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MEMORY, SECOND LANGUAGE READING, AND LEXICON: A COMPARISON BETWEEN SUCCESSFUL AND LESS SUCCESSFUL ADULTS AND CHILDREN

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1 *Introduction*

A body of research has been investigating the role of working memory (WM) both on first (L1) or second language (L2) acquisition of children and L2 acquisition of high-educated adults. The term working memory refers to the human capacity to temporarily store and manage new information. In this contribution, we want to address the question: What is the role of working memory in L2 acquisition of low-literate, low-educated adults? By low-literate or low-educated adults we refer to adult L2 learners in the range from no schooling at all to maximally two years of secondary education.

In this section, we present an overview of previous literature and research questions. Section 2 focuses on the design of the study we present and Section 3 on the results. In the final section, conclusions will be drawn and suggestions for further research given.

In his review of research on the role of working memory in adult second language learning, Juffs (2006a) pointed out that this role has long been of interest to researchers in L1 and L2 acquisition and that part of the explanation for individual differences among adults in success at learning a second language might be attributable to differences in working memory capacity. The main reason behind this view is that one component of the working memory, the phonological loop (that repeats and stores spoken language), can be considered an on-line capacity for processing and analyzing new verbal information (Baddeley, 1999, 2003; Baddeley, Gathercole & Papagno 1998; Baddeley & Hitch, 1974; Ellis, 2001). If there is a relationship between working memory and processing of verbal information, working memory will also play a role in learning to read (Baddeley & Gathercole, 1992; Carr Payne & Holzman, 1983; Goswami, Ziegler, Dalton, & Schneider; 2001).

However, according to Juffs (2006a: p. 89), "it still is an open question whether low-educated second language and literacy acquisition populations have short-term memory systems that are similar to literate, educated populations, and if so how their WM capacity can be measured." Looking at different measures that have been used, Juffs concludes that the role of the phonological loop has got many advocates and that three types of measures – digit span, word repetition and non-word repetition – have been used most, of which the non-word repetition span is supposed the be by far the best predictor of L2 acquisition. Or, to cite Ellis (1996, p. 102): "To put it bluntly, learners' ability to repeat total gobbledygook is a remarkably good predictor of their ability to acquire sophisticated language skills in both the L1 and the L2."

The conclusions that can be drawn from Juffs' review is, first of all, that the results seem to be very inconsistent and, if significant correlations are found between phonological loop measures and first or second language proficiency measures, the correlations are rather modest. For example, Cheung (1996) found some effects of word span measures in lower proficiency learners but not in higher ones, and did not find any relationship with vocabulary knowledge. Papagno & Vallar (1995) found that non-word repetition accounted for variance in vocabulary, while Juffs (2004, 2005, 2006b) did not find any relationship between word span and vocabulary. Secondly, most of the studies that have been done looked at the predictive value of WM measures of rather highly educated second language learners, not so much of specific LESLLA populations, unschooled illiterate and low-educated L2 learners.

As already noted, illiterates or low-literates are represented only in a few studies. We focus on three of them. The first is a brain-imaging study carried out by Petersson, Reis, Askelof, Castro-Caldas & Ingvar (2000), who found a poor performance on non-word tests of working memory but not on normal word repetition tasks, whereas the results of literates did not differ in word and non-word repetition tasks. Petersson *et al.* report that "learning to read and write during childhood alters the functional architecture of the brain (2000, p. 365)." This implies that knowing an alphabetic system permits literates to process phonological segments (sublexical elements) of unknown words, whereas this is not possible for illiterates.

In the second study, on Brazilian illiterate and semi-literate adults, Loureiro, Braga, Souza, Filho, Queiros & Dellatolas (2004: p.502) found that phonological memory (as measured by real word and non-word repetition tasks) was very low in the illiterate population. The scores for real words were much higher than for non-words. This memory ability was unrelated to letter knowledge. They therefore conclude that phonological memory, phonemic awareness and phonological sensitivity are not related in this population.

The third study, by Kosmiris, Tsapkini, Folia, Vlahou, & Kiosseoglou (2004), confirms Petersson *et al.*'s suggestions. Kosmiris *et al.* (2004, p. 825) compared semantic and phonological processing in three groups: high and low-educated literates and illiterates. They found that semantic processing was unaffected by literacy but positively affected by schooling. However, "explicit processing of the phonological characteristics of material appeared to be acquired with literacy or formal schooling, regardless of the level of education attained: those who had attended school and had acquired symbolic representation could perform the task, but those who had not, did very poorly (2004, p. 825)."

As Juffs concluded, the above studies suggest that establishing a test of working memory for illiterates will be difficult, because illiterates are likely to perform at floor level with non-word repetition tests, and therefore non-word repetition (although advocated to be the best possible measure) might not be a useful instrument for illiterates. More research is needed to find out whether non-word repetition can be used with adult illiterates and whether it correlates with other span measures like digit span and word repetition.

To resume, there is not much research on working memory in which adult illiterates are involved, and no research at all when literacy in L2 is involved. Besides, there are indications that learning to read and write an alphabetic writing system changes phonological processing in adults (Petersson *et al.*, 2000). Lastly, there are several studies on the relationship between working memory and second language (L2) vocabulary for children and adults, respectively, but none in which both groups are compared. Therefore, we wanted to probe the relationship:

- between several working memory measures;
- between these measures and the size of L2 vocabulary, both of adult and child learners; and,
- between working memory measures and basic reading skills or decoding skills.

More particularly, we wanted to compare adults and children in two ways:

- with regard to the scores on working memory tasks, and
- with regard to the correlations between these measures and L2 vocabulary knowledge and reading.

As one of Baddeley's strong claims is that working memory predicts the ease with which a second language is learned, we also wanted to find out if working memory in a group that was defined by their teachers as fast (adult) literacy learners, differs in scores on WM measures from a group of slow or average learners (we will use the term 'average' throughout this paper).

2 *Design of the Study*

2.1 *Participants*

The group of participants in our study consisted of 211 children from two cities in the southern part of the Netherlands and 70 adults from several cites all over the country. Since all adults were L2 learners and only some of the children, the L1 children were left out from the analyses we will present in this paper. As it turned out later, 13 learners from the group of adults had received some schooling in their home-country (ranging from 1 to 10 years). We left them out as well. The age of the adults ranged from 18-61 years, the mean age being 38. Most learners were from Turkey and Morocco; in addition, there was a group with a variety of L1 backgrounds. The children were divided according to their grade in (pre-)school, the adults according to their literacy levels in combination with the general proficiency level as defined by the Common European Framework of Reference for Languages (CEF) (Council of Europe, 2001). Level 1 stands for a very basic level of literacy (A) and a general L2 proficiency level below A1 (the lowest level of CEF), Level 2 stands for a higher level of literacy (B) and a proficiency level below A1 as well; Level 3 corresponds to literacy level C and CEF level A1, and Level 4 to general proficiency (CEF) level A2.[1] The last two groups of learners were extremely hard to find. It required a lot of traveling from city to city to meet them. Table 1 presents the participants in the study, together with relevant background data.

Table 1: Background data of the participants

	N	Gender		Age	Ethnic group		Grade/Level	
Children	116	Male	54	4 - 11 years	Turkish	44	Preschool	33
		Female	62		Moroccan	34	Grade 1-5	83
					Other	38		
Adults	57	Male	7	18 - 61 years	Turkish	4	Level 1	25
		Female	50		Moroccan	36	Level 2	13
					Other	17	Level 3	11
							Level 4	
Total	173							

2.2 Instruments

For this study, two types of span tests were used: a digit span task and a non-word repetition task because, given earlier results discussed above, we were not sure whether those span tasks would measure the same in illiterate learners. In order to gain evidence of a potential relationship between WM capacity and L2 vocabulary learning on the one hand and learning to read on the other, an L2 vocabulary test and a word reading task for decoding fluency were administered.

[1] The Common European Framework describes three levels of language proficiency: that of Basic User (A), Independent (B) and Proficient User (C). Each level is subdivided into two sublevels, e.g., A1 (Breakthrough) and A2 (Waystage). For details see Janssen-van Dieten (2006) and Stockmann (2006).

2.2.1 Digit Span

The digit span task is a subtest of the Wechsler Intelligence Scale for Children (revised version: WISC-R, similar to WAIS-III). Subjects are presented a series of digits and are asked to repeat them in the order they were presented (forward digit span) or starting with the last digit (backward digit span). For the children, both the forward and the backward digit span were used. Since the backward span task turned out to be too difficult for the adults in a pilot study (the first six participants did not understand at all what was required), this part was left out. Digit series started with three digits (e.g., 6-2-9) and went up to eight digits (e.g., 3-8-2-9-5-1-7-4). For practical reasons, the task was carried out in Dutch; it had been checked before the test that participants knew numbers 1 to 10 in Dutch.

2.2.2 Non-Word Repetition

The non-word repetition task (NRT) that is used here was developed by Gerrits (De Bree, Wilsenach & Gerrits, 2004) based on Dollagahan & Campbell (1998). This task has commonly been employed as a diagnostic instrument for young L2 learners from Turkey, Morocco and Surinam to investigate phonological processing. The stimuli were 24 pseudo-words, ranging in syllable length from two (*keefuus*) to six (*peetaaneisookooniеf*). No consonant clusters were used. The standard score of the NRT is the percent of correctly pronounced phonemes. As it is well known that adults have serious problems in acquiring native-like phonological skills (pronunciation), we doubted whether this measure would be adequate for assessing their WM capacity. Therefore, we calculated another score, the number of items that were repeated correctly (NRT span score); this score is comparable to the digit span score. For the NRT span sore, small deviations in the pronunciation of phonemes were not taken into account, e.g. *keefienuu* pronounced as *keefienoe* was accepted as a correct repetition of a three-syllable word.

2.2.3 Vocabulary

To assess receptive vocabulary, a subtest of the TAK ("Language Test for All Children," Verhoeven & Vermeer, 2002) was used. This subtest has the form of a picture selection task and consists of four pictures on each page. The child is asked to point to the right picture (e.g., where is the bike? where do you see someone reading?). This task was also used for the adult learners: the lexical items all relate to frequent Dutch words and belong to the domain of daily life and are of relevance to adults as well. Since for the older children in the sample a reading-based variant of the vocabulary test was used, we could simply use the test score for comparison. Therefore, the estimation of vocabulary size, which can be calculated on the basis of the test scores, was used for group comparisons.

2.2.4 *Word Reading (Decoding Fluency)*

As a word reading task, the first card of the DMT (Three Minute Test) was used. Items on the first card are monosyllabic words without consonant clusters. Subjects were asked to read aloud for one minute. The reading score is the number of correctly read words within one minute. Small deviations in the pronunciation of typical Dutch vowels were not counted as mistakes.

3 *Results*

3.1 *Correlations between Working Memory Measures*

Table 2 presents the correlations between the three WM measures (forward digit span, percentage of correctly repeated phonemes in NRT, and number of correctly repeated syllables in NRT), for all subjects and separately for children and adults.

Table 2: Correlations between forward digit span (DST), percentage of correctly repeated phonemes of the NRT and NRT span score for all participants, and for children and adults separately

	% of correct phonemes NRT	NRT span score
All subjects (N=173)		
Forward DST	.563**	.460**
% of correct phonemes NRT		.643**
Children (N=116)		
Forward DST	.579**	.438**
% of correct phonemes NRT		.619**
Adults (N= 57)		
Forward DST	.527**	.490**
% of correct phonemes NRT		.728**

** p< .01

For all L2 participants, the correlations between the three measures of WM are high and significant (p<.01). The highest correlation is between the two NRT scores, the next highest is between the digit span score and the percentage of correct phonemes on the NRT and the lowest is between the digit span and the NRT span scores. This pattern is the same for the children as for the adults. For the adults, the correlations between two of the three measures are higher than for children, but the pattern again is the same.[2]

These results are comparable to those reported in other studies, as Gathercole & Baddeley (1990) and Papagno & Vallar (1995:104), who suggest that both measures tap the same underlying construct, namely phonological working memory, but in contrast with the results of Snowling, Chiat & Hulme (1991), who claim that a non-word repetition task measures both WM capacity and phonological processing, and De Bree *et al.* (2004), who found that a low score on the NRT phoneme score did not predict a low score on the digit span task (in a population with a risk of dyslexia).

3.2 Working Memory and Vocabulary Size

First, the scores on the WM measures are compared to the estimated vocabulary size of both adults and children (Table 3). Next, the correlations are presented in Table 4.

Table 3: Means, Sd and t-value of WM scores and estimated vocabulary size for adults and children

	Age group	N	Mean	Std. deviation	t-value[3]
Forward DST	child	116	4.29	1.50	2.71**
	adult	58	3.66	1.37	
% of correct phonemes NRT	child	116	85.07	13.19	.88
	adult	57	83.35	9.42	
NRT span score	child	116	11.90	5.02	1.18
	adult	57	10.95	4.85	
Estimated vocabulary size	child	116	5691.48	3552.29	9.07**
	adult	57	2394.11	1149.27	

** $p<.01$

[2] For Dutch L1 children the correlations are respectively .604 (digit span and phoneme score), .540 for digit span and NRT span score, and .590 for the two NRT scores. This pattern slightly deviates from that of the L2 learners.

[3] Both the t-value and the F-value are statistic measures to compare the scores of two or more different groups (in this case children and adults). If, for instance, the t-value exceeds a certain value (1.96), the difference between the groups are considered to be significant, which means that there is only a small chance that the differences did show up accidentally (the p-value).

As Table 3 shows, all WM scores are higher for the children than for the adults. Some research refers to the fact that working memory deteriorates slightly when people are getting older (though with different outcomes). According to Zimmerman & Woo-Sam (1973), the digit span score of the WAIS (Wechsler Adult Intelligence Scale) gradually shows lower scores after the age of 35. On average, the children can repeat between 4 and 5 digits, adults between 3 and 4 digits. While all three WM scores are higher for the children, the difference between children and adults is significant only for the DST. This is probably due to the fact that children work with Dutch digits on a daily basis; illiterate adults do not.

The estimated vocabulary size of the children (mean age 7.6) is significantly higher than that of the adults in the sample, which is not surprising given the fact that children of that age attend school during the entire week, while most adult learners were women without a job who came to the literacy course three times a week on average.

Table 4: Correlations between WM scores and estimated vocabulary size

		Estimated vocabulary size
All subjects (N=173)	Forward DST	.509**
	% of correct phonemes NRT	304**
	NRT span score	.322**
Children (N=116)	Forward DST	.570**
	% of correct phonemes NRT	349**
	NRT span score	363**
Adults (N=57)	Forward DST	.085*
	% of correct phonemes NRT	.041*
	NRT span score	.195*

** p< .01 * p<.05

As shown in Table 4, for the whole group, all working memory scores correlate significantly with vocabulary size (p<.01), but surprisingly enough, the correlation is much higher for the digit span score than for the score that is claimed to be a better predictor of L2 vocabulary, the non-word repetition task (Ellis, 1996; Service, 1992; Service & Kohonen, 1995). When we only consider the children, all working memory correlations with vocabulary are high and significant, and again the digit span provides the highest correlation. A similar finding is reported by Baddeley *et al.* (1998): for 3-year-olds, non-word repetition is more strongly correlated with vocabulary measures than digit span, for 8-year-olds neither span correlates, and for 13-year-olds, only simple digit span is related to vocabulary measures. The mean age of the children in our sample is 7.6 years, which might account for the more important role of the digit span. However, when we focus on the adult learners in our sample, none of the working memory measures in Table 4 correlates significantly with L2 vocabulary size. On the contrary, two of the correlations are close to zero. However, we have to be cautious in drawing conclusions here, given the correlations with L2 proficiency levels that will be presented in subsection 3.4.

3.3 Working Memory and Reading Ability

This subsection on reading ability relates only to the results of the adult learners as we do not have comparable data from the elementary school pupils. In Table 5, the correlations between WM scores and reading scores are provided.

Table 5: Correlations between WM scores and reading score for adults

		Reading score (DMT)
Adults (N=57)	Forward DST	.157
	% of correct phonemes NRT	.229
	NRT span score	.395*

* p<.05

When the correlations of WM scores and word reading scores in Table 5 are compared with the correlations of WM scores and vocabulary size in Table 4, the former are slightly higher, and significant for the NRT span score ($p<.05$). A correlation, however, does not say anything about causality; it might well be that the better reading skills have a positive effect on the ability to repeat longer pseudo-words.

To conclude, for the children in our study we find positive and significant correlations between WM scores and L2 vocabulary, but not for the unschooled adults in our study. Working memory scores do not seem to explain variation in L2 vocabulary. The only significant correlation found in the adult sample is the correlation between non-word span and decoding. The most plausible explanation for that seems to be that literacy favorably affects the ability to remember and repeat longer pseudo-words.

3.4 Other Variables: Duration of Lessons, Length of Residence and Age

One of the variables that might be a good indicator of growth in vocabulary and increase in reading ability in the adults is the number of L2 lessons they attended. Since the WM tasks we used were either in L2 Dutch (digit span) or a non-word repetition task that only consisted of Dutch phonemes, we add the correlations with the WM scores as well. Table 6 presents an overview of these correlations.

Table 6: Correlations WM measures, vocabulary size and reading score with duration of L2 lessons, length of residence and age, for adults (N=57, for reading N=43)

	L2 lessons in months	Length of residence	Age
Forward DST	.168	-.393**	-.265*
% correct phonemes NRT	.366**	-.499**	-.324*
NRT span score	.253	-.521**	-.386**
Estimated vocabulary size	.414**	-.063	-.202
Reading score DMT	.337*	-.280	-.344*

**p<.01 *p<.05

As might be expected, the correlations between number of months of L2 lessons, ranging from less than six months to more than five years, and vocabulary size and reading scores are significant, although not very high. One of the WM scores (i.e., the proportion of correctly pronounced phonemes) also correlates significantly with the number of L2 lessons. It should be noted that pronunciation will get ample attention in L2 lessons, especially in L2 literacy courses.

All correlations with age and length of residence are negative and significant for all three WM scores: the older the learner, the lower the working memory scores are. The negative correlations with length of residence in the Netherlands are probably caused by the fact that this measure is confounded with age. Since there is a negative correlation with age, and most older people have been in the Netherlands much longer than the young people, the correlation with length of residence is also negative.

3.5 L2 Proficiency Levels Compared for WM, Vocabulary Size and Reading Scores

We divided the adult learners according to the literacy level they reached or the level of the class they were attending. This is only a global indication; of course, within each group variation existed. The levels A, B, and C are literacy levels, A1 and A2 are CEF levels of general language proficiency. Table 7 gives an overview of the WM scores, the estimated vocabulary size and the reading scores for the four groups of learners.

Surprisingly, all WM scores in Table 7 (except for the digit span at the level B group) seem to increase with the literacy/L2 proficiency level the students have reached. On all WM measures, the average scores are highest in the highest level group and lowest in the lowest one. The difference between the level groups is significant for the NRT scores, not for the digit span. Pairwise comparisons (Tukey HSD) reveal that only the

Table 7: Working memory scores, estimated vocabulary size, reading scores and F-values for four proficiency levels of learner groups (A, B, C are literacy levels; A1,2 are general L2 proficiency levels)

	Literacy – L2 prof. levels	N	Mean	SD	F-value
Forward DST	A – below A1	25	3.36	1.11	2.46
	B – below A1	13	3.31	1.38	(p=.10)
	C – A1	11	4.27	1.79	
	A2	8	4.38	1.30	
	Total	57	3.67	1.39	
% correct phonemes NRT	A – below A1	25	79.25	9.30	4.54**
	B – below A1	13	84.56	10.29	(p=.007)
	C – A1	11	86.03	6.73	
	A2	8	91.28	5.95	
	Total	57	83.46	9.51	
NRT span score	A – below A1	25	8.24	3.80	10.28**
	B – below A1	13	11.00	3.58	(p=.000)
	C – A1	11	13.09	4.95	
	A2	8	16.00	3.82	
	Total	57	10.89	4.79	
Estimated vocabulary size (TAK)	A – below A1	25	1738.56	903.45	13.23**
	B – below A1	13	2312.85	967.74	(p=.000)
	C – A1	11	2696.91	773.50	
	A2	8	3983.38	920.78	
	Total	57	2369.54	1155.39	
Reading score (DMT)	A – below A1	11	12.18	12.16	14.76**
	B – below A1	13	24.15	13.28	(p=.000)
	C – A1	11	28.00	10.02	
	A2	8	46.88	7.51	
	Total	43	26.30	15.94	

** p<.01

differences between level A2 and literacy level A are significant for the two NRT measures; for the NRT span score, the difference between level A2 and level B and between level A and C was also significant. We have to be cautious here, as the mean age of the groups also differs (respectively 43, 35, 36, and 32 years). The difference between the age groups is also significant (F=2.21, p=0.03).

The same pattern can be observed for estimated vocabulary size and reading score (timed word reading, number of correctly read words per minute). The scores are lowest for the lowest level groups and highest for the highest level groups. For vocabulary size, all pairwise comparisons (Tukey HSD) are significant except for the difference between level A and B and between level B and C; the highest level group differs significantly from all other groups (all p<.05). For reading, the highest level group differs significantly from all other groups, and pairwise comparisons are also significant for the differences between level A compared with C and level B and level A2.

For reasons of presentation, we have clustered the four level groups of adults in slow/average learners and above average learners (or successful learners), who attained proficiency level A1 and/or A2, which is normally not achieved by illiterates. In this way, the differences between the two groups become much more manifest, as can be seen in Table 8.

Table 8: Groups WM scores for average and above average adult literacy learners

	groups	N	Mean	SD	t-value
Forward DST	Average	38	3.32	1.16	-2.74**
	Above average	20	4.40	1.52	p=.008
% correct	Average	38	80.71	9.73	-3.080**
phonemes NRT	Above average	20	88.22	6.60	p=.003
NRT span score	Average	38	9.03	3.84	-4.800**
	Above average	20	14.58	4.58	p=.000

As can be inferred from Table 8, the two groups differ significantly on all working memory scores, with the above average students outperforming the average students. In fact, this information contradicts the absence of correlations with vocabulary size, since here the higher WM scores go together with higher proficiency levels in Dutch.

4 *Conclusion and Discussion*

The conclusions that can be drawn from this study are the following:

- The group of successful (above average) adult learners differs significantly from the average literacy learners on all three WM tests (Tables 7 and 8).
- For adults, no relationship was found between WM tests and vocabulary size (see Table 4).
- For adults, only one significant correlation was found between NRT span score and the word reading score (see Table 5).

The most striking result from the above comparisons is that significant correlations were found between WM scores and vocabulary knowledge for all subjects and for children, but not for adults. It is almost paradoxical that this absence of correlations between WM scores and vocabulary size among adults goes together with significant differences between average and above average learners. There are several potential accounts. First, it may be possible that the vocabulary test used in this study is not an adequate measuring of adult vocabulary knowledge (compare the results of Cheung (1996) and Juffs (2004, 2005, 2006b) who did not find a correlation between word span and vocabulary size). Furthermore, how do we know that high WM scores predict a large vocabulary size and not the other way around, that a large vocabulary size predicts large WM scores? Second, WM scores may be not-so-good predictors of adult L2 vocabulary size, but they may be better predictors of general language proficiency (as good WM scores go together with proficiency level A1 and A2). Third, it may be that the lower mean age of the successful learners is the factor that accounts for the success of the above average group and the lack of success of the average group. Therefore, we should try match the two groups for age and other relevant background variables as well as possible.

The significant correlation we found between the non-word span and the reading score (see Table 5) does not indicate the direction of the relationship: does a higher non-word span cause a better reading score or is a better reader better at repeating non-words?

Further research is needed to disentangle the several potential predictors of L2 acquisition of LESLLA populations more thoroughly, for example by using L1 measures (i.e., in the native language of L2 learners), by designing experiments in which working memory measures are combined with a vocabulary learning intervention program, by looking for more adequate forms of assessment of vocabulary size or by investigating the impact of reading on both working memory and vocabulary growth.

One of the most important implications of this research for L2 acquisition of illiterate or low-educated L2 learners is that teaching matters: not only do vocabulary and reading scores grow with the amount of instruction received (as expected), but working memory also grows. Besides teaching, one of the most stable predictors of L2 acquisition seems to be the opportunities adults get or create to use the second language in contacts with L2-speaking relatives, friends, and colleagues.

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