Memory Immortal

Memory and Modification Techniques in Homosapiens

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Abstract

This paper aims to explore the design of human memory, presently available techniques for improving memory performance, and provide an overview of future enhancements to the brain.

General Terms Cognitive Neuroscience, Mnemonics, Memory Enhancement, Memory Re-consolidation, Myosin vB

1. Introduction

The human mind is an extremely complex, highly interconnected set of systems capable of pattern interpretation, cognitive learning, and external expression. In a highly orchestrated manner, over 10^{10} neurons create interconnections from birth until death to construct not only higher thought functions, but also the ability to store and retrieve complex data. [13] As a key component of human ingenuity and emotion, memory is the most important tool available to an individual's mind in an array of tasks including education, decision making, linguistics, and physical activity. In fact, the ability of homosapiens to extend their cognizance is a unique feature of the species–the ability to spread thoughts outside of the mind on cave walls, paper, and more recently, technology. [9] In an environment with increasing multitasking and informational demands, it is necessary for humanity to pursue means of enhancing the capacity and performance of recollection through personal algorithmic, pharmaceutical, and technological techniques.[1]

1.1 The Construction of Memory

1.1.1 Neurons and Synapses

The cells in a brain, neurons which carry out all signal processing, appear to be fixed at birth.[13] Neurons possess two states, either on or off, determined by their inputs. Communication occurs between neu-

[1] The efficacy and moral concerns of these techniques will not be discussed.

rons via hundreds of synapses, which the neuron uses to select a state. These connections are controlled by hormonal release from the hippocampus region of the brain set in motion by stimuli, producing a cascade effect of activation of proteins generated from the myosin Vb gene at synapse sites. [12] In short, the storage of memory is a rapid reconfiguration of neuron connections in a lattice used to store data, whereby packets of information are stored in a spatially coherent manner within the brain aided by the myosin molecule. [1]

1.1.2 Memory Types

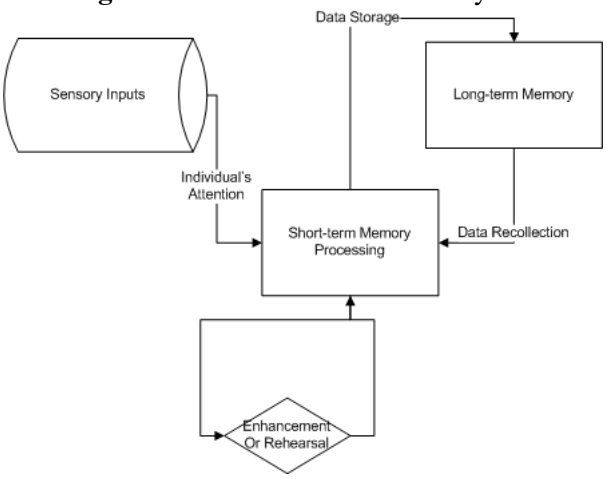
Memory may be classified as either short term, records which may be stored for minutes or hours, or long term. Long term is the critical storage medium for constructive learning in individuals. [2] Furthermore, long term memory may be broken down into the following categories:

- Implicit: Those memories and learned actions which require minimal mental effort to learn and recall. For example, walking or riding a bicycle.
- Explicit: A deliberate effort is exerted to retain information and recall it at will. An example would be memorizing the countries of the world.
- Semantic: Deeply ingrained information pertinent to everyday function. For example, the number of hours in a day.[2, 5]

1.1.3 Basic Memory Model

The human memory is still not fully understood. It is possible to abstract basic operation in a simple model. Given a number of inputs, an individual uses short-term memory as work space to perform decision processing and computation rapidly. Upon multiple usage of information in the short-term memory space, committal of information to long-term memory occurs. [5] However, to strengthen memories it is necessary for them to be recalled and stored periodically to ensure synapse connections are not lost.

Figure 1. The Multi-store Memory Model



1.1.4 Density of Memory States

Memory is a highly dense storage medium. For example, if described in terms of binary data the estimated storage of the brain may be calculated as:

$$(10^{11}\mathrm{n})(100^{\mathrm{syn}}/_{\mathrm{n}})(10^{\mathrm{bits}}/_{\mathrm{syn}}) = 10^{4}\mathrm{GigaBytes}$$

[13, 10]

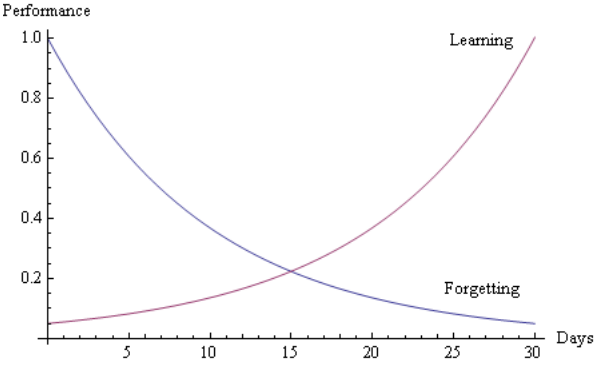
Not only is this a significant quantity of data to be stored in a relatively small volume, but the brain is also capable of breaking these interconnections and selectively freeing or compressing memory for new collections of information. Thus, in theory, the effective memory capacity of the human mind is infinite given changes in the environment requiring adaptations of the individuals memory spectrum. This ability is known as neuroplasticity–retraining synapses' connections at a later point in time to represent new education, traumatic situations, or the names of new grandchildren. [8]

1.1.5 Forgetfulness

The rate at which information is lost in mind, with regards to neuroplasticity, follows a basic pattern as described in the multi-store model, see Figure 1. If a user is not able to rehearse their information or enhance the strength of neuron-neuron connections, memories are lost exponentially in contrast to a traditional learning curve. [14] For example, the likelihood of a student achieving a correct answer on a quiz described in Figure 2. Finding the intersection of these brain functions is the key to most research being carried out concerning memory retention and maximizing efficient usage of the human mind's capabilities.[2]

[2] Also crucial to understanding degenerate diseases including Alzheimer's and front-temporal dementia.

Figure 2. Memory Correctness with Time



[14]

2. Memory Enhancement Techniques

2.1 Algorithmic and Lifestyle

The primary aim of any technique discussed in this paper is increase of neuroplasticity while reducing retroactive interference or new learning "pushing out" old memories. [4] As described previously, the brain appears to maximize usage of available storage space by erasing old information or combining data into individual packets within the network of its neurons.

2.1.1 Cognitive Vitality

Just like a muscle, it is possible to exercise a brain and improve memory retention. [7] Examples of exercise include, Sudoku, consistent reading and writing, creativity in alternative fields such as music, or even physical exercise whereby increasing blood flow to the brain. [7] Although neurons are generally not lost with age, synapse strength decreases, causing an overall loss of neuroplasticity and increase in memory retrieval and processing time.[6] Other causes of degradation include brain inflammation, oxidative stress, hormonal fluctuations, and anyloid deposition in the brain. Re-

maining active mentally is an excellent means for combating these issues.[7] Other means include stimulation during sleep, for example with rose scents, to increase the capability of learning pathways in the brain. [3]

2.1.2 Rehearsal and Space Repetition

Just as an actor practices learning lines for a performance, it is possible to internalize data through repetitive algorithmic approaches. In general, "cramming" is not an effective technique, but rather carefully timed practice and interrogation of subject material. The timing of repetition is crucial, known as the spacing effect, attributed to Hermann Ebbinghaus. [14] By increasing the time between repetition of material, it is possible to effectively never forget items assuming an individual implements space repetition and rehearsal in their lifestyle. Unfortunately, this method requires constant interruption of everyday tasks to practice material in regularly spaced intervals.

2.2 Pharmaceutical

2.2.1 Available[3]

In a competitive environment requiring increasing memory performance, some individuals are turning to chemistry and pharmaceutical companies for help. Although there are no FDA[4] approved drugs available to enhance memory performance there are others intended to treat specific memory deficiencies common in elderly patients. Stimulants and hallucinogens have also been shown to increase memory retention. A summary of currently produced memory enhancers is listed below for convenience with potential risks.

Table 1. Cognitive Drugs

Drug	Result of Usage	Side Effects
Adderal	optimize dopamine and norepinephrine levels, enhance concentration	headaches, insomnia, heart attack, addiction
Aniracetam	increase release of glutamate, speeding brain function	anxiety, insomnia, dizziness
Aricept	Alzheimer's treatment, reduces neurotransmitter breakdown	nausea, diarrhea
Methamphetamine	dopamine release, increasing creative concentration	addiction, stroke, death
Modafinil	Narcolepsy medication, improves concentration and patter recognition	nausea, rash, chest pain
Nicotine	behaves like a neurotransmitter increasing memory speed and retention	addiction, cancer
Rolipram	antidepressant, found to improve cognition	vomiting, headache
Vasopressin	produced naturally in hypothalamus, helps form new memories and improves learning	wheezing, coma, severe chest pain, belching

[14]

2.2.2 In Development

New evidence suggests it is possible to wipe out an entire long term memory using a protein kinase inhibitor, PKMzeta.[5] When given to rats, signs of amnesia are ex-

[3] Some items discussed may be illegal or unattainable unless prescribed by a physician.

[4] Federal Drug Administration

[5] Protein Kinase M Zeta

hibited. [9] Proper application of PKMzeta in humans could lead to selective reclamation of long term memory space, leading to an increase in overall memory storage by dropping "stale" memories.

2.3 Technological

2.3.1 Computer Programs

Software available for personal computers simplifies the role an individual plays in extending the abilities of their memories. For example, "Anki," a simple spaced repetitive learning system, presents questions to the user on timed basis and reports whether or not the user's answers are correct.[6] More sophisticated applications exist, such as SuperMemo, allowing for higher granularity with which the user may define goals and fight off forgetting knowledge.[14] Significant research has been performed on these programs, but they target the brain in the same manner as flashcards and require substantial user effort to achieve results.

2.3.2 Implants

As nanotechnology and prosthetics progress, the limits of interface with the human brain are being dissolved. Researchers at the University of Toronto have demonstrated deep brain stimulation capable of increasing neural plasticity in patients allowing for more accurate recall of memories. [11] The difficulty in designing such techniques is not improving capacity of the brain, but in making memories addressable and searchable as a computer database. Research at DARPA is already underway to produce such implants, allowing for brain level access to maps, tactical dictionaries, and enemy positions. Researchers are confident that these techniques will be successful, but how far in the future they cannot determine. [11] One thing they are certain of, is the massive technological leap such a creation will create for humanity when the lines between biology and engineering are crossed.

[6] http://ichi2.net/anki/

3. Conclusions

Language and writing extended human memories and history to the physical world, opening the door for modern society, and eventually technological development. Within the past two centuries, humanity has explored the functions of memory, perfecting techniques of learning and memorization. Pharmaceuticals continue this progression, providing potent mixtures capable of elevating brain function past normal limits. Finally, technology represents the culmination of human memories–cataloging experiences and helping us process information overload. Eventually, the entirety of the Internet may be available not at your fingertips, but at your hippocampus. Certainly, such a radical change has many adversaries with concerns about the implications of altering the very organ which makes humanity unique among all other organisms. Whether or not their misgivings are valid, eventually they may be nothing more than fully index-able bits on a chip mounted behind your ear–a reminder of a time before total recall and unlimited capacity of homosapien memory.

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