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WORKING MEMORY, SECOND LANGUAGE ACQUISITION AND LOW-EDUCATED SECOND LANGUAGE AND LITERACY LEARNERS

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1 *Introduction*

The role of memory in language learning has long been of interest to researchers in first and second language acquisition (SLA) (Baddeley, 1999; Ellis, 2001). At an intuitive level, it seems obvious that part of the explanation for individual differences among adults in success at learning a second language (L2) is attributable to differences in memory capacity. In SLA, researchers have focused on short-term rather than long-term memory differences because they think short-term memory is more responsible for differences in language development. The reason for this belief is that short-term memory is an on-line capacity for processing and analyzing new information (words, grammatical structures and so on); the basic idea is that the bigger the on-line capacity an individual has for new information, the more information will pass into off-line, long-term memory. It is an open question whether low-educated second language and literacy acquisition populations (LESLLA) have short-term memory systems that are similar to literate, educated populations, and if so how their working memory capacity can be measured. This paper will survey the literature on this topic, and will make some suggestions about how models of memory (as they have been applied to second language learning) may and may not be applied to LESLLA contexts.

The review is organized as follows. First, different models are presented, along with the principal research results and main areas of disagreement among researchers. Section three deals with working memory and second language acquisition research. Finally, section four addresses how these models may or may not be appropriate to LESSLA contexts.

2 *Models of Working Memory*

In the psychological literature, theories of working memory can be divided into two main approaches, each with their own constructs (or ways of operationalizing working memory) and tests that measure those constructs in individuals. The first is called 'phonological working memory' (PWM) (Baddeley & Hitch, 1974; Gathercole & Baddeley, 1993). PWM tests measure the capacity of an individual to remember a series of unrelated items with covert 'inner speech' rehearsal (Ellis, 2001:34). This ability is measured by requiring participants to remember lists of unrelated digits, real words, or non-words; in *some* versions of this non-word repetition test, these non-words have phonemes that are not in the native language (L1). The second is reading span memory (RSM) (Daneman & Carpenter, 1980). Tests of RSM claim to measure the resources available to *simultaneously* store and process information. RSM tests require participants to read aloud lists of sentences written on cards (or on a computer) and then recall the final word of each sentence *without* covert rehearsal. The key difference between the tests for PWM and RSM is that the RSM requires both processing and storage, whereas the PWM only requires the participant to repeat polysyllabic words or repeat a string of unrelated words correctly. PWM and RSM are traditionally treated as separate (Baddeley & Hitch, 1974; Carpenter, Miyake, & Just, 1994; Daneman & Carpenter, 1980; Roberts & Gibson, 2003; Sawyer, 1999) because scores on the tests do not correlate. Carpenter, Miyake, & Just (1994:1078) specifically state that 'traditional' span measures (digit, word) do not decline with age and do not correlate with sentence comprehension impairment, whereas RSM does decline with age and correlates with sentence comprehension scores. However, debate and speculation remain on the validity of this separation (Ellis, 2005:339). The next two subsections describe these models in more detail.

2.1 Phonological Working Memory

Research into phonological working memory (PWM) (sometimes referred to as phonological short-term memory (PSM)) is primarily associated with the British psychologist Alan Baddeley and his colleagues (Baddeley, 1999; Baddeley *et al.* 1998). Variation in phonological working memory ability is said to be related to language learning in children and adults. The capacity for phonological working memory has been operationalized in two different ways.

The first test is the ability to repeat nonsense words of different syllable length (e.g. 'landiplation', 'geplore'). In some cases, the word to be repeated can be up to nine syllables long (Pappagno & Vallar, 1995). Participants have to repeat the nonsense words *accurately*. The version of the test with non-words that contain unfamiliar sounds is used to assess the ability to encode new phonological sequences because using strings of unfamiliar sounds prevents the participant from accessing stored knowledge to help in the repetition.

The second way phonological working memory is defined is as the ability to reliably remember *lists* of unrelated words in the same order as they were presented (Harrington & Sawyer, 1992; Just *et al.*, 1996; Cheung, 1996). This test is the word *span* or digit *span* test. The presentation of the words can be either in written or aural mode. The test typically begins with five 'lists', with each one containing two words. The length of the list then increases, and can reach up to 10 words. There are five lists at each level (2, 3, 4, word level etc.) to make sure that the participant in the study can reliably remember a list at that particular level. Variations exist on this model, but the basic idea is that individuals vary in their ability to remember lists of items in the same order as they are presented.

Some confusion between the *repetition* task and the simple *span* task exists in the developmental literature (Ben-Yehudah & Fiez, in press). Differences the method used to measure PWM may explain some differences in how useful the tests are in predicting vocabulary size and language development (Cheung, 1996:872), although some researchers suggest that *both* measures tap the same underlying construct, namely PWM (Pappagno & Vallar, 1995;104).

The construct of PWM is related to a larger model of memory, which is described and summarized in detail in Baddeley (2000b). The model is provided in Figure 1. PWM is a measure of the component labeled the 'Phonological Loop' in Figure 1.

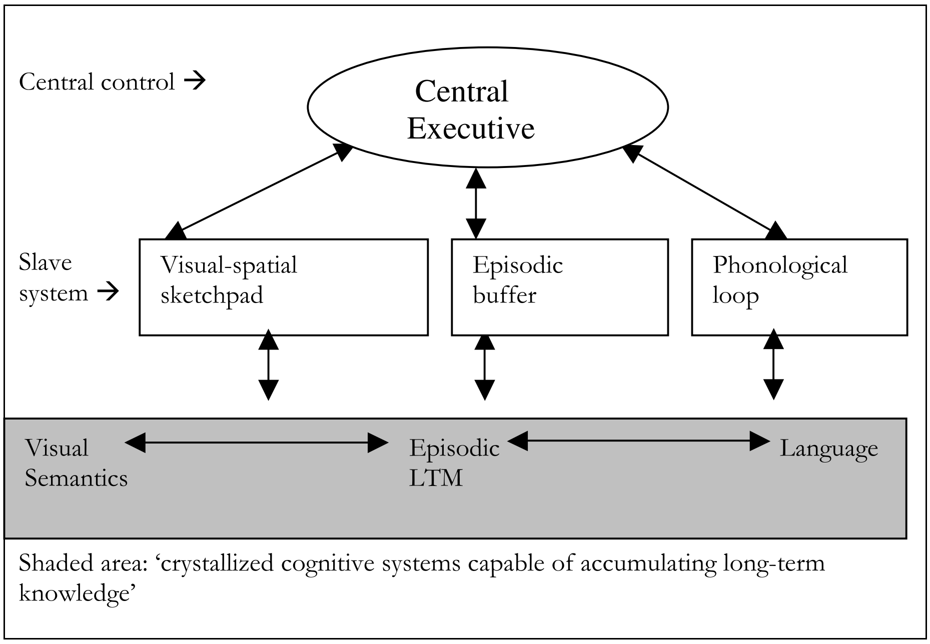


Figure 1: Working Memory Model, Baddeley (2000b).

The model contains other components that are related to PWM. The Central Executive directs attention – obviously one cannot remember something one has not paid attention to. (This claim does not rule out 'subliminal noticing', see Schmidt, 1990). The visual-spatial sketchpad relates to visual memory. An interesting development is the addition of the 'Episodic buffer' to the model. Although the construct 'episodic memory' is not new (see papers in Baddeley *et al.*, 2002), the reason for this modification is that the episodic buffer may explain the behavior of individuals who have phonological loop deficits. These individuals fail or do very poorly on the tests that measure PWM and have difficulty with new memory/learning. However, they can recall narratives and even groups of playing cards that have already passed in games such as contract bridge.

The body of research that claims to support the role of the phonological loop in language learning is extensive (e.g. Baddeley, Gathercole, & Pappagno, 1998; Ellis, 2001). The phonological loop has been implicated in the acquisition of *new* words in *children*, and does not reflect the knowledge that a child already has. Baddeley, Gathercole, & Pappagno (1998:159, Table 1) report that in partial correlations for 3 year-olds, non-word repetition is more strongly correlated with vocabulary measures than digit span (0.31 vs. 0.16 (ns), whereas for 8 year-olds *neither* span correlates (0.22 (ns) vs. 0.23 (ns)). In the data they report for 13 year olds, simple digit span is related to vocabulary measures (r= 0.46, p = 0.05). One point to make here is that the values of r are not very high, e.g. 0.46, which means that the memory test explains only limited amount of the variance. In addition, these 'now you see it, now you don't' effects of different measures of PWM in L1 learning are (for reasons unclear to me) *not* given enough attention in L2 reviews of this literature (but see Cheung, 1996 and Pappagno & Vallar, 1995). Baddeley *et al.* (1998:167; Baddeley, 1999) also discuss research with *adults*. This work supports a role for the phonological loop in learning *new* words in adults; however, it has not been implicated in studies of sentence processing (see section 2.2) or in the acquisition of complex morphosyntax. Before going into the role of PWM in L2 learning further, I turn to a more detailed account of RSM.

2.2 Reading Span and Working Memory

The Daneman & Carpenter (1980) working memory measure (RSM) is the foundation of a large literature in the research into the psychology of reading and comprehension for *adults*. As far as I am aware, RSM measures have not been used to track first language *development* in children, probably because the task would be far too demanding, and because very young children cannot read. Since its introduction of the test in 1980, Just, Carpenter and colleagues (Just *et al.*, 1996) have developed the constrained capacity model to explain individual differences in reading comprehension, speed and accuracy in resolving ambiguous sentences (King & Just, 1991; MacDonald, Just & Carpenter, 1992). The model also relates to differences in scores on standardized tests such as the Scholastic Aptitude Test (SAT). The SAT is a test in the United States that assesses academic preparedness for university study. Daneman & Hannon (2001) report that that the higher one's RSM the better the scores are on these standard tests.

A striking example of the effect of differences in RSM has been reported on reading and processing of individual sentences. Research into the process of reading with eye-tracking and self-paced reading (as well as off-line experiments) has shown that reading involves *incremental* sentence processing. This view holds that a native-speaker reader of an alphabetical script such as English, Dutch, or French does not 'take in' a large amount of text (say 7-10 words) and then decides the appropriate syntax for that set of words. Rather, each word is processed rapidly, and the reader makes assumptions immediately about a possible syntactic structure for that word and the ones that follow. This view accounts for readers being misled by ambiguous sentences, and the subsequent 'surprise' when their reading goes off track because the structure they had assumed turns out to be wrong. This 'surprise' is known as the garden path (GP) effect. This incremental processing theory emphasizes structural, cue-based, and pragmatic principles in its account for the resolution of ambiguity, but also allows a role for frequency effects (see recent papers by Gibson and colleagues, as well as Frazier (1996) and colleagues, and MacDonald and colleagues listed in the references).

An interesting facet of working memory capacity in this model of reading is that the effects of individual memory differences are not fixed, but task-dependent (Just *et al.*, 1996; Miyake & Friedman, 1998). For example, a high-memory-capacity individual will be more accurate in comprehension and resolve an ambiguity at crucial points in reading a sentence such as (1) more quickly than a low capacity individual.

(1) The evidence *examined* by the lawyer convinced the jury.

In (1) the verb 'examined' is *temporarily* ambiguous between a main verb and a reduced relative clause structure. Pragmatic information may be used to quickly resolve the parse in favor of a reduced relative clause reading because 'evidence' is inanimate and unlikely to be the agent of any 'examining'. High WM capacity readers are able to resolve this ambiguity more quickly than low WM capacity readers. According to Just and colleagues, this is because high capacity readers are able to combine pragmatic and syntactic information in parsing more efficiently than low span readers. On the other hand, in a sentence such as (2), while high capacity readers are also more accurate in comprehension, they take *more time* to resolve the parse:

(2) The soldiers *warned* during the midnight raid attacked after midnight.

The account of this difference in processing speed between (1) and (2) for high WM capacity readers is that in (1) high WM individuals are able to make rapid use of pragmatic information, whereas in (2) the ambiguity of 'warned' sets up three *purely syntactic* possible parses: a main verb reading, an intransitive verb reading, and a reduced relative reading. Just and colleagues argue that high WM individuals in this case are able to maintain all three possible parses active in parallel, and hence take *longer* to process them. Ultimately, however, they are more accurate with comprehension probes, whereas low WM capacity individuals are faster, but less accurate. Low WM individuals allow the parse to crash, and therefore read more quickly. However, the cost is that they reject these sentences as implausible or fail to understand the relationships among the noun phrases.

2.3 Issues in PWM and RSM Research

The two constructs of working memory have been the source of considerable debate in the psychology literature. For example, there is a lack of clarity on the domain of memory in the Central Executive, illustrated in Figure 1: Baddeley (2000a,b) disallows the Central Executive any capacity for storage, contra many assumptions by Just, Carpenter and colleagues that the RSM taps 'central executive capacity'. Recall that Daneman & Carpenter (1980:451), King & Just (1991:582), Carpenter, Miyake, & Just (1994:1078) claim that traditional span measures (digit, word) do not decline with age and do not correlate with sentence comprehension impairment, so the phonological loop ought not to be the source of individual differences in this area. However, Jenkins, Myerson Hale & Fry (1999) report that spans increased with age in children and decline with adults in the absence of a secondary task. Moreover, subjects with larger spans showed greater interference effects from a secondary task. This latter finding is not easily explained by current WM theories, which predict that a high WM should be an advantage when the individual is carrying out two tasks. Finally, in his 1999 textbook, Baddeley makes no mention of RSM, and does not cite any of the studies based on the RSM tests.

Also at issue is whether working memory is a domain general capacity (Just, Carpenter & Keller, 1996) or whether separate working memories exist that serve specific domains, e.g. syntactic processing, especially local ambiguity resolution, vs. discourse level integration and comprehension (Waters & Caplan, 1996a,b). Waters & Caplan (1996a:52) argue that the memory load imposed by the RSM 'is unrelated to the computations that the sentence task requires' and that bad performance on the RSM test may reflect a low ability to rehearse words rather than a limited storage capacity. Waters & Caplan (1996b) review studies from impaired populations whose WM capacity is reduced, but who are no worse than 'normals' in comprehending syntactically complex sentences. In addition, Waters and Caplan (1996b) failed to find RSM effects with normals and GP sentences.

Finally, MacDonald & Christiansen (2002) suggest that results of WM/RSM experiments reflect nothing more than language experience. They agree that there are capacity differences, but suggest that capacity differences are due to varying amounts of exposure to text. For example, they argue that superior performance by some individuals on subject relative clauses (e.g. 'the leopard that __ chased the lion climbed the tree') compared to objective relatives (e.g. the leopard that the lion chased __ climbed the tree') appears because good readers simply read more. This argument stems from a theoretical position that denies the existence of a symbolic system whose deployment is constrained by an independent working memory. Just and Varma (2002) strongly dispute points by MacDonald & Christiansen (2002). They refer to specific biological predictions their model has made about patterns of brain activity, which have been borne out. In support of the Just & Varma position one can cite independent studies of Event-Related Potentials (ERP) that do show some effects of High Span vs. Low span subjects with L1 processing of German (Fiebach, Schlesewsky, and Friederici, 2002; Vos, Gunter, Schriefers, Friederici, 2001). Specifically, Vos *et al* (2001) found a three-way interaction among syntactic structure (relative clause type, subject vs. object relative), processing load, and working memory. Hence, when compared to the low span learners, high span learners comprehended object relative clauses better and showed a different pattern of brain activity during processing.

3 Working Memory and Second Language Acquisition

3.1 Early Research on L1 and L2 Working Memory

The literature on working memory and L2 acquisition has emerged later and is much more sparse than in L1 processing and acquisition (Harrington and Sawyer, 1992; Osaka & Osaka, 1992; Osaka *et al.*, 1993). However, since the early 1990s an increasing interest in the topic has developed (Myles *et al.* 1998, 1999; Kroll *et al.*, 2002; Mackey *et al.* 2002, Robinson, 2002; Williams & Lovatt, 2003).

A considerable amount of research exists into the relationship between the simple digit span or non-word span as well as non-word repetition operationalizations of PWM (Cheung, 1996; Ellis & Sinclair, 1996; Service, 1992; Service & Kohonen, 1995). However, the reading span measure of working memory is much less well investigated than the word span measure or non-word repetition measure. Early research concerned the relationship among working memory measures in the L1 and the L2, and their correlations with proficiency scores on standardized tests (e.g. the TOEFL, Test of English as a Foreign Language, and the TOEIC, Test of English for International Communication). Some researchers found reliable relationships between L1 and L2 RSM memory test scores: Harrington & Sawyer, 1992 (r=0.39); Osaka & Osaka, 1992, (r=0.84); Berquist, 1997 (r=0.48); Miyake and Friedman, 1998 (r=0.58). Harrington & Sawyer (1992) found relationships between RSM and reading and grammar scores in their study, but Berquist (1997) did not, and suggested that PWM was a better predictor of proficiency.

Where PWM is concerned, Ellis (1996, 2001) in particular has been a strong advocate of the role of the phonological loop in acquisition across the life span. In a frequently cited paper, Ellis (1996, p 102) claimed that working memory as measured by a *non-word* repetition test was the best predictor of success in L2 learning: "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". However, the research results are somewhat perplexing in that they are inconsistent across levels of learners and L1 groups. Moreover, there are inconsistencies in the relationships between scores on the PWM and RSM, which for L1 speakers are not supposed to correlate. For example, Berquist found that PWM (word span) and RSM correlated, whereas Harrington & Sawyer (1992) did not. In addition, effects of PWM (word span) can be found in lower proficiency learners but not in higher ones, but no relationship with vocabulary knowledge was found (Cheung, 1996:872). Regression analyses using non-word repetition accounts for variance in vocabulary (Pappagno & Vallar, 1995), but not for grammar (Harrington & Sawyer, 1992, p. 31; Service & Kohnen, 1995:170). Williams & Lovatt (2003) report that *rate* of learning is more related to PWM (word span) than the ultimate accuracy. Finally, Juffs (2004, 2005, 2006) did not find any relationship between PWM (word span) and measures of vocabulary and grammar on a standard test of vocabulary and grammar. For L2 learners, it is unclear whether PWM and RSM are related and which *subdomains* of language (vocabulary, morpho-syntax, etc.) and for which *type* of learner working memory capacity can make reliable predictions.

3.2 Working Memory and Second Language Sentence Processing

Juffs & Harrington (1995) were the first L2 acquisition researchers to use a self-paced reading paradigm to look at real-time L2 processing of syntax, although some studies had investigated the lexicon using reaction time data (for a review, see Juffs, 2001). Based on this 1995 study, and further research (Juffs, 1998a,b; Juffs & Harrington, 1996), the indications are that L2 learners process their L2 word-by-word in a similar but not identical way to native speakers. (For literature reviews see Clahsen & Felser, 2006; Fender, 2001.)

The similarities between L1 and L2 processing are that the profiles of decision-making at the word level during processing seem to depend on argument structure, i.e. the number of noun phrases and prepositional phrases that are required by the meaning of the verb. The evidence for this comes from Garden Path (GP) sentences. Recall that a conscious GP effect occurs when the hearer or reader cannot interpret the clause without an effort that brings the structure to his or her *conscious* attention. The situation in (4a) presents such a processing challenge because 'the socks' is initially interpreted as the object of 'mended', but must later be reanalyzed as the subject of the verb 'fell'. In (4b), in contrast, no surprise effect occurs.

(4) a ¿After Mary mended the socks fell off the table.

b After Mary mended the socks they fell off the table.

Non-native speakers seem to be 'Garden-Pathed' in the same way native speakers are (Juffs & Harrington, 1996; Juffs, 2004); they do not seem to accumulate 'chunks' of text before deciding on a parse, but (like native speakers) decide on a structure as soon as possible and then go back and revise it if it is necessary. Furthermore, Juffs (1998a; 2006) showed that resolution of clauses containing reduced relative clauses depended on knowledge of verb requirements and that learners were sensitive to likelihood that lexical material could be the internal argument/object.

However, the differences between native speakers and non-native speakers include evidence for the effects of the L1 in reading. A body of research has investigated knowledge of complex questions in English by speakers whose languages form questions differently. For example, consider the sentence: 'Who does the doctor know __ examined the patient in the hospital?' Many linguists assume that the word 'who' has been 'moved' from the subject position of the second clause in the sentence by a 'rule'; this movement leaves behind a 'trace', indicated by the line ' __' that is between 'know' and 'examined'. The language processor seeks to match the moved 'who' with the trace as soon as possible during reading. In languages like Chinese, the word 'who' remains in the position where the '__' is in the English sentence. In other words, the wh-words do not appear at the beginning of the sentence in these languages. These languages are said to lack 'wh-movement'. Juffs & Harrington (1995) reported data that suggested that the lack of wh-movement in the L1 could affect processing of L2 wh-traces, in particular the extraction of an subject from a subordinate clause. Moreover, there is a hint from data in Juffs (1998a,b) that speakers of head final languages (Subject-Object-Verb order, e.g. Japanese and Korean) appear to slow down on processing verbs and objects, which may suggest an effect of L1 word order. Fender (2003) has subsequently reported that Japanese learners were superior to speakers of Arabic in simple word recognition, whereas Arabic speakers were superior to Japanese in syntactic integration. These results suggest that Japanese learners are at a particular disadvantage in processing head-initial syntax, despite their superior ability to recognize words. In contrast, some researchers have failed to find L1 word order effects in the processing of some structures, e.g. Felser *et al.* (2003); Marinis *et al.* (2005).

Similar to findings for native speakers of English reported by Just and his colleagues, some of the intra-group differences are as great as the between-group differences in studies of second language speakers (Juffs, 1998a,b). It appears that a large amount of individual variation occurs in experiments of this type, whether they are in L1 or the L2. One question, therefore, is whether these individual differences can be tracked to individual differences in working memory, because the processing pressures in garden path sentences provide a context where differences in working memory may affect parsing decisions. Few researchers have reported reliable correlations of WM measures with difficulties in ambiguity resolution, e.g. Williams, Möbius, & Kim (1999). Some effects have been found in the Competition Model framework (Miyake & Friedman, 1998), but the simple three word paradigms used in that research tell us little about processing more than three words, and nothing at all about long-distance dependencies and ambiguity resolution, which are characteristic of natural language systems (Gibson, 1992; Harrington, 2001).

In a series of studies, Juffs (2004, 2005, 2006) sought to investigate these issues with three groups of non-native speakers: Chinese speakers, Japanese speakers and Spanish speakers. Of particular interest was the relationship of PWM to RSM and the role of working memory in explaining individual differences in processing performance, and hence the parsing success or failure that leads to differences in acquisition. The following sentence types were used: garden path sentences (5), reduced relative clauses (6), and wh- questions (7).

(5) ¿After the children cleaned the house looked neat and tidy. (Garden Path)

(6) The bad boys <u>watched</u> *almost every* day were playing in the park.

Sentence (6) is an especially challenging sentence to read because the verb 'watched' is temporarily ambiguous in *three* ways: it could be a either main verb that is transitive, a main verb that is 'intransitive', or a reduced relative clause. In addition, the ambiguity is not resolved until the end of the adverbial 'almost every *day*' because one could imagine, for example, that the words 'almost every' would be followed by a noun that is the direct object of 'watch', e.g. 'watched *almost every episode of the series'.* Hence, 'almost every day' is a very bad cue for ambiguity resolution. Such sentences are especially difficult for some readers, compared to their unambiguous counterparts such as 'The bad boys *chosen* for the game were playing in the park'. The latter sentence is not ambiguous because the morphological shape of 'chosen' alerts the reader to its status. Naturally, for non-native speakers, this prediction assumes that learners know the morphology of past participles in English (see Juffs (1998b, 2006) for discussion).

In (7), one can compare a wh-phrase extracted from a Subject position (7a) to a wh-phrase extracted from an Object position. Research shows that sentences such as (7a) are especially hard to process.

(7) a Who does the nurse know __ saw the patient at the hospital? (finite, Subject)

b Who does the nurse know the doctor saw ___ in his office? (finite, Object)

The results from this series of experiments were not generally supportive of a role for working memory in explaining individual differences in processing of sentences of the three types in (5) – (7) or in explaining differences in general proficiency. To summarize the results, Juffs (2004, 2005, 2006) reports that a relationship existed between PWM and RSM for the Japanese and the Spanish-speaking learners, but no such relationship was found for Chinese participants in the study. This pattern, or lack of a pattern, is not predicted by the L1 literature (which predicts no relationship between PWM and RSM), and is not consistent across L2 groups.

For the Chinese-speaking and the Japanese-speaking participants, no relationship between working memory scores and general proficiency test scores was found. For the Spanish-speaking learners, a very weak relationship between the RSM and the general proficiency emerged, but no relationship between PWM (word span) and general proficiency.

In reading sentences such as (5), only a very marginal effect of PWM was found to exist, and only if all the data were aggregated. For processing times during reading of the most memory-taxing parts of sentences in (6) and (7), i.e., the main verbs, differences in working memory did not correlate with individual differences in reading time. However, the first language was a reliable predictor of difficulty. This L1 influence was due more to structural properties of the first language rather than script (writing system), because the Chinese (logographic) and Spanish (alphabetic) speakers patterned together, and the Japanese speakers (mixed logographic and syllabary) behaved differently. The Japanese speakers had particular problems processing finite verbs.

4 *Working Memory and Less-Educated Second Language Learners*

To establish differences in working memory for learners who are low educated and/or non-literate will be a challenge. The difficulties for these populations in completing psychometric tests have been well documented since Luria (1976). Even for people from western cultures, it is necessary to consider cultural contexts when 'testing' non-literate and less-educated learners. For example, Gonzalez *et al.*, (2004, p. 267) reported that in two tasks of verbal fluency, non-literate participants were not different from literate participants with verbal fluency tasks that were related to shopping, but were reliably different in a task that involved animals. They attribute the interaction of literacy with task type to cultural differences between literates and non-literates of *similar* background (i.e., in Portugal). One can only imagine how magnified such differences would be in samples drawn from populations as different as literate native speakers and non-literate non-native speakers.

As already noted, the research on working memory and (second) language learning is limited and has not produced replicable results in some contexts. Naturally, work on memory and LESLLA populations with working memory is very limited indeed, given the cultural assumptions that learners bring to 'testing'. By cultural assumptions, I mean that LESLLA populations do not have a mental schema for what they should do in a test situation or what kind of 'event' a test is in some cases. A search of the Linguistics and Behavior Abstracts, using the key words 'memory' and 'illiterate', resulted in only 21 hits, and a search using the key words 'memory', 'literacy' and 'bilingualism' resulted in only six hits. (I note that the term 'illiterate' is not one that is preferred among LESLLA researchers. However, it is indeed used in the literature in psychology.)

In spite of the limited amount of research, one can make some observations where working memory, reading and LESLLA populations are concerned. It is almost too obvious to state that students who have low levels of literacy (and therefore low levels of computer literacy) will not be able to complete tasks that are routinely administered to college-age and college-educated native speakers. This effectively rules out the RST as a measure of working memory for non-literate participants, and leaves PWM and measures that tap that capacity via non-technological means as plausible ways to measure working memory in LESLLA populations.

In one of the few papers to emerge from the literature, Loureiro *et al.* (2004, p. 502) report on a study of 97 Brazilian illiterate [sic] and semi-literate adults. They found that phonological memory (as measured by real word and non-word repetition tasks) was very low in the population they term 'illiterate' (68 out of their total 97 participants). The scores for real words were much higher than for non-words. They also report that 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.

In another study, Petersson *et al.* (2000) published brain-imaging results that suggest a reason for poor performance on non-word tests of working memory in non-literate populations. Petersson *et al.* (2000:365) report that 'learning to read and write during childhood alters the functional architecture of the brain'. The result that is particularly relevant for PWM is that literates do not differ in word and non-word repetition tasks, but illiterates do differ. Petersson *et al.* (2000:373) interpret the patterns of brain activity to indicate that 'literates automatically recruit a phonological processing network with sufficient competence for sublexical processing and segmentation during simple immediate verbal repetition, whether words or pseudowords, while this is not the case for the illiterate group.' The implication is that knowing an alphabetic system allows literates to process phonological segments (sublexical elements) of unknown words, whereas this is not possible for illiterates. Moreover, Kosmiris *et al.* (2004)'s findings that suggest level of literacy is a factor in phonological tasks is an important confirmation of suggestions made by Petersson. In their study, Komiris *et al.* (2004, p. 825) compare semantic and phonological processing in three groups: high and low educated literates and non-literates. They found that semantic processing was unaffected by literacy, but augmented by schooling; in contrast Komiris *et al.* (2004, p. 825) state that: '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'.

Exploring the implications of this research for non-literate adult learners of a second language awaits further research. A pessimistic view might be that if we assume a critical period for language (DeKeyser, 2000; Johnson & Newport, 1989), then learning a new language will be particularly hard for non-literate adults because they will find the L2 especially challenging because by definition it consists of 'pseudo-' or 'non' words for them. However, some caution is in order before one becomes too pessimistic. First, debate on the critical period continues, even for phonology (e.g., Birdsong, 2005; Flege *et al.*, 2005), and it may be that other factors such as motivation, exposure, and culture play an even greater role than age in predicting success. One must also take care in how one defines success in a second language, since success probably goes beyond a definition based narrowly on morpho-syntactic and phonological features to one based on the ability to participate meaningfully in another culture. In addition, evidence exists that some illiterates can become literate in their L2 as adults; this is an achievement that should not be possible if a true neurally based-critical period exists. Finally, differences among children in non-word repetition capacity exist, and differences do predict vocabulary size and growth in these children. Since children are not literate at age 3, and can learn language, the implication is that the phonological loop for non-literates might still be a useful measure to explore.

In general, the results in this literature suggest that establishing a test of working memory for non-literates will be difficult, because non-literates are likely to perform at floor level with non-word repetition tests. Without a *range* in scores, there can be no correlation with other language proficiency measures, not even those that are not related to literacy. Since pseudo-words are not processed in the same way in illiterates as they are in literates, real word and digits in the L1 could possibly be used exclusively. Overall, given that some researchers (e.g. Pappagno & Vallar, 1995; Williams & Lovatt, 2003) have used span tasks successfully, the span tasks hold out the most promise for preliminary research with illiterates. For less-educated learners who are somewhat literate in their first language, use of PWM repetition seems plausible based on Kosmiris *et al.* (2004)'s findings. Researchers may want to begin by testing students who are less-educated, but literate, with a word span or digit span from their own language and then follow up with a non-word repetition task if the establishment of a measure of working memory that could predict L2 acquisition is desired.

Finally, Baddeley's construct of the 'episodic memory buffer' may have some promise as a test for the ability to relate long-term knowledge and memory. Differences may exist in the ability to recall characteristics that are associated with known words and construct imaginary situations with those words. For example, Baddeley (2000b) suggests that when accessing long-term memory for use on-line, one could imagine an exercise that would require a participant to think about how an elephant would perform as an ice-hockey player. This novel situation would require the participant to hold in memory the characteristics of elephants (large, ungainly, long trunk) and ice hockey (slippery surface, fast, violent) to construct a scenario: an elephant might play well in goal, be slow, and able to 'body-check' effectively. Differences in the ability to access such knowledge and construct 'new' or imaginary situations with that knowledge might be used to predict language learning outcomes. This task may be particularly promising because some researchers report that the participants who are most successful at the RSM task are those participants who covertly construct a story with the words that are the target of recall, even though they are not supposed to engage in covert rehearsal (Osaka & Osaka, 1992; Juffs, 2004). Hence, episodic memory may mediate between visual spatial long-term memory and long-term memory for language.

The problem with the episodic buffer is that it is an innovation in the model, and as far as I am aware, no tests of episodic working memory have been established, at least not with the 'pedigree' of the PWM and the RSM. Indeed, in his introduction to the edited volume on episodic memory, Baddeley (2002:7) writes: 'I was tempted to crash the episodic memory party with a presentation on the buffer, ..., [but] at under 1 year old, the episodic buffer is a little young for parties.' Moreover, questions must remain about this construct, since it has only been proposed on the basis of the study of patients who have medically defined memory and language deficits, which is not the case for LESLLA (Baddeley, 2002, Jefferies *et al.*, 2004).

5 Conclusion

The role of working memory in explaining individual differences in L2 learning has a history of less than twenty years. Many problems remain in replicating the relationships between PWM, RSM, language proficiency and reading even when experimental participants are literate L2 learners. The role of the L1 appears more important than differences in working memory in explaining performance on some on-line processing and reading tasks (c.f. Marinis *et al.*, 2005). Moreover, the little research that does exist with non-literate populations suggests that they perform poorly on such tests and that literacy may change brain architecture to the extent that non-word tests may not be useful as a measure of working memory. Given the cultural assumptions that decontextualized psychometric tests make, and the problems that LESLLA populations have in understanding such tests, extreme caution is necessary before any predictions or conclusions about the abilities of non-literate and low-educated learners' ability to succeed in acquiring proficiency in an L2 can be made on the basis of current tests of working memory.

References

Baddeley, A. D., & Hitch, G. (1974). Working memory. In G. H. Bower (Ed.), *The psychology of learning and motivation* (Vol. 8, pp. 47-89). New York: Academic Press.

Baddeley, A.D. (1999). *Essentials of Human Memory*. Hove: Psychology Press.

Baddeley, A.D. (2000a). Short-term and working memory. In E. Tulving & F. Craik (Eds.), *The Oxford Handbook of Memory* (pp. 77-92). New York: Oxford University Press.

Baddeley, A.D. (2000b). The episodic buffer: a new component of working memory? *Trends in Cognitive Sciences,* 4, 417-423

Baddeley, A.D. Aggleton, J.P. & Conway, M.A. (Eds.) (2002). *Episodic Memory: New Directions in Research*. New York: Oxford University Press.

Baddeley, A.D., Gathercole, S., & Pappagno, C. (1998). The phonological loop as a language learning device. *The Psychological Review,* 105, 158-173.

Ben-Yahudah, G., & Fiez, J. (in press). Development of verbal working memory. In D. Coch., K. Fischer & G. Dawson (Eds). *Human Behavior and the Developing Brain*, 2nd edition.

Berquist, B. (1997). Individual differences in working memory span and L2 proficiency: capacity or processing capacity? *Proceedings of the GALA '97 Conference on Language Acquisition*, Edinburgh, UK.

Birdsong, D. (2005). Nativelikeness and non-nativelikeness in L2A research. *International Review of Applied Linguistics,* 43, 319-328.

Caplan, D., & Waters, G. S. (2002). Working memory and connectionist parsers: a reply. *Psychological Review,* 109, 66-74.

Carpenter, P., Just, M. A., & Reichle, E. D. (2000). Working memory and executive function. *Current Opinion in Neurobiology,* 10, 195-199.

Carpenter, P., Miyake, A., & Just, M. (1994). Working memory constraints in comprehension: evidence from individual differences, aphasia, and aging. In A. Gernsbacher- Morton (Ed.), *Handbook of Psycholinguistics* (pp. 1075-1122). San Diego: Academic Publishers.

Cheung, H. (1996). Non-word span as a unique predictor of second language vocabulary learning. *Developmental Psychology,* 32, 867-873.

Clahsen, H., & Felser, C. (2006). Grammatical processing in language learners. *Applied Psycholinguistics*, 27, 3-42.

Daneman, M., & Carpenter, P. (1980). Individual differences in working memory and reading. *Journal of Verbal Learning and Verbal Behavior,* 19, 450-466.

Daneman, M., & Hannon, B. (2001). Using working memory theory to investigate the construct validity of multiple-choice reading comprehension tests such at the SAT. *Journal of Experimental Psychology: General,* 130. 208-233.

Ellis, N. C. (1996). Phonological memory, chunking, and points of order. *Studies in Second Language Acquisition,* 18, 91-126.

Ellis, N. C. (2001). Memory for language. In P. Robinson (Ed.), *Cognition and second language instruction* (pp. 33-68). New York: Cambridge University Press.

Ellis, N. C., & Sinclair, S. (1996). Working memory in the acquisition of vocabulary and syntax. *Quarterly Journal of Experimental Psychology,* 49, 234-250.

Felser, C., Roberts, L., & Marinis, T. (2003). The processing of ambiguous sentences by first and second language learners of English. *Applied Psycholinguistics,* 24, 453-489.

Fender, M. (2001). A review of L1 and L2 ESL word integration skills and the nature of L2/ESL word integration development of lower level text processing. *Language Learning,* 51, 319-396.

Fender, M. (2003). English word recognition and word integration skills of native Arabic-speaking and Japanese-speaking learners of English as a Second Language. *Applied Psycholinguistics,* 24, 289-315.

Fiebach, C. J., Schlesewsky, M., & Friederici, A. D. (2002). Separating syntactic memory costs and syntactic integration costs during parsing: the processing of German wh-questions. *Journal of Memory and Language,* 47, 250-272.

Flege, J. E., Birdsong, D., Bialystok, E., Mack, M., Sung, H., & Tsukaa, K. (2005). Degree of foreign accent in English sentences produced by Korean children and adults. *Journal of Phonetics,* 33, 262-290.

Friedman, N. P., & Miyake, A. (2004). The reading span test and its predictive power for reading comprehension ability. *Journal of Memory and Language,* 51*,* 136-158.

Gathercole, S. E., & Thorn, A. S. C. (1998). Phonological short-term memory and foreign language learning. In A. F. Healy & L. E. Bourne (Eds.), *Foreign language learning: psycholinguistic studies on training and retention* (pp. 141-158). Mahwah, NJ: Erlbaum.

Gibson, E. (1992). Review article: On the adequacy of the Competition Model. *Language,* 68*,* 812-830.

Gonzalez da Silva, C., Petersson, K. M., Faisca, L., Ingvar, M., & Reis, A. (2004). The effects of literacy and education on the quantitative and qualitative aspects of semantic verbal fluency. *Journal of Clinical and Experimental Neuropsychology*, 26, 266-277.

Harrington, M. W. (2001). Sentence processing. In P. Robinson (Ed.), *Cognition and second language instruction* (pp. 91-124). New York: Cambridge University Press.

Harrington, M.W., & Sawyer, M. (1992). L2 working memory capacity and L2 reading skills. *Studies in Second Language Acquisition,* 14, 1, 25-38.

Jefferies, E., Ralph, M. A. L., & Baddeley, A. D. (2004). Automatic and Controlled Processing in Sentence Recall: The Role of Long-Term and Working Memory. *Journal of Memory and Language,* 51, 623-643.

Jenkins, L., Myerson, J., Hale, S., & Fry, A. (1996). Individual and developmental differences in working memory across the life span. *Psychonomic Bulletin and Review,* 6, 28-40.

Johnson, J., & Newport, E. (1989). Critical period effects in second language learning: the influence of maturational state on the acquisition of English as a second language. *Cognitive Psychology,* 21, 60-99.

Juffs, A. (1998a). Main verb vs. reduced relative clause ambiguity resolution in second language sentence processing. *Language Learning,* 48, 107-147.

Juffs, A. (1998b). Some effects of first language argument structure and syntax on second language processing. *Second Language Research,* 14, 406-424.

Juffs, A. (2001). Psycholinguistically-oriented second language research. *Annual Review of Applied Linguistics,* 21, 207-223.

Juffs, A. (2004). Representation, processing and working memory in a second language. *Transactions of the Philological Society,* 102, 199-226.

Juffs, A. (2005). Some effects of first language and working memory in the processing of long distance wh- questions. *Second Language Research*, 21, 121-151.

Juffs, A. (2006). Processing reduced relative versus main verb ambiguity in English as a Second Language: A replication study with working memory. In R. Slabakova, S. Montrul & P. Prevost, (Eds.), *Inquiries in Linguistic Development in Honor of Lydia White*. (pp. 213-232). Amsterdam: John Benjamins.

Juffs, A., & Harrington, M. (1995). Parsing effects in L2 sentence processing: Subject and object asymmetries in *wh*-extraction. *Studies in Second Language Acquisition,* 17, 483-516.

Juffs, A., & Harrington, M. (1996). Garden path sentences and error data in second language sentence processing research. *Language Learning,* 46, 286-324.

Just, M. A., & Carpenter, P. (1992). A capacity theory of comprehension: individual differences in working memory. *Psychological Review,* 99, 122-149.

Just, M. A., & Varma, S. (2002). A hybrid architecture for working memory: Reply to MacDonald and Christianson 2002. *Psychological Review,* 109, 55-65.

Just, M. A., Carpenter, P., & Keller, T. A. (1996). The capacity theory of comprehension: new frontiers of evidence and arguments. *The Psychological Review,* 103, 773-780.

King, J., & Just, M. A. (1991). Individual differences in syntactic processing: the role of working memory. *Journal of Memory and Language,* 30, 580-602.

Kosmidis, M. H., Tsapkini, K., Folia, V., Vlahou, C. H., & Kiosseoglou, G. (2004). Semantic and phonological processing in illiterates. *Journal of the International Neuropsychological Society*, 10, 818-827.

Kroll, J., Michael, E., Tokowicz, N., & Dufour, R. (2002). The development of lexical fluency in a second language. *Second Language Research,* 18, 137-171.

Loureiro, C. d. S., Braga, L. W., Souza, L. d. N., Filho, G. N., Queiroz, E., & Dellatolas, G. (2004). Degree of illiteracy and phonological and metaphonological skills in unschooled adults. *Brain and Language,* 89, 499-502.

Luria, A. R. (1976). *Cognitive development, its cultural and social foundations*. Cambridge, MA: Harvard University Press.

MacDonald, M. C. (1993). The interaction of lexical and syntactic ambiguity. *Journal of Memory and Language,* 32, 692-715.

MacDonald, M. C. (1994). Probabilistic constraints and syntactic ambiguity resolution. *Language and Cognitive Processes,* 9, 2, 157-201.

MacDonald, M. C., & Christiansen, M. H. (2002). Reassessing working memory: comment on Just and Carpenter 1992 and Waters and Caplan 1996. *Psychological Review,* 109, 35-54.

MacDonald, M. C., Pearlmutter, N. J., & Seidenberg, M. S. (1994). The lexical nature of syntactic ambiguity resolution. *Psychological Review,* 101, 4, 676-703.

MacDonald, M.C., Just, M., & Carpenter, P. (1992). Working memory constraints on the processing of syntactic ambiguity. *Cognitive Psychology,* 24, 56-98.

Mackey, A., Philp, J., Egi, T., Fujii, A., & Tatsumi, T. (2002). Individual differences in working memory, noticing of interactional feedback and L2 development. In P. Robinson (Ed.), *Individual differences and instructed language learning* (pp. 181-209). Philadelphia: John Benjamins.

Marinis, T., Roberts, L., Felser, C. & Clahsen, H. (2005). Gaps in second language sentence processing. *Studies in Second Language Acquisition*, 27, 53-78.

Miyake, A., & Friedman, N. F. (1998). Individual differences in second language proficiency: working memory as language aptitude. In A. F. Healy & L. E. Bourne

(Eds.), *Foreign language learning: psycholinguistic studies on training and retention* (pp. 339-364). Mahwah, NJ: Erlbaum.

Myles, F., Hooper, J., & Mitchell, R. (1998). Rote or rule? Exploring the role of formulaic language in the foreign language classroom. *Language Learning,* 48, 323-364.

Myles, F., Mitchell, R., & Hooper, J. (1999). Interrogative chunks in French L2: A basis for creative construction? *Studies in Second Language Acquisition,* 21, 49-80.

Osaka, M., & Osaka, N. (1992). Language independent working memory as measured by Japanese and English reading span tests. *Bulletin of the Psychonomic Society,* 30, 287-289.

Osaka, M., Osaka, N., & Groner, R. (1993). Language independent working memory as measured by Japanese and English reading span tests. *Bulletin of the Psychonomic society,* 31, 117-118.

Papagno, C., & Vallar, G. (1995). Verbal short-term memory and vocabulary learning in polyglots. *Quarterly Journal of Experimental Psychology*, 48A, 98-107.

Petersson, K. M., Reis, A., Askelof, S., Castro-Caldas, A., & Ingvar, M. (2000). Language processing modulated by literacy: a network analysis of verbal repetition in literate and illiterate subjects. *Journal of Cognitive Neuroscience*, 12, 364-382.

Roberts, R., & Gibson, E. (2003). Individual differences in sentence memory. *Journal of Psycholinguistic Research,* 31, 573-598.

Robinson, P. (2002). Effects of individual differences in intelligence, aptitude and working memory on incidental SLA. In P. Robinson (Ed.), *Individual differences and instructed language learning* (pp. 211-251). Philadelphia: John Benjamins.

Schmidt, R. (1990). The role of consciousness in second language learning. *Applied Linguistics,* 11, 2, 129-158.

Service, E. (1992). Phonology, working memory, and foreign-language learning. *Quarterly Journal of Experimental Psychology,* 45A, 21-50.

Service, E., & Kohonen, V. (1995). Is the relation between phonological memory and foreign language learning accounted for by vocabulary acquisition. *Applied Psycholinguistics,* 16, 155-172.

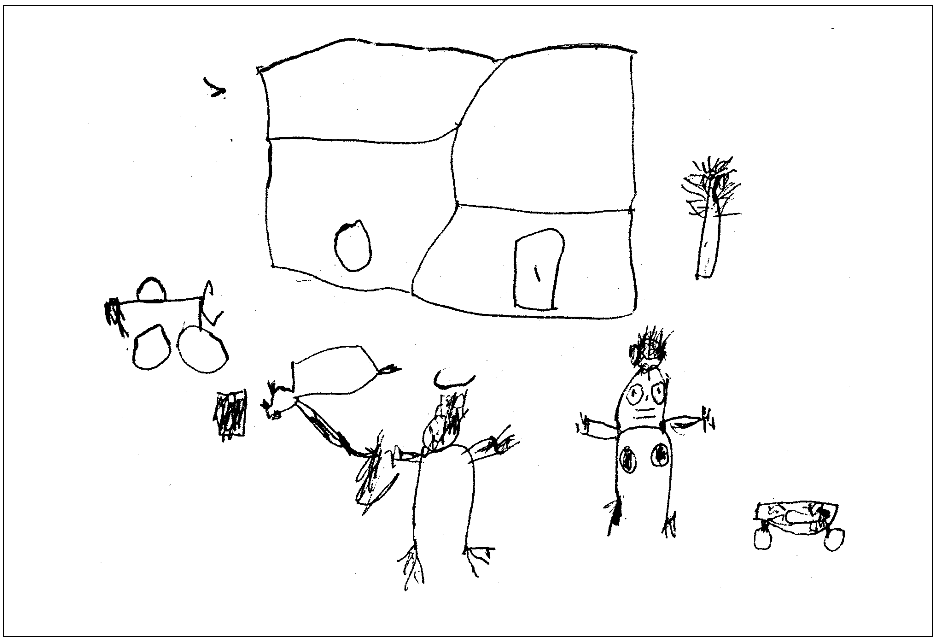
Vos, S. H., Gunter, T. C., Schriefers, H., & Friederici, A. D. (2001). Syntactic parsing and working memory: the effects of syntactic complexity, reading span and concurrent load. *Language and Cognitive Processes,* 16, 65-103.

Waters, G. S., & Caplan, D. (1996a). Processing resource capacity and the comprehension of garden path sentences. *Memory and Cognition,* 24, 342-355.

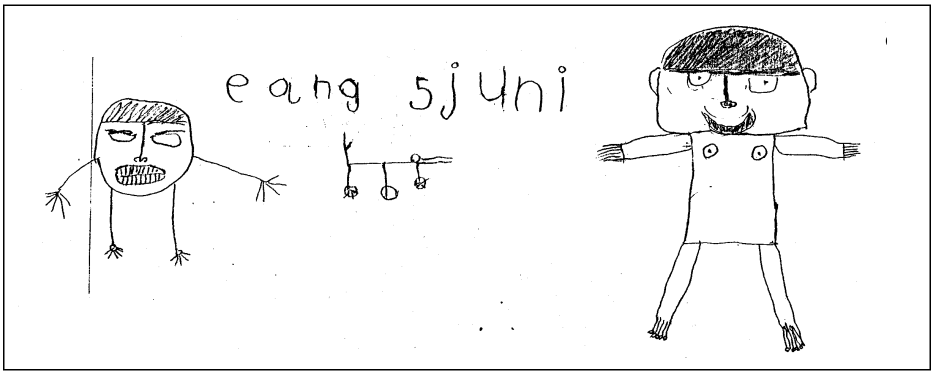
Waters, G. S., & Caplan, D. (1996b). The measurement of verbal working memory capacity and its relation to reading comprehension. *The Quarterly Journal of Experimental Psychology,* 49A, 51-79.

Waters, G. S., & Caplan, D. (1996c). The capacity theory of sentence comprehension: Critique of Just and Carpenter (1992). *Psychological Review,* 103, 4, 761-772.

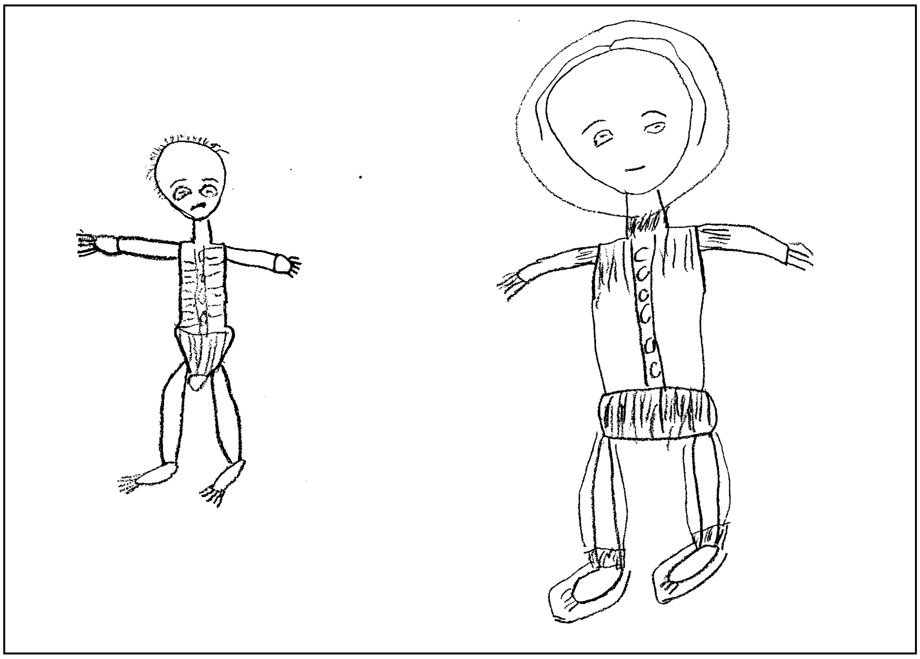
Williams, J. N., & Lovatt, P. (2003). Phonological Memory and Rule Learning. *Language Learning,* 53, 67-121.



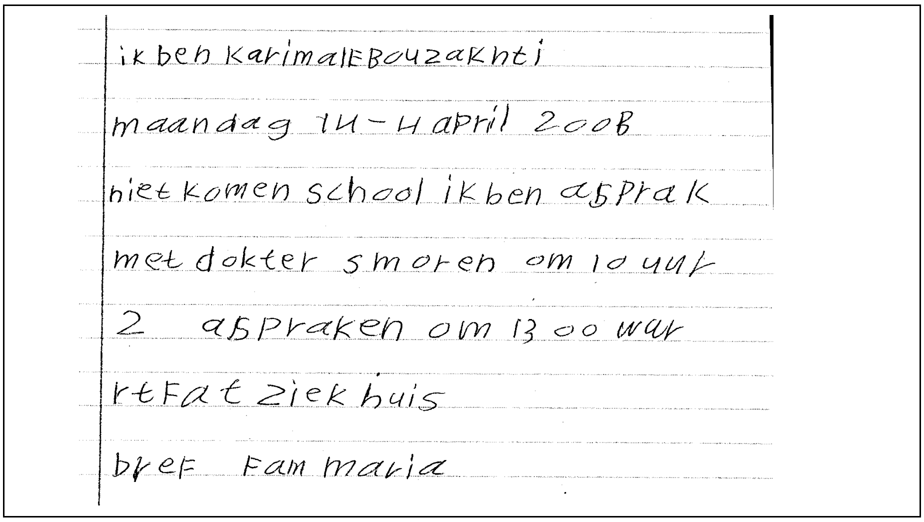
Drawing by Bya, a 24-years-old literacy student with a Berber background, after one year of courses not only in Dutch and literacy, but also in cycling and sewing. She is mother of two sons. The drawing shows herself with the baby carriage, a man walking a dog (with dog shit on the pavement). The drawing was made in function of a lesson on prepositions (next to, in front of, in, etc.).



Drawing by Eang, a 60-year-old Khmer (Cambodian) refugee, after one year SLA and literacy instruction. She learnt how to read and write her name and the date (June, 5) in Dutch as her second language. It is a double self-portrait, first she represented herself as a stick figure, then, after looking at her neighbor's drawing, as a woman with a laughing mouth, breasts, and a substantial body. In the middle a bike (one pedal between two wheels). The drawing was made in a lesson on transport (How do you get to school?).



Portrait of Fouzia and her baby. The baby is a bit 'skinny', as Fouzia told, because he/she has ten weeks more to grow, so you can only see ribs and bones, the skin is not yet there.



ik ben KarimaIEBouzaKhti
maandag 14-4 april 2008
niet komen school ik ben afsprak
met dokter smoren om 10 uur
2 afspraken om 13 00 uur
rtfat ziek huis
bref fam maria

This letter is written by Karima, a 23 year-old literacy student from Morocco. Her first name and her family name are on the top. She proves to know the functional purpose of writing: sending a message to the teacher when she cannot come to school. She has to see the doctor at ten in the morning; the second visit is to the doctor in the Radboud hospital (rtfat ziekhuis). She closes off by writing the name of the addressee: her teacher Maria.

Literacy classes in the USA

Literacy classes in the USA

Dutch literacy class

Modern technology in literacy classes