Investigating implicit learning difficulties in children with Developmental Language Disorder using the Tower of Hanoi Puzzle

Nick Riches, Ewa Dabrowska

Outline

Developmental Language Disorder

Implicit versus explicit learning in language acquisition

Testing proceduralisation

Aims

Questions

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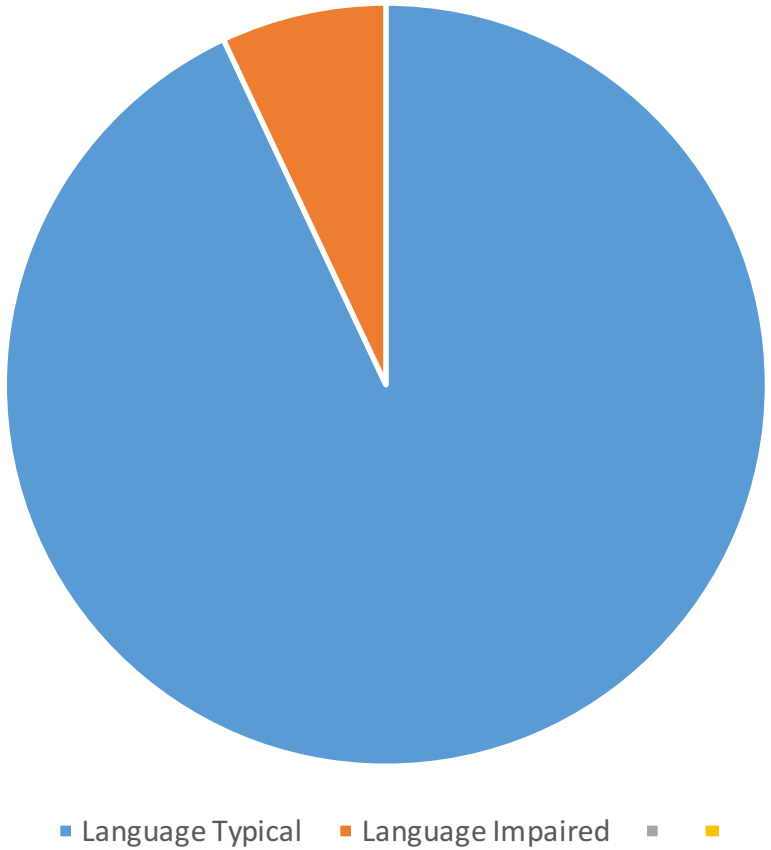
Specific Language Impairment (Developmental language disorder)



About 7% of children

“Him drop it”

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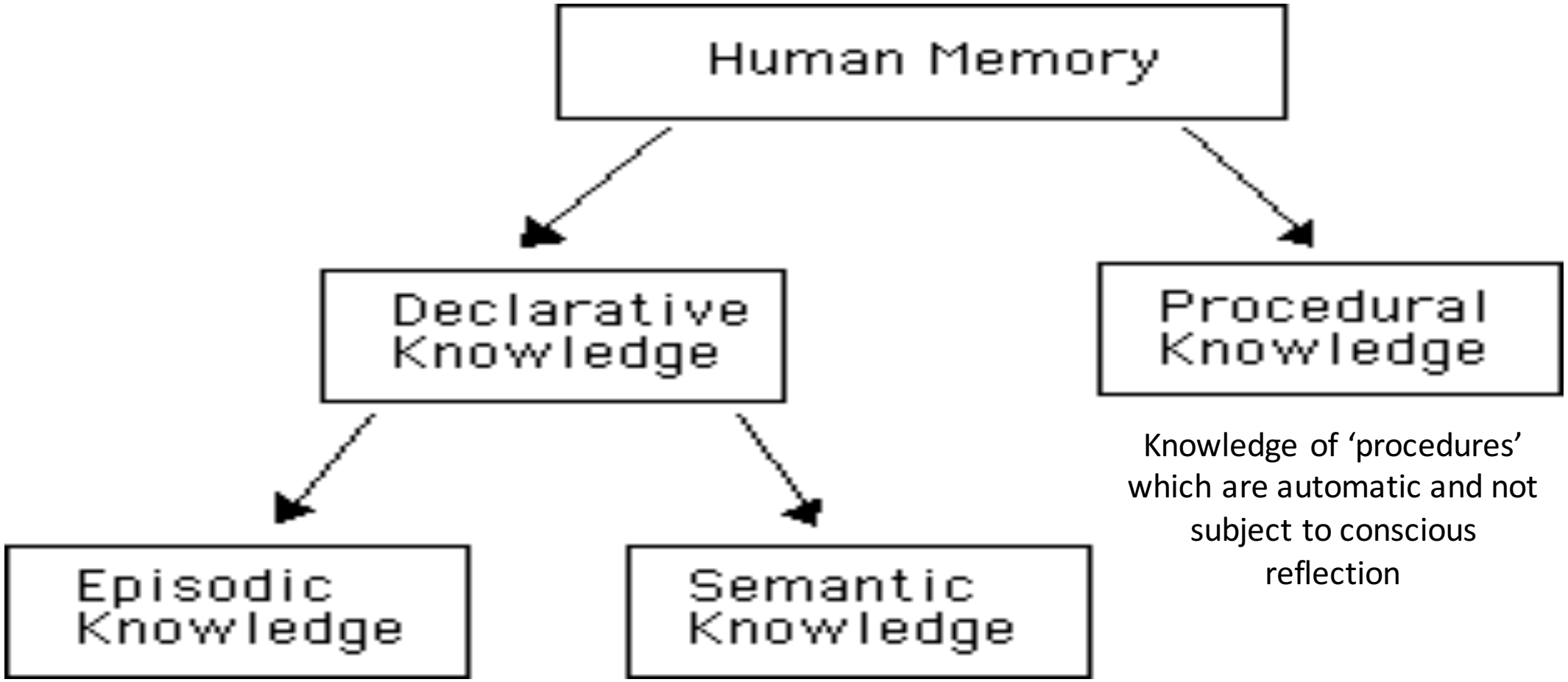
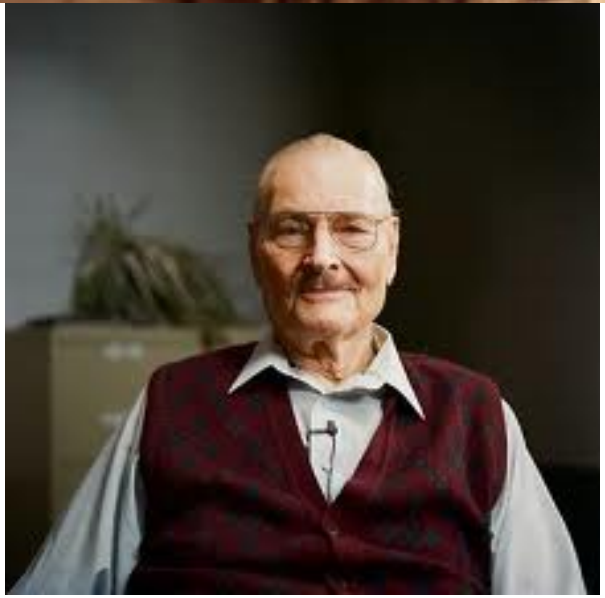
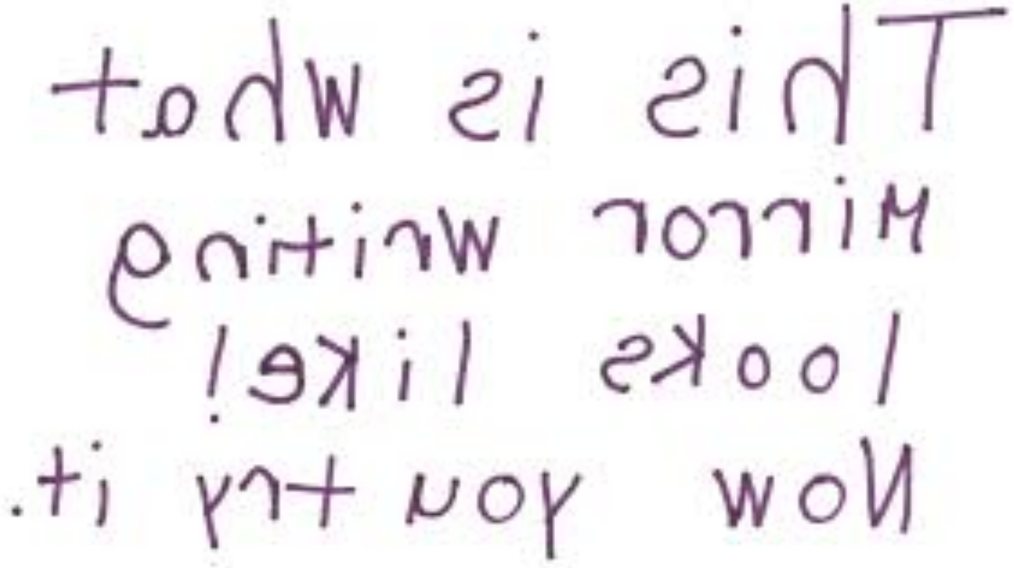
Human memory



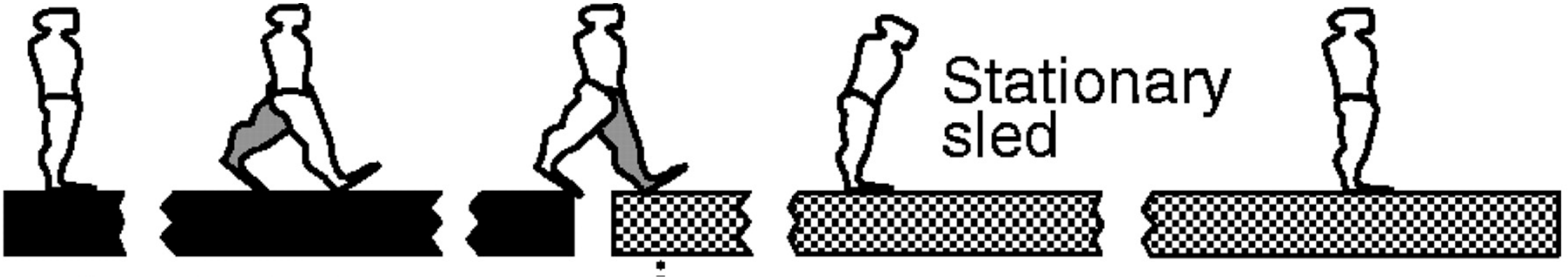
Knowledge of ‘procedures’ which are automatic and not subject to conscious reflection

Patient HM



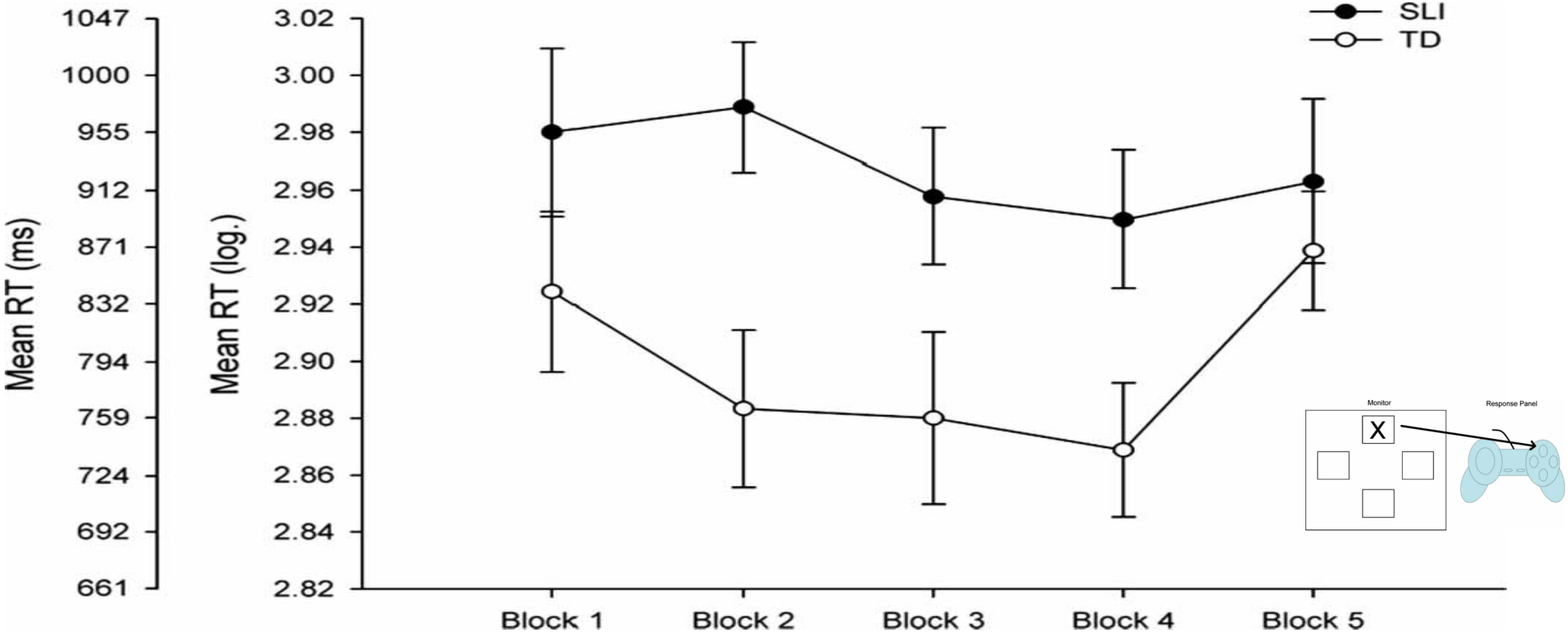


Broken escalator phenomenon



‘Choking’

The SRT task


SLI
TD
Mean RT (ms)
1047
1000
955
912
871
832
794
759
724
692
661
Mean RT (log.)
3.02
3.00
2.98
2.96
2.94
2.92
2.90
2.88
2.86
2.84
2.82
Block 1
Block 2
Block 3
Block 4
Block 5
Monitor
Response Panel
X

Language within the memory system (Ullman & Pierpoint, 2005)

Syntax

Rule-governed processes, e.g.
Morphological inflection, e.g. laugh-**ed**
Structure-building, e.g. det + N → NP
Lexical retrieval

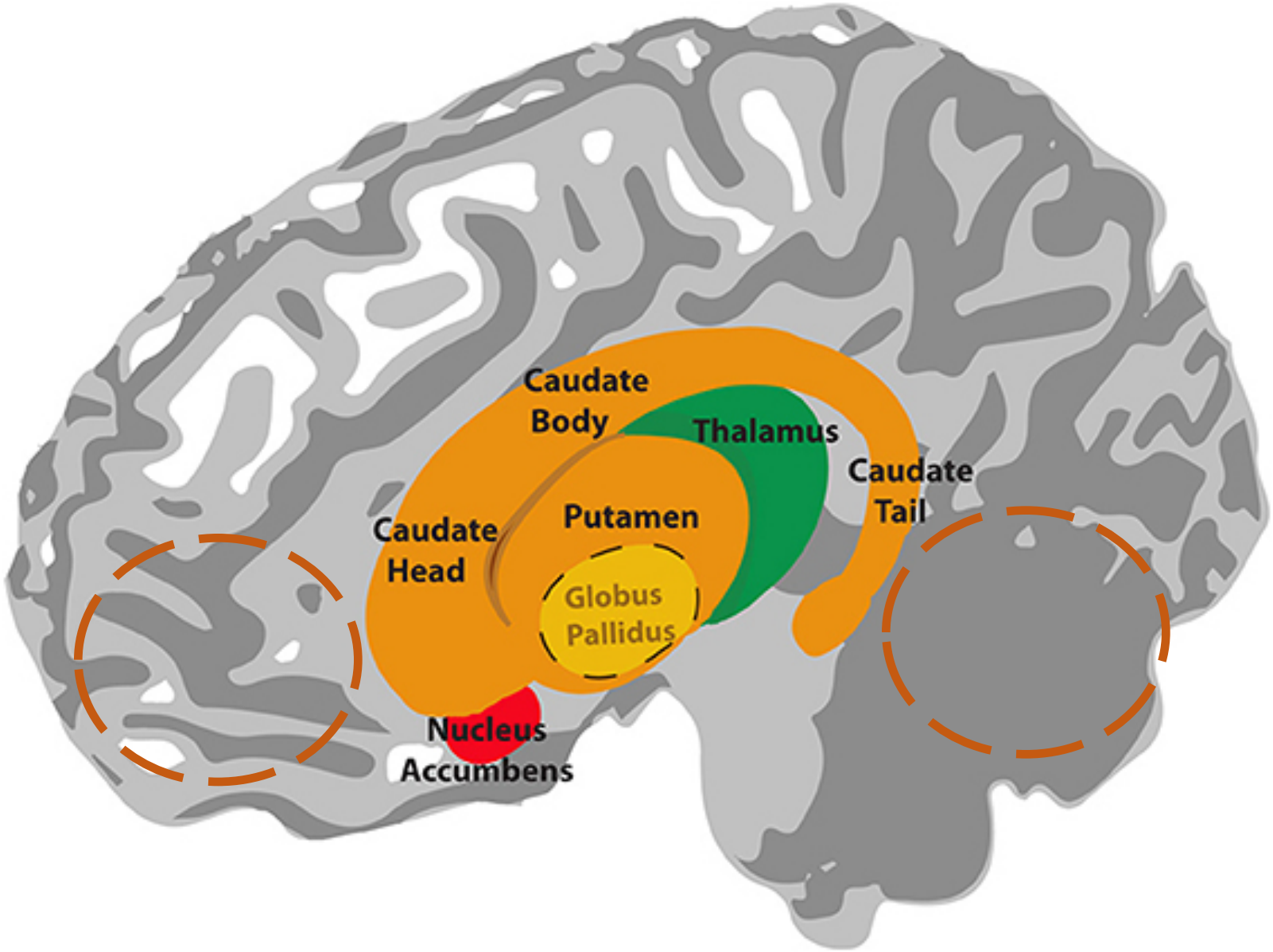
Plus

Working memory
Temporal processing

The lexicon

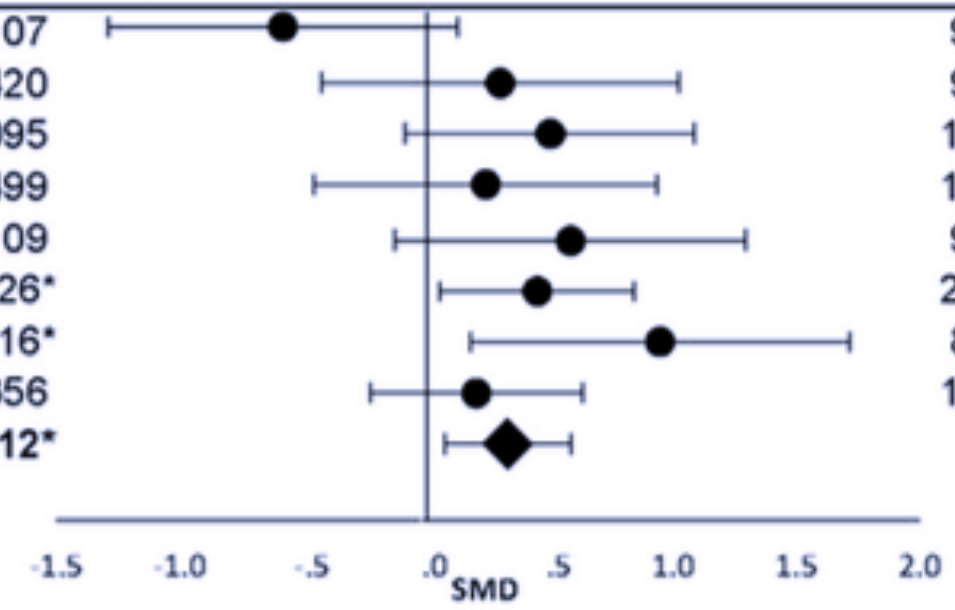
Arbitrary from-meaning pairings

Neuroanatomical correlates



Lum et al. 2014

Study	SMD	Variance	95% C.I. Lower	95% C.I. Upper	*p*-value	Weight
Gabriel et al. (2011)	-.582	.13	-1.29	.13	.107	9.9%
Gabriel et al. (2012)[a]	.298	.14	-.43	1.02	.420	9.5%
Gabriel et al. (2013)	.500	.09	-.09	1.09	.095	12.9%
Gabriel et al. (in press)	.240	1.26	-.46	.94	.499	10.1%
Lum & Bleses (2012)	.582	.13	-.13	1.29	.109	9.8%
Lum et al. (2012)	.448	.04	.05	.84	.026*	20.5%
Lum et al. (2010a)	.945	.15	.18	1.71	.016*	8.7%
Tomblin et al. (2007)	.202	.05	-.23	.63	.356	18.7%
Weighted Average	**.328**	**.02**	**.07**	**.58**	**.012***	



Notes: [a]Effect size is the average of results over two conditions. In one condition participants completed the SRT Task using response pad as an input device and in the second participants used a touchscreen.
*$p < .05$; **$p < .001$

Lum et al. 2012

Group/language measure	Working memory			Declarative memory		Procedural memory
	Central executive	Phonological loop	Visuo-spatial sketchpad	Verbal information	Visual information	
TD						
Lexical abilities	.092	.123	−.029	.480**	.251	.233
Grammatical abilities	.096	.028	.080	.235	−.096	.305*
SLI						
Lexical abilities	.101	−.041	.028	.394*	.216	−.008
Grammatical abilities	.189	.131	−.049	.305*	.018	.112

Note: *$p < .05$, **$p < .001$.

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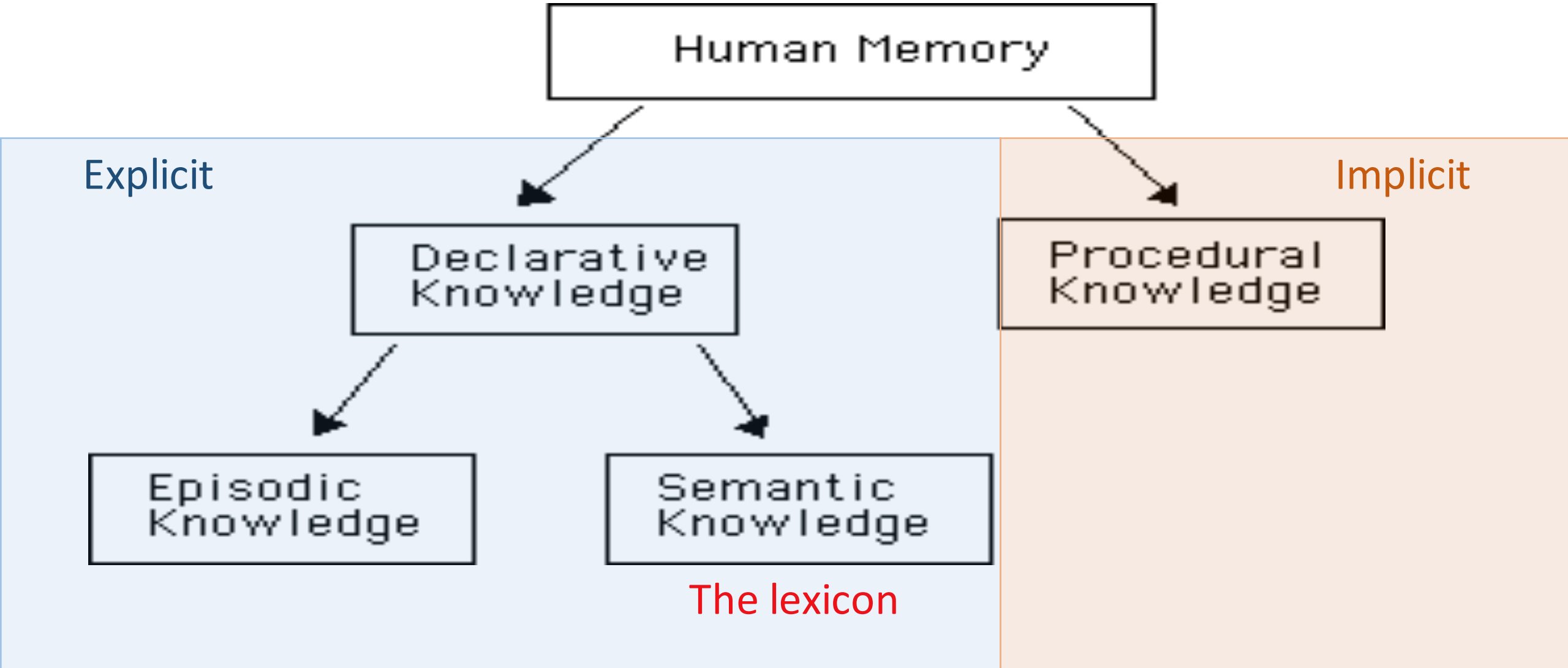
Implicit versus explicit learning

- **Implicit:** We are unaware of both learning and resulting knowledge
- **Explicit:** We are aware of learning and resulting knowledge. We use deliberate strategies.

- West et al. 2017

Human memory



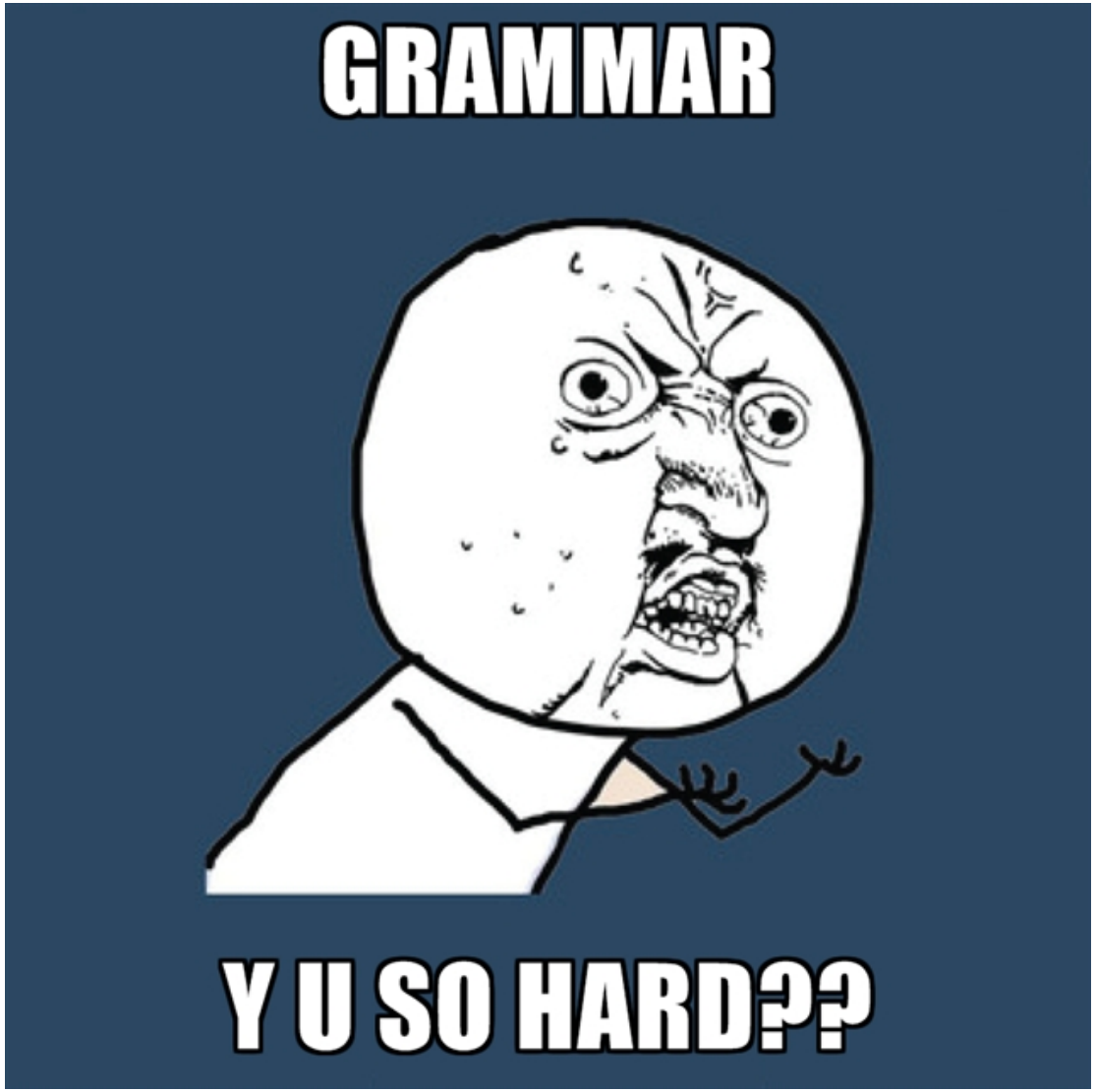
Powerful implicit learning mechanisms

Poverty of the stimulus

- **Who** did the teacher praise [~~Jack~~] because he drew a picture?
- **What** did the teacher praise Jack because he drew [~~a picture~~]?

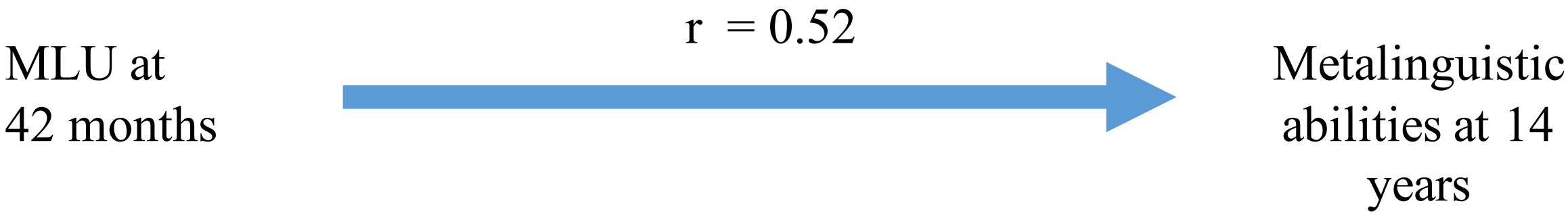
Innate implicit knowledge ?

Explicit / metalinguistic knowledge



But.....

Skehan and Ducroquet (1988)



Poor metalinguistic abilities in young children?

Crib talk (Levy, 1989; Nelson, 2006; Weir, 1970)

1. block . . . yellow block . . . look at the yellow block ...light ...see yellow blanket ...up there in yellow light
2. Anthony jump out gain . . . Anthony jump another big bottle . . . big bottle
3. What colour...What colour blanket...What colour mop . . . What colour glass
4. I go up there ...She go up there

Poor metalinguistic abilities in young children?

Child aged 2;6

Child: This is a running-stick
Father: A running-stick?
Child: Yes, because I run with it.

Eve Clark – First Language Acquisition, 2013

Poor metalinguistic abilities in young children?

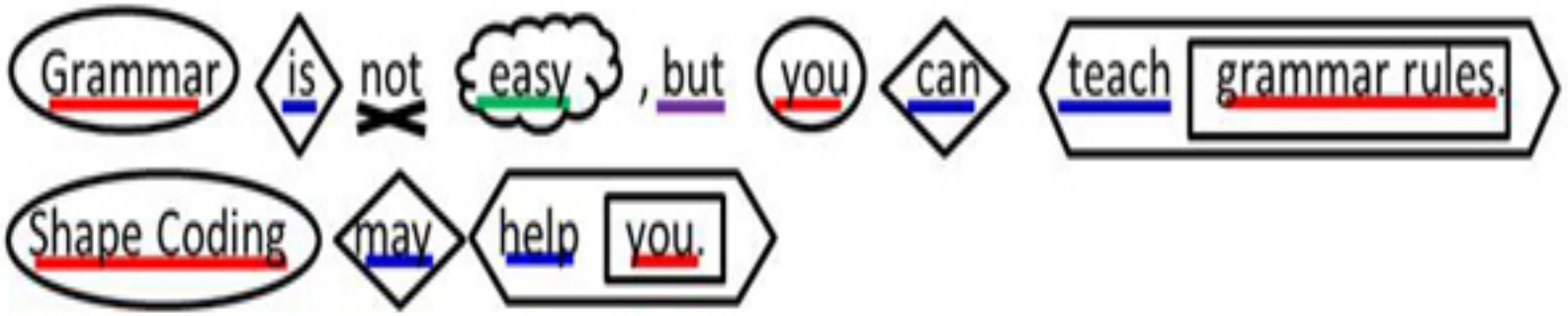
Spontaneous repairs at 18 months

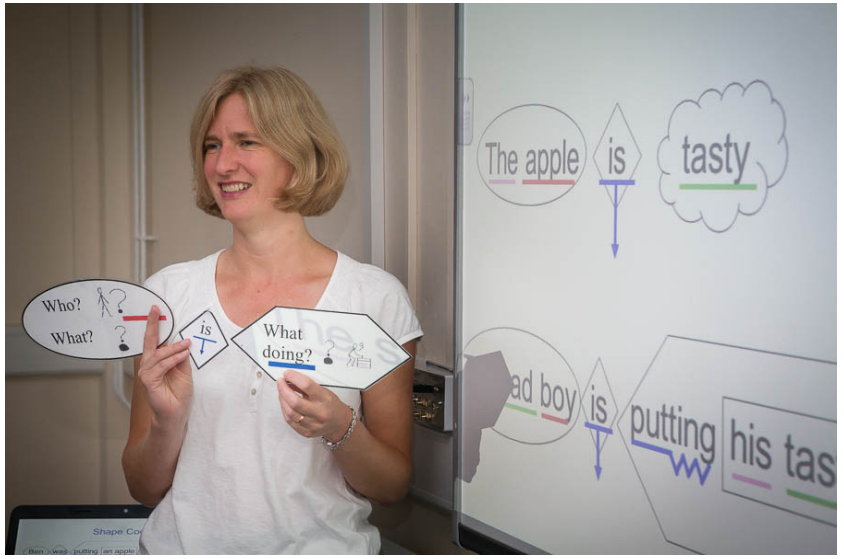
Oversegmentation errors

’I am heiv’
‘behave’ → ‘be heiv’
(Peters 1985)

Explicit training can be very powerful

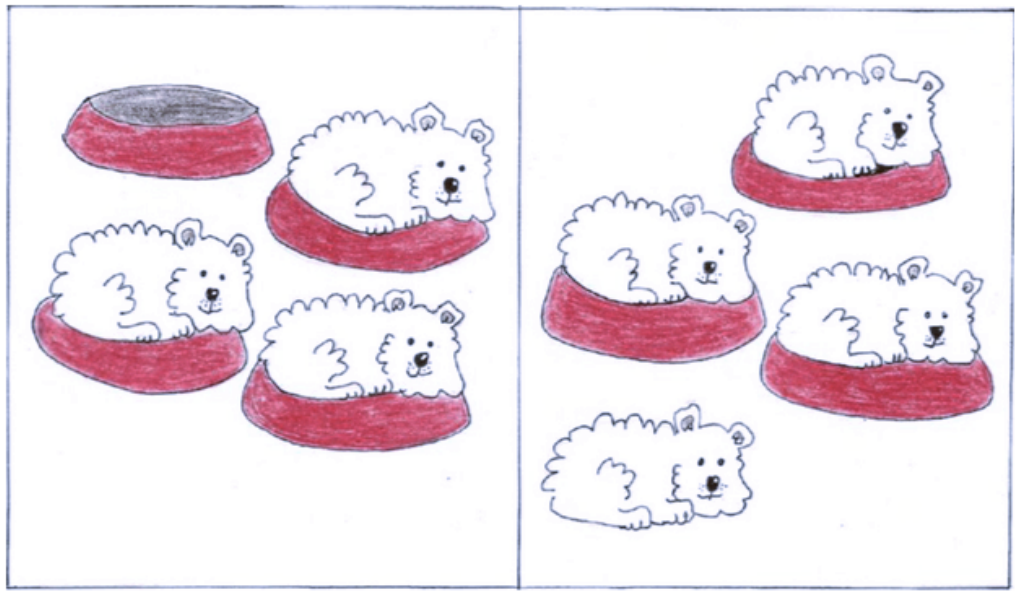
- E.g. Susan Ebbels, shape coding





Dabrowska & Street, 2010

"Every dog has a bowl in it"



The Implicit-Explicit ‘dance’

Procedural / Skill-learning literature

- Procedural learning reflects from a process whereby explicit information is made implicit (e.g. Fitts, 1954)

- Cognitive phase
- Associative phase
- Autonomous phase (also called the procedural phase)

Ullman, 2015

“ both first and second language learners should generally depend initially on declarative memory for grammatical functions (… with the exact nature of this dependence perhaps differing between first and second language learners), but both should gradually learn grammar in procedural memory.” (960)

Learning a grammatical construction

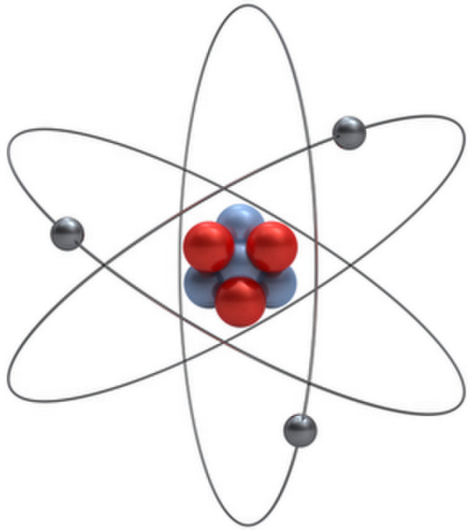
1. Acquisition of analysed exemplars	**Implicit and explicit**
2. Analogical mapping	**Mostly explicit**
3. Routinization/entrenchment	**Implicit = Proceduralisation**

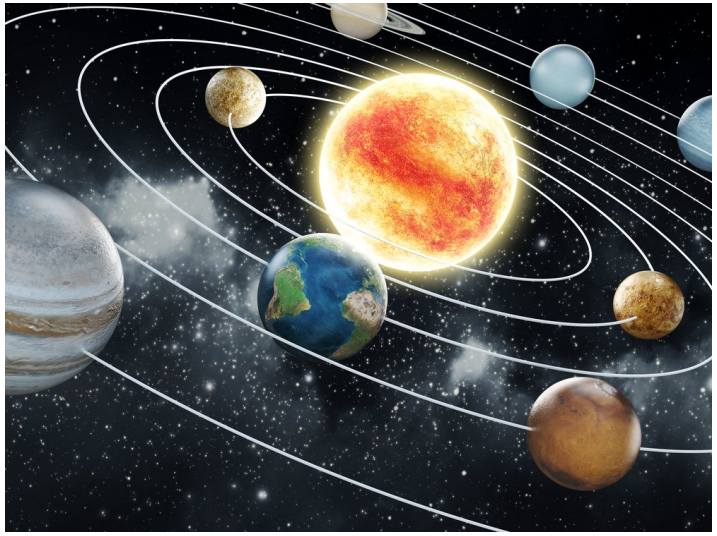
Map language learning onto the procedural learning / 'skill-learning' literature (e.g. Fitts and colleagues)

Explicit → Implicit

Adapted from a slide by Ewa Dabrowska

Analogical / structure mapping – Dedre Genter

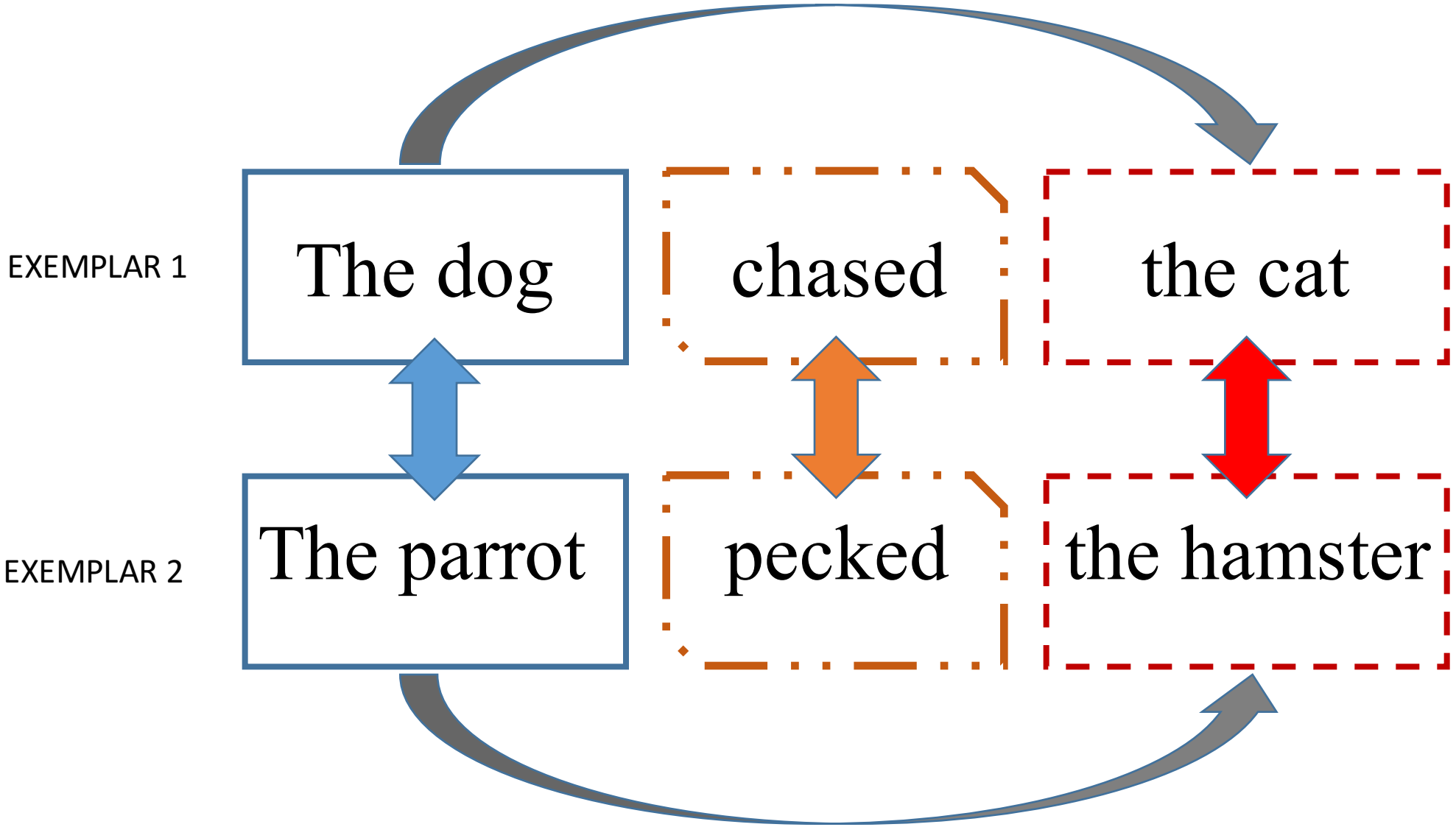




Electron → Nucleus

Planet → Sun

Analogy in language



Learning a grammatical construction

1. Acquisition of analysed exemplars	**Implicit and explicit**
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Kahneman & Tversky

System 1

- Evolutionarily old
- Shared with animals
- Implicit knowledge
- Automatic
- Effortless
- Fast
- Parallel
- High capacity
- Rigid
- Handles routine situations

System 2

- Evolutionarily recent
- Distinctively human
- Explicit knowledge
- Controlled
- Effortful
- Slow
- Sequential
- Low capacity
- Flexible
- Handles novel situations

Where does language learning and processing fit into this?

Kahneman & Tversky

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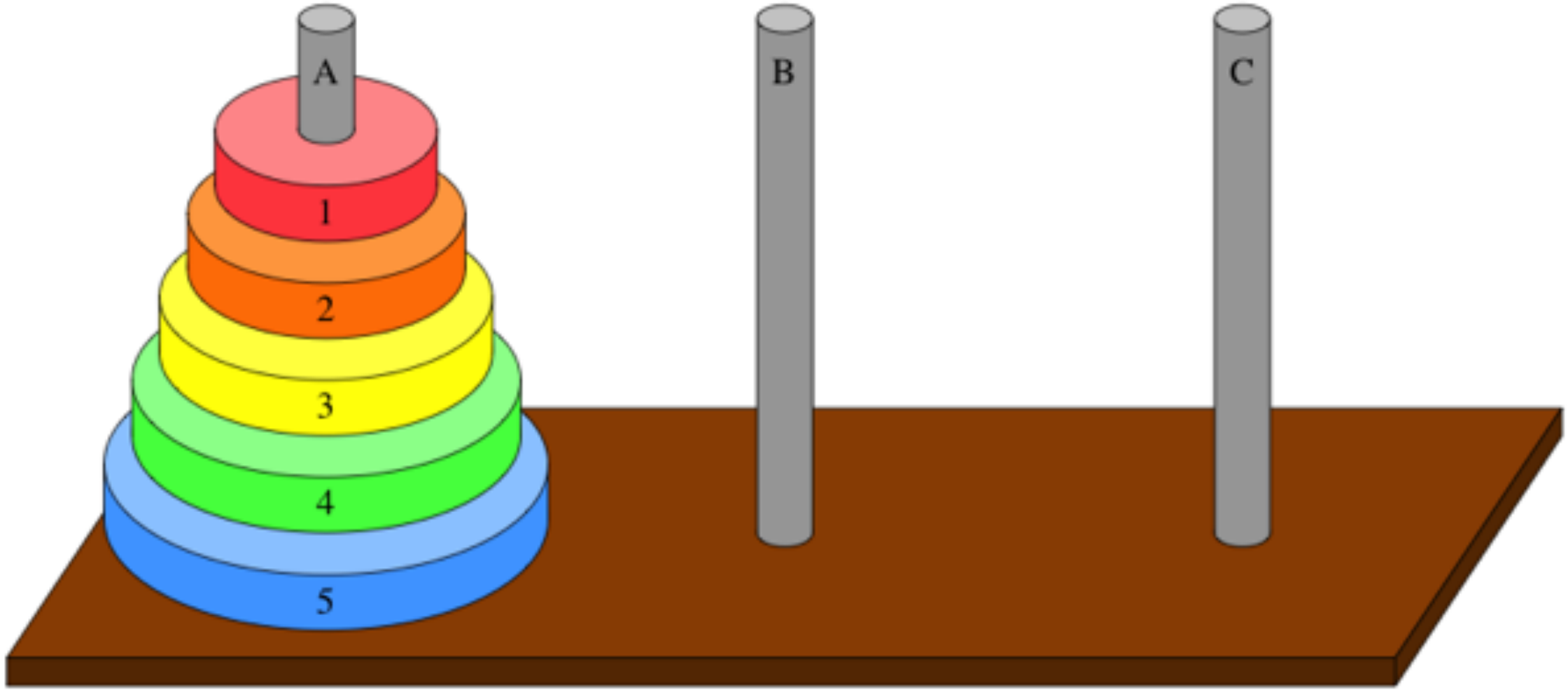
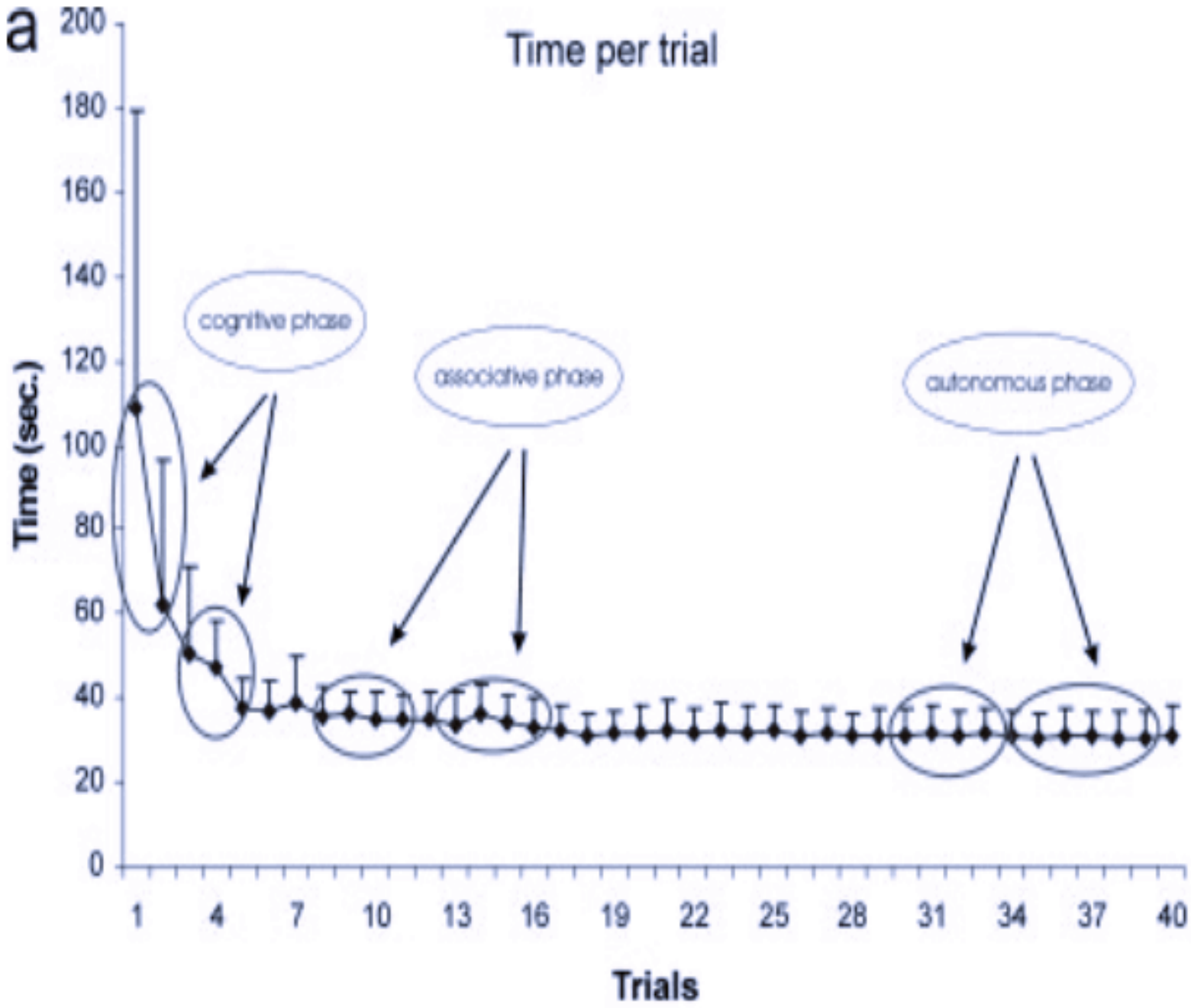
Is SRT fit for purpose?

- Poor test-retest **reliability** (West et al., 2017)
- Stimuli are **not language-like**
- No **transfer** from declarative to procedural
- Confounded with **motor control**
- Only provides a 'snapshot'
- Is it truly implicit? (Shanks & Johnstone, 1999)

An alternative – the tower of Hanoi?




a
Time per trial
Time (sec.)
200
180
160
140
120
100
80
60
40
20
0
cognitive phase
associative phase
autonomous phase
1
4
7
10
13
16
19
22
25
28
31
34
37
40
Trials

Advantages

- Test-retest reliability is not such an issue as we are looking at improvements in performance for **repeated** trials
- Task has a **'language-like'** hierarchical structure
- Task involves **transfer** from declarative to procedural memory
  - Provides a glimpse of each **stage** of the proceduralisation process
- Less confounded with **motor control**
- Rich source of data - **multiple** means of assessing performance

Assessing performance

- Mean RT per move
- RT for first move
- Time to solution
- Number of moves to solution
- Number of trials to complete a particular 'phase'
- Decline in performance when children are asked to do a concurrent task
- Generalisation can be measured (reverse orientation, e.g. right-to-left, left-to-right)

Different phases (Hubert et al. 2007)

- ‘Cognitive’ phase =

period until participant produces first optimum solution

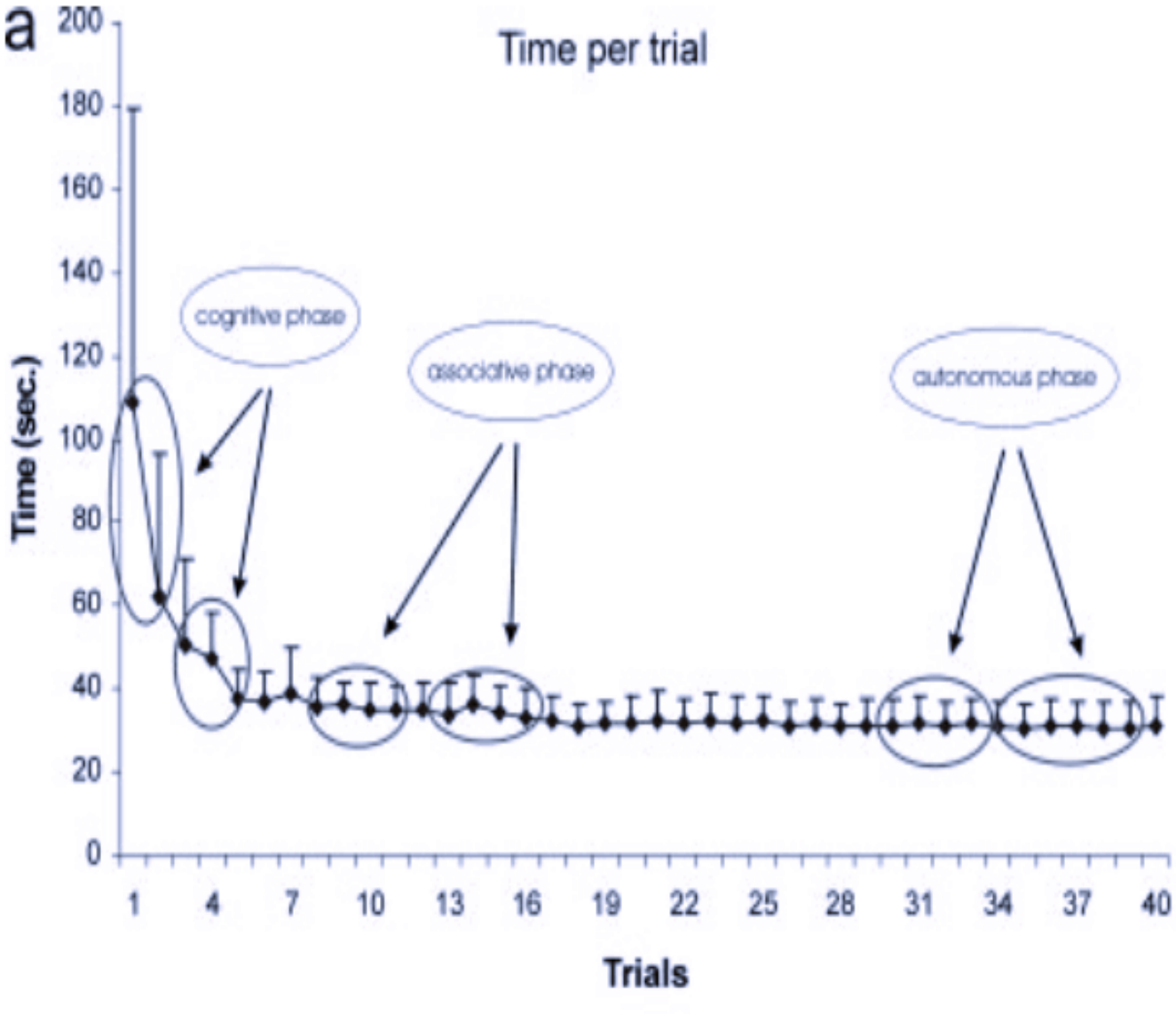
- ‘Associative’ phase =

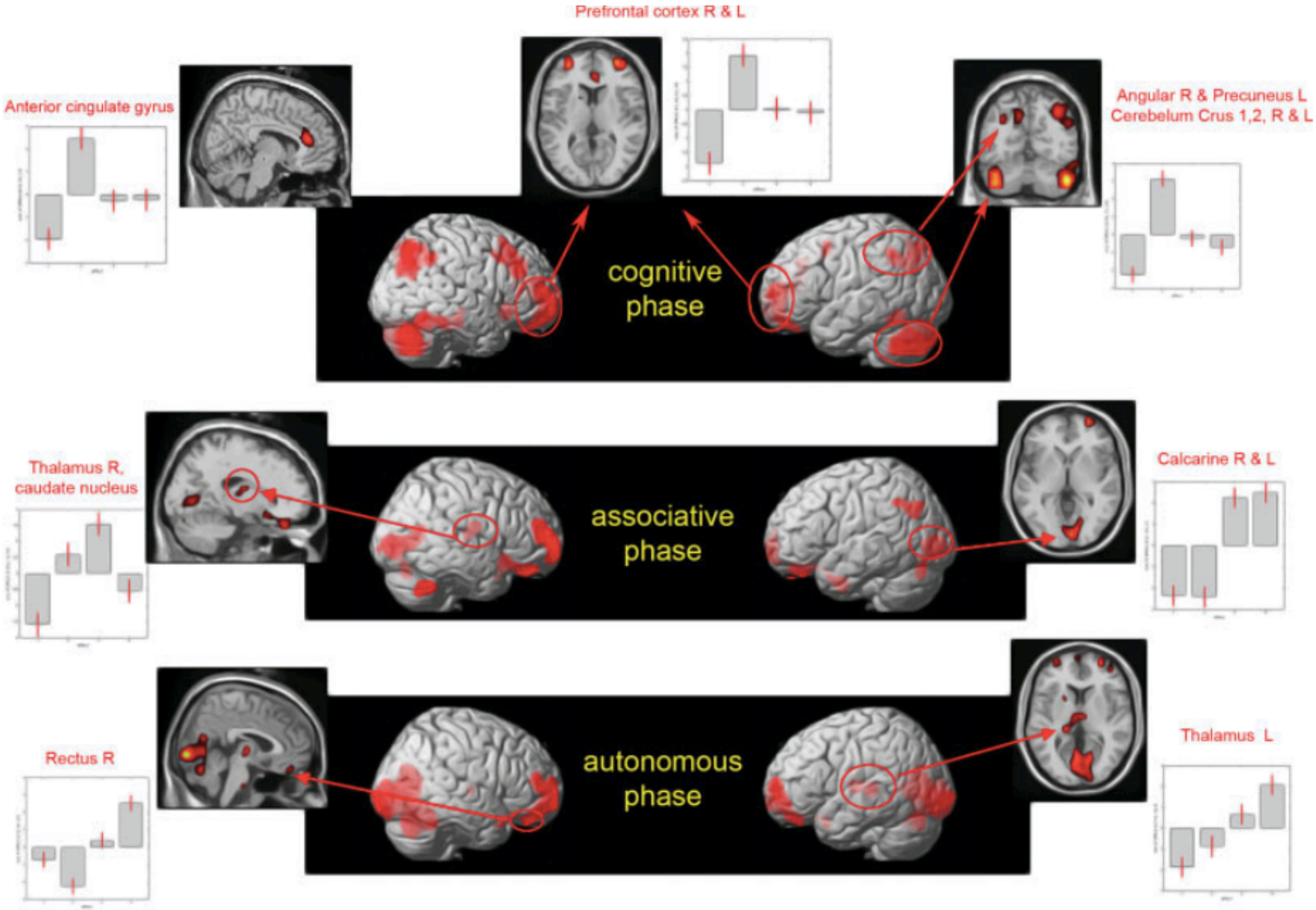
period from first optimum solution till ‘mastery’ (5 optimum solutions in a row)

- ‘Autonomous’ phase =

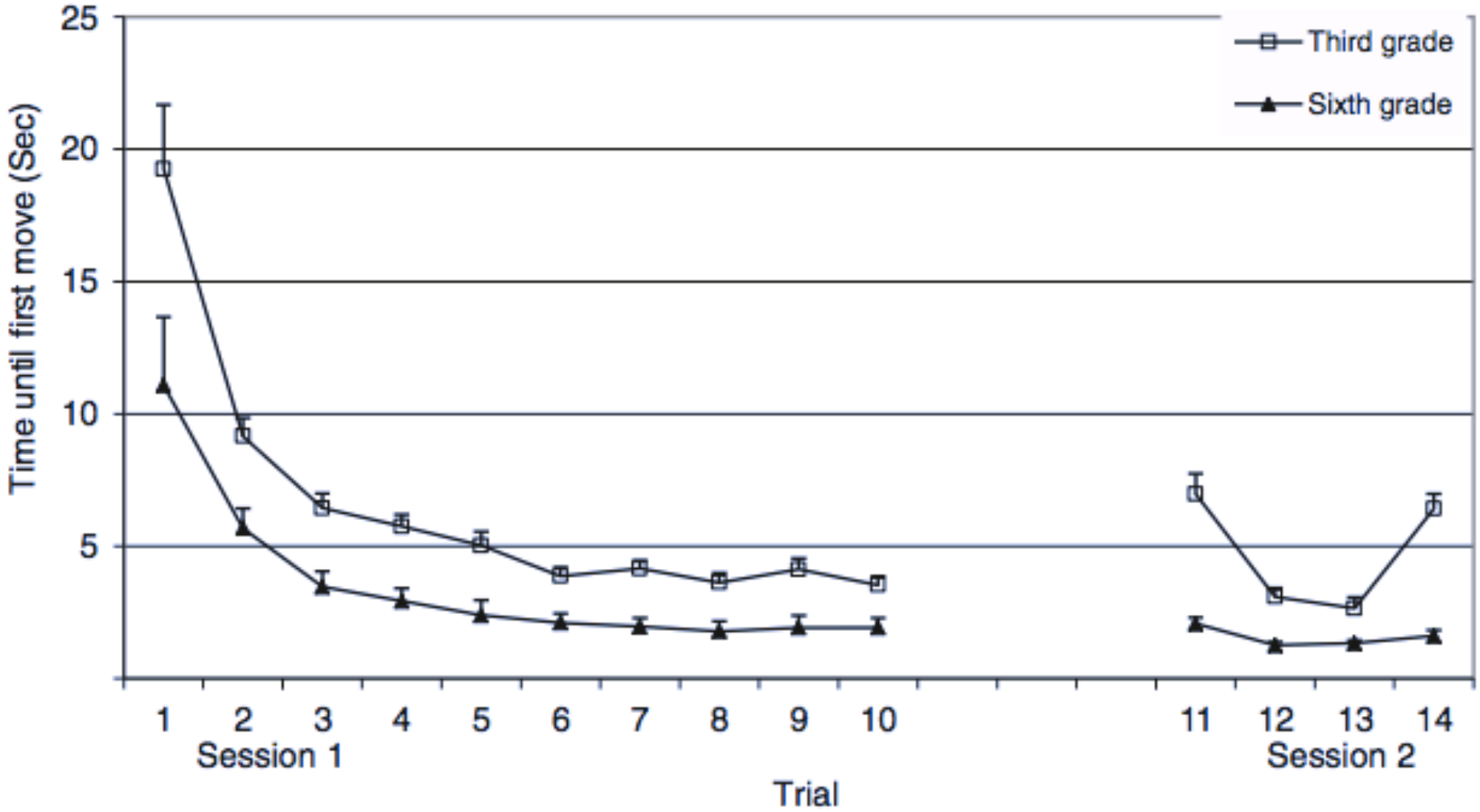
repeated production of optimum solution

CORRESPOND TO HYPOTHESISED STAGES IN PROCEDURAL LEARNING




Prefrontal cortex R & L
Anterior cingulate gyrus
Angular R & Precuneus L
Cerebelum Crus 1,2, R & L
cognitive
phase
Thalamus R,
caudate nucleus
Calcarine R & L
associative
phase
Rectus R
Thalamus L
autonomous
phase

Schiff & Vakil (2015)



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Research questions

- Are there proceduralisation difficulties in DLD and to what extent are these associated with different linguistic skills?
- What stages of the proceduralisation process are affected? (associative or autonomous)?
- Investigate relationship between proceduralisation and language (variety of measures of vocabulary / syntax)

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- Will the initial cognitive stage act as a confound?
  - Possible solutions – 3 discs only, demonstrating first move
- Will children engage in a task involving repeated trials?
- Will it be possible to dissect the proceduralisation into **discrete** stages