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A SYSTEMATIC REVIEW ON EXPERIENTIAL KNOWLEDGE OF WITNESSES USING BEOS PROFILING

Savithri K.K, Dr Priyanka Kacker

M.Phil. Forensic Psychology Student
School of Behavioural Sciences, National Forensic Sciences University, Gandhinagar, Gujarat
Savithrikk5897@gmail.com

Senior Assistant professor
School of Behavioural Sciences, National Forensic Sciences University, Gandhinagar, Gujarat
drpriyankakacker@gmail.com

Abstract

This review study focuses on a forensic psychological tool, Brain electrical Oscillation Signature Profiling, and its mechanism. In precise, this paper reviews the studies of eyewitness testimony and BEOS in particular. The previous empirical studies and review articles elucidate that BEOS can be used to overcome the effect of internal and external factors in eyewitness testimony. False memory or confabulatory experiences would not affect the accuracy of Brain Electrical Oscillation Signature Profiling. During the trial process, witness testimony can do through BEOS in the future. More empirical researches are necessary for the application of forensic psychology tools in the field of witness testimony.

Keywords: *BEOS, eyewitness testimony, forensic psychological tools, Witness interrogation*

INTRODUCTION

India, one of the fast-growing countries in the world being appreciated by all other countries for India's diplomacy, economy, good neighbouring, combating against terrorism, and other criminal activities, etc. In India, the criminal justice system is powerful, which is the only institution on which all people can rely firmly. However, there is a high leap in the crime rate. For supporting crime investigation and the criminal justice system, here we have applications of science. Through different areas of science, experts are helping our criminal justice system to give a precise verdict. Forensic Psychology is the application of behavioural science in jurisprudence, helping the crime investigation and court to reveal the truth by using forensic psychological techniques. Forensic psychology is the psychology applied to law. Forensic is a term derived from the Latin word – *Forensis*, which means concerned with the law. In a broader sense, forensic psychology is the science and application of psychological principles, theories applied to legal issues, all aspects of the law. Forensic Psychology facilitates the detection of deception and crime investigation by using various techniques such as layered voice analysis, polygraph, suspect detection system, and Brain Electrical Oscillation Signature Profiling. Forensic psychology is one of the emerging super-specialty streams in India. It is developing day by day in terms of research, applications in crime investigation, and academic activities. Forensic psychology is not only concentrated on crime investigation, it is also working on crime prevention and offender/victim rehabilitations.

There are different techniques used in crime investigations to detect the deception of offenders. One of the main technologies is a brain lie detector. Brain fingerprinting is one of the technologies detecting the P300 MERMER. This technology is utilized by the FBI and other agencies all over the world. Another technology is Indian-made, known as Brain Electrical Oscillation Signature Profiling is an advanced technology that detects memory related to the crime/event developed by Prof. C.R. Mukundan.

BEOS is working on the principle of experiential knowledge stored in autobiographical memory. BEOS has been using in forensic setup since 2003(*Puranik et al 2009*). From the birth of BEOS, so many offenders got convicted by the criminal justice system. A lot of innocent people got their normal life back. Brain Electrical Oscillation Signature Profiling is mostly used in suspects and offenders. They are not detecting deception. Perhaps brain lie detectors identify the presence of crime-related memory. However, the BEOS have not explored in witness testimony. Some factors affecting eyewitness testimony accuracy. This could be internal and external factors, but more than that false memory, misinformation, confabulated information, boisterous environment conditions influence the recollection of crime events. Forensic Psychological tool BEOS is also working in the episodic and semantic memory distinction. In this study, the researcher deliberates on the application of Brain Electric Oscillation Signature Profiling in divergent areas of lie detection. The review tries to link between eyewitness testimony and BEOS for a new strategy to testify witnesses inaccuracy. How the

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BEOS can be pertinent to other disciplines of the judiciary system. Through this review, the researcher trying to disentangle the vast use of memory-based lie detectors especially the Brain Electrical Oscillation Signature Profiling and the researcher tries to understand the neuropsychological process behind this technology.

EXPOUNDING THE ESSENCE OF BRAIN ELECTRICAL OSCILLATION SIGNATURE PROFILING

Real Experiences and experiential knowledge of the brain: Experiences can be defined as the confrontation of reality. It can be Personal happenings, emotional encounters, events, or anything that is encountered by a person in their life. This event will record in your brain, especially in your memory. Like experience, knowledge is also stored in our memory. There is a huge difference between knowledge and experience. Experience is our life experienced event or happening, we sensed it and we perceived it. Ultimately it is a personal event. Knowledge is something that we share. In short, knowledge is shared information. Experience is stored in autobiographical memory and knowledge is stowed in our semantic memory. Knowledge is acquired information through books, academic settings, or shared by someone. We have not experienced it, but we knew it.

In that sense, we can say that experiences are real. When a person sees a murder in front of him, that incident which he has been saw is an experience. For that particular event, he will produce experiential knowledge. Experience and knowledge are hellishly associated with human memory. As further whenever we try to recollect our happenings or experiences, actually we are remembering that event. Sensory modalities and motor modalities are intertwined with our experiences. When we recollect the information that we learned without practical involvement or observation, we recall that information. It's a pure semantic memory recall.

REMEMBRANCE AND RECALL: BRAIN MECHANISM OF MEMORY

Memory is a lively arrangement that gets details from the senses, arranges, and modifies it just the same way it accumulates it off, after which retrieves the details from storages (Alan Baddeley, 1996). Memory is the ability to encode, store, recall information. Brain electrical oscillation signature profile working principle is based on the human memory system. BEOS is constructed on the assessment of two memory systems are semantic memory and autobiographical memory episodes. Knowing which is based on the semantic memory of the individual. Recall of information related to semantic memory can be detected from the activation of some brain areas. Knowing is associated with the activation of the dorso- frontal cortex of the brain. Knowing is the process of recognition. Remembrance is related to autobiographical memory episodes. Remembrance is the autobiographical information is stored in the memory. Remembrance or experiential knowledge is the memory of events experienced by the individual. Stimulation of the anterior cingulated cortex, orbitofrontal cortex, ventral brain, and the medial temporal cortex is associated with remembrance. The experience remembered are mental imageries involving sensory, motor components, proprioceptive, and emotional components. Remembrance involves attending to the internal cognitive processing related to specific events.

Experiential knowledge is connected to long-term memory processing. When we used to recall past events, we utilize episodic memory. Therefore BEOS is measuring the internal processing of remembrance in the brain. Episodic memory stores the information about specific events or episodes related to one's own life. Information about personal experiences is called autobiographical episodes.

RELEVANCE OF MEMORY IN JUDICIARY SETTINGS – EYEWITNESS TESTIMONY

In judicial settings application of memory is mostly used in eyewitness testimony. Eyewitness affirms what they noticed through his/her experience. That discernment can be either with the unaided human sense or with the manual of an instrument. Eyewitness recollect in a complex manner. Recollection of records about what we have passively seen and what we have actively observed differs. There is a conventional work of Ebbinghaus, which is an experimental method on memory quantity and amount of facts that can reproduce within a period. Consistent with this idea, when time accelerates, retention of information will decrease. A few researchers found the memory traces.

Eyewitness testimony refers to lexical statements from people regarding what they observed and can allegedly remember the crime events during the trial process. Eyewitness identification is a specific type of recognition where the person identifies another person who has been present at the crime scene. Witness recollects a particular action of that person or particular action that occurred in that crime event.

The accuracy of Eyewitness testimony closely depends upon the memory factors of the individual. In almost all memory experiments researchers focused only on memory performance. They forgot to take look at memory as a conscious experience. Here in eyewitness testimony, memory accounts for the conscious experience of events. So that memory, behaviour, knowledge, and experiences are closely correlated (Tulving1989). Conscious experience in memory distinguishes between the knowledge of past events and the recollection of events.

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HOW INDIAN EVIDENCE ACT STATES EYEWITNESS TESTIMONY

A witness is a person who has personally seen an event happens. The event could be a crime or an accident or anything. According to the Indian Evidence act Section 118 to 134 talks about who can testify as a witness, how can one testify, what statements will be considered as testimony?.
A witness who needs to testify before the court must at least have the capacity to understand the questions that are posed to him and answer such questions with rationality.
According to the Indian Evidence act 1872, all persons shall be competent to testify unless the court considers that they are prevented from understanding the questions put to them, or from giving rational answers to those questions. Even a small child is capable to give evidence to the judiciary. If the child can give rational answers to the court. Raju Devendra Choubey Vs. The state of Chhattisgarh is one of the criminal cases held in Chhattisgarh where the sole witness of murder was a child of 13 years old. There different types of witnesses are victim-witness, Accused witness, Independent witness, and Hostile witness.

AIM AND OBJECTIVES OF THE STUDY

The present review aims to facilitate on-going scientific efforts to explore the process of BEOS, forensic psychology tools, and memory influences in eyewitness testimony.
This dissertation aims to study the application of BEOS profiling in various settings of the judicial system. Also study focuses on the use of human memory in the judicial process and to understand the underlying neurological process of memory-based lie detection specifically BEOS. To address the gaps in the studies and to understand knowledge, the researcher aims to examine the following objectives. It reviews the studies in brain electrical oscillation signature profiling and studies in eyewitness testimony. The review aimed to synthesize the findings of included studies, themes of the studies, psychological factors associated with eyewitness testimony.

- Target and population used in studies
- Methods were used
- Experiential knowledge produced for real experiences
- Experiential knowledge produced for the unreal experiences
- Results of studies
- Theoretical model of BEOS
- Neurological explanation for BEOS profiling
- Application of Memory in Eyewitness testimony
- Neurological links of memory

METHODOLOGY

Procedures were followed according to the guidance provided by the Centre for Reviews and Dissemination (2009), and Petticrew and Roberts (2006).

Objectives of the Review

- To study BEOS application in various settings of the judicial system.
- To understand the scientific efforts behind the BEOS.
- To study the memory influences in eyewitness testimony.
- To understand the underlying neurological process of BEOS
- To understand the gaps in the studies

Data Resources

The researcher has used certain keywords such as “Brain electrical Oscillation signature profiling research studies”, “BEOS”, “Human Brain Oscillation studies”, “Eye witness testimony studies in psychology” etc. in Google browser. Science Direct, Jstor, PsycINFO, Google Scholar, GAP internationals, Research Gate portal were used to search the appropriate research articles and papers. Total 54 papers were used to study as a part of this dissertation. Cochrane library database and PsycINFO bases were used to collect appropriate studies.

Exclusion/Inclusion Criteria

All research studies were required to describe original research and be available in the English language. This systematic review is based on some variables in forensic psychology are eyewitness testimony, memory-based lie detection, neurological processes of the brain in recollection of memory. Brain Electrical Oscillation Signature profiling was invented in 2003. Studies of BEOS from 2003 were included. Novel advanced studies in BEOS were included. Memory research works that led to the development of BEOS were included. Human Brain

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Oscillations were discovered by Hans Berger in 1929 from the invention of the Electroencephalogram. Studies of Human Brain Oscillations related to memory, specifically remembrance and knowing-based memory were included. Other Human Brain Oscillations studies were excluded. Online available Published research works, reviews were eligible for inclusion. Detailed pertained information of Inclusion criteria is explained below.

Sample

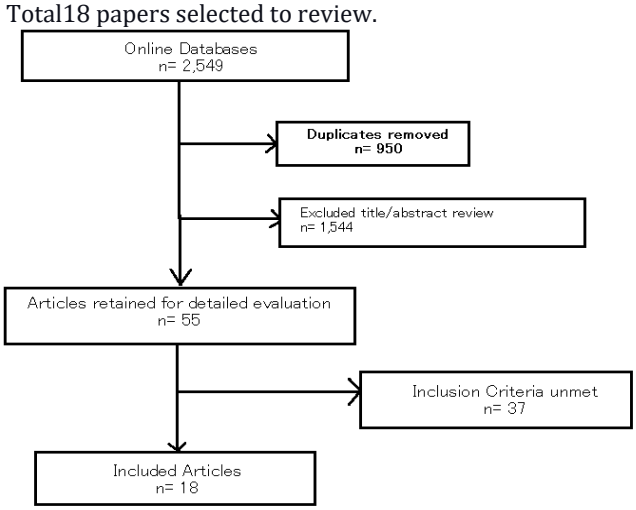
This review selected the population that used in BEOS experiments. The study comprised of the normal population such as adults, age of 18 and older, and offender population in BEOS cases.

Types of studies

Experimental research studies of BEOS and human brain oscillations were included. Reviews of Brain oscillatory theories were included in this study. Experimental studies in eyewitness testimony, memory, and reviews of eyewitness testimony, memory are also used in the study. Case studies in BEOS and its history were used.

Study Selection and Data Collection

Selection of studies: Search on Cochrane library database using the keyword "Brain Electrical Oscillation Signature Profiling", found 0 trails. For "eyewitness testimony", 33 trials were found. In PsycINFO, 119 trials were found for the term "eyewitness testimony memory" and 0 results for BEOS. Search on Science Direct using the term "Brain electrical Oscillation signature profiling", the researcher found 1,176 trails but that results were addressed only single words of the term. So these search results were excluded from the review. The term "eyewitness testimony psychology" was used and detected in 1,101 trials. 120 research papers were found in Research Gate for BEOS. Total 2549 trials were reviewed and abstract, Title assessed. All abstracts were read and reviewed as per the inclusion and exclusion criteria. After reviewing the abstracts, the researcher reviewed the full papers of research articles/papers. Appropriate studies were chosen from the 2549 research results. Of this total 55 research papers were included because they met the criteria of inclusion. Of this 37 papers were unselected due to fewer data. Total18 papers selected to review.



Quality Assessment and Data extraction

Included studies were evaluated using a protocol adapted from the Critical Appraisal Skills Programme and Centre for Reviews and Dissemination (2009). Total four domains were analysed.

1) Initial screening (adequate sample description; clarity of aims; appropriateness of design/methodological approach relative to stated aims).
2) Risk of selection bias (sampling size and sampling criteria, study design)
3) Classification Bias (reliability of procedures)
4) Measurement bias (use of objective measures, data sufficient to support findings; design/methodological procedures)

Data Extraction: Under the inclusion criteria, data systematically extracted from the studies. Data extracted from general information about sample, methodological factors, theoretical perspectives, and results (findings, variables)

1. Types of methods: Experimental studies, review studies of BEOS, and eyewitness testimony were used to extract the data.

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2. Population: Adults, age 18 and older, offenders have participated in previous studies considered as the population for this study. Studies were conducted with adults, from age 18 and older, and offenders were selected.
3. Theoretical perspectives: Theoretical underpinnings of BEOS, Brain waves, Eyewitness testimony, and the Neurological process behind BEOS were extracted from review studies and experimental studies. Most theories were selected from review studies.
4. Case studies: One case study (Puranik et al) of BEOS was selected to know the application of BEOS in different criminal cases.
5. Specific Factors: Experimental studies of BEOS, especially in the investigation of cold crimes, cybercrimes, etc. Brain Oscillation theories and Brain waves information extricated from review studies (Basar et al). The memory influences in eyewitness testimony featured in this review study.
6. Results: In experimental studies of BEOS, experiential knowledge of real experiences is differentiated from knowing experiences. The results could differentiate real experiences from knowing experiences were extracted from experimental studies.
7. Findings: Findings in review studies and experimental studies were accentuated for this review studies, specifically a gap of knowledge.

RESULTS

Details of the research paper, which discussing brain electrical oscillation signature profiling, development of BEOS, Brain process behind the working of BEOS, and eyewitness testimony, the factors affecting the recollection of an event, are presented in Table 1. (Appendix)
Three studies were used in the same sample population, age 20- 25 years old participants were used in that 3 studies. (Isai, C. & Kacker 2020, Kacker and Roy, S 2020, Nandini,N. and Kacker,P. 2017 ,TIFAC-DFS Report 2008; Mukundan 2008a, 2008b, 2005; Wagh et al., 2009; Vaya et al. 2009a, b,Kacker, 2018, Isai, C. & Kacker 2020, Kacker and Roy, S 2020, Nandini,N. and Kacker,P. 2017 , Heuer and Reisberg 1990, Gustafsson, Torun, & Fredrik, 2019).The theoretical background of BEOS was reviewed from five studies majorly.(Parmar and Mukundan 2017, Mukundan et al 2018 , Mukundan et al 2017, Kacker, 2018 Endel Tulving,1989).
Human Brain Oscillations theories were reviewed mainly from two studies by Basar et al 1999, Basar et al 2000. Eyewitness Testimony is affected by internal and external factors. Eyewitness performance can be affected by event factors, retention factors, retrieval factors, and witness factors. Event factors are the duration of the event, frequency of viewing, event complexity, violence, and seriousness. Witness factors such as stress/fear, age, personality characteristics, and expectations. (Wells, 1978) Six research studies were reviewed on Eyewitness testimony, its influencing factors in recollection of memory. (Wells, 1978, Heuer and Reisberg 1990, Gustafsson, Torun, & Fredrik, 2019, Albright, 2017, Loftus, 2019).

Descriptive Data Synthesis
The data organized to identify the themes across the studies, that is, theoretical perspectives of Brain electrical Oscillation Signature profiling and its development, processes, Human brain oscillation theories information, and novel application of BEOS in different areas of knowledge, and eyewitness testimony, and affected by the memory factors. (Described in Table 2, appendix)

Theoretical perspectives of Brain electrical Oscillation Signature profiling
Origin and Theoretical framework: Brain electrical Oscillation Signature Profile/ BEOS is criminal inquisition tool discovered by Prof. C.R. Mukundan, a computer – EEG-based strategy used to detect the presence of remembrance activity in suspects of the crime. BEOS is extracting electrical oscillation signature from the brain by presenting probes. While recalling experiential knowledge, the examinee could recollect the autobiographical information encoded in autobiographical memory related to the happening of the crime or engagement in the crime. (Mukundan CR, 2005)
BEOS is based on the human memory system, so it is a memory-based test and not a deception detection test. BEOS is constructed on the assessment of two memory systems.

- Knowing – It is based on the semantic memory of the subject. By sharing knowledge with others, a person will get semantic information. Knowing is associated with activation from the dorso-frontal cortex.
- Remembrance – Remembrance is the autobiographical information which is encountered in our life. In other words, the events which are faced by the subject are called Remembrance or experiential knowledge. Stimulation of the anterior cingulated cortex, orbitofrontal cortex, ventral brain, and the medial temporal cortex is associated with remembrance.

The meaning behind the name – Brain electrical oscillation signature profile: brain oscillation which elucidates electrical activity of the brain produced during cognitive processing. A signature means a specific pattern of electrical activity while marking the remembrance or experiential knowledge. (Mukundan CR., et al. 2017)

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Accuracy of the BEOS profiling was determined a normative study conducted in Gujarat Directorate of Forensic Science's Laboratory by participating 56 in experimental and 54 in the control group(TIFAC-DFS Report 2008; Mukundan 2008a, 2008b, 2005; Wagh et al., 2009; Vaya et al. 2009a, b)

Probes of the BEOS

In forensic settings, four types of probes are used.

- Neutral probes: Neutral Probes can be defined as the brief linguistic syntax, which are free of individual information. This measures the registration process of memory and verifies that the offender is not suffering from any memory degenerative illness. Pre-probe baseline epoch is compared to the results of these probes.
- Control probes: Control probes are checking the verified autobiographical information of the offender in life. Here investigator testing the information which is expected to produce remembrance. Control probes are used for the self-validation procedure.
- Target A probe: These probes are designed in scenarios of criminal activities of the offender or suspect, discovered by the investigation officer.
- Target B probe: Target B probes are referred to as the form of actions and involvements of himself as claimed by the offender.

In BEOS two types of stimuli are used are Auditory and visual stimuli. The probes are recorded and designed in Visual and Auditory Stimulus programming on the computer.

After recording the probe next step is to check the error. Recorded probes are uploaded to Neurosignature System to present the probe.

BEOS using 32 channel electrode head cap. Head cap can be fitted in the scalp and conducting gel injected on discs of electrodes. The subject will be monitored by webcams.

Specific ranges of the power spectrum profile of BEOS

- Experiential Knowledge: EK shows the presence of remembrance of experience for the probes is presented to the subject.
- Emotional Response: Denoted as EM. This response is indicating an emotional upsurge of the individual while hearing probes. Encoding present accompanied by overwhelming blanking of further processing. The probe has produced a significant decrease in the activity of delta, theta, alpha, and gamma bands.
- Negative Response: Denoted as EM. If the probes are producing negative responses such as N400. It is treated as artifacts.
- Encoding (En): There will be a significant increase in delta, gamma, beta bands.
- Primary Processing (PP): There will be a significant activation in beta waves of the brain.
- Inattention (In): Inattention indicates that encoding of probes is not happening, which relates to the preoccupation with other thoughts or distraction, specifically denotes the offender is not listening to the statements.

Probes are marked with special markers called event markers. These event markers are very important to make analysis; all analysis depends upon how well we code the event markers. Witness recall, visual imagery recall is the part of event marker. Event markers are categorized into 21 sets. (Kacker, 2018, Parmar and Mukundan 2017, Mukundan et al 2018 , Mukundan et al 2017, Kacker, 2018)

Human Brain Oscillation – Brain Waves

Basar et al 2000 reviewed the experiments of brain oscillations in their article named Brain oscillation in perception and memory. They reviewed the experiments of oscillatory phenomena of the brain such as alpha, theta, or delta responses associated with sensory and cognitive functions. The researcher found that gamma oscillations, now considered as one of the key signals of the brain. This article argues that selectively distributed alpha, delta, theta, and gamma oscillations act as resonant communicators to large no. of neurons. Oscillatory phenomena are intertwined with memory and integrative functions.

In 1989 (Memory: Performance, Knowledge, and experience), Endel Tulving found that there is a relationship between memory, knowledge, behaviour, and experience. He emphasized the importance to take memory as a conscious experience. He points out that most of the studies are looking at memory performance, but the researchers forgot to take memory as a conscious experience of an individual. In that way memory, behaviour, knowledge, and experience are closely correlated as per the doctrine of concordance. Conscious experience in memory made a distinction between the noetic awareness (knowledge) of the past events and the anti-noetic awareness (recollection) of the event.

Basar et al 1999 wrote a review article on the role of the oscillatory process in sensory and cognitive functions. This article emphasizes the development of brain oscillatory theory. Basar et al give a detailed idea about the selectively distributed gamma oscillations. Gamma oscillations are the universal rhythm block. It correlates with high cognitive processes. In this review, the researcher has given a detailed view of selectively distributed alpha oscillations and selectively distributed delta oscillations.

Development in Brain Oscillations

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Brain Oscillations or Neural oscillations, which means steady, recurrent electrical impulses of the brain created when neurons get stimulated by spontaneous stimuli. Sensory-cognitive processes are result of brain oscillations (Basar, 2013). Brain oscillations are the functional building blocks of the sensory–cognitive process. Hans Berger is the one who first recorded the human brain in the electroencephalogram. Hans Berger paved the building stone of brain oscillation theory. Berger observed ~ 10 Hz rhythmic activity. This electrical activity is the alpha rhythm or Berger rhythm. Brain Oscillation theory developed tremendously with recent updates in the theory. Event–related oscillation in the alpha, delta, gamma, beta, and theta frequency made huge differences in the lie detection area. Especially, gamma oscillation distinguished between true and false memories. Gamma oscillations are related to high-order cognitive processing. Electroencephalogram records 4 types of brain. Delta ranges from 1 to 3.5 Hz, Theta wave ranges from 4 to 8 Hz, Alpha (8 to 13 Hz), Beta which ranges from 13 to 30 Hz, and Gamma (30 to 100Hz). Each brain wave has own its functions.

Functions of Brainwaves

- Delta wave is the slow wave with the highest amplitude. Present in children's sleep stages. Delta waves induce growth hormone.
- Theta waves are related to the subconscious activity of the individual. It can be seen in a deep relaxation state and meditation. It encourages the production of the human growth hormone. It accelerates memory and learning.
- Alpha waves are mostly found in the occipital lobe and parietal lobe. Alpha waves can be seen in all adults who are awake or relaxed with closed eyes. "Alpha Coma" is the abnormal case of alpha waves
- Beta is responsible for the behaviours and actions of an individual. Beta wave is related to sensation and perception. It can be mostly found in the temporal lobe and frontal lobe.
- Gamma wave is the high-frequency wave. Gamma is related to perception and consciousness, and hyper-alertness. Gamma waves are associated with higher-order cognitive processes.

Novel Application of BEOS in different knowledge areas

Isai, C. & Kacker (2020) conducted a study on the effect of repeated probes in the creation of remembrance, this study brought out that the Remembrance of an individual produced only at the time of an event that registered in the episodic memory of the person himself. Rote learning or repeated listening to the incidents will not elicit experiential knowledge (Isai, C. & Kacker 2020).

Human memory is connected to emotion. Positive emotions and negative emotions are capable to make deep impacts on memory. These experiences will produce experiential knowledge of the suspect's memory. In 2018, researchers came across both negative emotion and positive emotion almost equally produces experiential knowledge about the events which made them happy or sad. It was a BEOS based study and 20 participants participated. (Kacker, 2018)

Investigators established the significant role of BEOS in the cyber-crime investigation through their research on the cyber-crime investigation through BEOS profiling. They conducted a study between amateur hackers and professional hackers. Investigators established positivity for the use of BEOS in the cyber-crime investigation. (Kacker and Roy, S 2020)

Nandini,N. and Kacker,P. 2017 conducted a study on the induced paranormal experiences using brain electrical oscillation signature profiling. The study consists of 16 participants. These participants were further divided into experimental and control groups. The experimental group had seen 100 minutes horror video and the control group got the narration of the video. Before recording in BEOS, both groups underwent the paranormal belief test, to measure the level of paranormal belief in participants. All hypotheses formulated in this study are accepted. Researchers found visual imagery recall is influenced by gender differences. The study revealed that the experiment group elicited more visual imagery recall than the control group. Where in the experiment females elicited more visual imagery responses and males elicited more information recall information. The study discovered that females have more paranormal beliefs compared to males.

Kacker & Amrita, A. (2020) found that experiential knowledge cannot be manipulated with confabulated memory of suspects in the BEOS system. Results found that in BEOS real memories cannot be influenced by false memories.

A study by Pendse, A. & Kacker, P. 2020 on Cold crime investigation using BEOS discovered that BEOS could use for investigating cold cases. This study was quasi-experimental, and the number of EKs elicited in recent memory, and remote memory was studied and statistically analysed.

Eyewitness Testimony

As the great philosopher, Bentham said, "Witnesses are the eyes and ears of the justice." Yet there are potential threats to the eyewitness testimony, not actually from the memory factors of the human. Eyewitness testimony refers to verbal statements from people regarding what they observed and can allegedly remember the crime events during the trial process (Wells, 2002). Eyewitness identification is a specific type of recognition where the person identifies another person who has been present at the crime scene. Witness recollects a particular action of that person or particular action that occurred in that crime event. Eyewitness testimony is susceptible to errors and wrong recognition.

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Classical studies in eyewitness testimony were done by Dr. Elizabeth Loftus. She had perturbed about the ensuing facts that could act on the memory of eyewitnesses. The primary focus was on the effect of fallacious information that can be affected through visual representations and usages of terms in eyewitness interrogations. (McLeod, S. A.2014).

Heuer and Reisberg 1990 found that emotion promotes the memory in central information of an event and peripheral in detail. Before this study, the researcher believed that emotion will disrupt memory recollection. Most laboratory studies support the theory that details of emotionally arousing events are not remembered as accurately as details of neutral events; that is a negative emotion leads to generally worse memory (Loftus & Burns, 1982).

Loftus & Palmer (1974) found that witnesses to a filmed accident more frequently replied that the accident included broken glass when the question included the phrase "smashed into" rather than the descriptor "hit." The implied content of the question modified the memory of the event.

The experiments conducted by Dr. Loftus provide repeated examples of the fact that witnesses will incorporate post-event misinformation into their memory of an event. If incorrectly informed about the existence of a barn in a film, the witnesses will subsequently provide descriptions of the fictitious building.

Trace theory and the reconstructive view represent opposing approaches to memory. The former advocate's permanent memories are isomorphic with the original experience (e.g., Tulving, 1974). The latter proposes that memories are reconstructed from conceptual schemes (e.g., Bartlett, 1932) to fit the individual's understanding of the event. The eyewitness research bears strongly on this theoretical difference, favouring the reconstructive view.

When we experience an important event, there will be a complex process. This process is divided into 3 stages.

- First, the acquisition stage-the perception of the original event in which information enters a person's memory system.
- Second, there is the retention stage, the period between the event and the eventual recollection of a particular piece of information.
- Third, there is the retrieval stage, during which a person recalls stored information.

Eyewitness performance can be affected by event factors, retention factors, retrieval factors, and witness factors. Event factors are the duration of the event, frequency of viewing, event complexity, violence, and seriousness. Witness factors such as stress/fear, age, personality characteristics, and expectations. (Wells, 1978)

In a chapter named eyewitness recall and testimony, authors have taken an unconventional way to eyewitness testimony. First, they illuminate the distinction between memory- quantity and accuracy of memory. Second, they point up the metacognitive contribution and control processes of memory functioning and witness recall. The authors had strategically analyzed the complexities of the eyewitness testimony. (Pansky, A., Koriat, A., & Goldsmith, M. 2005.)

Gustafsson, Torun, & Fredrik, 2019 researched on memory retrieval effort and confidence in eyewitness testimony. According to these researchers, correct memories need less effort than incorrect memories. They found that incorrect memory puts more effort into cue than correct memory. Furthermore, investigators discovered that participants with correct memory have more confidence than participants with incorrect memory.

A study conducted by Albright, 2017 titled “why eyewitnesses fail”. It was on the errors that can be happened in eyewitness testimony. National Academy of Sciences assembled a group of experts who have been practicing eyewitness testimony. To know the mistakes and errors that could happen in eyewitness identification. Eventually, these experts found the errors and gave special directions to the judicial system. Loftus, 2019 wrote a special review article on Eyewitness Testimony and published it for the applied cognitive psychology journal. Loftus illuminates the importance and shoots up in the studies of eyewitness testimony. Loftus emphasizes the misinformation in eyewitness testimony and the confidence level of witnesses. Misinformation, confabulation, false memory, memory reconstruction, and emotion, other external factors are affecting the accuracy of eyewitness testimony.

DISCUSSION

Eyewitness testimony is an important stage of judicial system that could affect by some internal factors and external factors. Eyewitness testimony refers to lexical statements from people regarding what they observed and can allegedly remember the crime events during the trial process. Eyewitness identification is a specific type of recognition where the person identifies another person who has been present at the crime scene. Witness recollects a particular action of that person or particular action that occurred in that crime event.

` BEOS is constructed on the assessment of two memory systems. Knowing – It is based on the semantic memory of the subject. By sharing knowledge with others, a person will get semantic information. Knowing is associated with activation from the dorso-frontal cortex. Remembrance is the autobiographical information which is encountered in our life. In other words, the events which are faced by the subject are called Remembrance or experiential knowledge. Therefore, BEOS can be utilized in the field of eyewitness testimony.

The validity of eyewitness testimony is affected by the misinformation and confabulatory statements given by victims, statements given by eyewitnesses. Amrita,A. and Kacker,P.(2020) found that false memory or confabulated experience will not affect the real experience of the individual, which mean BEOS can differentiate between fake witness and true witness. BEOS is applicable in eyewitness testimony to overcome the issues of misinformation, false memory, and confabulatory experiences.

CONCLUSION

Brain Electrical Oscillation Signature profiling (BEOS) is a forensic psychological advanced technology to detect the offenders by assessing their experiential knowledge. BEOS has been constructed on the assessment of two memory systems. Knowing – It is based on the semantic memory of the subject. By sharing knowledge with others, a person will get semantic information. Remembrance is the autobiographical information which is encountered in our life. In other words, the events which are faced by the subject are called Remembrance or experiential knowledge. The validity of eyewitness testimony is affected by the misinformation and confabulatory statements given by victims, statements given by eyewitnesses. False memory or confabulated experience will not affect the real experience of the individual. As per the prior studies and reviews, BEOS can be used in the field of eyewitness testimony. Further, empirical researches should be done on this particular area to explore and execute different forensic psychological tools in the judicial system that will make judiciary execution more precise.

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