



Neuroethics of Augmenting Human Memory Using Wearable Pervasive and Ubiquitous Technologies

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Abstract. Neuroethics is a field of study that deals with the ethical and moral issues in neuroscience. Memory augmentation approaches and technologies, is rooted in the broad field of neuroscience and brings with it its own set of ethical issues. Memory augmentation is a new emergent field, where the well-being of humans is augmented using pervasive and ubiquitous technologies. Augmenting Alzheimer and dementia patients' memory with wearable pervasive computing technologies like lifelogging shows a promising memory improvement. But, is it ethical to augment memory, if so what ethical issue may arise? The emergent technologies like artificial intelligence, pervasive computing and IoT (Internet of Things) are frequently used in memory augmentation. The consequence of augmentation for treating memory deficit needs a careful look. This paper will highlight the basic ethical issues related to memory augmentation technologies.

Keywords: Neuroethics · Memory augmentation · Wearable pervasive and ubiquitous devices

1 Introduction

Ethics related to Artificial Intelligence (AI) is about creating intelligent machines. The possible harm caused by the machines on the human race is the main ethical concern in AI. Is it morally right to lead humans into competition with machines? This is man versus machine game. On the contrary, in the human augmentation scheme, the game is man versus an augmented man. In athletics, all athletes run for a gold medal. It is obligatory for them to be away from doping to have an equal competition platform. Using doping and coming to the running track leads to sanctions. Doping is nothing but a human augmentation psychopharmacological drug that alleviates mental alertness. Such medicines are designed for treating mental illness like ADHD (Attention Deficit Hyperactivity Disorder) [1]. But now, doping is used unethically to aid study and professional competitions. Human augmentation can be done using drugs, mental-implants (brain pacemaker) and neuro-technologies. In this paper, the ethical issues on a type of neuro-technologies for augmenting human memory will be discussed.

Memory enables individuals to encode, store and retrieve (recall) information. Due to a number of factors, the human memory is not capable of accurately recalling all information that one may need with 100% accuracy. Memory augmentation is desired

to increase the recall capacity for individuals with and without memory deficit. For an individual with a memory failure, life will not continue to be the same as before. Based on the severity, Alzheimer and dementia patients could not be able to remember their past. They even forget information including their families, home address, their learned experience in academics and professional life. Memory is identity, without having memory life will be so difficult and treating the illness with all possible means is crucial. In the other hand, individuals with a normal memory also have a desire to increase their recall capacity. College students use doping type drugs to aid their regular study to increase their recall for an exam [1].

Wearable pervasive and ubiquitous technologies are applied to augment human memory. Wearable lifelogging technologies (a type of pervasive computing) are widely applied to augment Alzheimer and dementia patients' memory deficits. There are also ubiquitous devices designed to augment students' memory.

Neuroethics discipline has emerged to manage the advancements in neuroscience research findings. It provides neuroscientists a critical look on the potential impact of the neuro-technologies on the society [2].

There is a desire to augment human memory using wearable pervasive computing technologies. But, considering the ethical issues before starting to develop a new and adopt an existing technology is important. System developers need to be aware of the consequences of their planned technologies. The personal, societal and cultural undesired impact of memory augmentation should be assessed at first. This is a short paper to speculate on some of the major neuroethics of augmenting human memory using wearable devices. The background section present human memory and memory augmentation then the ethical issues will be discussed in the discussion section.

2 Background

2.1 Human Memory

The human memory is one of the main cognitive functions that encodes stores and retrieves information [3]. According to the SPI (Serial, Parallel, and Independent) model of memory, the human brain encodes information serially. At the same instant, thousands of input stimuli could enter the human brain. However, memory encoding happens to the stimulus that gets attention in a serial manner. Encoded information will be stored in parallel and finally retrieved independently [4]. Forgetting is unable to retrieve memories. Encoding and retrieval are the two core functions of human memory [5].

Memory Encoding starts with sensory information encoding. It is triggered when input information such as visual, tactile (Sematosensory), auditory, olfactory and gustatory stimuli strikes the brain. Memory encoding ends with making a perception (semantic description of the senses). As a perception reaches working memory/short term memory if it gets the attention it will be sent to Long-term Memory to be encoded else it will be discarded just right there [4].

Memory Retrieval results in two types of output from Long-term memory. Declarative memory output is a mental image and non-declarative memory is a motor output [6]. Declarative memory retrieval includes both recall and recognition, where

recall is remembering in detail but recognition is remembering the highlight [6]. Free-recall and cued-recall are two types of recall. Free-recall is remembering the detail without having a cue and cued-recall is remembering after a cue is given [6].

2.2 Human Memory Augmentation

Augmenting memory is not only for individuals with memory deficit it also helps normal individuals develop a more effective memory [7]. Memory encoding, storage and retrieval are three functions in human memory; augmentation is used to support retrieval. Memory encoding accuracy is about the functioning of the sensory systems. Memory storage is an unconscious cognitive function. Synaptic interactions of neurons form groups of neurons for long-term memory and it occurs largely unconsciously [8]. Due to this, assisting the encoding and storage of human memory is not under the current trend of memory augmentation that this work focuses on. Augmenting memory is mainly the concern on increasing the retrieval of a memory. Once information is encoded in the human brain a human can't accurately retrieve all stored information from their past. Forgetting information is the nature of a human. This forgetting could include information which is vital to that individual.

Memory augmentation work includes the use of diaries, photos, to-do lists, calendar, address books and summarized notes to retain the past for the future. The recent trends in memory augmentation focus on using wearable cameras and life-logging technologies [3]. These tools record episodes of an individuals' life. This focus on episodic memory guards against an instance of when an individual loses his/her memory (or parts of it). These recordings of episodic memory are a collection of events that are captured in a particular time and place. It is also referred to as autobiographical memory [4, 8]. Semantic memory augmentation is also useful for human learning, decision making, and thinking.

Augmenting episodic memory can be implemented through a video recording of an individual's daily life activity using a wearable camera. Pervasive computing augmentation systems provide better assistance by generating cues from the recording and playing the cues in an unnoticeable way (e.g. as a Smartphone reminder app) [4, 8]. Research that brings together experts from neuroscience, cognitive psychology, sociology, information technology, and knowledge management disciplines has been conducted for augmenting episodic memory. It includes Forget-Me-Not [9], Memory for a life (M4L) O'Hara et al. [10] and Life-Logging [3].

Microsoft's SenseCam is the most widely known life-logging technology that is used to help patients with memory deficit by recording everyday life activities. After collecting the recordings it generates effective cues based on the context of the user (personal experiences). It also extracts thoughts, feelings and emotions from the time of the event recording. The device is used to sense the environment and record the events without human intervention. The wearer of the device can review the records using the log file as she/he requires and this improves the functioning of patients with recall problems [11].

There are also other approaches related to episodic memory augmentation. MyMemory is one such approach, it uses a mobile application to augment autobiographical memories using personal cues [12]. Odor triggered episodic memory augmentation is also available [13]. Wearable real-time face-recognition systems that use

face + voice recognition to replay part of the last conversation one has with the person they are currently interacting with also helps to remember the person along with the last conversation [14]. Photos and digital libraries are used as a cue to recall episodic memory of a specific event [15, 16] and the concept of lifelogging is used to augment memory recall in work meetings [8].

Augmenting Semantic Memory is used to recall a collection of facts and general knowledge. Recall for semantic memory is the most important for learning, professional working, critical thinking and decision making [4]. Students need to have good semantic memory recall to achieve passing marks in their lessons. The most frequently reported failure in memory recall is semantic memory recall of information required during the exam (what to answer for the questions appearing in the exam) [3].

For augmenting the human semantic memory, cognitive neuroscientists recommend repetition and recency of the information. Rehearsal (repetition) during studying and reviewing the studied material before going for an exam helps a student to recall [17]. Augmentation of human semantic memory recall is addressed through using wearable devices by providing digital ‘cues’ [18], where a cue is a stimulus that helps to recall associated memory. The stimuli can be any of the five sensory stimuli. For example, tactile information is used as a cue in the ubiquitous memory project [18] to augment students memory. Similarly, memory palace, a device used to create contextual (personal, individuals can put what they can easily remember) cues during the encoding phase of information mapping can be used to trigger semantic memory recall later [19].

3 Discussion

3.1 Ethical Issues in Human Memory Augmentations

While talking about the ethicality of memory augmentation, what first comes to everyone mind is the manipulation of memory by others as shown in Total Recall. Total Recall is an American film in 1990 starring by Arnold Schwarzenegger that tells a story of a person with a false memory implant. According to Levy [21], there is no way for such fictions to become reality. For such fictions to be real there must be a full understanding of how memory is stored in the hippocampus and later activated to retrieve it back. Even after years in 2013 Brain initiatives have been launched around the world to understand how the brain works [20]. But still, such manipulation is far from reality. Hence, the memory encoding is a result of sensory encoding, so without the conscious involvement of the individual, memory encoding will not be realized (it will be dumping of neural circuits). In anyways if thus kinds of fictions become possible, it will be unethical and immoral to apply it. The harm caused by such technologies on the individual, in the society and as mankind will outweigh than its benefit (there could be a benefit in treating post-traumatic disorder) [21].

However, the memory augmentation types discussed in this paper to augment episodic and semantic memories are not manipulation of an individual’s memory. In using wearable pervasive and ubiquitous computing devices for memory augmentation, ethical concerns can be categorized into four groups. (1) The precision of the device: as long as the pervasive and ubiquitous devices for augmenting episodic and semantic

memory are accurate in functionality their aids is acceptable. If there is a little error in the systems it will lead to unintended result [1]. (2) The privacy of the individual: the privacy includes the identity of the individual like autonomy, affection, cognition and behavior. The wearable devices should be designed by considering the maximum possible privacy and optimal autonomy of the individual [20]. (3) The confidentiality and security of the memories of the individual the recorded memories and lifelogging events should be free from unauthorized access. These memories/events/knowledge are the individuals' identity while designing and implementing the systems this confidentiality should never be compromised [1]. For example, the wearable devices used by individuals with memory illness should be designed to be used by themselves, i.e. it should be in accordance with their self-efficacy and mental health situation or if their situation needs support by others these individuals should be trusted by the patients. (4) The consequences of using the device on the individual health and social life: identifying the possible unintended consequences on the social and self is very crucial for the augmentation technology. The consequence of the augmentation on the health of the individual is debated as devaluating humans' imperfection. There is a widely held view that the imperfections of a human brain do have natural balance mechanisms. Enhancing recall may cause forgetting later. Forgetting is not only memory failure it also helps to facilitate later retrieval by reducing information overload from the human brain. This type of forgetting is not forgetting all past information. It is being selective in remembering. The type and volume of memories required to be remembered needs consideration [1]. Long-term and short-term side effect on the natural self also needs to be out planned. Considering the possible societal consequences is also necessary for having culturally informed neuroethics and free from cultural bias technologies [20].

On the other hand, augmenting normal functioning memory is one of the main ethical issues raised. Drugs used to help individuals with dementia disorder like ampakine can improve the memory performance of a healthy individual. Individuals who used ampakine have shown better performance in a memory test than before [22]. Similarly, in augmenting memory using wearable pervasive and ubiquitous devices ethical issues raised in having a problem on the society. Social problems in augmenting memory: in general, augmenting could never be fairly distributed [22]. As a result, the man vs. augmented man match will create disadvantageous individuals. Individuals who are privileged and have access for the augmented technologies will be advantageous and the other individuals will be disadvantageous. The other social problem created by augmenting is life will lose its standard of normalcy [22]. Individuals with their natural ability could be considered less recaller than the individual who uses augmented technology. Here, it is good to remember that augmenting have been practised from the genesis. Even during the renaissance, in the creation of paper and printing machines, there was a debate in using the machines. It was considered that will affect humans' natural ability in recalling memories from their brain. However, it is good to consider such ethical issues while designing memory augmentation technologies. Focusing on helping the natural ability to boost recall capability is always recommended [22]. Therefore, for wearable pervasive and ubiquitous technologies to have an augmented recall throughout ones' lifetime without a drawback the characteristic of the technology matters most. Figure 1 shows the conceptual framework for including neuroethics in the design of wearable pervasive and ubiquitous technologies.

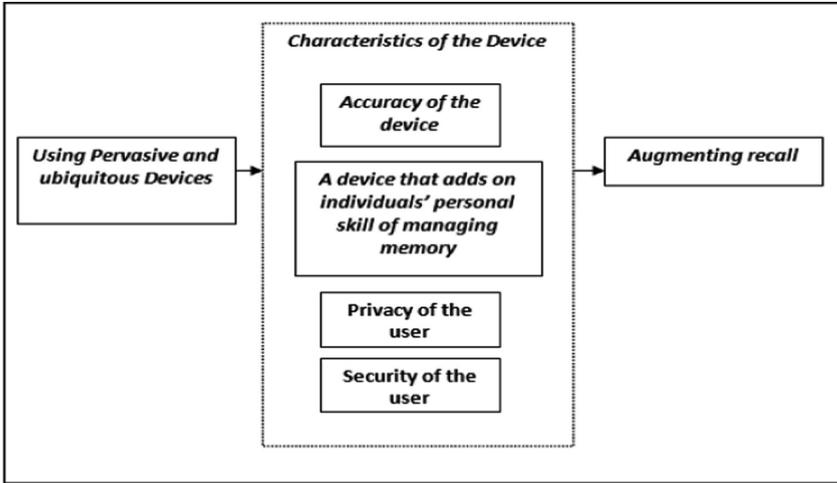


Fig. 1. Conceptual framework

4 Conclusion

The ethical issue for augmenting memory using wearable devices is highlighted in this paper. Relatively, using drugs to enhance memory is more debatable than using wearable devices. The harm caused by wearable devices will be insignificant as long as the device is precisely working and the privacy and security [23–28] of the individual are preserved. Moreover, considering societal aspects is also important to assure the ethicality of wearable devices. In augmenting healthy memories, designing technologies to boost recall by helping the natural ability is the most recommended type. This is a short paper to create an eye opener for other scholars to discuss it more.

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