Does vocabulary-training software support neuro-compatible vocabulary acquisition?

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This report aims to assess the strength of vocabulary training software based on research findings which come from a linguistic or psychological perspective. Findings regarding the mental lexicon, forgetting, spaced repetition and the keyword method will be considered in this report. There are numerous vocabulary-training programs currently available on both the Macintosh and Windows system, five are introduced in this paper. All programs realize flashcard methodologies on the computer: jMemorize runs on both PC and Macintosh. ProVoc has good multimedia features, however, it runs only on Macintosh. These two and also TeachMaster for the PC are freeware. The award-winning vTrain is free for educational institutions and Mylörn is free for up to 500 flashcards. While all of these programs obviously realize spaced repetition and thus fight forgetting, only Mylörn and TeachMaster seem to offer specific entries which mimic the links of our mental lexicon, like collocation, coordination, superordination and synonymy. There is a growing trend to incorporate neurological research findings, however, proof for the efficiency of these programs is yet to come.

心的辞書、忘却、間をおいた繰り返し、キーワード記憶術などの言語学や心理学における研究成果を踏まえた場合、語彙トレイニングのソフトウェアはどのように効果的だろうか？本論では、数多くある語彙トレーニングプログラムの中から5つを取り上げ紹介する。これらの5つのプログラムは全てコンピュータを用いたフラッシュカードシステムを取り入れている。jMemorizeはPCとマッキントッシュで用いることができる。ProVocはマルチメディアの面で優れているがマッキントッシュのみでの作動が可能である。これらの2つのソフトウェアとTeachMaster（PCのみで使用可能）は全てフリーウェアである。受賞ソフトウェアvTrainは教育機関においては無料で用いることができ、Mylörnはフラッシュカード500枚までは無料で使用できる。これらの全てのプログラムは間をおいた繰り返しを実施することで忘却の回避を試みている。なかでもMylörnとTeachMasterは連語、同等、上位、同義といった心的辞書における関連性を考慮した項目を提供している。脳研究の成果を取り入れた研究が増えつつあるが、これらのプログラムの効果は未だに十分に証明されてはいない。

Introduction

The instruction of German as a Foreign Language in Japan focuses on two main aspects: grammar and communication. Systematic vocabulary knowledge is often lacking. Without sufficient vocabulary knowledge, however, the grammar scaffolding is useless since it cannot be filled with content. Furthermore, and based on my own classroom experience, the learners' communicative ability will not progress beyond the most elementary level, since follow-up questions can neither be formulated nor answered. Therefore, sufficient knowledge of basic vocabulary is essential and instructors should stimulate the developmental process of this knowledge. In order to do this, findings from neuroscience and the cognitive sciences should be considered:

How is vocabulary organized in the learners' brains? How can the *mental lexicon* be systematically built up and sustained? How can instruction in this domain overcome the problem of forgetting, and which techniques should be taught to the learners? Do SW (Software) vocab-trainers support learners in these tasks? What are their strengths and weaknesses? These are the questions analysed in this paper. It is a revised and extended version of a recent report in German conducted by the current author.

Build-up of vocabulary: An essential element of FLA

A learner needs about 2000 words or word families for basic communication in a foreign language, whether this is German, English or another language. According to Nation (1990), such a vocabulary size covers about 87% percent of running words in English texts (p. 19). Many learners of German at university level, who study German as a selective subject for one year, know only about 500 words. Assuming similar conditions for German and English, this is not enough for communicating one's needs, since this is even far below the 850 words, which Odgen (1983) proposes as the basic words of the simplified language, Basic English. The importance of sufficient vocabulary is also supported by current research, e.g. by Koizumi (2005) for English: She shows that there is a strong correlation between size and depth of the active vocabulary and the speed of speech. Thus, active knowledge of vocabulary contributes substantially to speed of speech, which is one element of fluency. This is reason enough for intensifying the vocabulary acquisition process in language classes.

Organization of the mental lexicon

In a paper dictionary, words are ordered in a strictly alphabetical way, in a *one-dimensional* fashion. The organization of the human brain is quite different: Here, vocabulary items are highly interconnected through various kinds of links, forming a *multi-dimensional* network instead of a one-dimensional list.

Aitchison (2003) lists the following as important links among words: *Coordination* (link between words which cluster together on the same level of detail, e.g. salt, pepper), *collocation* (link between words which are often collocated with each other or used together, e.g. salt, water), *superordination* (link between the superordinate or cover term, e.g. insect, and its subordinates, e.g. ant, butterfly) and *synonymy* (link between words of same or similar meaning, e.g. starved, hungry). Experiments with native speakers

revealed, that coordination and collocation are the strongest connections among these (p. 86).

A replication of a native speakers language system is probably not possible in the foreign language learners' brain. Nevertheless, it can be assumed that the mental lexicon of a learner should be interconnected in a multi-dimensional way. Kleinschroth (2000) considers free associations as being one of the most effective ways of repeating vocabulary (p. 75) and thus indirectly supports this assumption: The more links an item of the mental lexicon possesses, the easier it is for the learner to find and traverse one of them to a connected item. Repetitions are important for storing vocabulary items permanently in long-term memory. Repetitions also counteract some aspects of forgetting.

Learning and forgetting

Please read the following group of nonsense syllables at a constant speed by stressing the underlined syllables: 'moss toil nam bil lock rin ket doop greath feek bime mash' After how many reading cycles could you reproduce this group error-free and with the same speed?

Hermann Ebbinghaus made a series from nine such syllable groups and read them aloud as often as he needed in order to be able to reproduce a given group at the same speed and without error, using the first syllable of that group as stimulus. On average, about 17 repetition cycles were needed (Ebbinghaus 1885).

Through such experiments Ebbinghaus found the so-called *forgetting curve*: There is more forgetting in the first hour (about 56%) than in the following month (about 23%). Accordingly, the retained portion after one month is about 21% and can be assumed to have reached the long-term memory. This *serial learning* was later complemented by other learning tasks, such as *pair association learning*.

Optimized learning methods and the spacing effect

In order to store learned items in the long-term memory, these items need to be repeated (Sousa 2006). Knowing the parameters of the forgetting curve we can use mathematical methods for optimizing the repetition procedure.

Successful recall of an item in the case of word cards (pair associations) means that the essential part of the flipside can be recalled on the stimulus of reading the front side. Every time, such a successful recall can be made, the forgetting curve for this item obviously starts again at 100% and fortunately decreases with a lower rate compared to the previous recall. Therefore, repetition time intervals can be increased after each successful recall without decreasing the success rate of the next recall trial. Knowing the parameters of the forgetting curves for both cases – successful and unsuccessful recall – thus helps to determine the optimum time schedule for repetitions.

About 40 years ago the Frenchman Paul Pimsleur, whose language courses are still available, based his teaching methodology on this idea: He assumed a required vocabulary of 2500 words and supplied the words in an audio-based form to the learner. The words are repeated in a systematic way, when there is still a good chance of recall. Pimsleur suggested a success-rate of about 60%, which means, 6 successful recalls among 10 trials (Pimsleur 1967).

Not long after the work of Pimsleur came the American, R. C. Atkinson who conducted several experiments in order to find optimum repetition strategies for pair association learning (Atkinson 1972). Atkinson let his subjects learn and repeat items in different ways, searching for the optimum order or time schedule of item presentation. Having the same learning time (2 hours; 20 sec per item) for the test group and the control group, changing just the order of items to be repeated and thus the timing of their presentation to the subject during the learning period, he found the following result: When a certain computer algorithm defined the repetition order, the retention after one week was about 80%. However, when the subjects chose by themselves which items to repeat, this retention rate was just under 60%. This suggests, that even experienced learners are mostly unaware of optimum learning schemes and intuitively or deliberately choose a repetition order, which is not optimal.

However, the idea of spaced repetitions was not popular. Repetitions often occured too soon, e.g. in language classes at schools. This is not only boring for the students, it is also not optimum for retention. Repetitions should be done as late as possible: If there is a longer time interval before the next recall trial for a given item, this item will – assuming a successful recall – be retained also for a longer time interval in the future. This so-called *spacing effect* has been shown in various experiments (Dempster 1988).

Recently, psychological research has looked for optimum time schedules for repetitions, as in Pavlik (2005): Pavlik tries to minimize a cost factor, mainly in terms of study time. Whereas repetition time per item was independent from success or failure in Atkinson's experiments, Pavlik pursued a different approach: He took into account, that an unsuccessful recall is usually accompanied by a short review – a conscious thought process in order to engrain the missed information or to relearn the forgotten item. Adding up both times – the time needed for the recall plus the time for the review – reveals that an unsuccessful recall is much more time-consuming than a successful recall. Therefore, Pavlik suggests to repeat not too late, such that the success rate for recalls is still very high, far higher than 90%.

Besides the optimum timing of repetition, mnemonic techniques are crucial for efficient learning. The following subchapter describes one successful memorization technique.

The keyword method

The *keyword method* is – like the spacing effect – well documented in psychological research. It is a mnemonic technique, explained here for the application of vocabulary acquisition: Learning a target word with a given meaning in a foreign language is done in two steps: First, a similar sounding keyword is needed, mostly in the mother language. Second, a vivid association has to be created involving both the meaning of the new word and that of the keyword.

Retrieving the target word from memory consists again of two steps: First, using the target word's meaning as a cue, the association connecting the target word's meaning and the keyword's meaning is retrieved. This yields the keyword. Second, using the keyword's sound pattern as a cue, the similar sounding target word is retrieved. This mechanism works also in the opposite direction.

An example taken from Sperber (1989): English native speakers who attempt to learn the German word 'Dach', which means 'roof' in English, can choose the English word 'duck' as a keyword (identical initial and intermediate phoneme /d/ and /a/, differing final consonants, 'ck' realized as plosive, 'ch' realized as a fricative). They could further imagine a roof full of noisy ducks as association connecting the meanings of target word (Dach=roof) and keyword (duck).

The retrieval works as follows: What is 'roof' in German? First, the mental image of noisy ducks on a roof yields the keyword 'duck'. Second, the similarity of sound patterns yields the target word 'Dach'.

Possible criticism could evolve from the necessity to traverse two links in the mental lexicon in order to retrieve one item from memory, which could be more time-consuming than having just a single link. However, proponents of the method like Atkinson (1975) argue, that – besides the two links connecting target word meaning and target word form – a new, direct mental link is established between meaning and form, such that the keyword becomes obsolete after a while (p. 132). However, in the beginning phase a slow retrieval is certainly better than no retrieval at all, especially where motivation among under-achievers is concerned.

Learning systems considering the mental lexicon and the spacing effect

One way of applying the above in a practical situation is to make the various links in the mental lexicon explicit to the learners by making them draw word maps with various links on paper (Neveling 2005). Having students work in pairs, covering parts of the word map and letting them guess and retrieve those interconnected words leads to a higher retention compared to a control group (p. 29).

Concerning the spacing effect: The widespread Leitner flashcard system (Leitner 1995) contains a word card box with sections of different sizes. *The Leitner principle* causes a card to proceed to the next section in case of successful recall, however, it must return to the first section in case of failure (Fig. 1). Thus the system realizes growing time intervals (repetition time is controlled by the events of sections getting full) between repetitions and thus takes the spacing effect into account. Used regularly, the distribution of cards in the box reflects the state of the learned items in our memory.

The first section contains new and forgotten word cards. Word cards in the second section reflect items in our working memory (just learned or relearned after forgetting for the first time, therefore rather unstable knowledge). Words in the third and forth sections represent items which are in an intermediate state in our memory. Cards in the fifth, the final and largest section, reflect items, which are already in our long-term memory (four successive successful recalls) (p. 64ff).

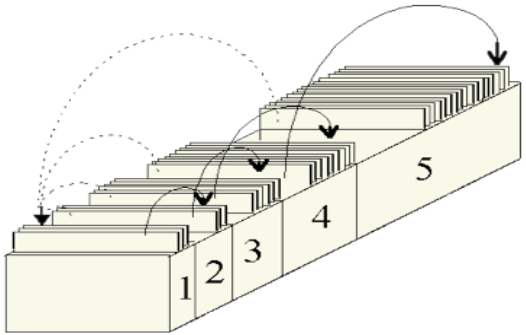

Figure 1. The Leitner Word card box.
Solid arrows: paths of a word card after successful recalls. Dashed arrows: Paths after unsuccessful repetition trials. A section ought to be repeated when it gets full. (Illustration: Stangl 2007)

Though often praised, there is also criticism: Lüders (2005) states that – if students create the cards by themselves – the cards are prone to errors, which an instructor cannot correct for practical reasons. Erroneous cards however will cause the learning of false data, which is hard to correct. Another problem concerns timing: When not used regularly or after a longer pause (e.g. after a long holiday), the distribution of cards in the box does not anymore reflect the current state of our mental lexicon: The distribution of cards is exactly as it was before the pause, however in our mental lexicon, many 'cards' meanwhile, have been forgotten. Consequently, many cards of the higher sections will have to be moved back during upcoming repetitions to the first section, which tends to overflow.

In this respect, the computer offers a more adequate model of our mental lexicon through the possibility of using time-stamps and the computer clock. A simple timing mechanism can ensure, that a vocabulary file always adequately reflects the learning state of all items.

Software for vocabulary acquisition

There are various vocabulary trainers available. Here, five of them are introduced which have been selected since they are mostly free of charge.

jMemorize is an open-source program, which can be downloaded from the Internet for free (Djemili 2007). Java Runtime Environment (JRE) is required, which is available for most current operating systems (MS Windows 2000, XP, Mac OS X or Linux) and is often already installed. The program organizes the data, which can be entered by the learner or imported from external files. It is very simple to use and the statistics are easy to understand and very transparent.

The control language can be chosen (e.g. English and German. According to Riad Djemili, the next version will include Japanese). The contents of the 'word cards' can contain Japanese characters, because Unicode is supported. Since the cards can hold an almost unlimited number of characters, the learners are not limited to learn just vocabulary equations (pair associations). They can add example sentences, collocations, coordination examples and whatever they wish. The time plans for repetitions can be manually defined, however, unfortunately not for individual files.

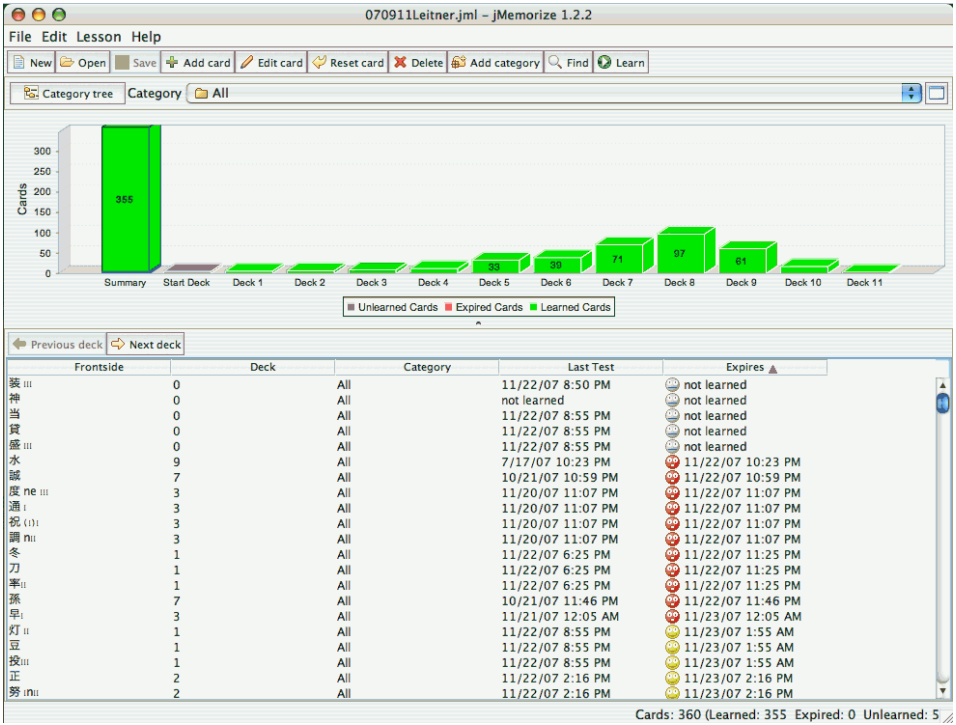

Figure 2. jMemorize (Mac OS, Windows or Linux; by Riad Djemeli).
Based on the Leitner box, with 12 sections, here called 'decks'. Application: Learning Kanjis. Repetition of cards is possible, after they have expired (red icons).

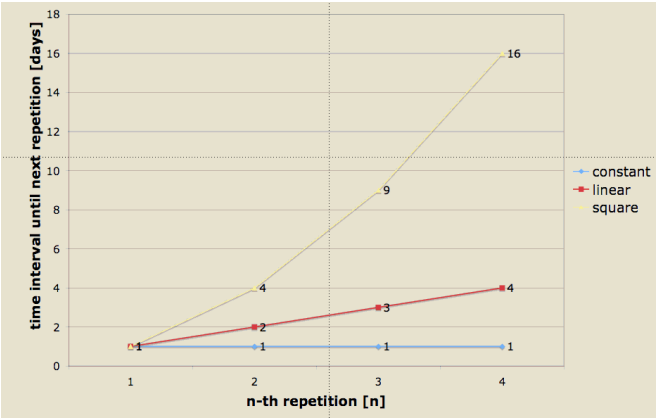

Figure 3. Three time plans, 1st- 4th repetition. (time spacing between two successive repetitions)

Pre-defined time plans are for example *constant* (repetitions every day), *linear* (repetitions after 1, 2, 3, 4, … days), *square* or quadratic (after 1, 4, 9, 16, … days), *exponential* (after 1, 2, 4, 8, … days), *cram* (after 5, 10, 15, 20, … minutes. Good for test preparations or workshops) or user defined (in minutes, hours and days). Figure 3 shows the first three of these time plans.

ProVoc (Bovet 2006) is also freeware, but available only for Macintosh (Requires Mac OS 10.3.9 and QuickTime 7 or newer) and supports Unicode (Japanese characters possible, interface language English). Simple key combinations allow adding audio (using a computer microphone), photographs or videos (taken with a computer camera) to each card and thus allow multimodal learning. There is less space on the cards compared to jMemorize, however, there is space for a comment beside the front side and flipside of a card, which can be used for keywords etc. Importing is very easy and learning modes can be user-defined; the files can also be downloaded on to an iPod. Time plans are less transparent compared to jMemorize. (See Fig. 4)

There are a number of programs for Windows, including *TeachMaster* (Meyer 2007), *VTrain* (Raedle 1999-2006, many OS, e.g. Windows 2000 and XP) and *Mylörn* (Spagniolo 2007). Only TeachMaster is freeware, but VTrain is free for schools and universities, and Mylörn offers a free trial version with up to 500 cards. With all three programs, audio files can be linked to cards.

Critical remarks

It should be stated that most programs focus on the learning of pair associations. The programs mainly support language learners in the systematic repetition of items, which means taking the spacing effect into account. However, the systematic construction of a mental lexicon with many connections through collocation, coordination, superordination and synonymy is often not supported, rather it is left to the learner. Exceptions are TeachMaster and Mylörn: A vocabulary item of TeachMaster consists of five entries, one of which is for synonyms. Only Mylörn offers all of the above-mentioned entries for interconnecting the mental lexicon, collocation, coordination (similar concept of), superordination (superior concept of entry) and synonymy.

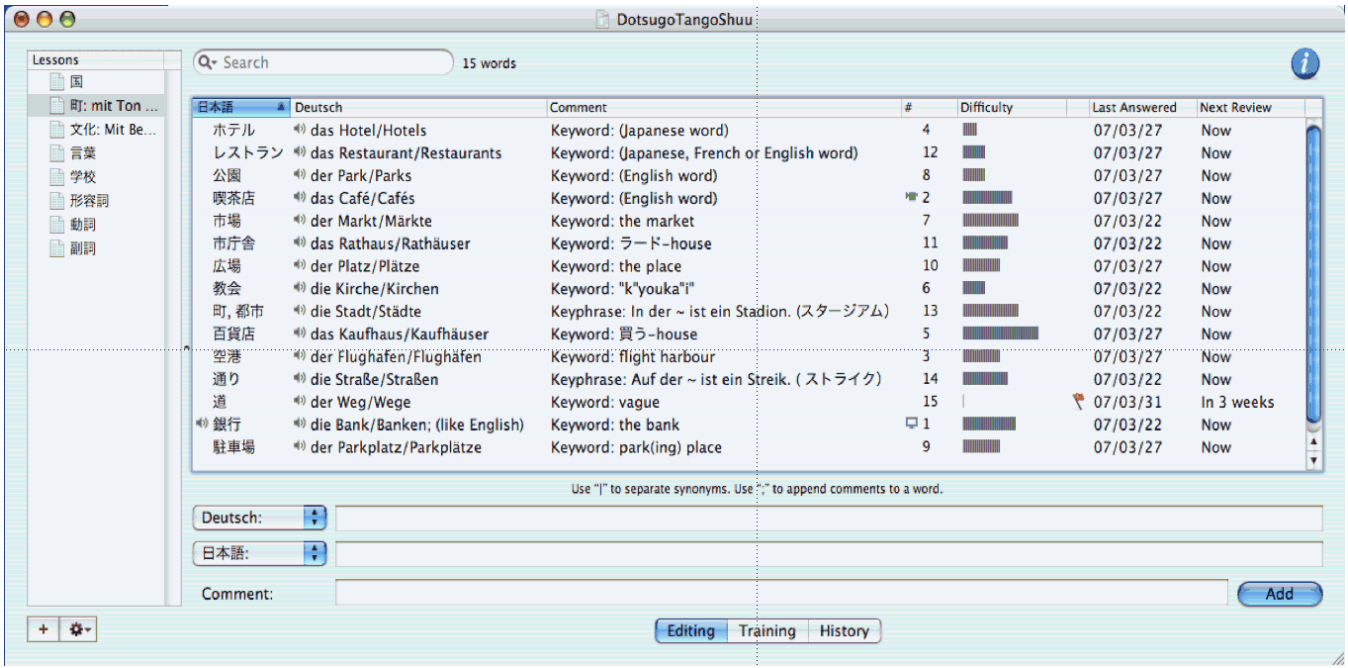

Figure 4. ProVoc (Mac OS; by Simon Bove).
For each flashcard: Two audio files (speaker icon) plus one picture or video (camera and screen icons) is possible.

It should also be noted that failure in the retrieval of learned items should not be seen in a negative way. Often, newly learned items are so similar to previously learned items (whether in meaning or in form) that retrieval mistakes are almost inevitable and constitute a necessary step in the learning process. The important point is to learn from mistakes, since these often point to hidden connections in the mental lexicon. Similar sound patterns are one rich source of such mistakes. According to Sousa (2006) the learners need to learn the *critical attributes*, the different parts within the similar items (p. 144). Constant modifications of word cards through adding records, which make such similarities and

differences explicit, are one approach for subsequent correct differentiation among competing retrieval candidates.

Hints for instructors

1. Learning techniques for vocabulary acquisition should explicitly be taught in language classes, e.g. *the keyword method*.
2. Word cards and word card boxes are a valuable tool for *individual learning* and should also be introduced.
3. There are a large number of software programs, which are useful for individual learning as well as for cooperative learning with a whole class. These programs mostly obey the spacing effect and thus support the transition of learned items from working memory to long-term memory.
4. The multi-dimensional linking of vocabulary items according to the characteristics of the mental lexicon is supported only by some of the programs (e.g. TeachMaster, Mylörn). For other programs, the instructor should supply good examples or suggest appropriate entries for the cards.

Hints for learners

1. Whether word card box or computer: It is advisable to constantly modify and extend word cards throughout the learning process after unsuccessful recalls. This will render hidden links in the mental lexicon explicit and thus helps to learn the critical attributes of items, needed for differentiating them from close neighbors.
2. A quick preview of the front side of the cards before the actual repetition cycle probably has a positive effect on the success rate during the repetition (priming).
3. A quick review of the forgotten cards after the actual repetition cycle probably has a positive effect on the success rate during the next repetition cycle.
4. Reviews should also be done outside of the usual learning environment (changing the context renders our knowledge more versatile and reliable).
5. Mistakes should not be seen negatively: They often point to latent connections between items. Becoming aware of these connections will improve the connectivity and thus the versatility of our mental lexicon.

Potential of CALL for vocabulary acquisition

This paper gave an overview of findings on the mental lexicon and learning from a theoretical point of view, it also presented some software programs which support the construction of such a mental lexicon. Some findings from theory (the spacing effect) are effectively taken into account by most of the programs, whereas others (multi-dimensionality of mental lexicon and connectivity of vocabulary items) are supported only by some of them. Studies are needed which show the advantages of such programs in order to develop an objective base for their comparison and selection. For the time being, jMemorize is recommended because of its ease of usage: It can be introduced and applied in just one lesson (Rude 2008). However, if audio-data is an issue and Windows is used, VTrain, MyLörn or TeachMaster might be the better choice.

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Appendix 1: Vocabulary-training software

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