

EMERGING TECHNOLOGIES

FROM MEMORY PALACES TO SPACING ALGORITHMS: APPROACHES TO SECOND-LANGUAGE VOCABULARY LEARNING

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An essential element of language learning is building one's personal store of words and expressions, a necessary component to improving competency in all areas of communication. In classroom settings, introductory textbooks provide a controlled set of new vocabulary items unit by unit, usually introduced first in dialogs and then gathered together in a list at the end of the chapter. While teachers urge students to learn new words in context, through dialogs or reading, many ignore the advice and focus on learning from lists, one column in the target language (L2), the other in the student's native language (L1). Flash cards continue to be a popular method of working with vocabulary, typically with the L2 and L1 on opposite sides. Today electronic texts and dedicated software programs provide considerable help in increasing vocabulary through reading (or listening) and in learning a targeted set of words or expressions. Glosses in L1 or L2 are often available, as may be multimedia annotations in the form of graphics, audio, or even video clips. Links to electronic dictionaries or to other on-line resources are also common. There has been considerable experimentation on the part of CALL (computer assisted language learning) practitioners with different kinds and combinations of glosses and other comprehension and vocabulary study aids. While many studies have analyzed the results of these projects, there has been less attention paid to programs which are dedicated, not to incidental vocabulary learning through reading, but to the intentional study of sets of vocabulary. This is an area of SLA (second language acquisition) that has been out of fashion, as the sense of rote learning it evokes is out of step with the model of communicative language learning, fostering as it does the idea of language as something mechanical and fixed. Yet, in this area, some interesting and innovative work is being done which goes well beyond simplistic electronic flash cards. In fact, integrating sophisticated tools for dedicated vocabulary study into on-line environments for language learning offers an important resource for serious, long-term language learning.

VOCABULARY STUDY THROUGH READING

Language learners at the novice and elementary levels typically work with specific lists of new vocabulary. As learners advance in their language study, they tend to learn new words not from formal introduction in textbooks but through reading or listening, deciphering unknown expressions through their contextual use, root meaning, structure, or similarity to known items, or by simply looking them up in a reference work. Of course, part of this process may include keeping one's own list of new words, but principally one learns by seeing or hearing words repeatedly, used in different ways, and gradually acquiring their meaning. Learning vocabulary in this way, through context, makes it much more likely that more understanding of its correct usage will be gained than through learning an item from a list, or from its appearance in a single (inauthentic) dialog. Seeing the new item in actual use also provides more information on variations it may undergo, such as stem changes, inflections, or affixes, all important aspects of being able to actually use a recently acquired item in real communication.

For language learners of my generation, there were few options other than a dictionary to discover the meaning of a new word whose meaning couldn't be guessed through contextual clues. I can recall well the experience of reading my first full-length novel in German, *The Magic Mountain*, by Thomas Mann, a wonderful novel, but a foolish choice for an intermediate-level German student. My list of new words was long and kept on note cards in the order they appeared in the novel. The volume of unknown words made oversight unwieldy and searching inefficient, leading to the frustration of repeatedly looking up the same

word and adding redundant items to my cards. Of course, one could argue that the multiple look-up and recording activity increased my time on task and the likelihood the word would be retained, but it was only my stubbornness that prevented me from giving up a few chapters into the first volume of the novel.

No sensible language teacher today would encourage such a reading choice, ignoring the findings of SLA research that provide guidance on the kinds of text to choose and the percentage of assumed new vocabulary best suited to learners at different levels (not above 5%; see Dodigovic, 2005). Also, today the text to be used is likely to be available in an electronic format, as digitized by the teacher, found in a collection of e-texts, supplied by a textbook publisher, or discovered on the Web. This allows for look-up in one of many on-line electronic dictionaries, some of which can be configured to look up automatically an item through an action such as double clicking or mouse hovering. For Japanese texts, for example, an extension to the Firefox browser, [rikaichan](#), provides pop-up definitions; [Maryamsoft](#) does the same for Persian. Additionally, tools for automatic glosses of texts are available, including [Gymn@zilla](#) and the [Berkeley Interlinear Text Collector \(BITC\)](#). Looked-up items can be put into an electronic list alphabetically arranged or even into a database, for future look-up or study. Of course, if an edition has been especially prepared for language learning, even more help is likely to be available, including a dedicated glossary, notes, grammar explanations, and cultural information. There may be a dedicated vocabulary tool as well, which not only keeps lists of new words but also might offer exercises or games for working with and retaining the new vocabulary. [Lextutor](#) (also known as the Compleat Lexical Tutor) features a powerful array of tools for working with vocabulary from texts.

On the other hand, one may elect to go in the other direction, starting with a particular set of vocabulary and finding a text that illustrates its use. This can be done by using a customized word list (for example, from items included in given chapters of a textbook) or a standard list such as the [Academic Word List](#) for English or the [HSK character set](#) (Hànyǔ Shuǐpíng Kǎoshì, Chinese Proficiency Test) for Mandarin. One could then do a search based on that vocabulary set, or a subset, to find appropriate texts in language corpora, or on the Web. Using a language corpus has the added benefit of the availability of an associated tool such as a concordance, to provide helpful resources, such as a keyword in context listing. [Lextutor](#) and [Antconc](#) provide useful tools for working with language corpora for vocabulary study. One recent study describes using word frequency lists to generate appropriate readings in English for Chinese students from a corpus generated by an on-line journal (Huang, 2007).

CALL literature of the past decade is rich in studies of incidental vocabulary learning and the efficacy of various approaches to glossing. Some point to the desirability of *dual-coding* (i.e., providing both a translation/definition and an image; Sadoski, 2005). Others show advantages of multimedia glosses (Xu, 2010). On the other hand, some results of extensive glossing have been “puzzling” (Yoshi & Flaitz, 2002, p. 49) or “discouraging, and even troubling” (Chun, 2007, p. 242). Studies highlight how dependent the usefulness of glosses is on individual learners and the context in which they are working (Ma & Kelly, 2006); factors such as motivation, learning style, and cultural background all may play a significant role. Because there does not seem to be a consensus on the best universal approach to providing comprehension aids to texts, it may be advisable to provide a variety of options to the learner and allow for some degree of personal choice and customization.

MEMORY PALACES AND MNEMONIC ELABORATION

Some studies have shown that collaborative or peer work with vocabulary building can be beneficial (Horst, Cobb, & Nicolae, 2005; Jones, 2006). One approach which moves in the opposite direction calls for individual learners to create a highly individualized system for vocabulary retention. This involves linking in one’s mind new vocabulary to something concrete and familiar to the learner, such as items in a room in one’s home. The familiar locale provides a memory hook which can be used to retrieve linked items by perusing mentally the trajectory through that physical space. This is, in fact, the classical *ars memoriae* or “method of loci” evoked by Cicero in *De oratore*, used by classical and medieval scholars to

remember speeches and for aid in recalling all kinds of systemizable knowledge. It was famously used by the Jesuit Matteo Ricci in 16th century China to help prepare candidates in learning language and culture for the all-important imperial exam. In our day, it is known to be used by winners of memory contests. The technique goes by a variety of names including the [Roman Room](#), the [Peg System](#), and the [Nook And Cranny](#) method; also used is the term “journeys,” as trips through familiar scenes can also be used as a pegging mechanism. One language teacher has devised a [Movie Method](#), in which films play this same role, in this case, for helping students remember Japanese vocabulary. An interesting electronic implementation of the concept of the Memory Palace is the Skill Builder, a vocabulary tool in the [Tactical Iraqi](#) language learning program, developed for the U.S. military. The program makes use of external structures in an Iraqi environment to introduce and systematize new material. This kind of embodied language learning seems worth future exploration, perhaps in the context of [Second Life](#) or other virtual environments.

The idea of associating a linguistic term to a concrete image is related to the concept of dual-coding, just used here in a more elaborate system. Associating a series of images or sequence of events to help in learning vocabulary seems to be particularly useful for languages such as Chinese, which by the nature of its Hānzì characters seems to invite such a technique. [Remembering the Kanji](#) by James Heising provides a well-known example for Japanese. His method involves breaking down characters into constituent parts (“primitives”) and assigning a meaning to each, derived from real or imagined etymology. To remember a character, a fanciful story is provided which includes the primitives and their meanings. Heisig’s method has a lot of believers as well as number of detractors, but it has inspired creation of a host of software tools geared to using it for vocabulary study, including [KanjiCan](#) (features additional character stories) and [KanjiGym](#) (includes stroke order animations). The popular on-line [Reviewing the Kanji](#) also is built around the Heisig method. Studies have shown (Kuo & Hooper, 2004) that having students create their own stories or mnemonic elaborations (as Heisig encourages his readers to do), for remembering vocabulary can be particularly effective. Reviewing the Kanji encourages users to do that and then to share on-line their character stories with others. Some Japanese learners have taken a further step, by linking stories together in so-called [kanji chains](#). Idiomteach is a program using a similar system of “etymological elaboration” to help students learn English idiomatic expressions (Boers, Demecheleer, & Eyckmans, 2004). Studies have demonstrated that the more effort a learner puts into figuring out a meaning and how to retain it (“depth of processing”), the more likely it is to be remembered (Loucky, 2006). From that perspective any kind of image, story, word associations, or other mnemonic aids a student actively generates is all for the better.

The keyword method, dating back to the 1970’s, also uses graphics as a memory aid. It involves a two-step process: first finding an L1 word which sounds similar to the pronunciation of the L2 item to be learned, then associating an image or story with both the meaning of the word and the keyword used to approximate its pronunciation. There has been considerable research on the keyword technique (summary in Nation, 2001, p. 311), with some doubts raised over how well it works for longer-term retention. It has fallen out of favor recently, but there are software programs such as [Linkword](#) which encourage its use. Using the L1 in this way may seem counter-intuitive, but in fact there have been projects with promising results that take advantage of code-mixing for vocabulary study (Celik, 2003).

Another technique using graphic representation as a memory aid is concept mapping. Several studies, such as that by Bahr and Dousereau (2001), discuss its use in language learning. An intriguing example of a free but powerful program for creating concept maps is [VUE](#) (Visual Understanding Environment), from Tufts University, a multi-platform tool which incorporates sophisticated search with a flexible graphic environment for linking items. Using VUE, one can not only link items visually to one another on a Web page in various ways, but one can also link to information on the Web. It’s easy to imagine how such a program could be used in language learning, to create maps of related vocabulary items or in techniques such as kanji chaining. VUE allows different kinds of visual linking, so one could conceivably

use different connectors for different kinds of word associations, such as collocations, meaning families, synonyms, etc. A similar free concept mapping program is [CmapTools](#), which features synchronous shared map editing, a great feature for group work. The kind of focus here on lexical fields and word trees would seem to be especially useful for more advanced students, who could use it for the study of idiomatic expressions or even proverbs. The [Collins Language Revolution](#) system uses mind-mapping combined with an audio program as its principal strategy for language learning.

SUPERMEMO AND SPACED REPETITION SOFTWARE

A popular blog, [Kanjitown](#), explores an individual experience in learning Japanese. The author uses extensively the memory techniques described in *Remembering the Kanji* and implements them through the use of a software program called [SuperMemo](#). SuperMemo is a Windows-only program created by [Piotr Wozniak](#) (not related to Steve Wozniak, who co-founded Apple Computer). The first version of his software was released in 1987, the most recent incarnation in 2006. The program, since expanded in scope, was originally designed to help learn vocabulary on the basis of findings in cognitive psychology, which go back to the 19th century (German psychologist Hermann Ebbinghaus's "forgetting curve"), namely that there is a frequent pattern for how people learn (and forget). This pattern dictates a particular rhythm for reviewing items to be learned until they are committed to long-term memory. Instead of studying or testing one's knowledge of a set of items every day, it is better to study them one day, wait perhaps 3 days to study them again, then wait another 7 days after that. In the 1940's, Sebastian Leitner devised a 5-step process, using index cards in a "learning box" (*Lernkartei*, still used in Germany today), a card file box divided into 5 compartments. Flash cards are moved from the initial compartment (daily review) to the next if they are remembered, if not they stay put. Each subsequent compartment has a longer time lag before having its cards reviewed. Being able to remember a card in the final compartment (reviewed only after a lengthy interval) allows it to exit the system, with the assumption that is now stored in permanent memory. A number of electronic flash card systems are based on the Leitner system such as [StudyProf](#) (includes a [Palm](#) app), [Teachmaster](#) (open source, Windows only), and [phase-6](#) (partners with a number of German publishers). The [MemoryLifter](#) used in the Multimedia Learning Suite and other educational software uses a version of the Leitner method called "the box system."

SuperMemo utilizes a similar approach, calculating when it is necessary to review an item just before it is likely to be forgotten. The process is built around the user's actions on reviewing an item, choosing on a scale of 0 to 5 how well or poorly the item was recalled. The system then schedules a review of that item based on that score and on the scores of previous viewings. This is not a trivial system to devise, and is far from being an exact science, as demonstrated by the eleven different spacing algorithms (the first, SM 0, for pen and paper, the latest, SM 11) Wozniak has developed for SuperMemo; a glance at the [walk-through](#) of the various algorithms shows how complex they are. The program in the last few years has been expanded beyond just vocabulary study, implementing what Wozniak calls incremental reading, a way to systematically collect texts and schedule the reading on all kinds of subjects. It resembles in a way the "memex" universal knowledge system imagined by Vannevar Bush in the 1930's, a system which some credit as an inspiration for the hypertextual linking system of the World Wide Web. Others have developed different algorithms for spaced learning, including the "Low-First Method," developed by Rika Mizuno. In contrast to Wozniak's work, there have been a number of studies on the effectiveness of Mizuno's approach in language learning (Nakata, 2008).

SuperMemo is a very powerful program and has many dedicated users. However, its user interface is awkward, and it is notoriously difficult to customize. In recent years a number of competing spaced repetition software (SRS) programs have emerged, with better interfaces, more features, and enhanced flexibility. [Mnemosyne](#) is an open source program using the same 0-5 scale but is much simpler to use than SuperMemo. It also, interestingly, collects data (anonymously) from users, which is collected and used to try to improve the spacing algorithm (which is based on SM 2). [Smart.fm](#) (formerly iKnow) is an

on-line SRS system which features an [API](#) (application programming interface) for developers, allowing it to be integrated easily into other systems or Web sites. It also features additional ways of working with vocabulary beyond virtual flash cards, including dictations, games, and quizzes. Other SRS programs of note include [Pauker](#) (includes a Java client for smart phones), [FullRecall](#) (touts a self-learning spacing algorithm) and [Surusu](#) (specifically designed to work with Remembering the Kanji).

A program that seems to be attracting a lot of interest recently is [Anki](#). Anki uses the concept of “facts,” which is a basic vocabulary item and its definition/explanation/annotation. Fields such as graphics, links, audio, and notes can be included. A “card” can be created in a variety of ways based on the fields entered for that fact. For Chinese, for example, one could have six fields such as character, pinyin, English equivalent, note/character story, picture, and pronunciation. Multiple cards could be generated from these fields, one card given in English and asking for the character, then showing when flipped, the character, plus other fields. Another card could show the character, yet another the pinyin, etc. The ability to easily create multiple kinds and directions of cards makes Anki much more flexible than other SRS programs. There are a large number of ready-made card sets, or “decks” in multiple languages which have been created for use in Anki. The program can import decks from a variety of other programs. It also features a plug-in system which allows for further expansion and customization.

OUTLOOK

Anki synchronizes with a free on-line site. It also features a mobile version, with an [iPhone](#) app under development. These features point to the current trends for electronic flash card programs, namely to permit full Web and mobile access, with desktop syncing. There are also more and more Web based flashcard systems that allow users to post their own lists to share with others. The most popular of these sites, including the [Flashcard Exchange](#) and [Quizlet](#), have accumulated thousands of sets in multiple languages. These include lists from a number of standard beginning language textbooks. With the growing popularity and availability of smarter, full-featured mobile phones, most of what has been written in recent years about “mobile assisted language learning” (MALL) is fast becoming irrelevant. Mobile applications are more and more expected to be as full-featured as desktop applications. An example of the increasing sophistication of programs running on mobile devices is [Flashcard Deluxe](#), a powerful SRS program for the iPhone, which syncs with desktops. It offers Leitner style or spaced repetition study and in-app browsing/download of decks from on-line sites such as Quizlet.

Programs like SuperMemo and Anki are designed for motivated individual learners. For such systems to work the way they are designed, users must have the discipline to work with the program on a regular basis, preferably daily. However, due to the spacing schedule such systems use, the amount of time spent is reduced by working with only the items that are new or need to be reviewed before they are forgotten. In that way, they are more efficient than a program like [Rosetta Stone](#), which includes in its system material familiar to the user, along with newer, more challenging items. The simple multiple choice items and encouraging feedback in Rosetta Stone may make the learner feel good, but it would be interesting to see a study of its efficacy compared to SRS systems. This is true as well for another well-known language learning approach, the [Pimsleur](#) method, which uses its own kind of constant review (“graduated interval recall”) in an audio-only environment. The [Gradint](#) program uses the Pimsleur approach. Another area for investigation would be incorporation of SRS into instructed language learning, including how to maximize its use with textbooks. One of the obvious integration possibilities is for publishers to provide vocabulary lists or export options from proprietary flash card programs, so as to allow integration into popular SRS programs. It would be welcome to see as well more experimentation along the lines of Virtual Vocabulary (ViVo) from the [University of Illinois-Chicago](#), an on-line environment for learning German, which integrates SRS into a more comprehensive on-line language environment, featuring a multimodal presentation with audio, image, sample sentences, writing with spell check, and grammar/cultural information (Schuetze & Weimer-Stuckmann, 2010). The WUFUN project, for

teaching English to Chinese students, also features an interesting combination of mnemonic elaborations with listening comprehension (Ma & Kelly, 2006).

Considerable work has been done in recent years developing frequency word lists in a variety of languages. This kind of data can be especially useful for integrating into a SRS system, to bring novice learners up to the point where they can begin incidental vocabulary acquisition through reading. SRS programs may be particularly useful for languages significantly different from one's own, such as Chinese or Japanese for speakers of Western European languages. Working with an SRS also probably makes the most sense for learners without ready access to an immersive environment for the language(s) they are studying. It may also be particularly useful for language maintenance, especially for those studying multiple languages. However, while SRS can be thought of as an extended "rehearsal" for language use, it is not close to simulating real language use, particularly when the SRS, as is usually the case, does not provide contextual examples. SRS involves students taking responsibility for their language learning. Tom Cobb (2005) [advocates](#) going further in that direction, encouraging language learners to use linguists' tools, including language corpora, to provide appropriate materials for their language study. This might involve using concordances to add examples in context to flashcards. With the increasing interest in self-guided language study and language maintenance, it seems a no-brainer for motivated learners to consider such an approach. It would be useful for CALL investigators to study independent language study using different combinations of tools such as SRS, commercial programs like Rosetta Stone, on-line services such as [Livemocha](#), podcast sites such as [ChinesePod](#), and social networking sites. Needed too are studies analyzing longer-term retention, more than the 1-2 weeks typically considered in vocabulary research projects as "long-term" recall. Finally, the efficacy of dedicated vocabulary study for enhancing actual communicative competency needs to be addressed.

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RESOURCE LIST

Memory Palaces and Mnemonic Elaboration

- [A concept map for defining vocabulary](#)
- [Adventures in Kanji-Town: How does Kanji-Town work? How do I create my own Kanji-Town](#)
- [All Japanese All The Time Dot Com: How to learn Japanese. On your own, having fun and to fluency.](#)
- [Chain Method](#)
- [CmapTools - Home Page Cmap.html](#)
- [Context Maps](#)
- [Dr. Gruneberg's Linkword Language Learning System - French, Spanish, German, Italian](#)
- [Immacolata - Still Remembering the Kanji](#)
- [KanjiCan](#)
- [KanjiGym](#)
- [Learn it and forget it - Reviewing the Kanji - Learning Japanese](#)
- [Mentat Wiki: Nook And Cranny Method](#)
- [Mind Mapping: A Wonderful Tool for Managing Vocabulary, Organizing Your Writing, and Working With Your Tutor - Foreign Language Mastery](#)

- [Mnemonics and memory improvement / The Roman room or Journey method](#)
- [One hanzi, one picture - Reviewing the Kanji - Learning Japanese](#)
- [Remembering The Kanji: Good or Bad?](#)
- [Review of James Heisig's Remembering the Kanji](#)
- [Reviewing the Kanji](#)
- [The Journey Method - Mnemonics Training from Mind Tools](#)
- [The Movie Method: What is the Movie Method?](#)
- [The Roman room or memory palace learning method](#)

SuperMemo and Spaced Repetition Software

- [Anki - friendly, intelligent flashcards](#)
- [Anki - Pinyin Toolkit - an Anki plugin for Chinese learners](#)
- [Anki - Six reasons why Anki beats Mnemosyne - Victory Manual](#)
- [Bridging the Gap between Intentional and Incidental Vocabulary Acquisition](#)
- [Chinese - The Mnemosyne Project](#)
- [Compleat Lexical Tutor](#)
- [Flash cards, vocabulary memorization, and studying games - Quizlet](#)
- [Flashcards Deluxe](#)
- [FullRecall - Software For Effective Memorization](#)
- [Gradint, a program for self-study of foreign languages](#)
- [Laurence Anthony's AntConc](#)
- [Long-Term Memory And Leitner Cardbox System](#)
- [Pauker](#)
- [Smart.fm - Wikipedia, the free encyclopedia](#)
- [Study slower, learn faster - Victory Manual](#)
- [Super Memory: Forget about forgetting](#)
- [Supermemo - No force in the world can convince me to SuperMemo!](#)
- [SuperMemo Algorithm](#)
- [SuperMemo is useless!](#)
- [SuperMemo Versions - SuperMemopedia](#)
- [The Theory Underlying Concept Maps and How to Construct and Use Them](#)
- [Want to Remember Everything You'll Ever Learn? Surrender to This Algorithm](#)
- [ZDT vs. Anki SRS](#)
- [ZDT, ANKI and MNEMOSYNE](#)