working memory is the capacity to hold small amounts of information in an active, easily accessible state, usually for less than 30 seconds at a time.

Visual Retention Test - It was assessed by showing a participant set of cards containing patterns that they had to replicate from their memory after 30 seconds. Similarly, recognition was assessed by showing the participant a card containing a set of objects which he/she would memorize. After a brief period of one minute thirty seconds, they would be shown a new set of cards, this time containing additional items that were not previously present from which the participant would have to recognize and note down names of previously shown objects. The Visual Learning and Memory Function test from the book 'The Brain Experience' was the last of the series of visual memory tests. The stimulus was a complex pattern presented on a card. The pattern contained 21 components each of which had to be replicated in the same manner after viewing the card for an extremely short period of 15 seconds. Each participant was given 3 trials consecutively before conducting the 4th and the last trial which would be conducted after 10 minutes. Scores obtained generally improve with each trial and reflected the rate of learning in a person. low scores obtained in the trial could be an indication of the presence of memory impairment or lesions in the temporal lobe.

Verbal Learning & Memory Function Test - It was conducted in which four passages are read out to the subject one at a time and he/she was required to recall and record immediately for the first part and after a delay for the second part. The subject was given four trails whose scores are then assessed. Low scores in the first trial Aren't given much significance as the subject usually shows improvement with the second and third trials. However, if the improvement is below the previously shown levels it is indicative of a learning deficit and memory impairment may be confirmed. Verbal learning deficit is suggestive of left temporal and frontal involvement.

Phase II – Information Collection from the Subject.

Information from the sample was collected through interviews to prepare two different scripts; one will be the common script 1 (based on a crime which they have never committed) and script 2 will be the subject's episodic memory-based script. The subject was supposed to memorize the entire Script 1 multiple times until the subject remembers the entire script. And script 2 will be presented once. This would help in the retrieval of the episodic memory of the entire scenario given by the subject.

Phase III – Probe Designing Process.

Once the specific episodic narrations of all 30 subjects and step by step detailed process were entered in notepad in the VASP system. Individuals episode was entered in the notepad in the VASP system, probes were designed in sequence. The standard set which has the repetitive memory script has consisted of 30 probes, divided into 5 scenarios including Control and Neutral Probes. The Specific sets consisted of 60 minimum and 90 maximum probes divided into 6 to 10 scenarios including Neutral and Control probes. Event Markers were given to each respective probe. The sets were uploaded into VASP after which the auditory probes were recorded, based on the gender. The recorded probes are then saved and uploaded into recorded probes in the VASP, which will automatically upload them into NSS for presentation during the BEOS testing.

Phase IV – BEOS Recording

After the completion of psychological tests, the subjects were brought to the BEOS lab for recording, according to the convenience of the subject. Once the subject is being brought to the BEOS lab, the following instructions were given to the subject. "At the very first the subject will be asked to seat comfortably in the chair, the subject was asked to keep away any electronic devices as it may hamper the recording. The subject was seated comfortably in a wooden chair. The subject was asked to rest their arms on the armrest. The harness was worn around the subject's chest. Then the head cap with 32 channels was placed on the subject's head. The placement of the head cap was significant for proper recording. The saline gel was then infused into electrodes using a syringe with the blunt needle. The reference point is attached to the earlobe and using the connector the head cap is then connected to the amplifier. The subject is asked to close the eyes for a baseline recording which lasts for 2 minutes. After the baseline session, a BEOS session is conducted where the probes are presented. The subject is asked to close the eyes and then the probes will be presented to the subject. Each probe is presented and there is a gap of 6 seconds between the presentations of probes. The gap is because the brain requires 6 seconds to respond to each probe. And it was also instructed that subject should not sleep while recording, otherwise, the probe presentation will be stopped automatically. The recording will be done using the BEOS instrument to run both scripts 1 and 2 for analysis.

Phase V – Data Analysis

After the recording of probes, the data analysis was done. Data analysis is a software-based analysis done by the Neuro Signature System itself. The analysed data was then used to measure the number of EKs produced by the subjects in Episodic & Repetitive Based Experiences & also the score of the memory test is also being taken into the consideration.

Result & Analysis

The data obtained based on the experiential knowledge on both sets of the scripts were analysed along with certain neuropsychological assessments. Here the statistical parameter that has been used are t-test & Mean Standard Deviation and the results were obtained through the desired hypothesis.

The objective of the research was to elicit the evidence that during the remembrance of the particular event the presence of Experiential Knowledge (EK) can be detected by the Neuro Signature System which can be further used in the forensic investigation. Also, to compare the significance of Experiential Knowledge of any event with the learning through repetition of information-based memory. The only motive for doing certain neuropsychological assessments was to check whether the individual possesses any kind of memory impairment or not.

After recording the response of 30 participants on their one episodic and the other repetitive events-based experiences. A total of 60 recordings were done. The analysis of the data was done using N.S.S. version 6.2 automated software to measure the Experiential Knowledge responses by each individual.

- Experiential Knowledge - Activity related to remembrance of the experience triggered by the probe presented.

Table 1 explains the Mean & Standard Deviation of Experiential Knowledge in Episodic & Repetitive Memory. The numbers of EKs were more in the Episodic Memory as compared with the Repetitive Memory.

Set of Probes	Mean	Standard Deviation
Episodic Memory	**4.23**	**2.431**
Repetitive Memory	**2.00**	**1.232**

While on the other side Table 2 signifies the paired sample t-test of Experiential Knowledge in Episodic & Repetitive Memory Script of Probes.

Script of Probes	t	df	Sig. 2 tailed
Episodic Specific Script - Repetitive Standard Script	**6.187**	**29**	**.000**

Table 3 shows the neuropsychological test that was conducted are listed below along with their maximum scores. Each test has a different total score and hence different weightage. While calculating the means it was observed that the mean value of tests where all participants have scored full have a lower value than in other tests where the participants show a variation in their scores.

Neuropsychological Test	Maximum Scores
PGI Remote Memory	**6**
PGI Attention Concentration	**15**
PGI Visual Retention	**13**
PGI Recognition	**10**
VBLMF	**20**
VSLMF	**23**

Table 4 signifies the scores of all the participants who went through the Neuropsychological Assessments Test to see whether they have any memory impairment or not.

Nos. of Participants	Remote Memory	Attention & Concentration	Visual Retention	Recognition	VBLMF					VSLMF				
Sr. No.	Obtained Score / Maximum Score	Obtained Score / Maximum Score	Obtained Score / Maximum Score	Obtained Score / Maximum Score	Trial 1	Trial 2	Trial 3	Trial 4	Total Score	Trial 1	Trial 2	Trial 3	Trial 4	Total Score
Subject 1	6/6	9/15	13/13	10/10	0	4	9	8	20	14	20	23	23	23
Subject 2	6/6	11/15	13/13	10/10	5	10	16	13	20	8	9	14	14	23
Subject 3	6/6	7/15	13/13	10/10	3	8	14	7	20	5	7	13	14	23
Subject 4	6/6	11/15	13/13	10/10	2	8	11	10	20	7	10	20	21	23
Subject 5	6/6	9/15	13/13	10/10	6	8	17	12	20	11	19	22	23	23
Subject 6	6/6	11/15	13/13	10/10	0	6	8	5	20	6	12	20	19	23
Subject 7	6/6	9/15	13/13	10/10	1	3	4	2	20	14	20	22	22	23
Subject 8	6/6	10/15	13/13	10/10	4	6	8	6	20	3	11	18	18	23
Subject 9	6/6	10/15	13/13	10/10	4	14	16	17	20	11	22	23	23	23
Subject 10	6/6	8/15	13/13	10/10	4	8	15	9	20	10	12	16	14	23
Subject 11	6/6	12/15	13/13	10/10	4	8	15	8	20	14	20	23	23	23
Subject 12	6/6	9/15	13/13	10/10	4	8	16	13	20	8	9	14	14	23
Subject 13	6/6	11/15	13/13	10/10	4	8	8	7	20	5	7	13	14	23
Subject 14	6/6	12/15	13/13	10/10	4	10	17	5	20	7	10	20	21	23
Subject 15	6/6	11/15	13/13	10/10	3	14	11	2	20	11	19	22	23	23
Subject 16	6/6	9/15	13/13	10/10	3	8	14	6	20	6	12	20	23	23
Subject 17	6/6	12/15	13/13	10/10	1	8	16	17	20	14	20	22	22	23
Subject 18	6/6	12/15	13/13	10/10	2	8	9	9	20	3	11	18	18	23

Subject 19	**6/6**	**12/15**	**13/13**	**10/10**	**3**	**8**	**14**	**9**	**20**	**11**	**22**	**23**	**23**	**23**
Subject 20	**6/6**	**10/15**	**13/13**	**10/10**	**2**	**8**	**11**	**17**	**20**	**10**	**12**	**16**	**14**	**23**
Subject 21	**6/6**	**11/15**	**13/13**	**10/10**	**4**	**8**	**9**	**6**	**20**	**10**	**20**	**18**	**22**	**23**
Subject 22	**6/6**	**9/15**	**13/13**	**10/10**	**3**	**8**	**16**	**2**	**20**	**11**	**9**	**23**	**21**	**23**
Subject 23	**6/6**	**6/15**	**13/13**	**10/10**	**1**	**10**	**17**	**5**	**20**	**3**	**7**	**18**	**22**	**23**
Subject 24	**6/6**	**6/15**	**13/13**	**10/10**	**4**	**14**	**15**	**10**	**20**	**14**	**10**	**20**	**19**	**23**
Subject 25	**6/6**	**11/15**	**13/13**	**10/10**	**2**	**10**	**17**	**12**	**20**	**3**	**19**	**22**	**23**	**23**
Subject 26	**6/6**	**11/15**	**13/13**	**10/10**	**1**	**4**	**11**	**13**	**20**	**7**	**12**	**13**	**14**	**23**
Subject 27	**6/6**	**13/15**	**13/13**	**10/10**	**2**	**14**	**8**	**10**	**20**	**5**	**20**	**22**	**22**	**23**
Subject 28	**6/6**	**12/15**	**13/13**	**10/10**	**7**	**7**	**8**	**11**	**20**	**8**	**11**	**18**	**23**	**23**
Subject 29	**6/6**	**11/15**	**13/13**	**10/10**	**6**	**7**	**13**	**1**	**20**	**5**	**22**	**23**	**14**	**23**
Subject 30	**6/6**	**10/15**	**13/13**	**10/10**	**1**	**14**	**8**	**10**	**20**	**14**	**12**	**14**	**21**	**23**

From Table 1 & Table 2 it is clear that Experiential Knowledge can only be obtained through any Specific Event-Based criteria, not from Repetition Information Based Memory which indicates that there is a significant difference between the numbers of Experiential Knowledge in both the set of Probes. On the other side taking the Neuropsychological Assessment into the consideration i.e. in Table 4 tests like Remote Memory, Visual Retention & Recognition all the individuals obtained full score while tests like Attention & Concentration, VBLMF, and VSLMF the variation of the score obtained by an individual can be observed. Although both in VBLMF & VSLMF, when an individual undergoes for significant trial there is an increase in their score with a total of 20 and 23 respectively. Hence, from a Neuropsychological perspective, we can say that when an individual learns something i.e. the information that he/she is obtaining through learning the parts of the brain through repetition is critically mediated by the Cortical Regions of the left posterior temporo-parietal cortex which somehow co-relates with the learning process of an individual. Thus, the score obtained by the 30 participants in the Neuropsychological Assessments shows that all the individuals do not possess any kind of Memory Impairment. On the other hand, taking the Forensic Psychological Investigation into the consideration the Experiential Knowledge of an individual of two different scenarios and its electrophysiological responses can be used in the forensic investigative purpose and are relevant during a remembrance of the incidence and also elicit the evidence for supporting that during the remembrance of the particular scenario by an individual the presence of experiential knowledge can be detected by the neuro signature system used in the forensic application. This shows the relevant significant difference between the Experiential Knowledge of Event-Based Memory (i.e. Episodic Memory) and the Learning through Repetition of Information-Based Memory. From the above results, it is clear that BEOS Profiling has correctly elicited the maximum rate of Experiential Knowledge.

Conclusion

Experiential Knowledge of an individual can be elicited only when the incident is Event-Based Memory which the individual has experienced (Episodic Memory) himself/herself. Memorizing an event multiple times or listening about an incident multiple times cannot create experience-based signatures in the individual's brain. So, it can be concluded that BEOS Profiling can be used to get clarification regarding the particular case that has committed the crime or not in context with the Forensic Psychological Investigation approach. This can help the investigators to differentiate between the suspect, eyewitness, and the victim. But in the context of the Neuropsychological approach, the neuropsychological assessment helps to identify the memory impairment possessed by the individual or not. Therefore, this research covers both the approaches i.e. the Neuropsychological approach as well as Forensic Investigation approach as well. Hence, repetition of information and the retrieval of the incident that took place with an individual affects the mindset of an individual which can be identified by one of the most important forensic psychological investigative tools i.e. BEOS.

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