**Flashcard-based design and spaced repetition for language acquisition in Computer Aided Language Learning (CALL): a literature review**

**Abstract**

**Purpose** – This literature review’s purpose is to research language acquisition, flashcard design and spaced repetition to find the best way to implement these into the system. This literature review found that language acquisition is highly dependent on comprehensible input…

**Methodology**

*Search and selection strategy*

Google Scholar and the University of Portsmouth’s library Discovery and catalogue search to find articles and books to get a rough feel and overview of the topic areas, journals and research. Articles related to computer assisted learning will be limited to articles from the past 11 years (2007 and onwards) to ensure relevancy. The target end users are familiar and use an immersion approach to learning languages and the majority are already familiar with research by linguist Stephen Krashen and as such his works will also be investigated. For existing software, Google search, the Google play store and the Apple app store where used to find current flashcard software and applications. Resources found had to be in English and relevant to the topic area. The articles found in language and linguistics journals will be limited to second language acquisition and selected upon relevance to language acquisition. The articles found in psychology journals will be selected upon relevance to language acquisition and/or learning with technology.

Research was also limited to what was available online and in the University of Portsmouth library. Many articles that appeared relevant to the topic at hand where inaccessible through the University of Portsmouth on some research database websites.

The main subject areas searched include:

* Language learning
* Language acquisition
* Spaced repetition and the Spacing effect
* Mnemonics in language learning
* Japanese Kanji
* Flashcards and existing flashcard software

Introduction

This literature review uses a combination of academic articles, books, internet webpages and existing systems to answer some important questions that will have a large impact on the design of the application. These questions include: How do we acquire language? How does the design of a flashcard-based Computer Aided Language Learning (CALL) application affect a user’s ability to acquire and retain language? What effect does spaced repetition have on the acquisition and retention of language in CALL applications? What other learning techniques can be used with such CALL applications to increase the efficiency of language acquisition and retention?

Knowledge obtained because of doing this literature review will be turned into requirements for the application.

Language learning has dramatically increased in accessibility to the public in recent years due to the advancement in technology and software development. Before the huge step in functionality with the Apple iPhone in 2007, many language learning projects where constrained by poor audio quality, limited storage capacity, poor internet connectivity, difficult text entry and low-resolution screens on older handheld devices, Godwin-Jones (2011).

Due to the boom in mobile technology, we currently have an abundance of language learning software, a lot of which are just simple apps with no real research on language acquisition to back up their teaching and learning methods. This literature review aims to look at the research behind language acquisition, as well as existing systems, to draw up requirements for an efficient language learning web app.

Second Language Learning and Acquisition

There are a variety of different approaches currently being used to learn second languages and while often these are intertwined together in a variety of ways, there are two main approaches that learners tend to choose.

The first is where the learner learns the “building blocks” of a language with a bottom-up approach, starting from the basics of the language’s grammar and vocabulary, learning how to string sentences together and how the language’s alphabet is pronounced. A good example of this would be standard language classes that uses a textbook as the main material and where a teacher takes the learner step by step through different structures. According to Krashen (1982, p. 10) this is language *learning* and refers to conscious knowledge of a second language, i.e. knowing the rules and being able to talk about them and that this is independent from language *acquisition.*

The second is to use a top-down approach where the learner spends as much time exposed to the foreign language as possible. The idea being that the longer and more time you spend with the language, the more you will become able to understand and eventually output. This type of approach is common in immersion or bilingual programs used at schools in countries where there are one or more official languages, for example in Canada where both English and French are official languages (Central Intelligence Agency, n.d.). Immersion-based strategies work better than standard classes and going abroad to a country which speaks the target language according to research by Freed, B. F., Segalowitz, N., & Dewey, D. P. (2004, p. 276).

Krashen (1982, p. 10) says that these two approaches are in fact two distinct and independent ways of developing second language competence. He states language *acquisition* to be “a process similar, if not identical, to the way children develop ability in their first language” and that conscious language *learning* helps us only as a “Monitor”, which can change the output, speaking/writing, of the language *acquisition* system before or after output, Krashen (1982, p. 15). This implies that conscious learning plays a limited role in second language performance therefore language acquisition is the more important to focus on in order to gain language ability.

The Input Hypothesis, Krashen (1982, p. 21), states that “We acquire by understanding language that contains a structure that’s just beyond our current level of competence *(i + 1)*. This is done with the help of context or extra-linguistic information.” This is something that immersion learners will experience due to the massive exposure they get to the second language. The more exposure the learner gets to the second language, the more chances there are of being exposed to *(i + 1)* comprehensible input which can explain why immersion-based programs work better than study abroad and standard classes. The concept of comprehensible input is now widely accepted by most applied linguists to be necessary for language acquisition, Cummins (2000, p. 8). Learning from comprehensible input would imply that language learning software should focus less on trying to teach the language and instead simply provide language learners with comprehensible language aimed towards their current level.

Learning vocabulary

There are a variety of different approaches that people use when trying to learn vocabulary in Japanese. Kanji make up the building blocks of a big part of Japanese vocabulary, but a lot of the approaches are used for both Kanji and Japanese words.

**Rote repetition**

Rote memorisation tends to be a go to approach for Japanese learners particularly when it comes to learning Kanji. Japanese children are taught to repetitively write out Kanji by hand until they know how to write them, and this approach makes its way to Japanese learners from textbooks and native Japanese teachers as rote learning is one of the most common strategies for teaching Kanji, Green & Shimizu (2002, p. 235). However, not only is rote repetition less efficient than spaced recall, Atkinson (1972, p. 126) but learners of Japanese that have no previously knowledge of Kanji will find it harder using this approach than a Japanese child learning Kanji in Japan that already has seen plenty of Kanji in daily life.

**Word lists**

Vocabulary lists of words out of context have been one of the more popular approaches to teaching and learning vocabulary in second language learning. While word lists provide an efficient study method where students can quickly learn a large amount of words in a short period of time, Dolch (1949, p. 142) points out that, as an example, just because a child might understand all the meanings of all words, it doesn’t mean that they can fully understand what they read. Word lists lack contextual information to help produce vocabulary acquisition. However, word lists can be used in conjunction with other techniques such as using imagery or an example sentence to provide context and word usage.

**Mnemonics**

Using memory techniques can be effective when learning Japanese vocabulary, particularly when it comes to Kanji. Parts of, or whole, Kanji can be combined to form new Kanji and whole words. Remembering the Kanji, a book by Heisig (2001), teaches learners a Kanji’s meaning and its stroke order by using mnemonic stories and keywords for each character. In the example below we have the character 泊, meaning *overnight,* which is built up of the components ⺡, meaning *water*, and 白, meaning *white*.



Figure 1: Example of Heisig’s (2001, p. 74) method.

By combining keywords from the components that build up a character, and the characters keyword, the learner can create mnemonic stories that allow them to remember a character for when they need to write it. This method is extremely fast in allowing learners to learn the meanings and how to write Kanji characters, but it doesn’t teach the learner how to read each of the characters. Learning lists of vocabulary using mnemonic devices show considerably better results over other strategies when building vocabulary according to Meara (1980, p. 225) and Cohen (1987, p. 59) and while Meara (1980, p. 225) does point out that research on mnemonics often "completely ignore the complex patterns of meaning relationships that characterise a proper, fully formed lexicon, as opposed to a mere word list”, if a learner already associates a word or Kanji with a particular meaning then learning its pronunciation afterwards might be easier in the long-term.

**Vocabulary acquisition by reading**

There is extensive research that demonstrates that vocabulary acquisition through reading is possible (Krashen, 1989, p. 454; Ponniah, 2011, p. 138; Hafiz, 1989, p. 10). Beheydt (1987, p. 63) states that we need context when learning vocabulary: “From a psychological as well as a linguistic point of view, undeniably the first guideline would be that vocabulary must be learned in context. The meanings of words are more easily somaticized if they are embedded in a meaningful context”.

With that all being said, there is a major issue with vocabulary acquisition via reading. This being that vocabulary acquisition via reading assumes that the learner already has a basic level of reading skill in the L2. Learning a language with a different orthography, such as English-speaking natives learning Japanese, can be particularly difficult (Bhide, 1990, p. 9). In fact, according to Laufer (1989, p. 319), the reader must be able to understand around 95% of words in a text to be able to acquire the words in the text they do not know. As a result, a means for making texts more comprehensible to lower this percentage is required if reading is to be used for vocabulary acquisition with beginners.

**Learning vocabulary with sentences**

This type of vocabulary learning is recommended by Antimoon (n.d.), a website about learning English written by two Polish men who learnt English as a second language. They recommend using sentence flashcards in conjunction with a spaced repetition software, such as Anki (n.d.) or SuperMemo (n.d.).

As with learning vocabulary by reading, it’s much more likely that better understanding of a word’s correct usage will be gained by seeing the word used in a variety of contexts than by seeing it in a single dialog or in a list as noted by Godwin-jones (2010, p. 4).

There’s also a couple of other reasons why sentence flashcards are favoured over other card types to learn vocabulary. These include being easier to make and review than standard L2 to L1 vocabulary cards. This is because the learner can take sentences from native sources by copying and pasting them into their flashcard program and they are easy to review because the goal is to simply understand and read the sentence correctly.

**Spaced repetition and the spacing effect**

Spacing out review sessions allows a person to consolidate their understanding of a subject, to learn partially missed or completely missed information on the previous run and to also give the learner feedback to allow them to test their correctness of the knowledge that they gained from the previous run, David P. & Mohamed (1965, p. 149). As such the learner will gain a deeper understanding of the topic with each review. The spacing effect appears to have huge potential for improving classroom learning, Dempster (1988, p. 632), as well as in second language acquisition, Godwin-Jones (2010, p. 7).

An experiment by Bloom & Shuell (1981, p. 247) showed that distributed practice allowed learners to remember “substantially more words than those students who had studied under conditions of massed practice”, finding that the performance of the distributed practice group was 35% better.

Melton (1970, p. 603) and Seabrook, Brown, Solity (2005, p. 119) discuss a “lag effect” which causes learners to learn better when the spaces between study periods gradually increase each time and Pavlik & Anderson (2005, p. 567) also found that the spacing effect becomes cumulatively beneficial due to each spaced practice providing an additional advantage suggesting that as time goes on, and the period between reviews increases, the better an item is understood and stored in long term memory.

The results from Cepeda et al. (2009, p. 244) also suggest that the gaps between learning sessions should be increased to months, instead of days or weeks to “efficiently promote truly long-lasting memory” which coincides with the lag effect discussed by Melton (1970, p. 603) and Seabrook et al., (2005, p. 119).

**Flashcards**

Flashcards often have a front and a back where the user must recall the back of the card to get the flashcard correct. Flashcards are a great way of increasing second language vocabulary as they often make the learner retrieve and recall L2 vocabulary from memory, which facilitates learning as shown in research by Barcroft (2007, p. 48) and Karpicke & Roediger (2008, p. 967).

Phillips (2011, p. 61) suggests that using an intelligent and computer-controlled spaced repetition flashcard system, such as Anki (n.d.) or SuperMemo (n.d.), might be an effective way to improve scores in language tests and Kornell (2009, p. 1314) looked into optimising flashcards and found that “flashcards should be studied in relatively large stacks across multiple days.” as well as spacing being more effective than cramming.

Analysing existing software and algorithms

When investigating the existing software, there are several criteria to look at in order to compare and contrast them. Nakata (2011, p. 28) provides a list of 11 criterion for analysing flashcard software which will be used to analyse the following software. Existing software will be software that language learners use for language learning.

Anki (n.d.) is an example of a spaced repetition flashcard software that’s used by a range of students for many different subjects (AnkiWeb, n.d.). Anki (n.d.) claims that “it's a lot more efficient than traditional study methods, you can either greatly decrease your time spent studying, or greatly increase the amount you learn.”. Anki has mobile, desktop and even a web version which all allow varying degrees of functionality. For this evaluation, we will be looking at the software designed to run on a Windows operating system.

Anki is a simple looking piece of software which allows users to create simple Front and Back flashcards, however, the software provides a flexible card and note creation system that allows users to make almost any type of flashcard they with by adding, removing and editing “Fields” on the cards.

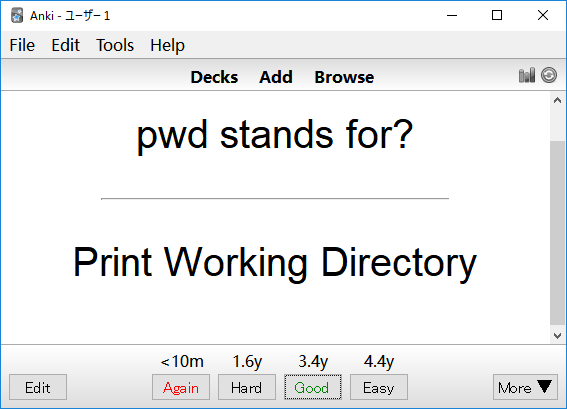
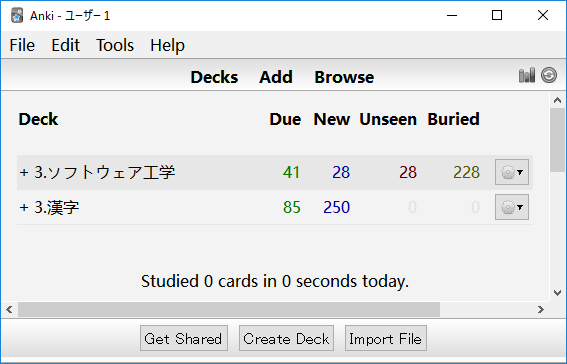


Figure 2. Anki’s home screen. Figure 3. An example of a flashcard in Anki.

The layout and style of cards can be changed very easily in Anki as the software uses HTML and CSS to display cards and gives access to changing this code to the user. Users can also create and share decks, note types and even code addons to create extra functionality.

Anki without addons supports Japanese learning but doesn’t allow the displaying of furigana. To get furigana functionality the learner must install a Japanese Support (n.d.) addon, which isn’t perfect in its furigana generation and makes simple mistakes like generating いちにん (ichninn) for the word 一人, which is usually, but not always, pronounced as ひとり (hitori).

According to Anki’s Manual (n.d.), “Anki’s spaced repetition algorithm is based on the SuperMemo 2 algorithm”. While there are a few changes, one of the changes that has

A learner could get 100% of items correct everyday but study fewer items or they could study more and get a lower percentage correct.

**Advantages and dis-advantages of flashcard-based interfaces**

**Flashcard design**

* *Note specifications for certain devices and operating systems*
* *Discuss any other design elements*

**Spaced repetition and the Leitner system**

* *Forgetting curve, Leitner algorithm*

**Spaced repetition algorithms**

* *Discuss the many different implementations of the SM2 algorithm and its flaws*
* *Discuss other algorithms*
* *Leitner system*

Quizlet

iKnow!

Using Dictionaries

Rahimi & Miri (2014, p. 1472) showed that students with access to a digital copy of a dictionary on their phones outperformed learners with a physical copy of the same dictionary. This study suggests that having easy access to a dictionary plays a vital role in a language learners success. The quick dictionary look-up Google Chrome extension rikaikun provides pop-up definitions for words and grammar and is very popular among Japanese learners with over 199,000 users, Speed (n.d.). A similar implementation of a hover over dictionary would be very useful for learners to have built-in to their language learning apps.

Conclusions and practical implications

Language acquisition relies on large amounts of input, often from an immersion environment, which exposes learners to plenty of “comprehensible input” which is essential for language acquisition to occur. Thus, the system to be developed should focus less on teaching learners about their L2 but instead provide a way of exposing the learner to i+1 comprehensible input to speed up language acquisition.

While a study that compares data of all the different learning strategies discussed in this literature review couldn’t be found, it appears that using comprehensible L2 sentence flashcards with spaced repetition is the most promising setup for learning vocabulary. When it comes to learning Kanji it appears that flashcards based on mnemonics may also be advantageous when combined with another strategy to help learners cover all aspects of Kanji e.g. pronunciation. Different layouts of these two types of flashcards need to be tested, however, and compared with results of other strategies.

Good flashcard systems allow users to make their own cards…

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