

Phonological memory in language development, second-language learning and reading

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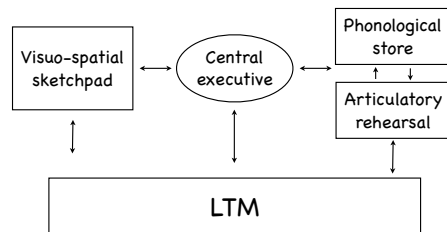
A connection between phonological working memory and language development

- two longitudinal studies of nonword repetition and language acquisition in the 1980's:
 - Sue Gathercole studied L1 development from age 4
 - I studied L2 (English) learning in Finnish children from age 9

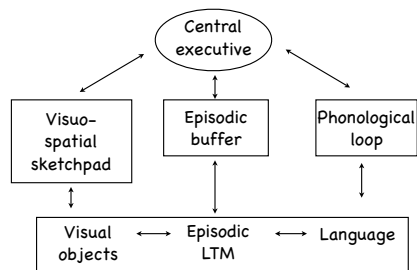
- both studies found a connection between pseudoword repetition and language learning (Gathercole & Baddeley, 1989; Service, 1989)
- both studies interpreted their findings in terms of phonological working memory (WM)

- working memory refers to the kind of memory that we use to temporarily store and process information when we perform everyday tasks
- e.g., when somebody spells their name to us we have to represent the letter names, transform them to letters and assemble the name from the letters
- this is easier when the letter names are highly familiar

**Working memory according to Baddeley and Hitch
(Baddeley, 1986)**

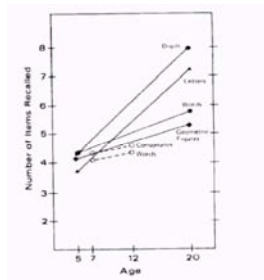


Working memory according to Baddeley (2003)

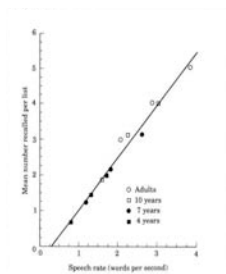


- children's performance in WM tasks improves with age

Development of memory spans for different types of material



Speech rate and phonological STM



- an expertise account of development:
 - WM capacity stays the same but familiarity with content increases with age (cf. Case, 1982; Ottem, Lian & Karlsen, 2007)

- learning foreign languages is a great challenge in countries whose native language is not a world language
- (however, even Finnish can be useful...
- ... for understanding fantasy languages in, e.g., The Lord of the Rings or Clockwork Orange)

Finland is not the only country with language learning blues



Finnish children learning English

- 1984–1987, a longitudinal study of 44 Finnish children progressing from grade 3 to grade 6
- hypothesis based on Baddeley & Hitch framework: the amount of language that can be stored in the phonological loop affects learning of new language

- the main result of the thesis (Service, 1989) was that the ability to accurately repeat pseudowords that sounded like English in the autumn of the 3rd form predicted both English school report mark and scores in a test in the spring of the 6th form
- thus, phonological STM accuracy appeared to be related to L2 learning
- articulation time (RT or duration) did NOT predict learning

This result has been replicated many times for beginning L2 learning, e.g.:

- Service & Craik (1993)
- Lehto (1995)
- Service & Kohonen (1995)
- Cheung (1996)
- Atkinson & Baddeley (1998)
- Dufva & Voeten (1999)
- Masoura & Gathercole (1999)
- Hu (2003)
- Speciale, Ellis, & Bywater (2004)
- French (2006)

Studies of both first and second language learning lead to a general hypothesis:

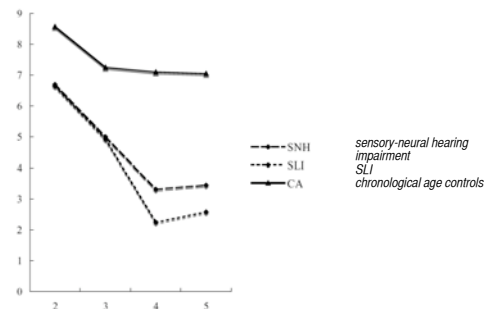
- the phonological loop is a language acquisition device (Baddeley, Gathercole & Papagno, 1998)
- phonological working memory appears to be especially important for vocabulary acquisition
 - a novel word form has to be first represented in WM before it can be stored in LTM

- the most common measures of phonological STM are

- digit span: 3-7-4-8-0-2-1
- pseudoword repetition: *nottyfomal*, *nabbosam*, *möhmäröinen*
- pseudoword span: *ponaf-tegin-nabik*
- pseudoword matching span: 1) *ponaf-tegin-nabik*
2) *tegin-ponaf-nabik*

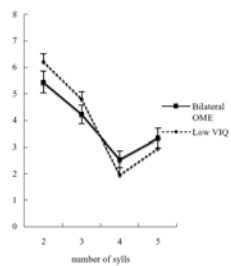
- children with specific language impairment (SLI) are especially poor at repeating pseudowords (e.g., Gathercole, 1989; Estes, Evans, & Else-Quest, 2007)
- their deficit may be qualitatively different from that of children with hearing loss

Briscoe, Bishop, and Norbury (2001): Repeating pseudowords of different length



- Gathercole, Tiffany et al. (2005): the effect of hearing loss due to OME on phonological memory
- OME was not associated with lower digit span in 5-year-olds
- pseudoword repetition was impaired
- the profile was different from children with a low VIQ but normal PIQ (> 85)

Gathercole, Tiffany et al. (2005): Low verbal IQ vs. acute hearing loss



We (Service, Maury ja Luotoniemi, 2007) investigated

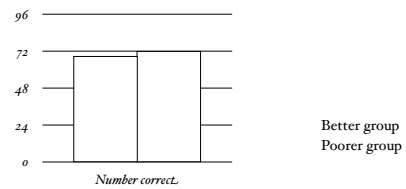
- whether good phonological STM (here = pseudoword span) is associated with better incidental learning of new word forms
- subjects: 46 students, among whom we selected the 16 with the best spans and 16 with the poorest spans

- Phase 1 (group selection):
 - pseudoword span: how many pseudowords can be immediately recalled in the correct order (e.g., *kunelo, jamune, nekusi, rovuula*) = efficiency of phonological STM
 - two groups were created: 1) those that could repeat a sequence of 3 or more pseudowords and 2) those that could repeat less than 3

- Phase 2.
 - the better group were presented 24 lists of 4 pseudowords (8 x 12 = 96 stimuli)
 - the poorer group were presented 32 lists of 3 pseudowords (8 x 12 = 96 stimuli)
 - after the STM task we gave surprise tasks of recall of the 12 pseudowords, cued recall of a missing syllable in them and recognition among 7 alternatives
 - /kune___/
 - /ku___lo/
 - /___nelo/

Results

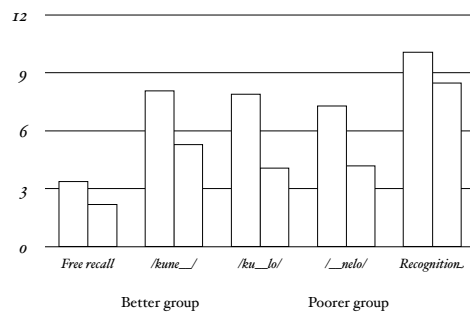
- Immediate memory for list items was the same: 68.9/96 for the better group and 72.1/96 for the poorer group.



Results (cont.)

- Thus, both groups had equal experience of hearing the pseudowords and correct recall
 - = each pseudoword had been successfully represented in WM an equal number of times.

Incidental learning by the groups



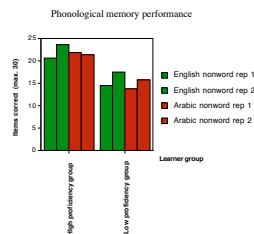
Conclusions

- it seems that representing a new word form in WM does not in itself improve its probability of being learned
- instead, the incidental learning of a form affects how well it can be immediately recalled together with other forms, in the order of presentation
- a good head for languages forms accurate representations for both immediate recall and long-term learning

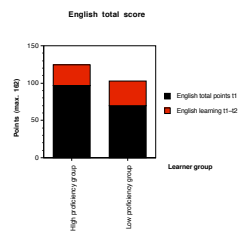
How can you learn if your head for languages is not good?

- Leif French (thesis 2003/2006):
 - 54 French speaking 11-12-year-olds from Quebecin participated in a 5-month immersion period in English, equivalent to 3 years of traditional classroom learning
 - the pupils were divided into to proficiency groups based on an initial English test

Pseudoword repetition before and after English immersion

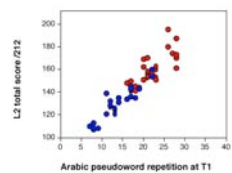


Both groups made progress in the immersion programme.



Phonological STM predicted English proficiency at the end of the immersion

L2 outcome at T2 as a function of pseudoword repetition at T1



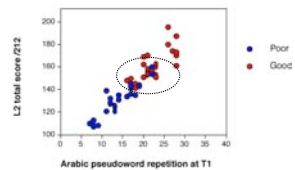
all $r = .93$

less proficient half $r = .92$

more proficient half $r = .78$

Groups now overlapped.

L2 outcome at T2 as a function of pseudoword repetition at T1



Phonological STM was correlated with new learning
only in the less proficient half.

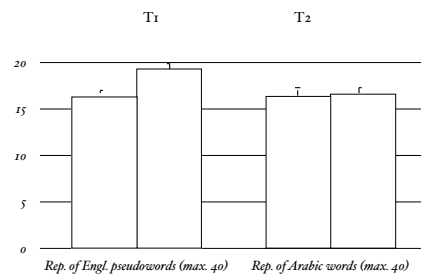
Correlations between phon. memory and new
learning with non-verbal ability controlled

	More proficient	Less proficient
English tot.	.13	.76***
List. comp.	.07	.66**
Vocabulary	.18	.44**
Structures	.01	.07

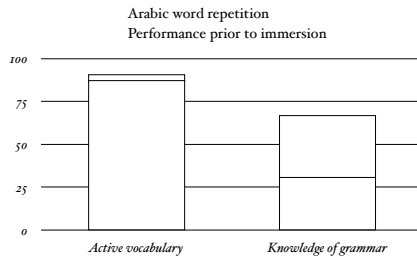
Grammar learning in immersion

- French & O'Brien (under revision 2007)
- a new sample of 104 students
- the study paid special attention to grammar learning

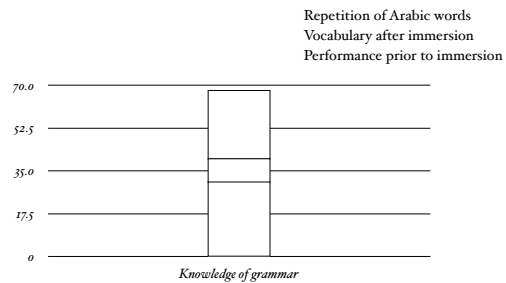
Development of phonological memory during immersion



Factors accounting for vocabulary and grammar after immersion (% of variation)



Effects of vocabulary and phonological memory on knowledge of grammar



So...

- it appears that the effect of phonological memory on vocabulary acquisition fades away with growing language proficiency as already learnt language increasingly supports new learning
- because of cumulative learning effects the head start provided by good phonological memory lingers on

- the effect of phonological memory on grammar learning appears to develop later
- still, identity as a language learner may develop and decisions to avoid further learning be taken too early

STM in developmental dyslexia: evidence for a general deficit

- Clinical question: What underlies the subtle learning difficulties in developmental dyslexia?
- Theoretical question: Could general representational quality be one determinant of performance in STM tasks?

Main collaborators:

Marja Laasonen
Veijo Virsu



Background: Dyslexia and STM

- Numerous studies have shown developmental dyslexia to be associated with a deficit in *phonological processing*, seen in, e.g., mental manipulation of sound units in words.
- Other studies have suggested a specific deficit in *phonological STM*, e.g., digit span.
- Still other studies have shown a deficit in *temporal acuity*, e.g., in reporting the order of rapid consecutive stimuli.

- Hypothesis concerning the deficit in dyslexia:
 - developmental dyslexia is associated with a *subtle representational deficit* for all kinds of material
 - this deficit is most easily detected in tasks that require temporal acuity or the representation of multiple elements in STM

- Relevance for STM theory
 - WM tasks that require the simultaneous representation of similar elements push the limits of the discriminative efficiency of a WM subsystem (e.g., the phonological loop)
 - Examples of such tasks are immediate serial recall or serial matching of verbal elements

- an association between performance in STM tasks with phonological material on the one hand and simple binary sensory stimuli on the other would suggest that general representational quality may underlie all STM tasks

Experiment

- Participants
 - 20 developmentally dyslexic adult readers
 - 24 fluent adult readers
 - age, education, IQ not significantly different

- *Phonological STM tasks*
 - digit span forwards
 - digit span backwards
 - pseudoword span (CVCV-stimuli)
 - pseudoword matching span (6 trials/length)
 - pseudoword pair repetition (20 pairs)

Setting for sensory STM tasks



Stimulus pulses 8 ms,
visual separation .5 degrees
visual angle,
auditory frequencies 750 Hz
and 3625 Hz.
SOA 630 ms,
separating pause 2000ms.

- ***Sensory STM matching tasks with binary patterns***

- Visual *item span*: lengthening sequences of light flashes in two locations (84% level)
- Auditory *item span*: lengthening sequences of tones of two frequencies (84%)
- Tactual *item span*: lengthening sequences of solenoid stimulation of index finger and middle finger (84%)

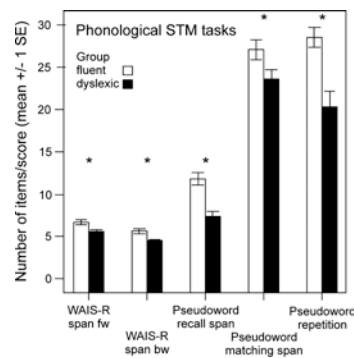
- ***Bimodal sensory STM matching tasks***

- Item spans for combinations of two modalities: lengthening binary sequences
- Only one LED, tone, finger was used

- *Time span tasks*
 - Visual: sequences of 5 stimuli with lengthening SOAs
 - Auditory: sequences of 5 stimuli with lengthening SOAs
 - Tactual: sequences of 5 stimuli with lengthening SOAs

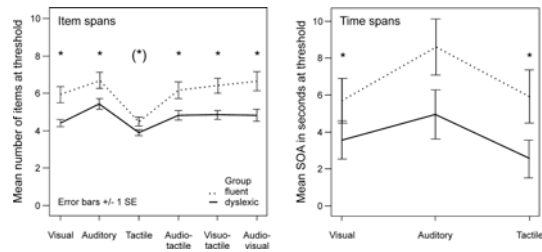
Results

- dyslexic participants performed more poorly in all phonological STM tasks



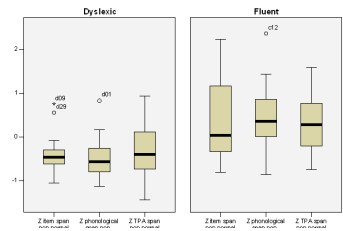
- Dyslexic participants also performed more poorly in the sensory STM tasks

Sensory STM



- A composite phonological STM variable was created by transforming all test scores to z-values and averaging over the 5 different tasks.
- A composite sensory STM item span variable was created by z-score transformation and averaging over the 6 different item span tasks.
- In addition, a composite temporal acuity variable from a previous study was explored.

Box plots of composite variables



- *phonological STM* was related to *sensory item span* in both the dyslexic participants, $r(18) = .51$, $p < .05$, and the fluent readers, $r(22) = .70$, $p < .01$.
- *temporal acuity* tasks from an earlier experiment also showed a correlational trend with *phonological STM* in dyslexic readers, $r(18) = .32$, $p = .166$, and fluent readers, $r(22) = .40$, $p = .056$
- this did not explain the phonological STM-item span relation

Conclusions

- phonological STM tasks and sensory STM tasks share variance
- common forms of developmental dyslexia are associated with poor performance on both

Conclusions (cont.)

- shared variance could depend on amount of central attentional capacity of WM to bind together stimuli into an episode OR
- general representational capacity that affects the amount of information encoded/stored for each item

Conclusions (cont.)

- poorer representational capacity could place compensatory demands on attentional WM capacity
- it could also slow down processing in many tasks (= poorer temporal acuity)
- dyslexia may be accompanied by subtle learning difficulties that are unrelated to reading or language

Collaborators

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