

# Memory Enhancement with the use of Neurofeedback and CVLT Repetition Techniques in the Case of Anterograde Amnesia

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## Abstract

Amnesia or amnesic syndrome is a memory deficiency caused not only by brain damage, several diseases or psychological trauma, but is also noticed as a temporal condition resulted from sedatives and hypnotic drugs use. A significant number of people are suffering from several types of amnesia. Therefore, it is essential to review amnesia several types, to analyze potential causes of the amnesic syndrome as well as to categorize commonly met symptoms. In this study, the authors' objective is to focus on the case of anterograde amnesia. Specifically, an evaluation and rehabilitation protocol is suggested aiming to improve the memory deficits that amnesic people are dealing with. The use of neurofeedback and memory enhancement procedures are blended in terms of a clinical memory rehabilitation protocol.

## Keywords

Anterograde amnesia; Neurofeedback training; CVLT test; Memory

## Introduction

Amnesia, as a memory deficiency, is mainly referred to three basic aspects a) memory function b) memory loss phenomena and c) the verbal class involved with these phenomena. On the other hand, amnesia can be related to memory loss, without the existence of a cognitive disorder [1]. It is worth noticing that amnesia is totally distinguished from dementia, while people suffering from dementia are linked with several neurological disorders affecting their cognition and memory.

Among several types of amnesia, the most common type is suggested to be post-traumatic amnesia. This type of amnesia is noticed after an accident or severe shock that occurred in the patient's life. Nevertheless, the most commonly met amnesia types are anterograde and retrograde amnesia. In the case of anterograde amnesia, people have trouble making new memories after the onset of the deficiency. On the contrary, people dealing with retrograde amnesia are facing troubles on accessing memories acquired before the onset of amnesia. These two types of amnesia often coexist in the same person [2]. Moreover, patients suffering from Alzheimer's disease are also noticed to present retrograde amnesia symptoms [3]. In the case of Korsakoff's syndrome, is suggested that origins from chronic alcoholism and malnutrition and is considered to be a commonly met amnesic disorder [4]. On the other hand, child amnesia is related to people who cannot recall memories from childhood or infancy ages. This type of amnesia is rather common and is linked with the conjuncture that people dismiss memories from the ages that they weren't able to speak [5]. Finally, transient global amnesia is related to a sudden, temporary memory loss which is not linked to a neurological state, such as epilepsy or stroke. Amnesia could also be related to neurological diseases such as multiple personality disorder or several psychological causes (psychogenic amnesia) [6].

## Amnesia causes and symptoms

The amnesic syndrome is commonly acquired from a trauma or a traumatic event that lead to brain damage in general. This could occur by an accident, a medical operation or an event that shocked the patient. In addition, oldaged people are seriously involved with memory recall disability. Moreover, incidents like a heart attack where patients may have spent time without an oxygen flow, a stroke, as well as a seizure, are able to cause not only a temporary memory loss condition but even a permanent one [7]. Diseases such as encephalitis and cancer can be equally responsible for amnesia related situations [8,9]. Loss of memory can also be caused due to alcohol or drug use [10] or by pharmaceuticals' side effects such as benzodiazepine (midazolam, flunitrazepam, lorazepam, temazepam, nitrazepam, triazolam, clonazepam, alprazolam, diazepam, and nimetazepam) or tetrabenazine [11]. Finally, mental and emotional disorders could also cause memory recall difficulties [12].

According to amnesia symptoms, regardless of the amnesia type, four typical symptoms are noticed. These are a) memory loss, b) faulty information and memories recall, c) problems

## Article Information

**DOI:** 10.31021/jnn.20192132  
**Article Type:** Research Article  
**Journal Type:** Open Access  
**Volume:** 2 **Issue:** 2  
**Manuscript ID:** JNN-2-132  
**Publisher:** Boffin Access Limited

**Received Date:** 25 March 2019  
**Accepted Date:** 17 May 2019  
**Published Date:** 22 May 2019

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**Citation:** Bobori C, Plerou A. Memory enhancement with the use of neurofeedback and CVLT repetition techniques in the case of anterograde amnesia. J Neurosci Neurosurg. 2019 May;2(2):132

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with temporary memory and d) confusion and disorientation feelings. Patients suffering from amnesia often forget or get confused about where they are and about the date of the specific day. Moreover, they fail in recognizing an object or even a familiar person. They are unable to describe clearly an object, even name it or identify its use [13]. Typically, these symptoms are identified with the use of patients' medical history recording, physical examination tests in order to evaluate patient's cognitive status as well as with the use of brain scanning techniques such as MRI, CT Scan, and EEG. EEG brain imaging technique is suggested in the cases that patient is under a cognitive procedure and the evaluation in terms of brain activation is required. Within this type of brain scan, specific brain areas could be evaluated while noticing electrical signal variations during various cognitive functions [14].

### Anterograde amnesia

Anterograde amnesia, or else called fixation amnesia, is a form of brain damage, that leads to a generalized inability of creating new memories after a traumatic event. It is worth noticing that no other mental abilities are affected. Patients are unable to memorize events, information newly obtained and new people that they have met during the present time. However, they are able to remember and recall people, memories and events from the past, namely from the time before the event or accident that triggered the anterograde amnesia disorder [15]. Patients suffering from anterograde amnesia are unable to recall recent memories while they can recall old memories in detail. In rare cases and after a lot of practice, these patients managed to recall some newly acquired memories. These patients are extremely easily distracted, as they immediately forget where they were or what they were doing at a specific time. Therefore they could repeat actions, questions or comments repeatedly as due to the fact they cannot recall recent memories [16].

The brain of people suffering from anterograde amnesia is able to access information even though they are unable to store them. In these cases, the obtained information is not accessed by the part of the human brain that is linked with long-term memory. Both hippocampus and hypothalamus are linked with cortex areas, were memories are suggested to be stored. Working memory is not linked with the hippocampus or the temporal lobe, therefore anterograde amnesia patients are still able to learn [17]. Nevertheless, a person suffering from anterograde amnesia should make a great effort and repeat actions continuously in order to learn something new. These patients won't be able to remember what they have done i.e. whether they have seen something before or that they had spent hours trying for something, whether they liked or disliked the procedure, and they shall always suggest that this is the first time that they are doing something. However, a repetitive learning procedure is suggested in order to improve the learning procedure [18]. For instance, in the case that a person suffering from anterograde amnesia begins today to learn how to knit, he won't remember about that the day after. Especially, the next day, he will not be able to recall what he did, whether he enjoyed it or whether he was good, or how many hours he spent for that. For each passing day, he will try the same thing again and again like this is his first time. However, if someone else is watching him he will notice that he is really making progress, ending something faster and more accurately. On the other hand, the person suffering from anterograde amnesia won't be able to notice or perceive any progress. This fact suggests that in these cases, the working memory is not influenced and the typical working memory function is retained [16].

### Anterograde amnesia and brain

The brain areas that are suggested to be linked with anterograde amnesia disorder are basically the temporal lobe, the hippocampus, the anterior lobe (basal ganglia) and the dorsal. All these areas are connected with both memory creation and storage. Short-term memory is suggested to be associated with the anterior lobe region while the long term is proposed to be linked with the hippocampus. The temporal lobe is composed of the hippocampus, the endocrine bark, and the subepocapicular cortex [19]. The temporal lobe is related to declarative memory processing and storage and is

connected with the neocortex where the long-term memories are stored. The human brain stem is consisted of the thalamus, the hypothalamus, the pituitary gland and is located in both human hemispheres [20]. The hippocampus is suggested to be related to long-term memory as well as space ability perception. According to relative research in the case that the hippocampus is injured or partially/fully removed could be connected with amnesic syndrome appearance. Additionally, increased cortisol, chronic post-traumatic stress, depression, bipolar disorder, and dementia are linked to gradual hippocampus damage or distortion and consequently potential memory loss problems. Nevertheless, data processing and storage procedure is an extraordinarily complicated procedure not yet fully perceived [21].

Anterograde amnesic syndrome's patients typically present lack of episodic memory (ability to retain autobiographical information related to space and time) rather than a lack of semantic memory (ability to retain information such as language, history, geography). In the case that the memory impairment is linked only with the one part of the temporal lobe, brains neuronal plasticity supports the brain to present normal or almost normal memory functions over time [22].

### Related work and known cases

The case of "HM" an amnesic patient from Canada is widely known since this is the first person diagnosed with anterograde amnesia. "HM" was suffering from extremely frequent epileptic seizures episodes during his childhood. The medical procedure at that time suggested, in order to deal with epileptic seizures, was the overall hippocampus removal [23]. Hippocampus region is the part of the human brain considered to be responsible for everyday life incidents memorization (short-term memory) while long term memory is related to the right and left hippocampal part cooperation. "HM" finally was under a surgery procedure, and even though epileptic seizures episodes had stopped, he started experiencing memory loss problems. He began to be unable to remember anything beginning from the day of the surgery, even though he was able to remember incidents and memories retrieved from his life before. "HM" finally died of old aged [24].

One other case of a man that suffered from anterograde amnesia is the case of a German man whose memory "stuck" in March 2005 when he visited a dentist. This case study is extremely interesting because of the fact that what triggered the amnesia and memory deficiency was not indicated. Finally, the case of "RB", another patient suffering from anterograde amnesia, a 52-year-old man is noted. "RB" underwent a surgical operation during which he suffered from an ischemic stroke. After his death, researchers noted that he had been suffering from severe damage to his hippocampus [25].

Another rather recent case is one of a musician named SZ. SZ showed extensive bilateral damage to his medial temporal lobes after suffering from herpes simplex encephalitis that resulted in severe anterograde amnesia. After a lot of practice, the patient was able to learn and play new music even though he was not able to recall or recognize any song from the past [26].

One more case of anterograde amnesia is one of a 49-years-old man. He had years of opioid and cocaine abuse and smoking as well as signs of hypertension who in the early stages developed stutter and later anterograde amnesia [27].

Finally, in the case of an 84-years-old man, he suddenly showed signs of acute anterograde amnesia which alarmed his wife and he was soon hospitalized. After a series of tests, doctors found out that the man suffered from an aortic dissection. The man did not present any symptom i.e. chest pain or irregular palpitations. After a few days from the onset of amnesia, the patient suffered severe chest pain and was soon unconscious resulting in him passing out a few days later [28].

### Methods

Authors' suggestion is a clinical protocol in order to minimize memory and learning difficulties in the case of people suffering

from anterograde amnesia. The suggested procedure focusses on episodic memory enhancement through a series of diagnostic and rehabilitation procedures. These procedures are suggested to be performed in a specific time frame. In order to evaluate participants' cognitive functioning before the protocol implementation, they are asked to assess a general cognitive functioning, as well as an episodic and working memory test. General cognitive functioning is suggested to be assessed with the Mini-Mental State Examination (MMSE) [29]. Episodic memory is suggested to be evaluated with a French version of the selective reminding task of Grober and Buschke [30]. In the Grober and Buschke task, the participants are asked to recall several words. Each one of these words describes an item that is clustered to a different semantic category. Participants are asked to recall immediately the cued series of these words before they are being interrupted by a distraction phase. After this distraction phase is followed by two minutes phase where participants are asked to recall these words freely, without a specific order. For the working memory evaluation, the California Verbal Learning Test (CVLT) is suggested [31]. In this evaluation, the participants need to repeat a string of single digits in the same order that they are initially provided (i.e., forward span) or in the reverse order (i.e., backward span). In addition, the use of EEG brain scanning technique is suggested in order to record, observe and evaluate participants brain function during the pre-evaluation and pre-test rehabilitation procedure. So, their electrical brain activity would be recorded during the evaluation procedure, as well as during several relative questions (please describe this object, please describe your day, please identify the last thing you remember, etc.).

## Participants

The suggested rehabilitation protocol is addressed to adult participants involved with a formal education who are suffering from anterograde amnesia. Anterograde amnesia disorder is confirmed according to DSM-IV-TR criteria [32]. In these patients, memory impairment is indicated in both verbal and visual recall abilities. In addition, they present executive functioning deficits. Participants suggested to be involved with this study are people suffering from this amnesic disorder without stroke, seizures, or head injury history.

## Protocol procedure

It's worth mentioning that anterograde amnesiac patients are unable to remember things they had done after a specific time (usually the day after). Therefore, the suggested protocol is proposed to be applied every day for a two months period. However, this period duration is likely to vary, depending on the patient's progress. This protocol is suggested to be applied in a controlled environment so external noise or stimuli that can distract participants to be avoided. This rehabilitation protocol is suggested to be applied in Bioinformatics and Human Electrophysiology Laboratory (BIHELab). BIHELab has a quite specially designed area that is fully equipped for electrophysiological and behavioral studies. This laboratory is located in the Informatics Department, Ionian University, Corfu, Greece. Additionally, all participants are asked to consent in order to participate in the rehabilitation procedure, completing and signing up the provided consent form. Initially, participants' performance in the above-mentioned assessments would be recorded. In this way, their potential progress could be objectively evaluated. Moreover, the initial group of participants could be clustered in two cognitive equivalents evaluation groups.

In order to record the brains activity, an electrode headset is placed in participants skull based on 10-20 position system. The recording process will start before the rehabilitation protocol with the use of CVLT test procedure being applied [31]. CVLT test is designed to evaluate the amount of new information that participants have learned. In addition, CVLT is used to evaluate participants mistakes and consequently to estimate the way they obtained this new information. With the use of CVLT test both free and cued recall ability, serial position effects perception, semantic clustering capability, intrusions perception, interference skills, and recognition abilities are measured. CVLT test procedure is described in detail as

following. Initially, a list of 16 words (nouns) is announced to the participants and they are asked to recall those a) immediately and b) after a period of time. This procedure is repeated for 5 times and participants need to repeat the process as many times as they can. As mentioned above, the participant's performance in each iteration is automatically recorded with the use of CVLT software [31]. Thereafter, the second list of words is provided to the participants, and the same procedure is to be followed. It's worth mentioning that each provided list contains words that differ. In addition, a final list of words is provided to the participant, and they need to place these words in specified categories. After the CVLT test procedure is finalized, the EEG brain activity recording is also completed. This procedure would be repeated every day approximately for the two months to follow. The retrieved data is about to be evaluated in terms of brain activity variations as well as in recall ability improvement.

## Neurofeedback training

Neurofeedback training is considered a type of biofeedback where brain activity is displayed in real time. For this procedure, an EEG recording machine is required while participants are trying to achieve their mind control, or else to achieve self-regulation of their brain function. Therefore, specified sensors are placed on participants scalp, while their brain electrical activity is measured and displayed in several formats, i.e. EEG raw data, video, sound etc. Several researchers provide evidence regarding neurofeedback training performance enhancement potentials. The main objective of this technique is to help participants to complete a specific function or task with fewer errors and greater efficiency, resulting in a more positive outcome [33].

In general, EEG neurofeedback training is suggested to enhance cognitive functions and learning procedure. Therefore in this rehabilitation protocol, the use of neurofeedback training is suggested in order to benefit from this technique effectiveness. Specifically, Alpha-Theta and Beta training protocols are suggested to be applied to the research group in contrasts to the control group. Participants clustering into control and research group is considered to be crucial in order to compare the potential differences among neurofeedback and non-neurofeedback trained participant performance [34]. In order to complete this procedure, EEG recording equipment is necessarily combined with the CVLT evaluation test software.

## Discussion and Future Work

Researchers are constantly studying cases of people with amnesia and trying to understand how the brain works. Based on cases of people with no obvious cause, researchers try to develop rehabilitation techniques for these cases. People who suffer from anterograde amnesia and amnesia syndrome are noted to carry a type of brain damage and memory dysfunctions. The suggested rehabilitation protocol is based on asking the participants to recall a series of suggested words and try to memorize them after a repetitional procedure blended with neurofeedback training protocols. The presented protocol suggests a potential beneficial effect of both CVLT word repetition evaluation and neurofeedback training in memory enhancement in the case of anterograde amnesia patients. Authors' future work leans towards to shed light not only on memory distortions in amnesia but also on the rehabilitation of these distortions.

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