

IT Tools for Memory Support

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Abstract

We investigated memory support tools used in therapy and rehabilitation as well as in everyday life for people who suffer from memory disorders caused by Alzheimer's, ADHD, ADD, etc.

By conducting literature research and an interview, we discovered that memory supporting tools offer a broad spectrum of services, supporting patients of different ages, conditions, and special needs due to different diseases from which they suffer. In this paper, an overview of tools that are available for use is given. Each type of tool is mapped with memory disorders in particular conditions. Its intended usage and target users are presented along with its advantages and disadvantages.

We also found out that therapies for dementia or post-stroke phase usually involve the use of physical objects that often have a personal meaning to the patients, which can be the reason why not many supporting systems are available for individuals suffering from those impairments.

Introduction

Human memory is a field studied extensively, however, the exact way in which it works is still not known to the full extent. To the best of our knowledge, no particular part of the brain is exclusively responsible for the memory. On the contrary, memory is a brain-wide process where different parts work complementary to each other, in a way similar to what in computer science is called “distributed processing”. Despite that, memory is mainly described as a single mechanism, even though different types of memory exist and take place in different parts of the brain:

- Sensory memory is the type of memory that enables to unconsciously and automatically store and recall impressions through the five senses. It is related to the unconscious experience of how things, look, sound, feel, smell, and taste, and cannot be prolonged via rehearsal.
- Short term memory is the type of memory used to recall for a short amount of time. It is usually recalled and processed at the same time and is of a critical importance in everyday functions such as reading a text. The availability of the short term memory is typically between 10 and 15 minutes and more rarely can be as short as a minute.
- Long term memory is used to store information over a long period of time. Contrary to the other memory types, it decays negligibly over time and it can store almost unlimited amount of information for almost unlimited time in accordance to the life span of human beings [1].

Memory disorders are in most cases connected with the long-term memory. They are common “when the formerly strengthened synaptic connections among the neurons in a neural network become weakened, or when the activation of a new network is superimposed over an older one, thus causing interference in the older memory”. Memory disorders can be caused by consumption of alcohol and drugs as well as diseases [1]. Amnesia or amnesic syndrome is the main memory disorder that can be caused by head injury where particular parts of the brain are affected. Traumatic events in cases of distressing situations and physical deficiencies such as a brain surgery can also cause such disorders, while they can be also caused by sedatives and hypnotic drugs [2]. The extent of the memory loss depends on the extent of the damage to the brain, and it can be a partially or total loss of memory. The main types of amnesia are retrograde amnesia and anterograde amnesia. Retrograde amnesia corresponds to the case where the person is unable to retrieve information acquired before a particular incident and the memory loss can vary from a few days or months to years or decades. On the other hand, anterograde amnesia corresponds to the case where new information from the short-term memory cannot be transferred to the long-term memory. As a consequence, individuals suffering from this type of amnesia are unable to recall memories for long periods of time [3].

Alzheimer's disease is a degenerative and ultimately fatal disease, directly affecting the brain since connection between cells and the brain is lost. The main symptoms of Alzheimer's are connected to memory disorders. More specifically, patients who suffer from Alzheimer's disease have difficulty in recalling recent memories since short-term memory is affected first. Commonly the person totally loses the ability to obtain new memories while in the later phases of the disease the long term memory is also affected, causing general memory loss. No treatment currently exists despite the extensive research that has been done [1, 4].

Stroke is one of the most frequent fatal diseases since it's statistically proven that it is the second most frequent cause of death caused from diseases [5]. Stroke occurs in the case where the blood-flow to the brain is blocked, resulting in the death of brain cells because of continuous insufficient oxygenation. That case is also known as ischemic stroke or in lighter cases temporary insufficient oxygenation, known as transient ischemic attack, or due to sudden bleeding in the brain damaging the cells (hemorrhagic stroke) [6]. Different types of disability can result depending upon the area of the brain that is damaged, including all three types of memory.

Attention deficit hyperactivity disorder (ADHD) or ADD is a mental disorder, mostly affecting children between the ages of 6-12, but can also continue even into adulthood [7]. There are three different types of ADHD - the predominantly inattentive, predominantly hyperactive-impulsive, and combined type. Each of them has different symptoms while predominantly inattentive form is related with short-memory disorders, resulting in problems processing information, focusing, and organizing, while also tending to forget things, without the long-term memory being directly affected [8].

In the lecture "How work within healthcare can be supported by computerised tools" [9], it is presented that healthcare can be done better with computerised tools because those tools are designed to help in the healthcare work process instead of interrupting the regular workflow. Thus, in this paper, we intend to investigate how computerised tools are designed and used to support memory during rehabilitation for illnesses that cause memory disorders. We will not study medical documentation and electronic patient records, image acquisition and processing, medical knowledge representation and decision support, and telemedicine in the regards to memory support, as the tools to be studied are not relevant to those topics.

Findings from literature

Examples found in literature cover various disabilities and disorders, that affect wide spectrum of people - from young children with ADHD to elderly with advanced stages of dementia. Those tools can generally be divided into two groups: tools aiming to support everyday life, remember daily tasks, etc., and those that were created to support rehabilitation or training of memory.

Therapy and rehabilitation tools

RoboMemo and ReMemo

RoboMemo also known as Cogmed RM is working memory training tool for children age 7 and up. It consists of about 25 lessons, each lasting 30-45 minutes over a 5-week period. At the end of each lesson, children will be rewarded. The exercise complexity adapts to users' capacity click by click in order to stretch their capacity to the maximum [10].



Figure 1: Main menu of RoboMemo software

ReMemo also known as Cogmed QM is the adults' counterpart for working memory training. Its training design is identical to RoboMemo but features a new interface for adults. Research and clinical evidence demonstrates that adults of all ages improved their working memory capacity by 20%, after as little as 30 minutes of training each weekday during five weeks [11]. In a two years project Arbetsminnesträningssprojekt (Working memory project) conducted since November 2005 with use of ReMemo, 8 out of 12 patients were found to have positive effect of working memory after performing everyday exercises [12]. Similar results were found by Gray et al. [13], who conducted studies on working memory among 60 teenagers with learning disabilities or ADHD, aged between 12-17 years old. Their study found that 70% of participants improved their WM by 3 weeks of using RoboMemo.

Advantages of using this system are apparent. Authors of [12] even claimed that "To date, [RoboMemo] has the strongest empirical evidence for its effectiveness in training WM." However, despite those merits, no long-lasting effects on memory were observed [13]. Moreover, the price of the software makes in not easily accessible, therefore making it hard to reach a big population of users.

Software for working memory training for Children With ADHD

Klingberg et al. conducted a study in which they tested how regular training (at least 20 minutes per day, 4-6 days a week, for at least 5 weeks) can improve WM of children with ADHD [14]. To test this, they used software developed specifically for this study. The software had 4 subsets of tasks - a visuo-spatial WM task, a backwards digit-span, a letter-span task and a choice reaction time task. One of the core qualities of the system was the adapting difficulty of levels, based on a progress made by a child. The study has shown that regular training with the system results in significant improvement of WM. However, the

paper didn't provide information on whether or not this type of training can result in long-term effects as well, or if the results were only temporary.

Moreover, this system has one major disadvantage - the paper doesn't provide sufficient documentation for it, and therefore it's difficult to say whether or not this software is actually available for public use, or was it developed only for the sake of the above mentioned study.

Everyday support tools

Electronic memory aids (EMA)

Electronic memory aids (EMA) is a broad term that covers variety of different, usually simple, devices that support memory in everyday tasks. It can include timers, alarm clocks, smartphones or tablets with notifications and reminders, locator devices, etc. [15]. For example, Kapur et al. name pagers and smartphones as one of the most commonly used EMAs [16]. Some specific examples of those EMAs, e.g. TimeFlex, the electronic timer, we are going to describe in more detail later. In this paragraph we aim to summarise findings from papers that discuss the studies on EMAs rather broadly, without focusing on the details of the device, therefore making them difficult to categorise.

Oriani et al. conducted the study in which they compared success rates of task completion relying solely on memory, using the list of tasks and using the EMA [17]. The subjects of this study were patients in the early stages of Alzheimer's disease. Not surprisingly, the authors have found that the use of EMAs significantly improves the success rate of task completion - all of the patients managed to complete the tasks. The device in question worked similarly to reminders on a smartphone - it was an alarm that could be calibrated to ring at certain date and time. After pressing the button, the alarm would stop ringing and would display information assigned to it. It should be noted however, that the study had a very low number of participants, with only 5 patients.

In their paper, Dry et al. described the findings from interviews and focus groups conducted with women who suffer from memory impairment as a result of brain injury. Some of them have already been using EMAs for support, and the rest have been given an EMA for testing (a PalmPilot). The authors have found that the participants had mixed emotions on use of EMAs in their daily lives. Some of them were positive about them and appreciated the support of it, but some of them felt discomfort and feared using the devices and relying on them too much, which was mostly rooted in a lack of experience with the new technology [18]. One of the reasons listed by one participant was that "[she] can't imagine having something I could carry around all the time and have my whole life on it. It's kinda scary and intimidating, but I'm fascinated in a good way." which clearly states where the problems lays (reluctance to being dependant on the technology), but also shows that those conclusions are not so relevant now, since the introduction of smartphones and tablets.

SenseCam

One of the most commonly mention memory aids in the literature were notebook-based diaries. An expected continuation of this method would be an electronic diaries, for example app-based. However, a more interesting approach was presented by Berry et al. [19]. In their study they tested a use of a SenseCam, a wearable camera, for creating a pictorial diary. This approach was tested in cooperation with a 63 year old woman with severe memory impairment. The participant wore the camera to document interesting or non-routine parts of her life. At the end of the day, pictures made by SenseCam were uploaded on a laptop to be revisited on the next day. The goal of this experiment was to see whether or not and to what extent this method can improve the autobiographical memory. The authors have found that the patient was able to recall on average 80% of recorded memories, compared to the written diary which allowed to recall 49% of events.

Findings from the interview

We did an Interview with Jenny Ström, who is a consultant and lecturer on ADD, ADHD and Asperger's. She has been dealing with ADD and Asperger's herself [20], as well as helping three of her children to overcome the obstacles of those disorders.

During the interview she presented to us multiple devices and solutions, including electronic devices, non-electronic objects and apps, that can help with supporting everyday life of a person with ADD and/or Asperger. In this section, we will focus on electronic tools and an app that help with supporting memory in everyday tasks.

Digital Pen - Livescribe

Livescribe is a smartpen that can be connected to a notebook, paper note, etc. It's a device that provides standard pen functionality, but also allows to record while taking notes and later on transfer both the recording and the notes in a digital form to a tablet or other device. Notebooks provided as a complement to the pen are made from paper which features a special dots patterns, which allows the pen to recognise precisely in what time and in which part of the page the note was taken [21]. Combining those two features (recording device and dotted paper) allow placing the note in time and replaying the relevant part of a recording based on a made note - to replay the recording from this particular time user simply needs to touch the note with a smartpen. That way, the student can write down only cue words or time slots to come back to the requested part of the recording.

This functionality allows for the pen to be used as a helping aid for cognitive memory. As said by Belson et al. "Cognitive load theory suggests that working memory is based on using three different systems: an executive attention function and two supporting functions, visuospatial and auditory/phonological." [22]. When more systems of WM are strained, the WM capacity might be overwhelmed. That's why use of digital pens might reduce the effort required by those areas, therefore reducing the cognitive load and allowing the note taker to focus more on the actual content rather than the sole action of taking notes. Similar observations were made in a study conducted in Berkley School of Information on how smartpens can help students with learning disabilities, including ADD and ADHD [23].

However, there are potential shortcoming in using this device as a support tool for kids. Study conducted by Belson et al. [22] has shown that 2 out of 7 children that participated in the conducted experiment have found using the pen cumbersome and confusing. Moreover, for 1 child out of 7, the pen was serving more as a distraction rather than a support tool.



Figure 2: Livescribe smartpen

Digital pens might be also be beneficial in more unexpected ways. For example, Lazar et al. [12] conducted a study in a residential living facility for elderly. Most of the residents there have dementia that affects their memory, speech, language, and physical abilities. As a part of rehabilitation, the facility offers art therapy, where residents get to create art pieces that are combined by the therapists with various forms of digital interaction. One of the participants was a women who used to play a piano. Because of her disabilities, playing the piano is no longer a possibility. That's why listening to her old recordings of her performances served only as a painful reminder and the therapists avoided to do so. They knew however, that if incorporated to the therapy in the right way, the recording could turn out to be very beneficial.

That's when they started to use Livescribe. While creating an exhibition of residents' work, they gave the participant a livescribe pen, which allowed her to touch the paintings/pieces of art while talking about the paintings and what they mean to her, as well as playing the tracks from her piano performances. That way the exhibition became interactive, allowing the viewers to watch the pieces of art accompanied with her music and narration, simply by tapping the artwork with a pen.

Timeglaset TimeFlex

Timeflex works like an electronic hourglass. It shows how much time had passed, both visually through a light bar, and in a numerical countdown on the display [25].



Figure 3: TimeFlex timer

It allows the user to customise different ranges of time, from 1 to 999 minutes, and assign them to colour-coded buttons. After the time has passed, it provides feedback of sound, vibration, or both.

It can be used as a time aid in cognition for people who have difficulty estimating time and planning. It can be useful when people are losing track of time, which can often be the case with memory disabilities.

However, to be beneficial, such a device should be used in a right context, e.g. for signalling the passage of time (e.g. that half of the time has past, or that the designated time is soon to be gone) for a currently ongoing task. As a support tool for people with severe memory impairment the device itself would probably not be enough, since it doesn't display an explanation on what the alarm means and what actions should it entail.

Talking Photo album (Talande Fotoalbum)

This tool is a photo album which allows placing pictures, notes, etc. in it, as well as recording a short voice memo (up to 10 seconds) to each page [26]. It's available in different shapes and formats, such as A3, A4, and A5 photo albums, as well as one-page devices that can serve as daily reminders, e.g. attached to the fridge or a wall. Recording is played either by pushing a button or a surface of an image, depending on a type of the device.



Figure 4: Talking photo album with a visible 'play' button, courtesy of Jenny Ström [20]

Such devices, combining both visual and audio cues, can be beneficial in various ways. An image can contain a map accompanied by a recording with instructions on how to get somewhere, a list of daily tasks, a picture of a family or friends with a short message from them, etc. This device is also advertised as a helping tool with augmentative and alternative communication.

DayCape App

DayCape is an app designed for children with Autism and Asperger's syndrome. Its main functionality is an image-based calendar which helps to plan the day and remind the child what activities are coming up next [27]. Each activity is illustrated with an image, to help children remember and visualise it. Tasks can have a certain duration set, which is visualised by a small figure slowly moving across the progress bar. The app allows a user to set up activities for the child using pre-set pictures, or by uploading personalised images. Once the activities are set up, notifications show up on the child's device to remind them of the activities they have been assigned [28].

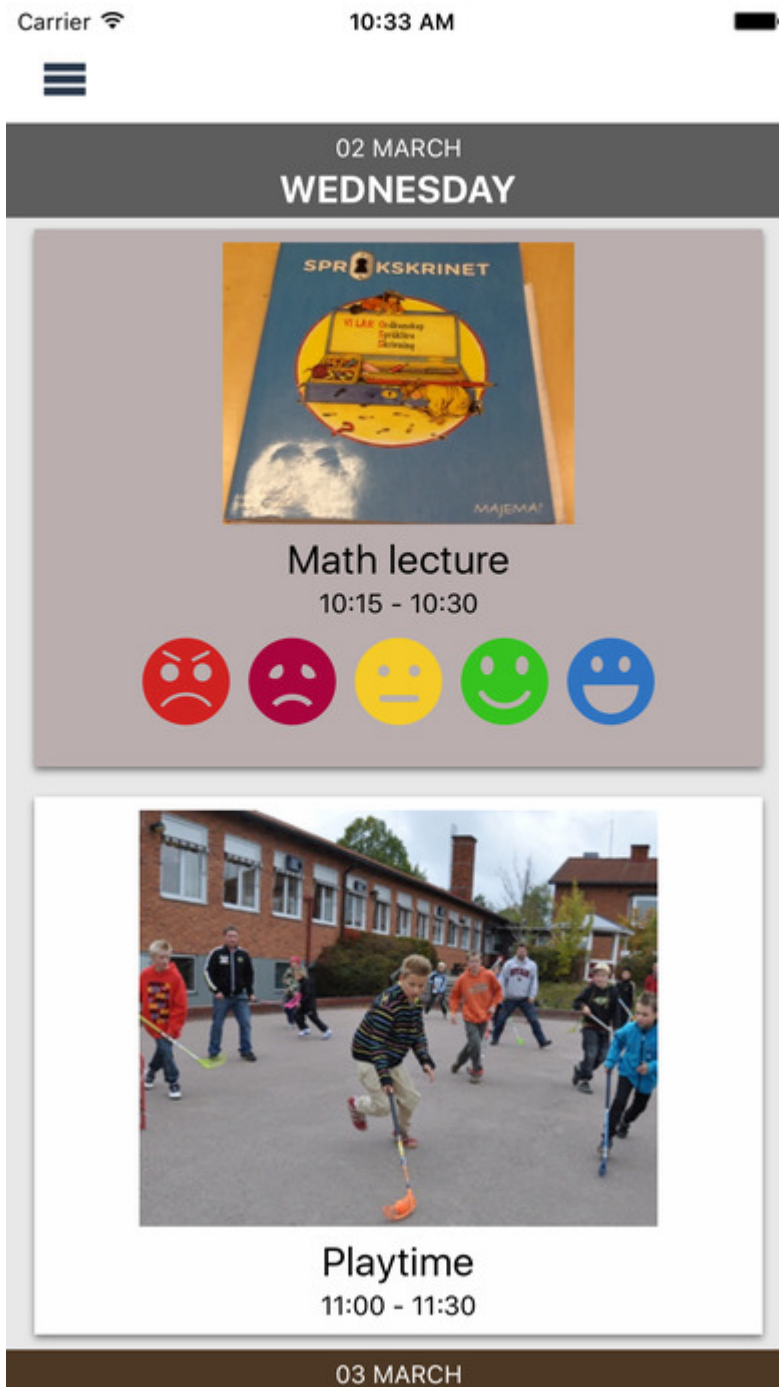


Figure 5: Screenshot from DayCape app

There's a separate module for parents and guardians allowing them to create a daily schedule for a child. The app pushes notifications on smartphone's screen, informing the child that it's time to finish or start new activity. It also keeps the parents/guardians informed on child's progress.

One possible disadvantage of this app could be that not all parents want for their kids to be smartphone users in the first place. However, this obstacle is becoming gradually less relevant, since children are now being introduced to technology, including smartphones and tablets, at a very young age.

Conclusions

Our research on memory supporting tools showed that a variety of such tools exist. Those memory supporting tools offer a broad spectrum of services, supporting patients of different ages, conditions, and special needs.

To the best of our knowledge, not much software or apps are available for individuals suffering from dementia or being in a post-stroke phase. It could be due to the fact that therapy for those impairments often involves the use of physical objects that have a personal meaning to the patients, like their belongings from the past or photographs. That is why the use of non-electronic aids is more common, such as memory boxes or memory books [29, 30].

IT tools for memory support for children with ADHD, learning disabilities, Asperger's, or autism are more common. One of the reasons for that could be that children and teenagers are more used to using technology in daily life than the elderly, therefore it could be easier for them to incorporate the use of IT tools into their routines.

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