

Retention in SLA Lexical Processing

ULF SCHUETZE

University of Victoria

GERLINDE WEIMER-STUCKMANN

University of Waterloo

ABSTRACT

Second language learners are faced with the challenging task of remembering many new words. Exactly how learners are supposed to accomplish that task is disputed. Research on lexical processing that has been carried out in cognitive psychology showed that rehearsing words in expanded patterns, that is, with a delay between each rehearsal, leads to high retention rates. This article reports on a study that was devised to test retention in second language vocabulary learning, comparing a uniform versus a graduated delay. The study used an online vocabulary program testing first-year students of German. Results showed that on long-term retention, a uniform delay led to higher retention rates than a graduated delay.

INTRODUCTION

In recent years, research into second language lexical processing has witnessed a revival. In particular, attention has been given to intentional learning. Most research on vocabulary in the context of intentional learning has addressed word associations and/or providing learners with clues (Meara, 2009) and task-types and activities that engage learners with words (Barcroft, 2007; Host, Cobb, & Nicolae, 2005; Webb, 2007). Little research has actually looked at the process of encoding and retrieving words in second language learning and that which exists has been carried out primarily in cognitive psychology (Balota, Duchek, & Logan, 2007; Carpenter & DeLosch, 2005; Cull, 2000; Karpicke & Roediger, 2007; Landauer & Bjork, 1978).

While the idea of intentionally rehearsing words is a long followed practice in second language learning, commonly used methods have been based on intuition rather than research. A good example of this is 'die Lernkartei' (Leitner, 1972). This is a learning device based on the concept of structured cyclical repetition using flashcards and a box with five to six sections of progressively larger sizes. Previously, Pimsleur (1967) had designed an audio-lingual language learning system following four learning principles, the second principle of which he named graduated interval recall defining eleven intervals on an exponential scale: 5 secs, 25 secs, 2 mts, 10 mts, 1 hr, 5 hrs, 1 day, 5 days, 25 days, 4 months, 2 years. However, we do not really know why he chose the exponential of five nor why he stipulated eleven practice sessions. The approach is reminiscent of the research of Ebbinghaus (1913), who conducted self-experiments on the forgetting of words. Using nonsense syllables, Ebbinghaus addressed the following question: How much time and learning effort can be saved after repetition with spaced intervals of 25 minutes, 1 hour, 9 hours, 1 day, 2 days, 6 days, and 31 days? He compared the learning time with the re-learning time and measured the seconds he had saved when relearning the material. Leitner's flash card boxes have been in use in the German school system for many years and their usefulness is promoted in teacher training programs (Schroeder & Roedig, 2007). English as a second language textbooks publish sets of flashcards to match their corpora or create multimedia vocabulary learning environments based on cyclical learning. The outstanding issue with this system is that there has been no published

research on how these flash cards are processed and handled. Students determine when and how long they will practice (and memorize).

Nevertheless, intentional vocabulary learning has been promoted by a number of experts in the field. Nation (2001), for example, advocates "direct learning of vocabulary" with word cards and states that this method of direct learning should be part of an overall vocabulary learning agenda. Oxford (1990) and Schmitt (2008) give particular consideration to rehearsals. Oxford (1990) promotes a staggered processing of learning material in her popular textbook, suggesting seven encounters with the optimal intervals of 15 minutes, 1 hour, 2 hours, 1 day, 4 days, 1 week, and 2 weeks. However, this method has not been assessed empirically.

Reviewing these studies in second language learning, it is obvious that we actually do not know which rehearsal patterns lead to optimal long-term retention of words. In order to address this issue, a two-year study was devised with first-year German students. The study used an online vocabulary program called ViVo (Virtual Vocabulary) that students used to learn the words of every chapter of their textbook in German 100A (Beginning German) as well as in German 100B (Advanced Beginning German).

CURRENT RESEARCH

Much of the contemporary research on second language lexical processing builds upon Baddeley's model of 'working memory' (Baddeley, 2007). That model consists of various components. A central executive directs attention to a word that needs to be processed. If attended to, the data enters working memory where it is controlled via a visuo-spatial sketchpad and a phonological loop. The sketchpad is argued to be responsible for processing visual information while the phonological loop stores auditory and phonological information and also includes the capacity to rehearse perceived input at a subvocal level. This latter aspect of subvocal rehearsal is particularly important for lexical processing as lexical items need to be rehearsed in order to receive the amount of attention necessary for forwarding to long-term memory. The phonological loop is temporary in nature and has a limited capacity. Its function of binding sequences of sounds is a two-step process: while some sequences are rehearsed, others are temporarily stored in the loop and called up when needed. If the sequences of the word can be identified, it is moved to long-term memory. However, in order to strengthen the connections of those sequences, the word needs to be encountered and processed in the phonological loop several times. An exception to this are words that have a strong emotional connotation or are linked to emotional events. These are directed to another component of working memory called the episodic buffer.

The episodic buffer provides a short-cut to long-term memory because information is bundled and subsequently processed in interconnected chunks, although working memory theory does not provide a detailed explanation of how that might work. What is relevant for the study and type of research presented in this paper are the workings of the phonological loop: words are rehearsed in a two-step process and their sequences need to be strengthened by rehearsing them several times.

In cognitive psychology, research has been carried out that explores various temporal spacing between repetitions and their consequence for the long-term retention of new material (Balota et al., 2007; Carpenter & DeLosch, 2005; Cull, 2000; Karpicke & Roediger, 2007; Landauer & Bjork, 1978). Based on the working memory model described above (Baddeley, 2007), these experiments used words that were repeated in different intervals to test what type of interval led to higher retention scores. These experiments and their derivative pedagogical techniques have been labeled 'spaced retrieval'. Results suggest that spaced learning

leads to higher retention than massed learning. In other words, the repetition of a lexical item and its corresponding L2 representation twenty times in a row will not lead to a twenty times higher retention rate; rather, recurrent exposure should be distributed across longer periods of time (Balota et al., 2007; Cull, 2000). The same studies also researched the interval length of spaced learning, addressing the question: if a lexical item is repeated, how long should the interval between repetitions be? Results from this line of experimental research have been inconclusive, in part because of the brief time allotted to the rehearsal sessions as a function of experimental research carried out under controlled conditions. For example, Carpenter & De-Losch (2005) explored spacing effects in name learning. In their experiments they presented thirty name/face pairs in a sequence of six seconds each. Distractor items, each six seconds long, were used to create three different conditions:

massed (0-0-0): the name/face pairs were presented three times in a row with zero distractor items in between; there are no intervals.

uniform (3-3-3): after one presentation of a name/face pair, three distractor items were presented before the next presentation of the name/face pair, etc.; the interval between each rehearsal is equal.

graduated (1-3-5 and 3-5-7): after the first presentation, there is one distractor item, after the second presentation three distractor items, etc.; the interval is increased over time.

Tests on retention were carried out five minutes after rehearsal. They concluded that items presented in uniform or graduated mode were retained more successfully than items on a massed schedule. The same result had been reported by Cull (2000) as well as by Karpicke & Roediger (2007). In regards to the phonological loop, the results indicate that the strengthening of sequences occurs when words are encountered in a spaced interval that allows for pauses between each encounter.

However, none of these studies showed a significant difference between uniform and graduated spacing. One problem with these studies is the short time-span they tested. The sound sequences might not have been strengthened enough by rehearsing words over a longer period of time for long-term retention to occur. Consequently, it is still unclear what effect a uniform or graduated spaced interval has on long-term memory.

The studies described above showed that even after five minutes, ten minutes or two days, differences between the intervals were not statistically significant. It therefore seems plausible to carry out retention tests at a later point in time. In the context of intentional learning, the challenge for studies in second language vocabulary acquisition therefore is to use the methods that have been tried in cognitive psychology and adapt them to the second language learning situation. In addition, rehearsals would be spread over several days, which reflects the organization of language courses. Following the outline of a textbook, students usually have considerable amounts of unstructured time, sometimes two weeks per chapter, to acquire and remember the associated vocabulary. A few second language acquisition researchers have therefore argued that an explicit memorization stage of words is beneficial (Mondria, 2003; Mondria & Mondria-deVries, 1994; Laufer, 2006; Schmitt, 2000). Hulstijn & Laufer (2001) claim that this type of intentional vocabulary learning will greatly improve retention following other strategies (i.e., inferring, verifying). However, there are conflicting reports regarding how often an item needs to be rehearsed or repeated ranging from five to twenty times (Nation, 2001; Schmitt, 2008).

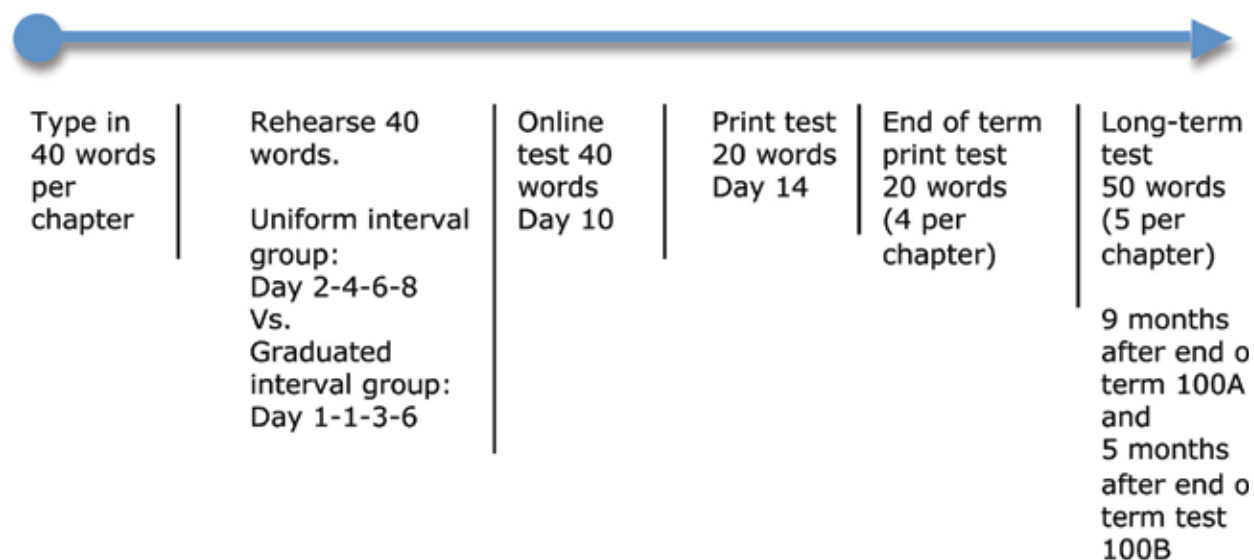
The overarching research question of the current study is to determine what type of rehearsals lead to long-term memory storage. In other words: In the context of second language

learning, does a uniform or graduated interval lead to higher retention rates of lexical items days and weeks after the lexical item has been encountered and rehearsed?

METHODOLOGY

The study was carried out over the time period of two years with first-year German as a second language students. Students rehearsed words with the help of the online vocabulary program ViVo. This program followed the outline of the textbook *Deutsch Na Klar*, 5th edition, 2008. Students had to rehearse forty words per chapter for the duration of the term in the fall of 2008 (German 100A) and continued in the spring of 2009 (German 100B). After a short learning phase at the beginning of each chapter, where students typed the words into the on-line program, words were rehearsed four times. After each chapter, students were presented with an online and a print test. In order to determine long-term retention, students were also administered a print test at the end of each term. In addition, students took a print test nine months after they had completed German 100A and five months after they had completed German 100B. For an overview of the timeline, see Figure 1.

Figure 1
Procedure of the Research Study (time line)



Participants

The study was carried out with 117 students of four sections of German 100A in the fall of 2008 and 90 students of three sections of German 100B in spring 2009.

All students used the ViVo computer program to learn vocabulary as a regular part of their course activities. Two sections of German 100A were assigned to learn vocabulary items following the uniform mode (evenly spaced intervals between training sessions) and two sections following the graduated mode (increasingly long intervals over training sessions). Most students continued learning German in German 100B and the uniform and graduated mode groupings were maintained through the second semester course.

In order to use ViVo as a research tool, all students had to fill out a questionnaire to establish

homogeneous groups. The questionnaire identified previous knowledge of German, previous instruction in German, German heritage, proficiency in other languages, and provided social data on faculty, major, and years of study. In addition, another questionnaire was administered at the end of each term. It used filter criteria so that the students' learning strategies would not interfere with the validity of the research findings. In particular, it asked if students had employed learning techniques that corresponded closely to the design and methodological concept of the online tool ViVo, asking, for example, if students had used another online vocabulary trainer or software, if they had made extensive use of flash card practice, and if they had studied the ViVo words outside ViVo on a self-made word list. Based on the two questionnaires, the data from several students were excluded from the study. There were also a number of students who simply did not use the program or who used it less than the required number of rehearsals. Their data was also removed from the study. In total, this research is based on the data from 86 students in the fall of 2008 and 69 students in the spring of 2009.

In September of 2009, students who had participated in the previous two studies were asked to participate in the long-term retention test. Students filled out a questionnaire regarding their exposure to the German language over the summer. If that exposure was high, for example by participating in an exchange program, students were excluded from the study. That left 25 students for the long-term retention study.

Corpus

The program selected vocabulary from the textbook used for first-year. It was organized by chapters following the format and divisions used in the textbook. For every chapter, students had to type forty words into a practice field that included a spell check. Each chapter was completed in ten days. In German 100A/B, students are supposed to acquire a learner corpora of about 100 to 120 words per chapter as determined by the textbook. Three criteria were employed to select the ViVo corpora. The first criterion was to select forty out of the 100 to 120 words per chapter as the lexical items to focus on for the purpose of this study. The number forty was chosen because the number is too high for students to rely on short-term memory performance (Baddeley, 2007; Cowan, 2001, 2005) in the sense of learning all lexical items the day before the quiz. The second criterion was to use the German frequency dictionary by Jones & Tschirner (2006) as a filter to select the more frequent words as 95% of written texts are comprised of the 4000-5000 most frequent words (Nation, 1990). The third criterion was to achieve a balanced mix of content words (nouns, verbs, adjectives), function words (prepositions, conjunctions, pronouns, adverbs), and cognates (defined as lexical L1 and L2 items that are semantically identical, e.g., 'die Lampe - the lamp', see Carroll, 1992). Aitchison (2003) refers to content words as words that have a meaning independent of other words and function words as words that are primarily used to connect other words; however, this distinction is not always so clear-cut and thus the corpora were built using this distinction only for general categorization. The ratio of content to function words was set at three to one to reflect their distribution in the textbook.

It should also be noted that using individual words for the corpus has its limitations. Every word has multiple layers in terms of its morphology, semantics and pragmatics. A complete understanding of a word can only be achieved by a learner if the learner has access to the many different contexts in which the word may occur.

Online Program

The software program called ViVo (Virtual Vocabulary) was used. The program was used by students to learn words in the target language. At the same time, it recorded student activity to allow the researchers to track the learners' progress.

ViVo presented lexical items to learners using images, sound files, lexicogrammatical information, target language sample sentences, and intercultural information. This approach was informed by research on multimedia (Jones & Plass, 2002; Kim & Gilman, 2008; Rimrott, 2009) as well as on different learning styles (Cohen, 2003; Oxford, 2003). For a detailed description of this aspect of our research project, see Schuetze and Weimer-Stuckmann (2010).

At the beginning of each chapter, students typed into ViVo the designated forty words. After that, they used ViVo according to their pre-assigned uniform or graduated rehearsal/practice schedule. In 2008/09, the lexical items were presented:

day two, four, six, eight (uniform)

day one (twice), three, six (graduated)

This particular schedule was chosen as it fit with the curriculum of German 100A and 100B (ten days per chapter, see above).

Retention Tests

Students were administered an online quiz on day ten of each chapter and a print quiz on day fourteen. The online test regulated the intervals: it was two days after the last rehearsal for the uniform group being consistent with the two day interval and four days for the graduated group to be consistent with the expanded interval. The online quiz tested all forty lexical items practiced with ViVo while the print quiz tested twenty of the forty items. This testing procedure was chosen to test retention per chapter.

In order to test long-term retention, students were given a print retention test at the end of each term. It consisted of twenty items, four per chapter. Each item had been tested in the earlier chapter print tests. This set-up was necessary to be able to compare the results of the long-term retention test to the individual chapter tests. In addition, students also wrote a print retention test at the beginning of their second-year course that covered the content of chapters one to ten (German 100A: chapter one to five; German 100B: chapter six to ten). These tests occurred nine months after German 100A and five months after German 100B had been completed. The test consisted of fifty items, five per chapter. All items had been previously tested to be able to compare their retention rate. For an overview of the procedure and time line, see Figure 1 above.

RESULTS

The analysis tabulated the data in several ways. First, the chapter tests were analyzed by frequency indicating that participants who used ViVo to the fullest – that is they participated in the learning phase by typing in the words and participated in at least three of the possible four rehearsals – outperformed participants who participated in less than three rehearsals. Detailed results have been reported by Weimer-Stuckmann (2009). Second, the data of those who participated in at least three rehearsals was analyzed chapter by chapter. Participants did

very well using both the uniform and the graduated interval. The uniform group outperformed the graduated group in German 100A as well as German 100B in all tests, in particular in the print tests, but differences were not statistically significant. All in all, 200 items (forty per chapter) were tested in online chapter tests and 100 items (twenty per chapter) in the print chapter tests.

Table 1
Chapter Tests German 100A and 100B One-Way ANOVA

	U Mean	SD	G Mean	SD	P
Online 100A (n=82 U; n=89 G)	91.24	14.08	91.22	8.25	.991
	Sum of Squares	df	Mean Squares	F	
	.016	1	.016	0.000	
	22062.62	169	130.348		
	22062.64	170			
Online 100B (n=46 U; n=56 G)	95.17	5.79	94.20	8.38	.293
	Sum of Squares	df	Mean Squares	F	
	78.514	1	78.514	1.118	
	7024.16	100	70.242		
	7102.67	101			
Print 100A (n=120 U; n=123 G)	94.93	7.48	92.72	10.63	.062
	Sum of Squares	df	Mean Squares	F	
	297.718	1	297.718	3.505	
	20468.38	241	84.931		
	20766.10	242			
Print 100B (n=55 U; n=64 G)	96.90	5.77	94.21	9.74	.075
	Sum of Squares	df	Mean Squares	F	
	214.097	1	214.097	3.217	
	7785.48	117	66.543		
	7999.58				

The capital U refers to the uniform group; the capital G to the graduated group. N refers to the number of participants. The one-way ANOVA used a 95% confidence interval. For example, the score of participants in the online tests of all 200 items using the uniform interval was 91.24% and of participants using the graduated interval it was 91.22%.

A look at each group revealed that participants performed consistently well, that is, they reached a high mean in each of the chapter tests. These results are in line with studies in cognitive psychology that investigated retention. Most of those studies, with the exception of

Landauer and Bjork (1978), did not report differences comparing the uniform and graduated interval. Those studies, as well as the chapter by chapter analysis carried out in this study, were on short-term retention. As interesting as it was to find out that both intervals lead to high retention rates using ViVo in second language learning, the research was designed to also analyze long-term retention.

Results of the long-term retention study are presented in Table 2. They showed that participants scored very well on both long-term retention tests at the end of the term of German 100A as well as at the end of the term of German 100B.

Table 2
Retention End of Term Print One-Way ANOVA

	Ch Mean	SD	R Mean	SD	P
Uniform 100A (n=110)	96.70	8.06	95.68	9.64	.394
	Sum of Squares	df	Mean Squares	F	
	57.528	1	57.528	.728	
	17223.01	218	79.005		
	17280.54	219			
Graduated 100A (n=124)	94.15	12.28	94.05	11.65	.947
	Sum of Squares	df	Mean Squares	F	
	.630	1	.630	.004	
	35280.99	246	143.419		
	35281.62	247			
Uniform 100B (n=52)	97.82	5.46	97.55	6.78	.833
	Sum of Squares	df	Mean Squares	F	
	1.698	1	1.698	.045	
	3413.72	90	37.930		
	3415.42	91			
Graduated 100B (n=46)	95.19	11.65	95.62	13.83	.863
	Sum of Squares	df	Mean Squares	F	
	4.868	1	4.868	.030	
	16684.01	102	163.569		
	16688.88	103			

Ch refers to chapter tests and R to the retention tests at the end of the term. N refers to the number of participants. For example, the average score of participants for all twenty items in the chapter tests was 96.70 and in the retention test, participants' average score for the same twenty items was 95.68.

Comparing the scores to the chapter test results showed no statistically significant differences (comparison was based on the twenty test items of the retention test). Interestingly, the retention tests of the graduated group were almost identical to the chapter tests.

The total scores of the long-term retention tests were also analyzed comparing the uniform (100A: 95.68; 100B: 97.55) to the graduated (100A: 94.05; 100B: 95.62) interval. Although the uniform interval scores were higher than the graduated ones, differences were not statistically significant (100A: $p = .249$; 100B: $p = .393$).

In summary, the chapter tests (see Table 1, above) analysis showed that participants in the uniform group scored higher in all tests compared to participants in the graduated group. The long-term retention tests confirmed this trend (see Table 2, above). However, none of the differences were statistically significant.

A further analysis (see Table 3, below) looked at the print retention test that participants performed nine months after German 100A and five months after German 100B had been completed.

Table 3
Retention Second Year Print One-Way ANOVA

	Ch Mean	SD	R Mean	SD	P
Uniform (n=60)	97.33	6.85	83.83	16.88	.000
	Sum of Squares	df	Mean Squares	F	
	5467.500	1	5467.500	32.931	
	19591.66	118	166.031		
	25059.16	119			
Graduated (n=33)	90.30	12.86	59.69	21.57	.000
	Sum of Squares	df	Mean Squares	F	
	15456.061	1	15456.061	48.984	
	20.193.939	64			
	35650.000	65			

Ch refers to chapter tests (100A and 100B combined) and R to the retention tests at the beginning of the second year course. N refers to the number of participants.

The average score of uniform group participants for all fifty items in the chapter tests was 97.33 and in the retention test, the same group of participants' average score for the same fifty items was 83.83. Results showed that the uniform group (participants who had worked with the uniform interval in 100A and 100B) did not recall as many items as in the previous tests. The fifty items tested, five per chapter, had all been previously tested to be able to compare retention rates. The participants still recalled a remarkable 83.83% of the items. The standard deviation was high and the difference statistically significant. Similar results emerged for the graduated group in that they also recalled fewer items correctly, in fact only 59.69%. Standard variation was higher than for the uniform group and the difference between the two groups was statistically significant.

A final analysis compared the uniform and the graduated group regarding the long-term retention tests and results were statistically significant (Uniform: 83.83 / Graduated: 59.59 / $p = .000$).

DISCUSSION

The study described here was designed to shed light on the question of whether one type of rehearsal interval – uniform or graduated – would result in higher rates of short- and long-term vocabulary retention among second language learners, an issue that has been discussed in cognitive psychology and second language acquisition research for some time. The study was based on the model of working memory, in particular the phonological loop that rehearses words in a two-step process: while some sound sequences are rehearsed, others are temporarily stored in the loop and called up when needed. In order to strengthen the connections of those sequences, a word needs to be encountered and processed in the phonological loop several times. Due to the limited capacity of the phonological loop, this process needs to be efficient in order to free up space for other words to be processed.

Studies carried out in cognitive psychology had used the working memory model to test retention intervals but results had not shed light on the question of if a uniform or graduated interval would lead to higher retention rates in long-term memory. Therefore the study presented here made modifications to those studies in cognitive psychology. Apart from theoretical considerations, the modifications also reflected the realities of text-book based instructed second language learning at the university level. Whereas in cognitive psychology participants learn and rehearse words within a short time frame followed by immediate or brief interval tests of recall, participants in the study described here rehearsed words several times over a time span of six to eight days and testing was carried out with a two/four day delay for short-term retention and an eleven-week to two-week delay (depending on the chapter) for long-term retention. An additional test was carried out several months after the participants had finished working with the online vocabulary program (ViVo) that was used for this study.

The results were suggestive of a consistent trend. Across the board, participants of German 100A and German 100B who rehearsed words in a uniform – every two days – interval recalled more words correctly than the graduated group who rehearsed words in a graduated – exponentially expanding – interval. Differences between the two groups were not statistically different in the short-term retention tests. However, in the long-term retention test, that was carried out several months after both groups had rehearsed the target vocabulary, the uniform group did significantly outperform the graduated group. These results support the working of the phonological loop—rehearsing sound sequences strengthens their connections—and the uniform interval seems to be more efficient than the graduated interval for long-term vocabulary retention. A possible explanation might be that the first and second rehearsal of the exponentially expanding (1-1-3-6) interval are not enough to sufficiently strengthen the sequences. However, this issue warrants further investigation.

In summation, this research was designed to look at the question of uniform versus graduated interval vocabulary training and its relationship to long-term retention in the context of an instructed second language learning situation. The principle finding is the trend that on long-term retention, uniform intervals were found to be more effective than graduated intervals.

However, there are certain limitations to this research and its results. First, the study revealed a ceiling effect in the short-term retention tests as was evidenced by the fact that the average scores of participants were very high. It would be useful to further investigate this issue by reducing the number of rehearsals from four to three. With only three rehearsals, it would be

more challenging for learners to recall words correctly in the short-term retention tests which might make it easier to discriminate between the uniform and graduated interval. Alternatively, a larger number of vocabulary items could be included on the chapter tests and the individual words used could be drawn from lower frequency bands, thus lessening the possibility of incidental exposure outside of the ViVo environment. This proposed future research could potentially shed additional light on the effects of uniform versus graduated interval vocabulary rehearsal and the effects on short- and long-term retention.

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AUTHORS' BIODATA

Ulf Schuetze is an Assistant Professor of Second Language Acquisition in the Department of Germanic and Slavic Studies at the University of Victoria. His research interest is in information technology and second language acquisition. His research project on lexical processing brings together linguistics, second language acquisition, cognitive psychology, and computer-assisted language learning.

Gerlinde Weimer-Stuckmann recently completed her MA thesis on lexical processing at the University of Victoria. With over 20 years of language teaching experience in Germany as well as in Canada and as a trained speech pathologist, she has now started her Ph.D. at the University of Waterloo.

AUTHORS' ADDRESSES

Dr. Ulf Schuetze
Dept. of Germanic & Slavic Studies
P.O. Box 3045
University of Victoria
Victoria, BC, V8W3P4, Canada
Email: ulfs@uvic.ca

Ms. Gerlinde Weimer-Stuckmann
Dept. of Germanic & Slavic Studies
Modern Languages Building R. 313
University of Waterloo
200 University West
Waterloo, ON, N2L3G1, Canada
Email: gweimer@uvic.ca