# *Computer-Assisted Memory Retention*

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**Abstract**
This paper presents a computer system which can enhance student's abilities to transfer information from their short term memory to long term memory. We also discuss the design and results of our experiment with the computer system.

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## Introduction

Educators encourage students to think creatively. However, students still need to memorise a large amount of information for studies and examinations, particularly in language learning. For example, they need to remember a large amount of vocabularies and rules of grammar before they can write a paper. Unfortunately, however, the majority of them are frustrated because they encounter problems for memory: It is easier to forget than to remember.

We present a computer system which aims at helping learners with items retention in long-term memory using animation and audio presentations. It will help learners associate vocabulary with images, monitor and assess their progress by giving interactive practices and posttests after each lesson. Students can repeat practices according to their needs or instant comments given by the virtual vocabulary tutor.

## Cognitive theories about ways for storing information

Human memory has different forms. According to Aben et al. (2012), Cowen (2008), Martinez (2010) and Norman (2002), one form of human memory is defined as 'long-term memory', which is durable with a huge capacity. With the huge capacity, long-term memory stores many pieces of knowledge such as names, facts, and records past events and life experiences. Another form, known as 'short-term memory', is a temporary storage of information with a limited capacity. It holds a limited amount of information within a short time.

## Working Memory

It should be remarked that there is another form of human memory, known as 'working memory'. Although a few authors such as Martinez (2010) and Norman (2002) did not mention the existence of working memory in their works, most studies acknowledge the existence of working memory (e.g., Aben et al., 2012; Cowen, 2008; Gathercole and Alloway, 2006; Nadel and Hardt, 2011). Unfortunately, sometimes it is difficult to distinguish short-term memory even they have different definition (Cowen, 2008 and Aben et al., 2012). This paper, as with most other studies (e.g. Cowan et al., 2005; Ranganath and D'Esposito, 2005; Postle, 2006), uses the definition by Baddeley (1992), who defined working memory as "the maintenance and controlled manipulation of a limited amount of information before recall" (Aben et al., 2012).

Despite whether working memory exist or not, it is commonly agreed that new information are passed through different stages to long-term memory (Aben et al., 2012, p.1). Martinez (2010) explained the flows between forms of memory as: When information flows from short-term memory into long-term memory, it processes 'learning', which preserves information in long-term memory for a long time. On the other hand, when information flows from long-term memory into short-term memory, it processes 'remembering', which happens whenever we think back on a piece of knowledge.

Both ‘learning’ and ‘remembering’ processes requires time and effort. Since we store only a selected portion of experiences into long-term memory, we do not remember all the information we experience (Martinez, 2010).

**Visual Memory**

It is believed that the memory consists of the visual-spatial sketch pad, which stores and manipulates visual-spatial materials. Thus, information presents visually would help learners to make a match between those images and words, and helps them recognize and memorise words more easily. Moreover, these visual images can also serve as cues for retrieving information from long-term memory, as they are similar to real objects.

It also suggests that information in memory may be stored in two forms, verbal codes and imaginal codes. With the help of those visual and audio presentations, the information can be stored and remembered better according to the Dual Code Theory (Beacham et al., 2002).

Our mind holds not only words, but also images and sounds (Martinez, 2010). The ‘learning’ process can be enhanced if we associate items with pictures and sounds (Balota and Marsh, 2004). Computers can definitely be effective aids in this area.

Computers can display special effects of visual representations such as animations on the screen. Audio representations such as pronunciations and real-time spoken comments can be played from the audio clips. In other words, computers can provide interactive multi-media learning environment which are totally different from books with plain text and still pictures for human. Thus, multi-media technologies may provide memory traces to assist human in storing items in long-term memory.

**Related Works**

Many organisations around the world provide memory training programmes. The common rationale through these programmes is that memorisation is not gifted. It can be trained by effective memorise skills and practices in order to fully exploit the potential of human’s memory. They also emphasised the strategies are designed on the basis of the cognitive theory.

The aforesaid training programmes highly promote their course curriculum is well-structured and designed on the basis of the psychological theory about memory. However, not all programmes utilise computers as the medium.

Most training programmes that do not use computers are group-based, i.e. train memory in classes. The instructor would deliver the strategies through games and activities instead of uninterrupted lectures. As the class sizes are big in most cases, individual’s learning processes can hardly be determined. In other words, it would be very difficult for teachers to accommodate individual differences since the instructor may not able to monitor the individual learning process in a big class. Research shows that there is a need for enhancing learning process effectiveness and efficiency in higher education (Garrison & Vaughan, 2007), but their teaching practice has not yet completely integrated monitoring and feedback session into the course curriculum and

activity. In this sense, learners may not exactly know their strengths and weaknesses during the whole process. The effectiveness of these courses may thus be hindered.

In recent years, organisations started using computers as a medium of memory training. Various commercial computerized memory training programmes have been made available. One example of these programmes is Cogmed (http://www.cogmed.com/). Cogmed uses an interactive platform with a highly animated user interface to train users' working memory with different brain exercises (games) involving both visuospatial and verbal working memory tasks. Each user is followed up with a specialist who is referred to as a 'Coach' (pragya, 2012; Melby-Lervag and Hulme, 2012). Another example is known as branded as CogniFit (http://www.cognifit.com/). CogniFit trains users' working memory through numerous brain games and cognitive assessments provided online. CogniFit is free to use, and users can add specific applications to their training for as low as US$4.99 (CogniFit, 2012). The providers of these two programmes claimed that the programmes are scientifically-proven to work.

There has been a great debate on the effectiveness of these memory training programmes. A number of studies suggest that the capacity of working memory can be expanded through training (e.g. Klingberg et al., 2005; Morrison and Chein, 2011; Verhaeghen, Cerella, and Basak, 2004; Westerberg et al., 2007). Morrison and Chein (2011), for example, stated "the results of individual studies encourage optimism regarding the value of working memory training as a tool for general cognitive enhancement" (p.46). Takeuchi et al. (2010) observed that working memory training indeed impacts structural connectivity of the brain. They argued working memory training improved the structural integrity of the white matter region in the parietal regions and the region close to the corpus callosum. They believe that these structural changes may underlie the enhancement of working memory capacity and other cognitive functions (p.3297).

However, there are some skeptical researchers such as Morrison and Chein, Shistead, Redick and Engle (2010, 2012). They believed the results are inconsistent because of inadequate controls and ineffective measurement of the abilities (2010, p.245). They argued that transfer of working memory training has to be demonstrated using a wider variety tasks, and there is a need to direct demonstrate that the capacity of working memory indeed expanded through training (2012, p.1). Most promising results (e.g. increased intelligence) cannot be interpreted as changes in working memory capacity" (2012, p.1). In their meta-analytic review, Malby-Lervag and Hulme (2013) concluded that current training programmes can only produce short-term improvements working memory tasks. It is worth notice that, according to Malby-Lervag and Hulme (2013), no convincing evidence proves that memory training programmes give durable effects (p.283).

Formative assessments and effective feedbacks can let students self-regulate their learning (Nicol & Dick, 2006). In this sense, the importance of formative assessment and feedback is again pinpointed. Providing constructive and effective feedbacks as well as tests for learners during the learning process are crucial for facilitating them to manage their learning. While they better understand what they retrieve and perform in the learning process, they can take control of their learning. The proposed computer system will be developed by integrating this belief and providing different interactive

capabilities including drill and practice and test taking, etc. The details of our approach will be further explained in the next sections.

**Experiments**

This project aims at improving the deeper level of processing by using the computer. Students were invited to participate in various experiments. During the experiment, students selected a learning domain according to their interest and needs. By displaying animations on the screen, learners can associate them with the related items.

This system will provide memory traces by displaying visual and audio presentations for vocabulary acquisition systemically. Interactive practices will be given according to users' performance so as to accommodate individual differences and to consolidate the taught items. With the help of those visual and audio presentations, information can be stored and remembered better (Wu & Wu, 2008). In other words, it makes word retention no longer difficult again.

In this sense, this system supports a good strategy for storing items in long-term memory. More importantly, users can make use of the system according to their needs anytime and anywhere. It is cost-effective in terms of money and time.

English is used as the first target because of the following reasons. It is easier to measure the memory retention of English vocabulary. Moreover, English vocabulary acquisition is very useful to students and thus it will motivate them to participate in experiments. In the computer system (Figure 1), a virtual vocabulary tutor tells learners whether he/she has identified English vocabulary with the help of visual and audio presentations successfully. Spoken comments are given by the tutor as well. If he/she fails in a vocabulary test after a lesson, the tutor encourages them to do more practices till he/she reaches the level preset. If he/she achieves good results in a test, the tutor will recommend him/her to have lessons in other learning domains. Finally, learners will be tested for the taught vocabulary with no preparation after months to check whether they can retain words in long-term memory.

Students were divided by two groups and the first group acted as a pilot group. They used the computer system with animation. After a period of time, they were retested the taught items again to check their memory retention. Results were collected for assessing the effectiveness of the proposed computer system. The performance of the pilot group was used to compare with the second group using software package which display still pictures only.

According to the final test results, the average performance of the group with animation was 20% better than the second group. It proves the feasibilities of using animation to transfer information from short term memory to long time memory.

| Stage | Purpose(s) | Action(s) |
|---|---|---|
| Introduction | To select the learning domain according to the participant's interest and needs. | The virtual vocabulary tutor introduces lesson objectives to participants. |
| Lesson(s) | To associate visual and audio presentations with English vocabulary. | Images are displayed with vocabulary items on the screen and the their pronunciation were also be played. |
| Practice(s) | To ensure the participant has associated words with their visual and audio representations successfully in each lesson. | Interactive practices are be given for practicipants. |
| Test | To assess his/her performance in the test. | Participants are tested to check whether they understand the words and their usage or not.<br>- If yes, he/she can proceed to other learning domains.<br>- If no, he/she may need to do more practices till he/she reaches the level preset. |
| Retest | To assess whether the participants can retain words after a period of time by testing them the taught items. | Participants are retested again after a period of time. |

**Figure 1: Stages of the Experiment**

**Future Research**

Autistic students and hearing impaired individuals are deficient in vocabulary and thus made them have difficulties in communicating with people. After proper modification of this computer system, they can use this system for their learning. Since visual and audio presentations are provided, they can learn words more easily. The practices also help them consolidate the taught words in an interactive way. Thus, it can help storing words in long-term memory.

Research shows that deaf children and hearing impaired individuals can memorise up to 218 new words for everyday household items with the help of audiovisual speech driven from computers and thus facilitate them to speak rather well (Barker, 2003). Current research also shows that the use of photos engaged exceptional students in learning (Carnahan, 2006) and help in achieving educational goals (Close, 2007). Therefore, this system will be an effective learning tool for normal and disabled students.

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