Testing cognitive individual differences: a practical introduction

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Outline

- Part 1: Working memory
  - Baddeley's Working Memory model
  - How to test components of WM
- Part 2: Aptitude
  - Carroll's definition of aptitude (and some criticisms)
  - How to test aptitude (LLAMA and ALPACAA tests)
- Part 3: Relationship between WM and aptitude

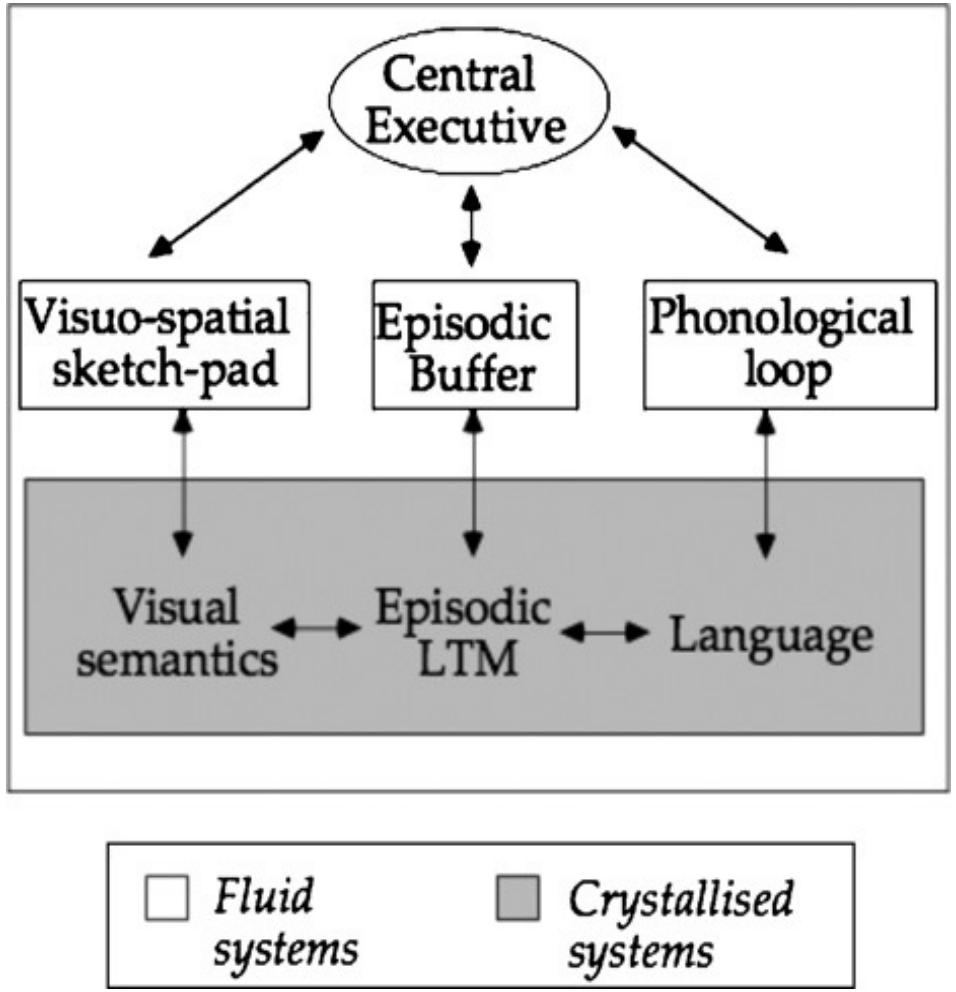
Part 1 : Working Memory

What is working memory?

"Working memory refers to the system or systems that are assumed to be necessary in order to keep things in mind while performing complex tasks such as reasoning, comprehension and learning."
Baddeley (2010, p. 136)

STM: maintenance of information

WM: maintenance and manipulation



Central Executive

- Originally: storage capacity
  - Not in recent models
- Allocation of attentional resources
- Inhibitory control
- **Testing in Adults**
- Attention measures, e.g. TMTs
- Manipulation measures
  - Backwards digit span
  - O-span
  - Reading span
  - Stroop
  - Flanker
  - Simon

Working memory test battery for children (Pickering & Gathercole, 2001)

- Central Executive:
  - Listening Recall
  - Counting Recall
  - Backwards digits
- Visuo-spatial sketchpad
  - Block recall (Corsi)
  - Mazes memory
- Phonological loop
  - Digits recall
  - Word list recall
  - Non-word recall
  - Word list matching task

Research on central executive/ executive working memory (EWM)

- L1 acquisition
- Daneman & Carpenter (1980): reading span correlated with comprehension in university aged students.
- Oakhill & Yuill (1986): younger children WM related to pronoun resolution.
- Does not seem to be related to syntactic processing in adults.
  - But Roberts et al (2007) found in relationship in very complex sentences.
  - Just & Carpenter (1990) found WM effects on processing subject versus object relative clauses.

- L2 acquisition
- Correlations between WM and performance on English proficiency measures (Kormos & Safar 2008).
- Mixed evidence in terms of syntactic processing (eye-tracking/ reaction times).
- Linck & Weiss (2015) longitudinal
  - CE: predictive of vocabulary and grammar
    - O-span task
  - Inhibitory control: not-predictive
    - Simon task
- Wen (2016): EWM = language processing

Slave systems: part 1

- **Phonological loop**
- "Language”
- Most extensively investigated
- Rehearsal (sub-vocal)
- “providing a system in which sequences of well-learned items such as digits, letters, and words that are readily retrievable from long-term memory may be maintained almost perfectly, provided the sequence is short enough to be repeated before its constituent features are disrupted by decay or interference.” Baddeley et al (2011, p. 1399)

- **Testing**
- Often uses span tasks
  - Forwards digits span.
  - Non-word repetition
- Integration with LTM
- Smaller in L2 than L1.
  - Increases with proficiency

Research on Phonological loop (PSTM/ PWM) in L2 acquisition

- Vocabulary
- Early data on PSTM & vocab learning:
- Series of studies using digits span tasks found correlations with L2 vocabulary learning in experimental settings.
- Data was more mixed in classroom contexts.
- Gathercole (2006) suggested PSTM relevant at initial stages of language learning.
- However, Linck et al (2013) suggested PSTM relevant to advanced learners learning vocabulary.

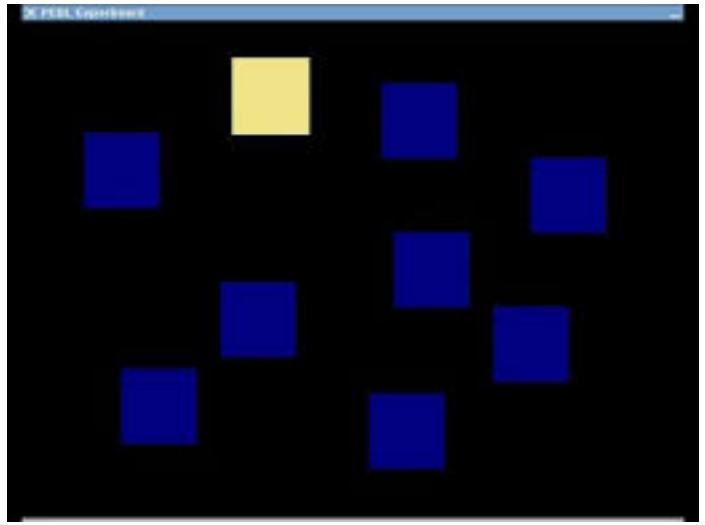
- Grammar
- Robinson (1997) found that PSTM correlated with grammar/ rule learning in intermediate English learners.
- French & O'Brien (2008): PSTM correlated with grammatical development in an intensive French class, even when other factors were considered.

- Wen (2016): PWM = language learning device

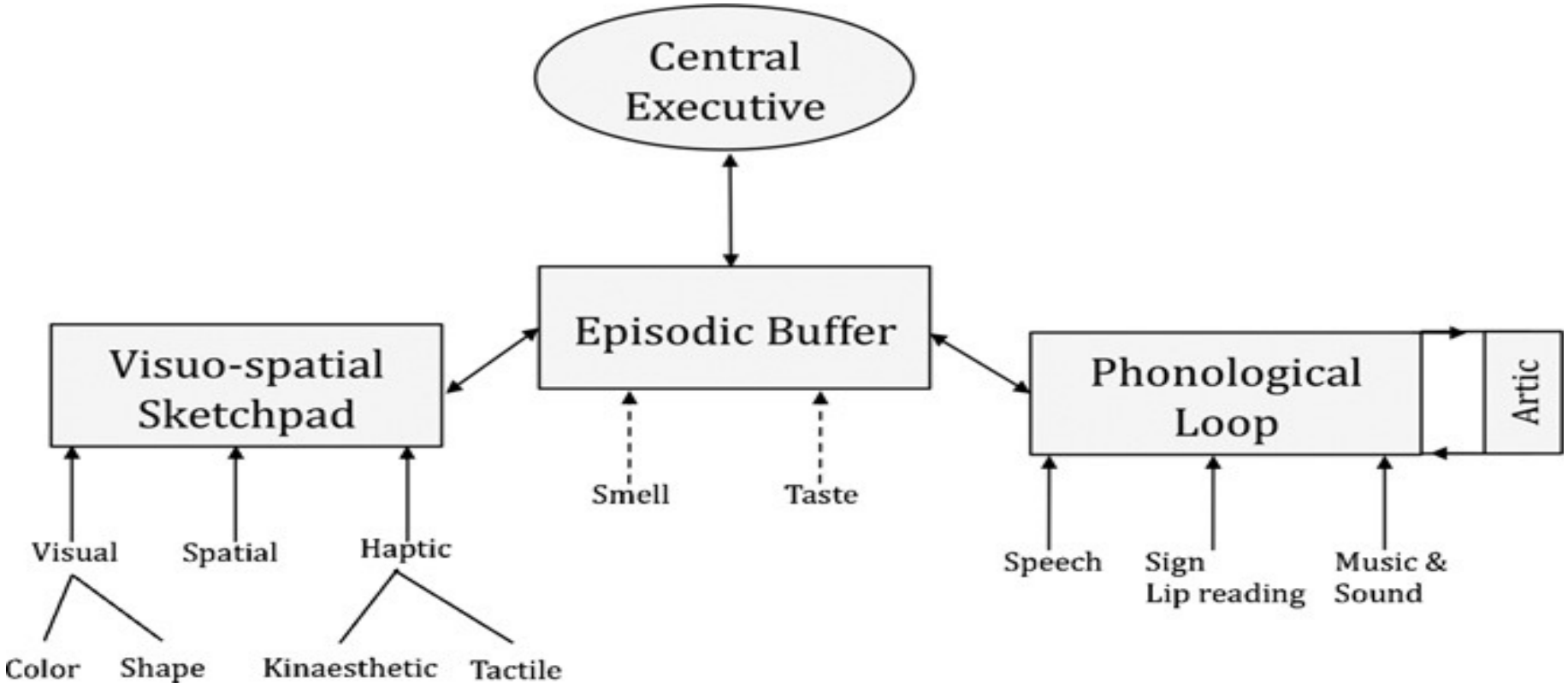
Slave systems part 2

- **Visuo-spatial sketchpad**
- Often not considered related to language.
- Children improve with age – linked to ability to link with phonological recoding (Pickering, 2001)
- Linked to reading skills.

- **Testing**
- Corsi block



Revised WM model (Baddeley et al 2011)



PEBL: The Psychology Experiment Building Language Test battery

- Mueller & Piper (2014)

- **Program**
- http://pebl.sourceforge.net
- Use existing experiments
- Design your own
- Available across platform
- Windows: portable version

- **Manual and wiki**
- To create your own experiments
- http://pebl.sourceforge.net/documentation.html
- Explanations of existing experiments
- http://pebl.sourceforge.net/wiki/index.php?title=PEBL_Test_Battery

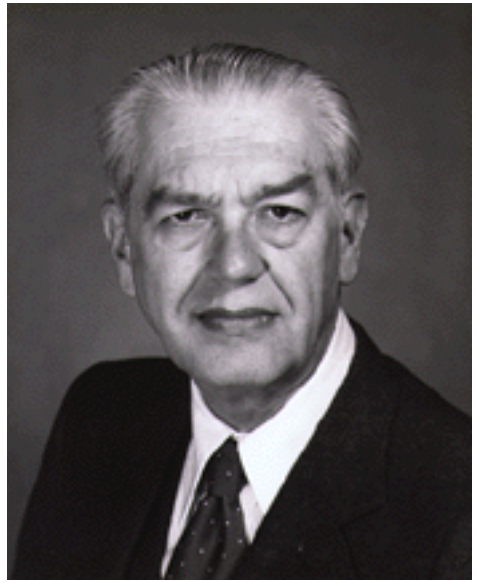
Videos of Prof Alan Baddeley and Prof Susan Gathercole discussing WM

- Two main components to working memory:
- https://www.youtube.com/watch?v=S65D2oazf8M
    - Short term memory (temporary storage of information)
    - Central executive (way the storage is controlled)
        - https://www.youtube.com/watch?v=aseitqCZKQo
- Baddeley & Hitch suggested three dependent parts to short term memory:
        - Phonological loop/ Phonological STM – storing phonological information
            - https://www.youtube.com/watch?v=2zF15C3vnIw
            - https://www.youtube.com/watch?v=ZQEHLqjJAhQ&t=14s
        - Visio-spatial sketchpad – where you have parked your car
            - https://www.youtube.com/watch?v=BeuWVWEW4bI
        - episodic buffer – links to long term memory
            - https://www.youtube.com/watch?v=3a_cF46UiEU&t=22s
- Further lecture by Prof Alan Baddeley (c. 40 mins)
            - https://www.youtube.com/watch?v=yL2ul2bR0Ok

Part 2 : Aptitude

What is Language Learning Aptitude

"the amount of time a student needs to learn a given task, unit of instruction, or curriculum to an acceptable criterion of mastery under optimal conditions of instruction and student motivation." (Carroll 1990 p. 26)



- A 'knack for learning languages'. A cognitive variable - something you are born with.
- What does it mean?
- aptitude is different from other cognitive systems, including intelligence
- aptitude is stable (doesn't change)
- aptitude is made up of different components

Criticisms of Carroll's approach

- Teaching approach = audiolingualism
- Krashen's (1981)
- acquisition vs learning - aptitude not relevant.
- Skehan (2002)
  - Outdated - particularly in terms of memory capacity
- Robinson (2005)
  - not so interested in rate of learning any more.
- more interested in
  - ultimate attainment.
  - relevance of aptitude in various conditions.

- MLAT: Carroll & Sapon (1959)
- Predictive test for learning rate in instructed learners. Three components:
- grammatical sensitivity
  - Words in sentence
- phonetic coding ability
  - number learning (aural)
  - phonetic script (aural)
  - spelling cues
- memory capacity
  - Paired associates.
- Overlap between highest MLAT scores and IQ.

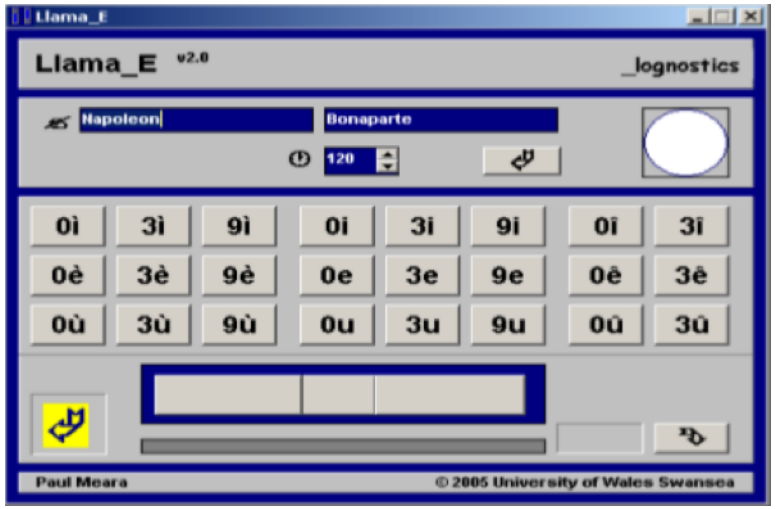
Li (2015) Construct validity: meta analysis of 66 studies.

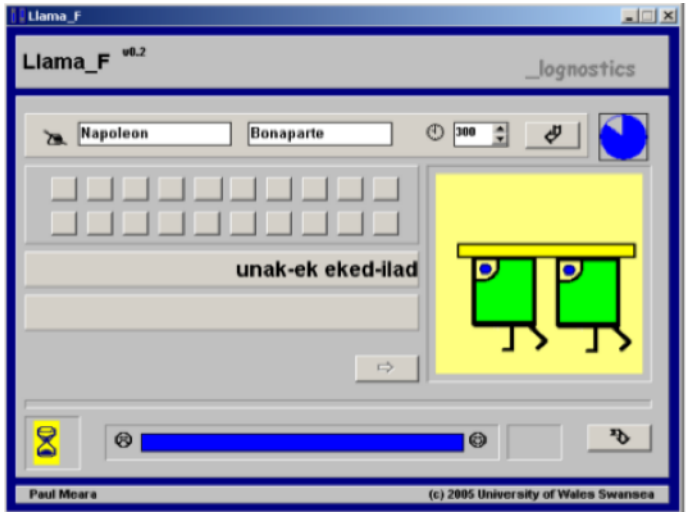
- Aptitude is independent of other individual differences, e.g. motivation.
- executive working memory (EWM) more strongly associated with aptitude than phonological short-term memory (PSTM).
  - BUT Linck et al (2013): relevance of PSTM to advanced learners.
- strong predictor of general proficiency but not vocabulary learning or L2 writing.
- different components predicted different aspects of learning.
- negative correlation between anxiety and aptitude.
  - Sparks & Patton (2013): anxiety as result not cause of low aptitude

Swansea LLAMA tests (Meara, 2005)

www.lognostics.co.uk/tools/llama

- Free, loosely based on MLAT
- LLAMA B = vocabulary measure
- LLAMA D = sound recognition (implicit learning)
- LLAMA E = sound-symbol correspondence
- LLAMA F = grammatical inferencing
- Has not been fully validated.





Previous validation work: Grañena

- Grañena (2013):
- Internal consistency, Gender and Language neutrality
- n=187 aged 18-39
- L1s: Spanish, Chinese and English
- internal consistency but two forms of aptitude
- LLAMA D measures implicit and others explicit?

- Grañena (2018):
- Compared 4 LLAMA tests with 4 Hi-LAB (n=135)
- Found 3 underlying constructs across the tests.
- Only the factor with LLAMA D and ALTM Synonym
- (Hi-LAB) significantly predicted L2 fluency (pruned speech rate per min).

Rogers, V., Meara, P., Barnett-Legh, T., Curry, C., & Davie, E. (2017). Examining the LLAMA aptitude tests.. *Journal of the European Second Language Association*, *1*(1), 49–60.
DOI: http://doi.org/10.22599/jesla.24

- **How much of the LLAMA test score variance do the individual factors measures account for?**
- Factors included age, L1, L2 status, education level, gender, playing of logic puzzles.
- 404 participants in total.
- 346 took all 4 parts of the LLAMA tests and background questionnaires.

- Multiple regression analysis for 6 factors. Overall variance for:
  - LLAMA B: R2 = 9.1%
  - LLAMA D: R2 = 4.8%
  - LLAMA E: R2 = 3.4%
  - LLAMA F: R2 = 6.6%
- Only L2 status consistently was significant $p<.05$ (not for E).
  - LLAMA B: β = -.250, contribution to variance = 6.0
  - LLAMA D: β = .136, contribution to variance = 1.8
  - LLAMA F: β = -.165, contribution to variance = 2.6

Part 3: Relationship between Working Memory and Aptitude

Wen's (2016) P/ E model

- Two components of WM relevant for language learning:

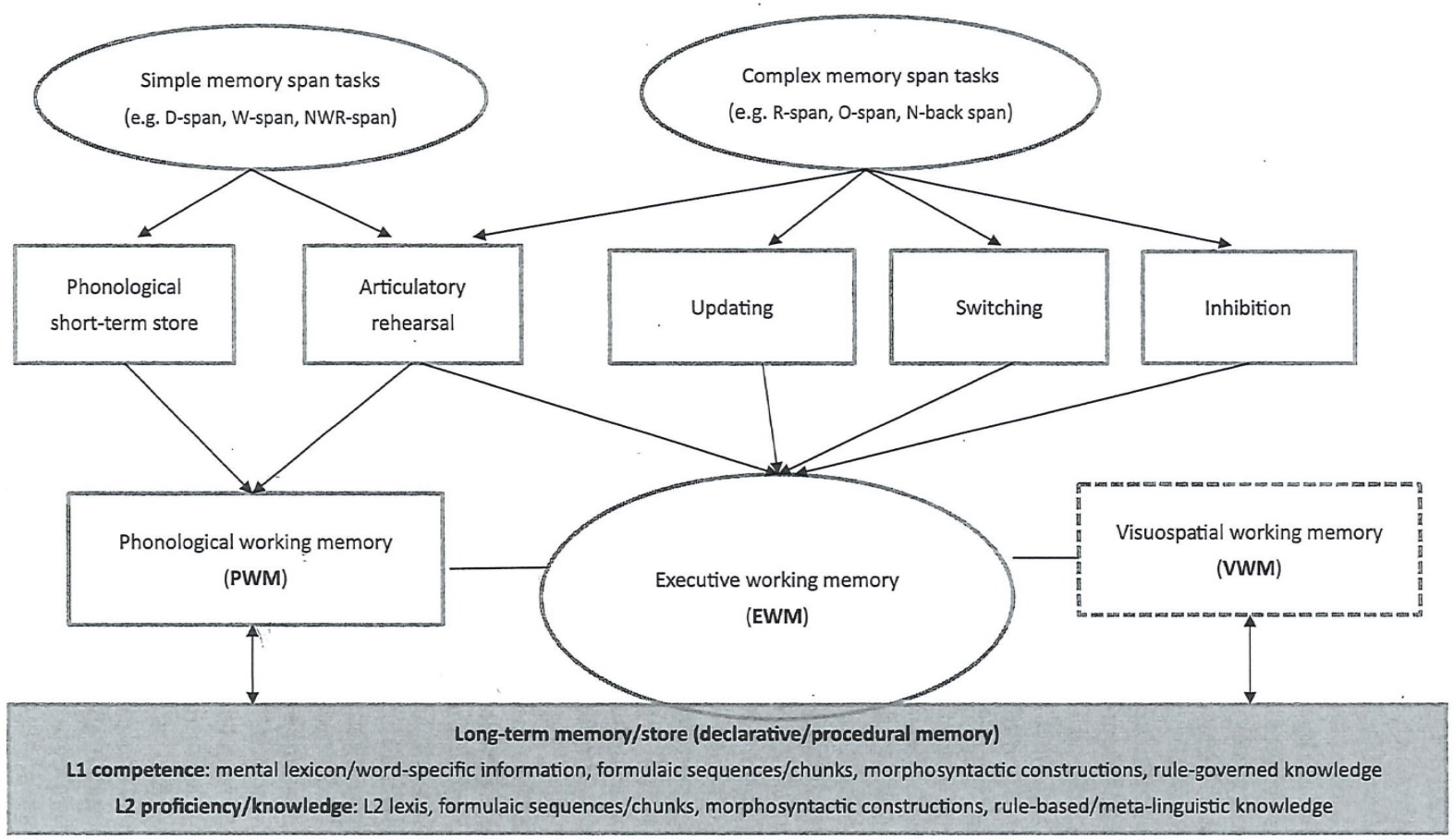


Figure 6.1 An integrated conceptual framework for WM in SLA research

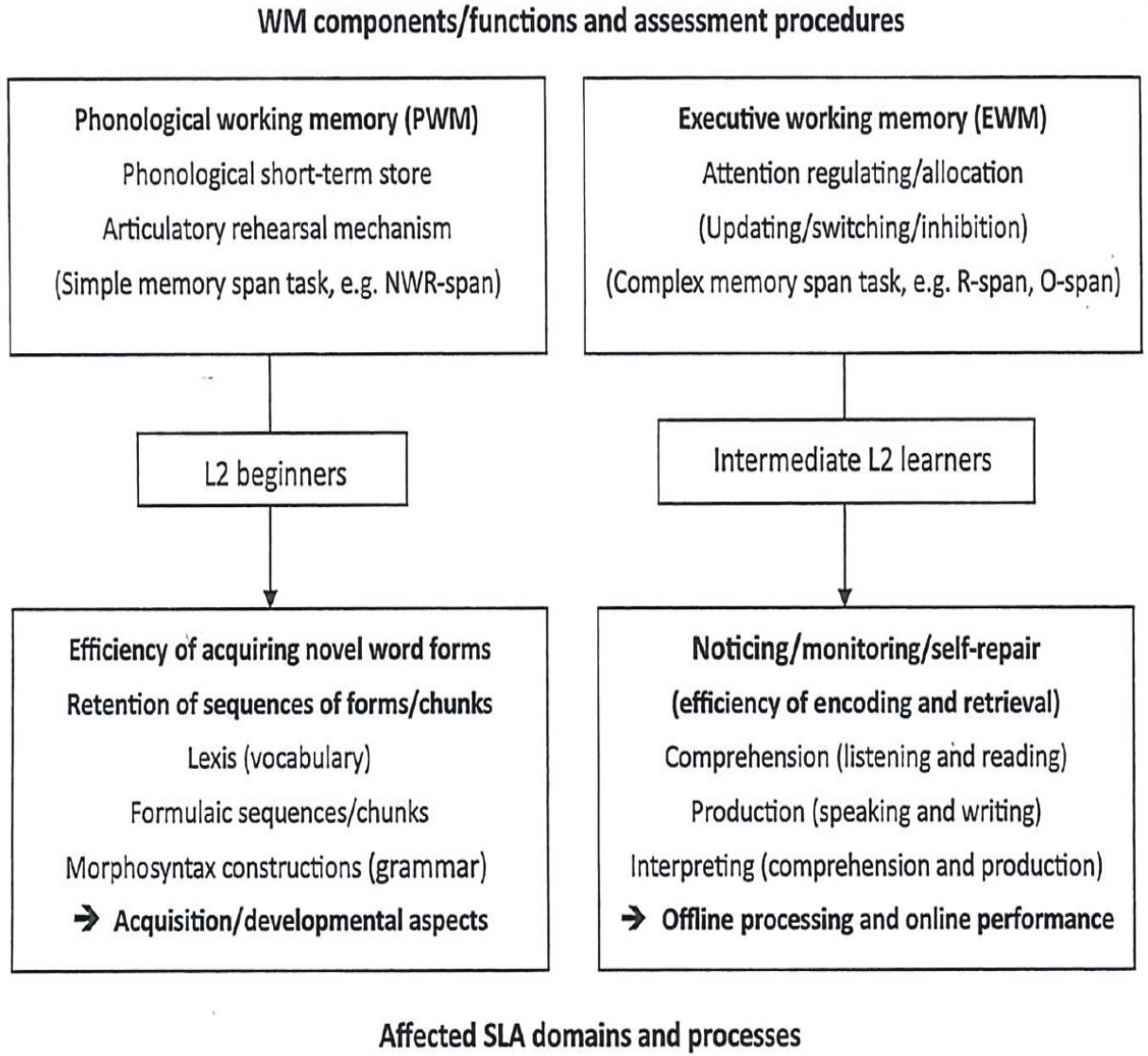


Figure 7.1 The P/E hypothesis for low and (post-)intermediate L2 learners

WM as L2 aptitude

- Wen (2016, p. 142)

❖ “to what extent [can] PWM… complement (or even replace) the phonetic coding ability of language aptitude and, similarly, to what extent EWM can outperform the language analytical ability of language aptitude.”

❖“premature… to claim that WM ‘replaces’ L2 aptitude given our currently limited knowledge of their relationship and relatively scare empirical evidence”

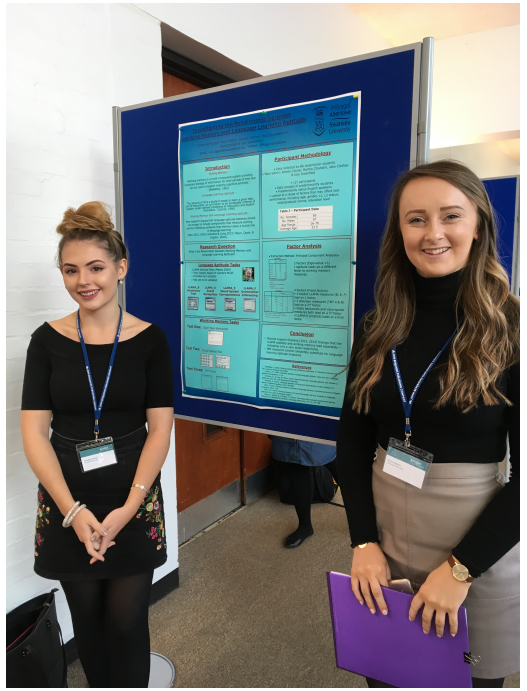
Rogers et al (2017)

- What is the Relationship between Working Memory and Language Learning Aptitude?

- Methodology:
  - ❖ All four LLAMA sub-tests.
  - ❖ Working memory tests:
    - ❖ Visuo-spatial task (reading)
    - ❖ Auditory digits backwards task (PSTM)
    - ❖ TMT part A & B: attentional control (Central executive)
  - ❖ Background questionnaire

Table I – Participant Data

No. Females	60
No. Males	67
Age Range	16-78
Average Age	33.5



Results

- LLAMA aptitude tests measure two constructs (similar to Grañena 2013).
- LLAMA B, E & F measure something different to LLAMA D.
- No LLAMA test loads on the same factor as any of the working memory and attention tests.
- TMT parts A & B measure different aspect of WM to the digits backwards (PSTM) and visio-spatial/ storage measures.
- Even if forced to four factors, LLAMA tests load differently to the WM/attention tests.
- Possible evidence against Wen's integrated Model.
  - At least WM as aptitude argument.

Pattern Matrix[a]

	Component	
	1	2
LLAMA E	.807	
LLAMA F	.799	
LLAMA B	.670	
LLAMA D	.546	
WM3 (A)		.906
WM3 (B)		.877
WM1 (Visual)		-.498
WM2 (Digits)		-.392

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.
a. Rotation converged in 6 iterations.

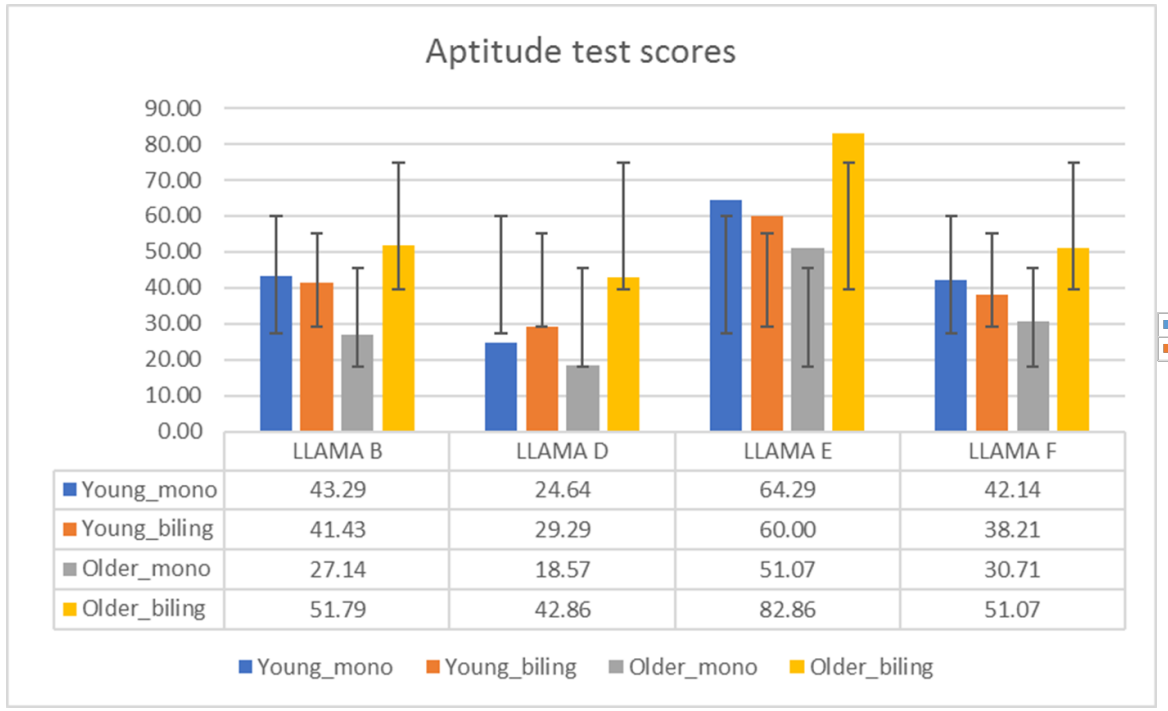
Pattern Matrix[a]

	Component			
	1	2	3	4
LLAMA F	.831			
LLAMA E	.828			
LLAMA B	.672			
WM3 (A)		.914		
WM3 (B)		.867		
WM2 (Digits)			.897	
WM1 (Visual)			.586	
LLAMA D				.947

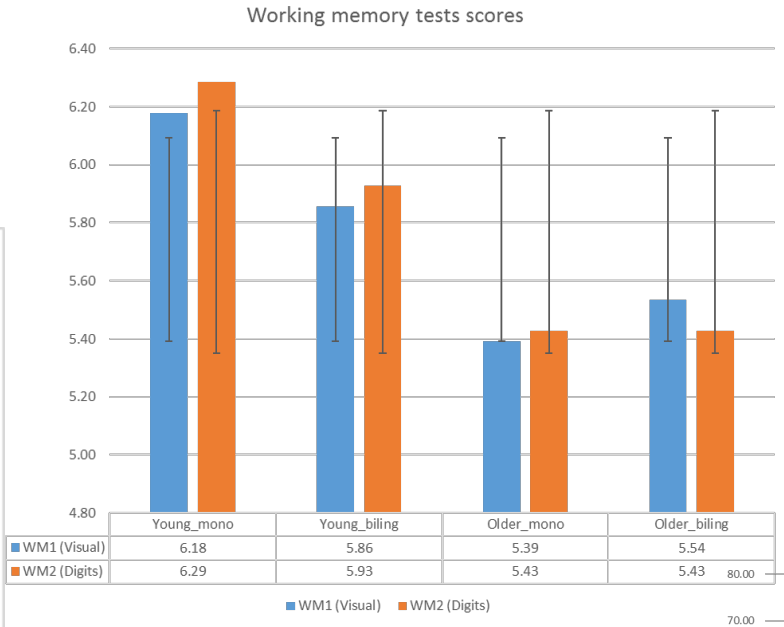
Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.
a. Rotation converged in 6 iterations.

Further evidence: age and bilingualism

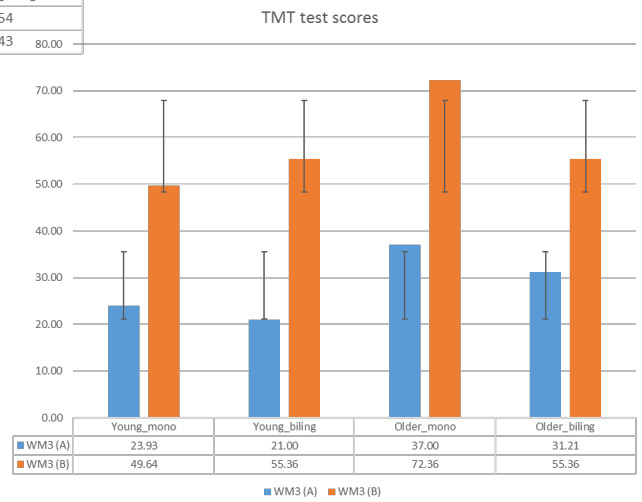
	Group 1	Group 2
Mean age (range)	21 (18-23)	61.5 (50-78)
Bilingual	14 (7 F, 7M)	14 (7 F, 7M)
Monolingual	14 (7 F, 7M)	14 (7 F, 7M)
n	28	28



	LLAMA B	LLAMA D	LLAMA E	LLAMA F
Young_mono	43.29	24.64	64.29	42.14
Young_biling	41.43	29.29	60.00	38.21
Older_mono	27.14	18.57	51.07	30.71
Older_biling	51.79	42.86	82.86	51.07



	Young_mono	Young_biling	Older_mono	Older_biling
WM1 (Visual)	6.18	5.86	5.39	5.54
WM2 (Digits)	6.29	5.93	5.43	5.43



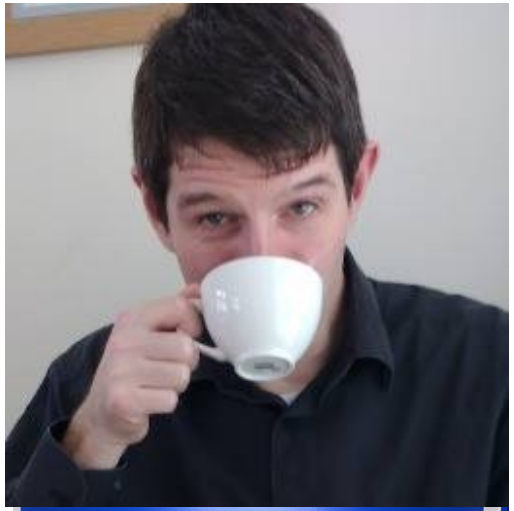
	Young_mono	Young_biling	Older_mono	Older_biling
WM3 (A)	23.93	21.00	37.00	31.21
WM3 (B)	49.64	55.36	72.36	55.36

Analysis and discussion

- WM and aptitude are affected by age and bilingualism in different ways.
- Bilingual advantage in older group across 3 of the LLAMA aptitude tests.
- Age advantage on one of the WM tests.
- This suggests that aptitude tests are not interchangeable with WM tests.
- WM may be a component of aptitude.

Overall conclusion for part 3

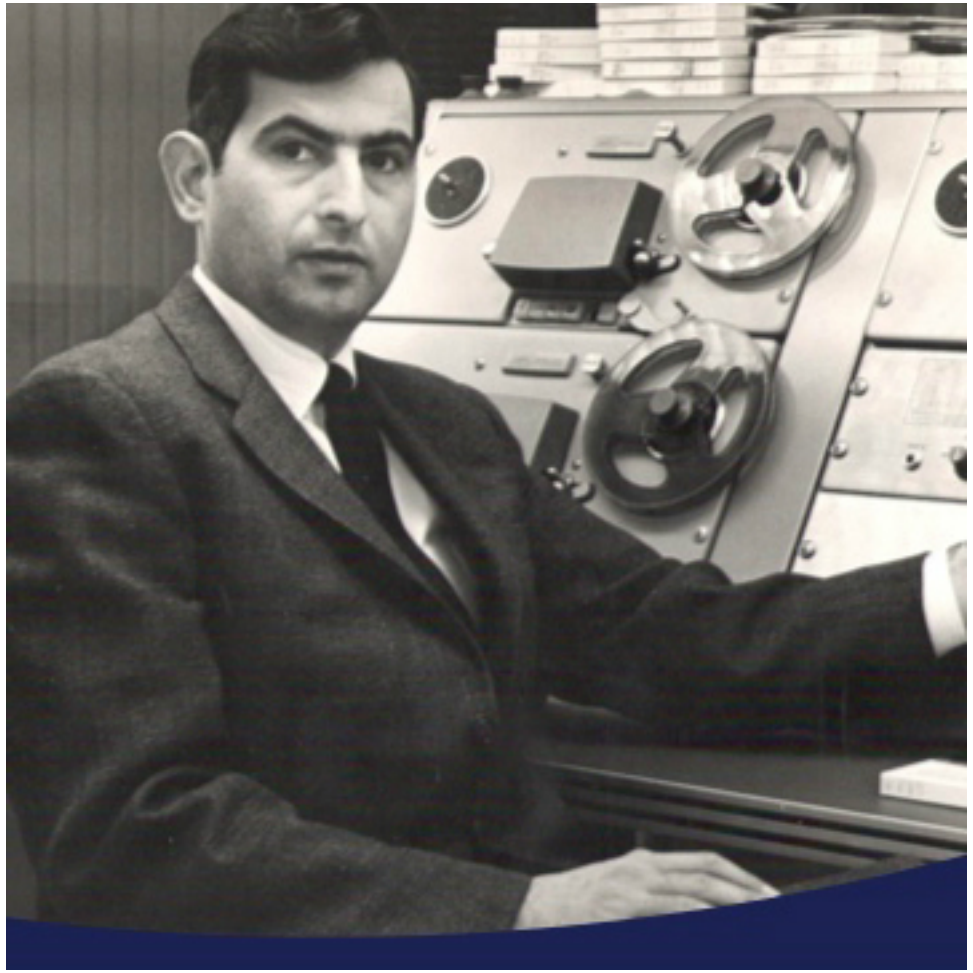
- WM may be related to language learning aptitude.
- Don't know enough yet to claim WM 'replaces' aptitude.
- Developed OpenSesame versions for reaction time and item analysis (technical help: Brian Rogers).
  - Revised layout of LLAMA E (Paul Meara)
  - Fixed some glitches in previous versions.
- Allows modelling of different scoring systems.
- Currently being tests with 2018-19 BA dissertation students



Part 4: Extra information on aptitude

PLAB: Pimsleur Language Aptitude Battery

- Pimsleur (1966)
- Developed as an alternative to MLAT.
- English vocabulary size as measure of overall verbal ability
- language analysis measures
- sound discrimination measures
- motivation



Aptitude and learning conditions

- Implicit versus Explicit learning conditions:
- Krashen (1981) aptitude only applies in explicit learning.
- Robinson (2002) aptitude applies to all conditions.
- Nation & McLaughlin (1986) aptitude is more relevant in implicit learning.

- Wesche (1981): aptitude profiles (analytic vs memory) related to teaching methodology (analytic vs situational) -higher satisfaction and achievement.
- Erlam (2005) L2 French: different types of instruction lead to different correlations with aptitude (Words in sentence)
- Kormos & Safar (2008) Hungarian learners of English: low correlations between aptitude and proficiency.
- Granʹena (2015): two types of aptitude (explicit and implicit) linked to different cognitive styles (rational versus intuitive).
- Problem: can't compare studies as using different tests/ sub-components and calling it 'aptitude'.

Aptitude and Age

- Fundamental Difference Hypothesis (Bley-Vroman 1990. 2009)
- L1 is learnt implicitly
  instructed L2 via analysis & analogy (explicitly)
  Success depends on how good analytic capacities & memory are (link to aptitude)
- Dekeyser (2000)
  Hungarian learners of English.
  aptitude relevant for adults & adolescents not younger learners (< 15 years old)
  high aptitude for those with high levels of achievement.
  But: small numbers.
- Ross et al (2002): aptitude only important after puberty (age 12).
- Abrahamsson & Hyltenstam (2008)
  100 Spanish speakers of Swedish - passed as native speakers divided into two groups based on age of arrival (younger/older than 12)
  younger than 12 - no effect of aptitude (range of scores). older than 12 - all had high aptitude.
  High aptitude to compensate for late arrival?
- Muñoz (2014)
  48 bilingual Catalan-Spanish learners of English (aged 10-11) significant correlations with all subcomponents of eMLAT. aptitude relevant to instructed younger learners.
- Harley & Hart (1997):
  different aspects of aptitude important at different ages. memory more important with younger learners. analytical ability more important with older learners

Aptitude and literacy and dyslexia

- relationship between L2 aptitude and difficulties in L1 literacy.
- Dufva et al (2001) L1 literacy predictive of L2 aptitude (80% of variance)
  Linguistic Coding Difference Hypothesis (Sparks 2006)
- Views problems with L2 as related to language learning problems in L1.
  15%-20% children have difficulties with L1 literacy Difficulties may resurface in L2.
- Area of difficulty: phonological processing.
- Phonemic awareness (ability to segment sounds) phonological decoding (ability to relate sound to symbol/spelling)

- Sparks & Ganschow (1991): tests for mild dyslexia similar to phonemic coding ability.
- Issue: now sound is processes and linked to the spelling.
- Dylexia: lack of connection between known sounds and symbols (spellings).
- L2 learners: difficulty is segmenting the sound.

Aptitude and education/ training effects

- Changes in aptitude due to training
  (e.g. Grigornko et al., 2000; McLaugh- lin, 1990; Sternberg and Grigorenko, 2002)
- Changes in aptitude due to experience
  (e.g. Kormos, 2013; Safar and Kormos, 2008; Sawyer, 1992; Sparks et al., 1995; Thompson, 2013)
- Are these changes in aptitude or test performance? How could you distinguish?
- Multilinguals more able to adjust their L2 learning strategy to facilitate specific language components.
- but not more successful overall. Nayak et al (1990)