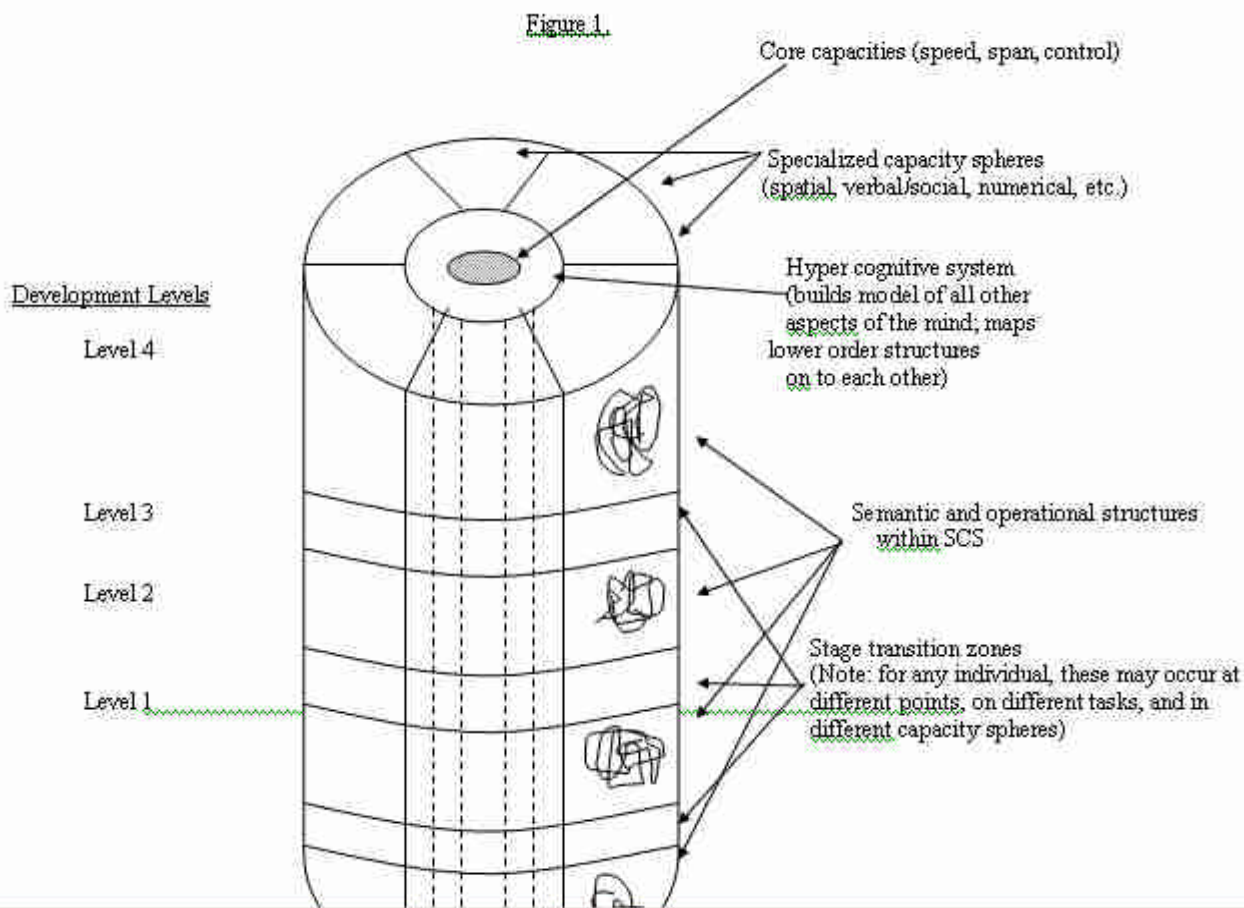


Processing efficiency, representational
capacity, self-awareness and reasoning:
Specifying their relations
in development

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Processing Efficiency

- Speed of processing
- Control of processing
- Representational capacity

Criteria for Domains

- They serve an identifiable *special* adaptational *function* (e.g., orientation in space, distribution of objects).
- They are responsible for the representation of a particular *type of relations* between objects (e.g., relations between objects in space, quantitative relations).
- They involve *specialized processes* for the processing of the type of relations concerned (e.g., mental rotation, number operations).
- They are *biased to a particular symbol system* that appropriate for the functioning of the domain (e.g., mental images, number notation).

Hypercognition

- Working
 - Self-monitoring
 - Self-regulation
 - Self-representation
- Long-term
 - Theory of mind
 - Folk psychology
 - Implicit theories

(b) Demetriou's model
of working memory

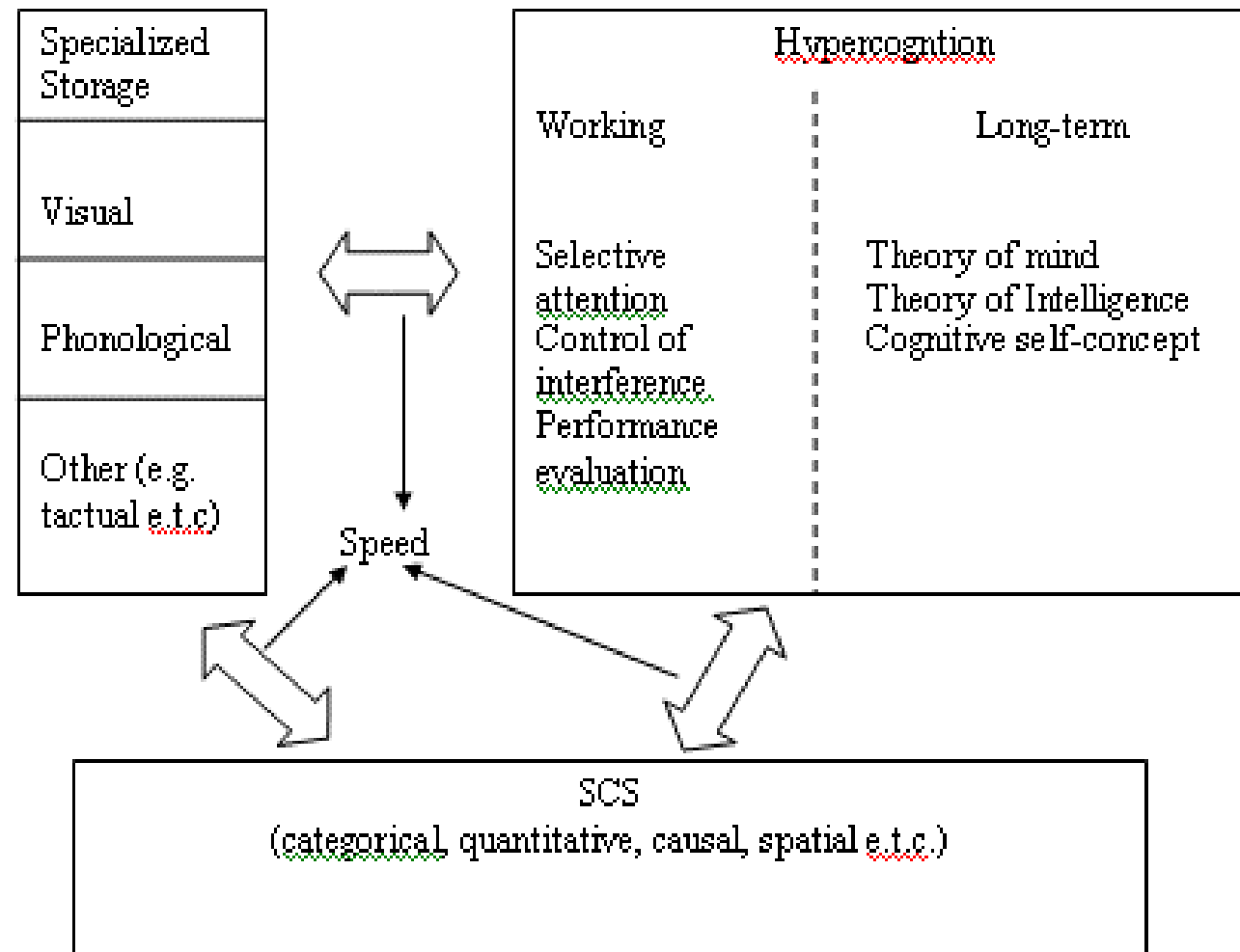


Figure 2.

Measuring Mental Structure and Development

- Processing Efficiency
 - Speed of processing
 - Control of processing
 - Working memory
 - Short-term storage
 - Executive control

Measuring Mental Structure and Development

- Specialized Capacity Systems
 - Quantitative
 - Causal
 - Spatial
 - Categorical
 - Verbal
 - Social
 - Drawing

Measuring Mental Structure and Development

- Hypercognitive
 - Self-representations about all processes
 - Comparisons of tasks in order to specify the mental processes involved in them.
 - Comparison of the subjective experiences produced by cognitive tasks.

Developmental Construction

- Tasks are constructed so as to systematically vary in difficulty.
- Difficulty is specified in terms of complexity, familiarity, and abstractness
- Tasks of supposedly equivalent difficulty are constructed for each of the systems

Task Structure for Processing Efficiency

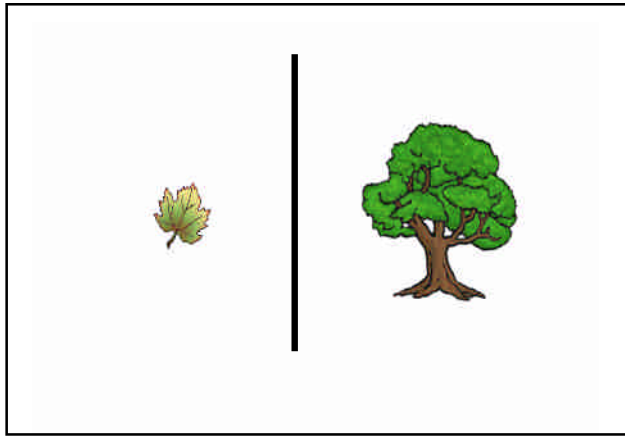
- General Speed
- PD = Speed + discrimination processes;
- PC = Speed + PD + control of interference between perceptual attributes;
- CC = Speed + PD + PC + control of interference from perceptual attributes to knowledge in long-term memory;
- WM = Speed + PD + PC + CC + storage and retrieval processes;
- Infl = Speed + PD + PC + CC + WM + planning and integration processes;
- Reason = Speed + PD + PC + CC + WM + Infl + inferential processes;

Processing Efficiency tasks

- Speed of processing

7

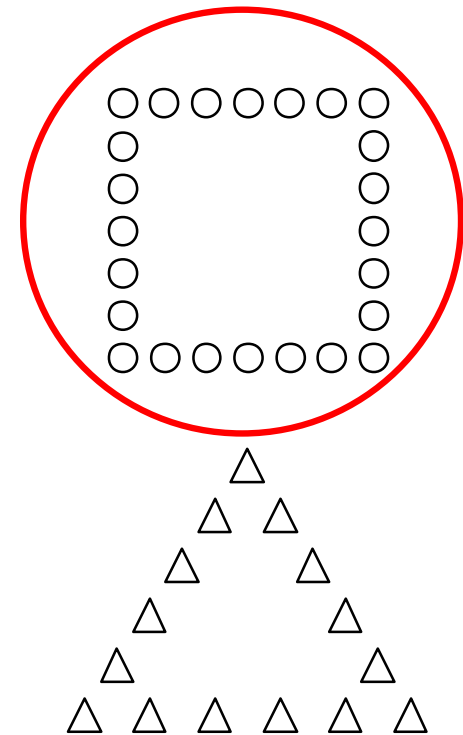
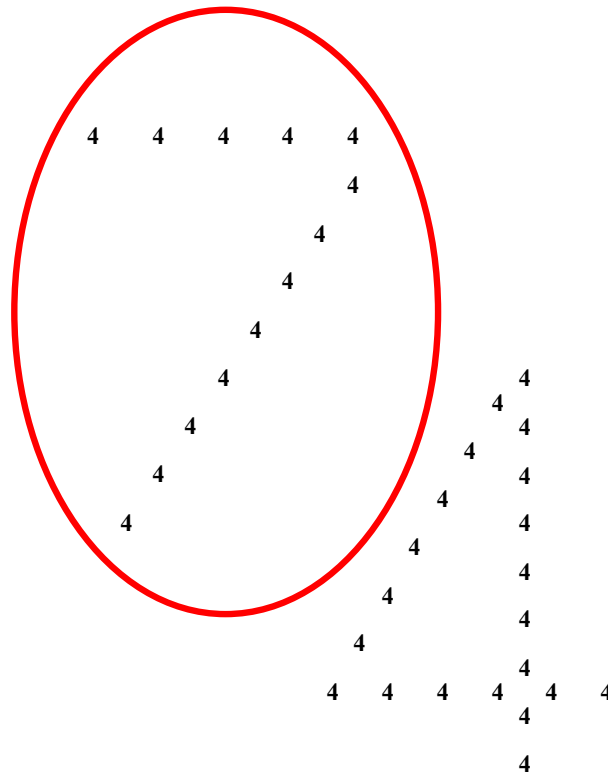
- Perceptual Discrimination



- Perceptual Control

ΚΌΚΚΙΒΟ

ΚΌΚΚΙΒΟ



- Conceptual Control

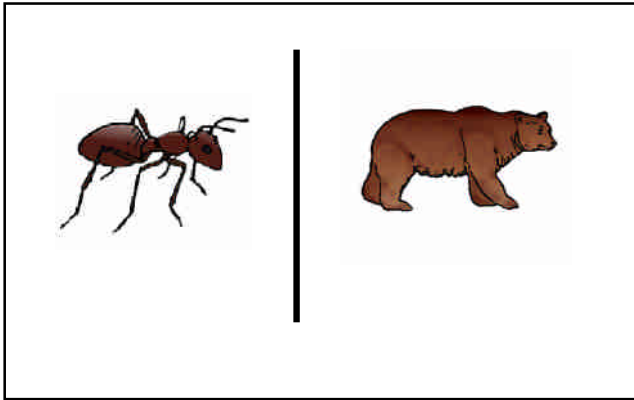
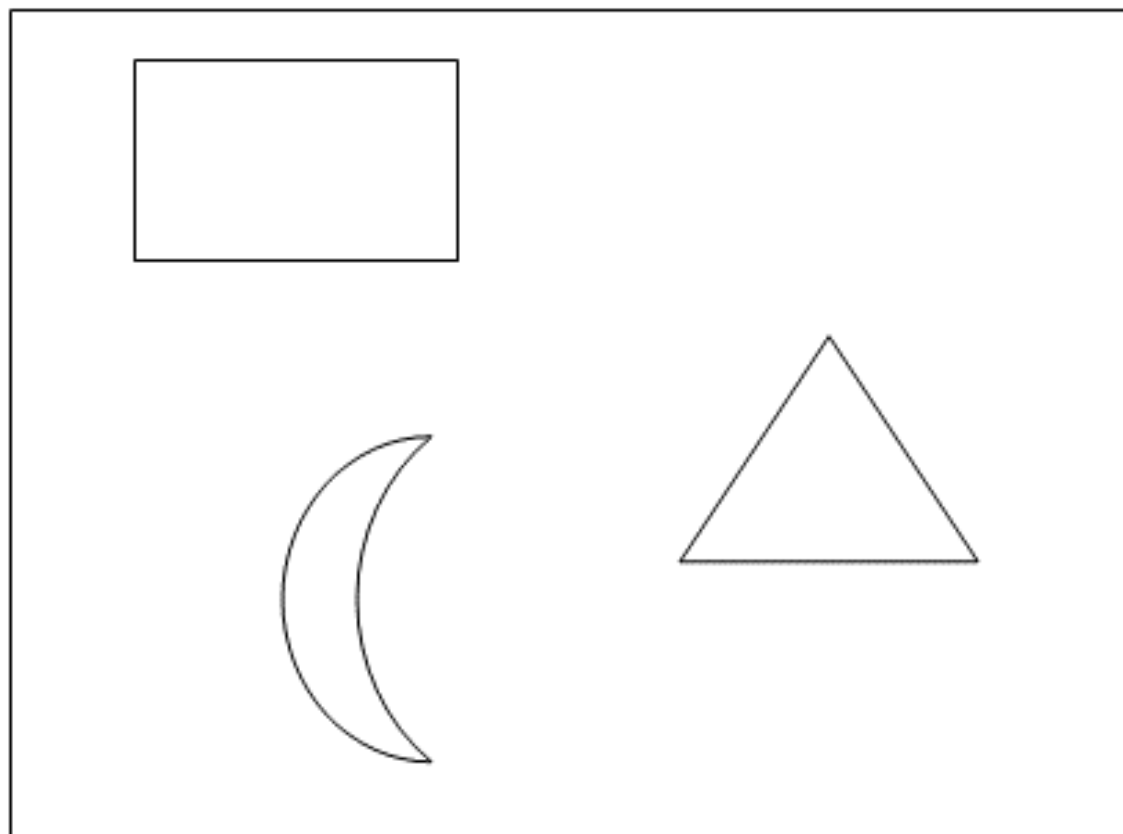


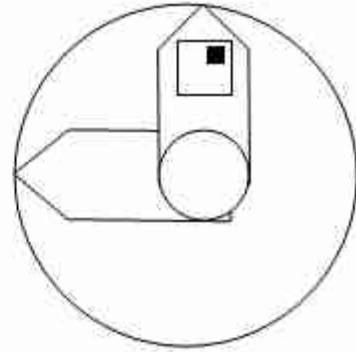
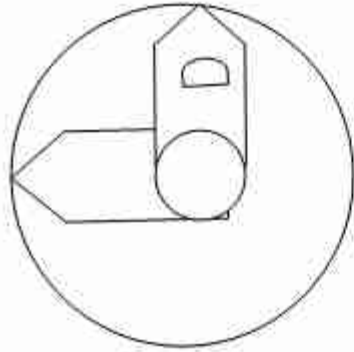
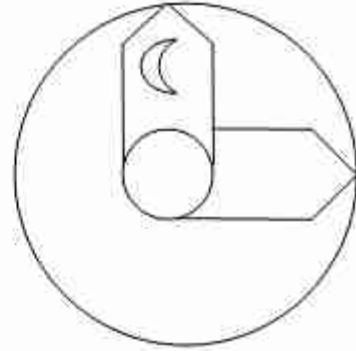
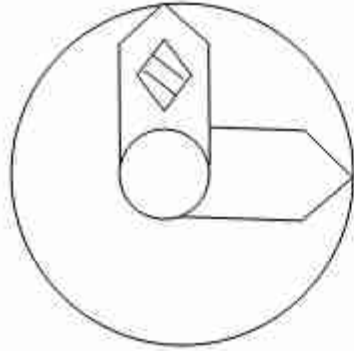
Figure 4.



that of the list of stimuli in the experimental task.

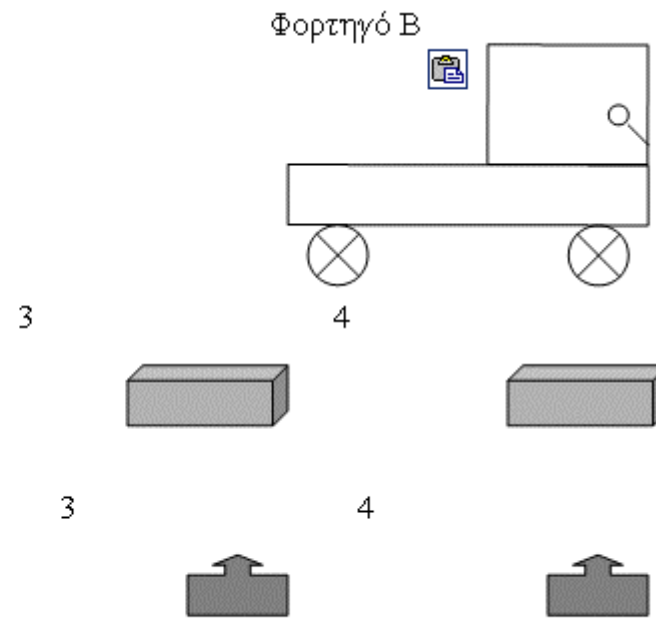
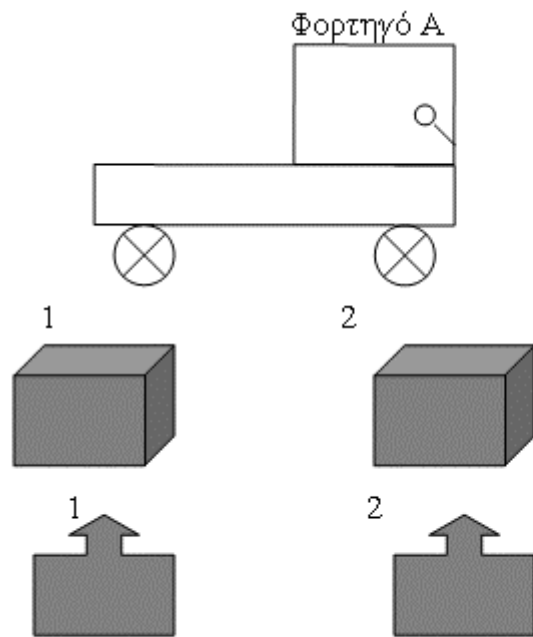
Difficulty level	Stimuli
2	32 57 60 40
3	30 70 90 73 48 64





Isolation of variables

Make the tracks so that their difference in speed is due only to weight



Verbal Analogies

- 1) ink : pen :: paint :: - [color, *brush*, paper].
- 2) bed : sleep :: - [paper, *table*, water] : --- [*eating*, rain, book].
- 3) (children : parents :: family) ::: (students : teachers :: - [school, *education*, lesson])
- 4) {(tail : fish :: feed : mammals) ::: - [*movement*, animals, vertebrates]} :::: {(propeller : ship :: wheels : car) ::: - [vehicles, *transportation*, carriers]}

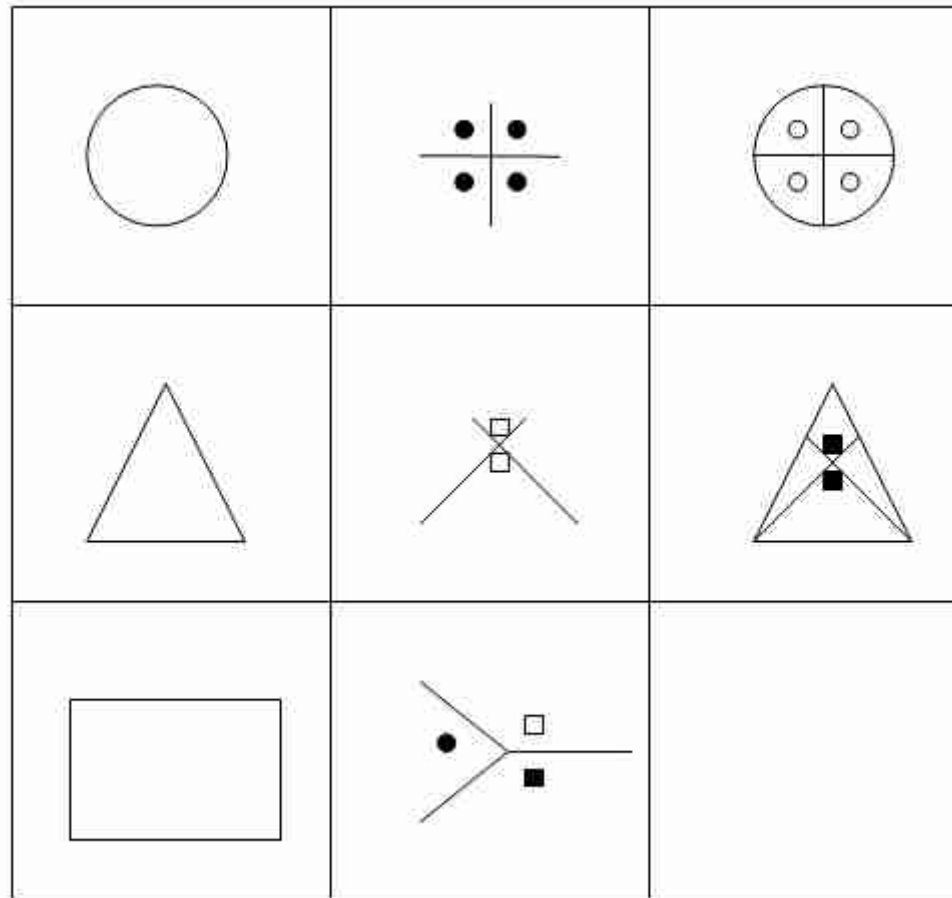
Syllogistic Reasoning

- If animals live in a cage then they are not happy. The bird is happy => [the bird lives in the cage, *the bird does not live in the cage*, none of the two].
- If peacocks have more beautiful feathers than cocks and sparrows have more uglier feathers than peacocks => [sparrows have more beautiful feathers than peacocks, *sparrows have more uglier feathers than peacocks*, none of the two].
- If the bird is in the nest then it sings; the bird sings => [the bird is not in the nest, the bird is in the nest, *none of the two*].
- If elephants are heavier than horses and if elephants are heavier than dogs => [horses are heavier than dogs, elephants are heavier than dogs, *none of the two*].

Class inclusion



Raven-like matrices



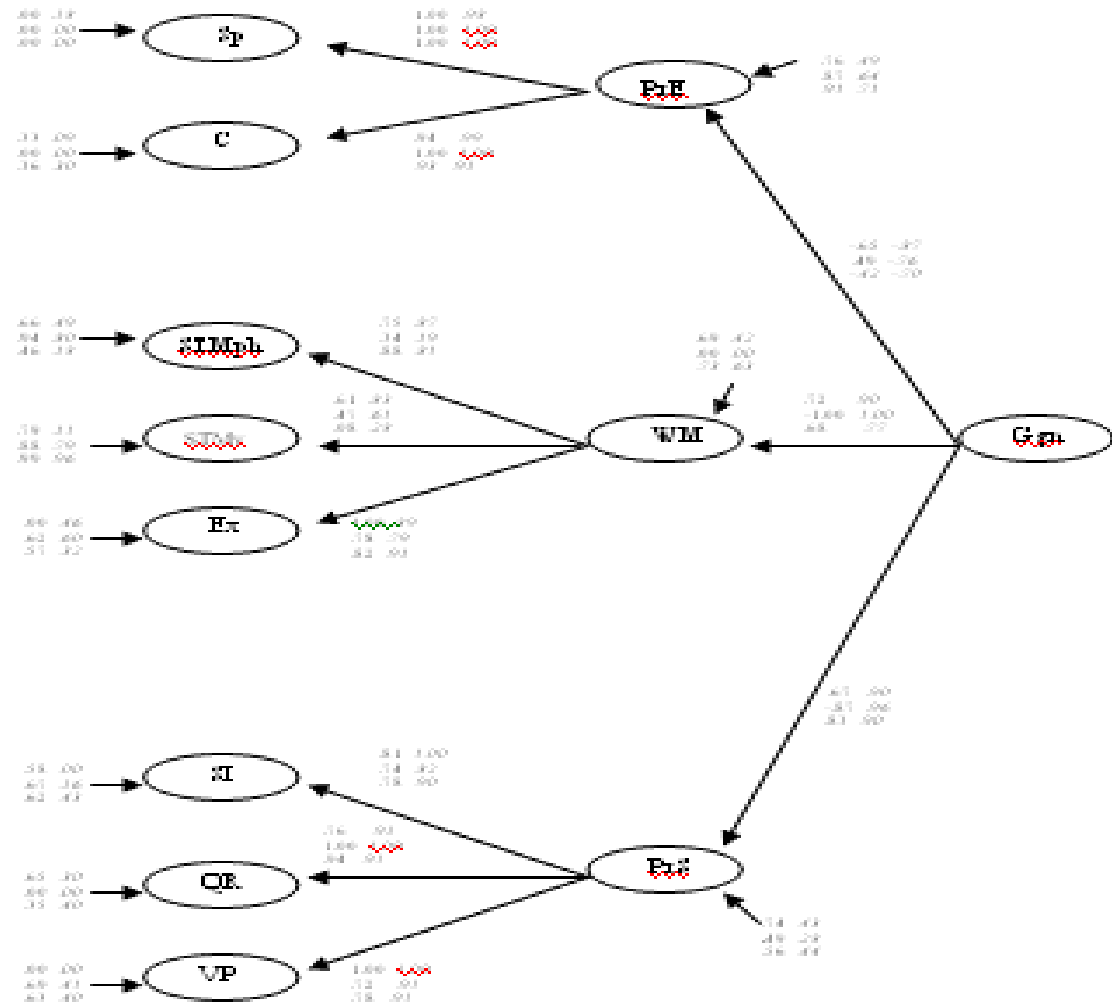
Mathematical Reasoning

- ARITHMETIC OPERATIONS
- $9 * 3 = 6$
- $(2 \# 4) @ 2 = 6$
- $(3 * 2 @ 4) \# 3 = 7$
- $(3 \# 3) * 1 = (12 @ 3) \$ 2$

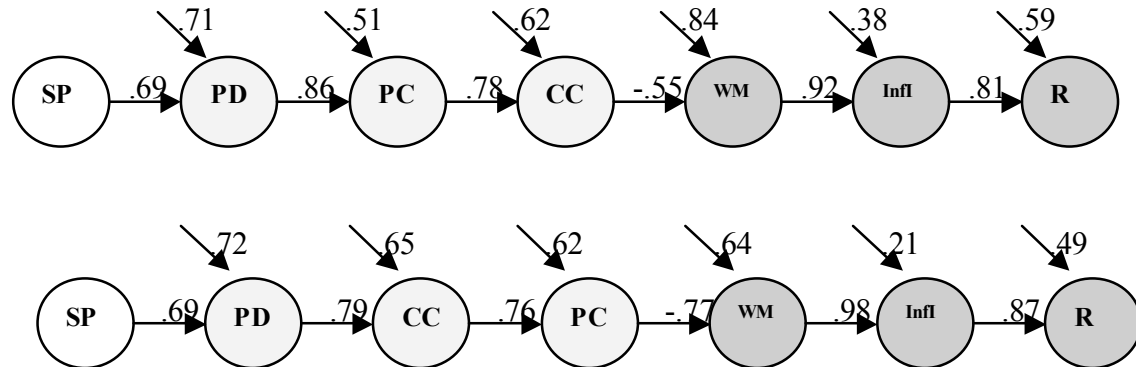
- NUMERICAL ANALOGIES
- $6 : 12 :: 8 : ?$
- $6 : 3 :: 8 : ?$
- $3 : 9 :: 6 : ?$
- $3 : 1 :: 6 : ?$
- $6 : 8 :: 9 : ?$
- $6 : 4 :: 9 : ?$

- ALGEBRAIC REASONING
- Specify x , given that $x = y + 3$ and $y=1$
- Specify m given that $m = 3n + 1$ and $n = 4$
- Specify x , given that $x = y + z$ and $x + y + z = 20$).

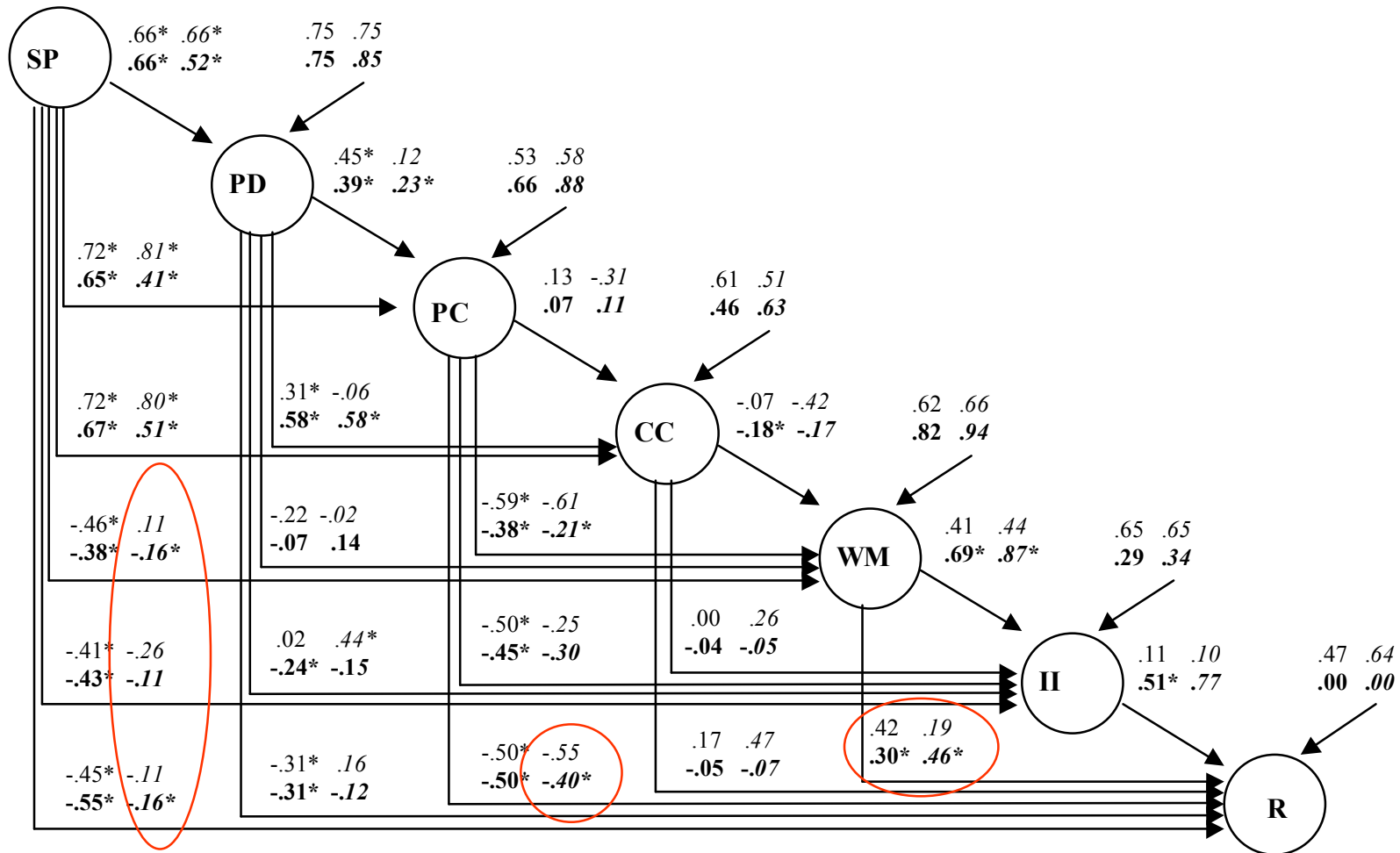
Figure 2



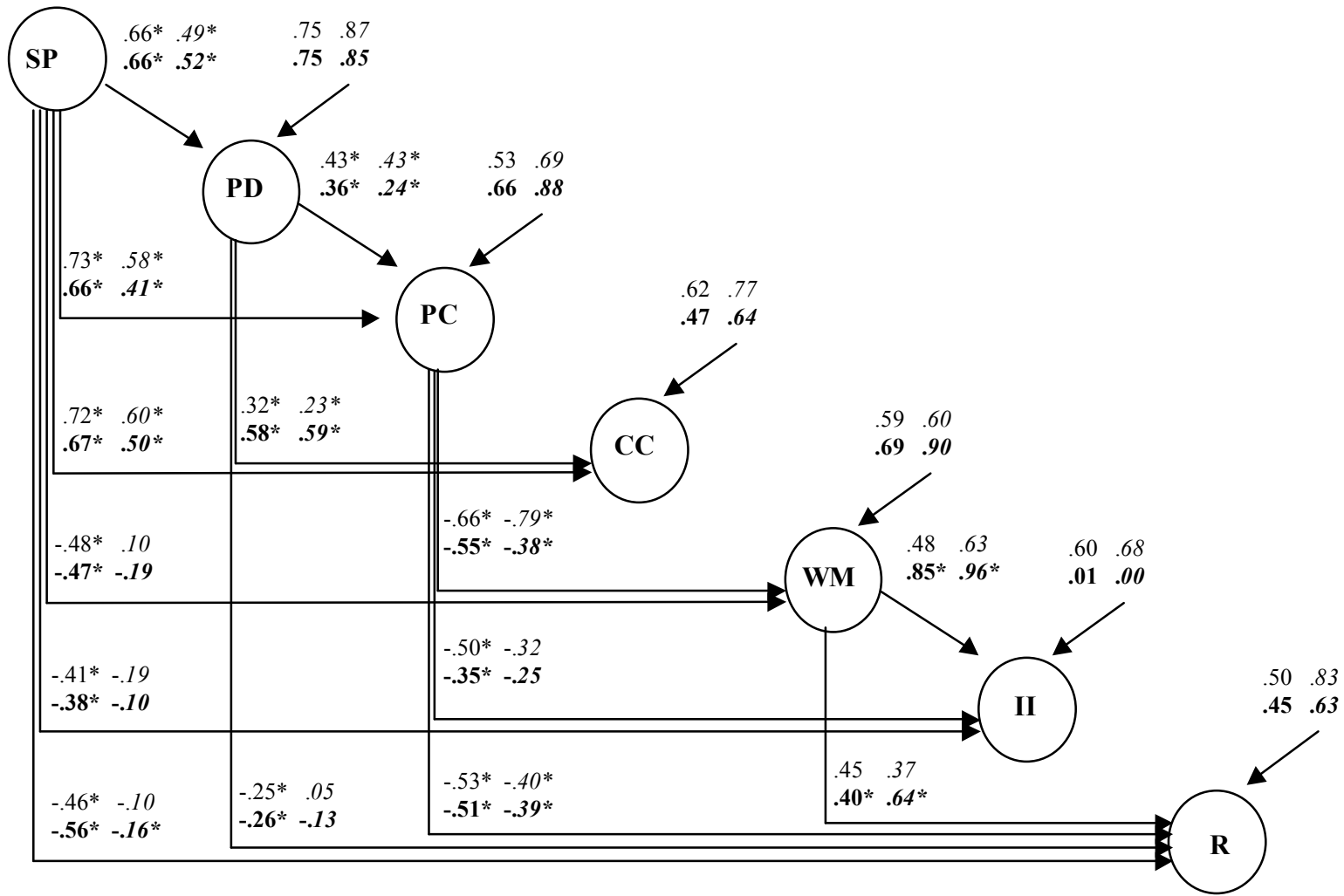
The Simplex Model



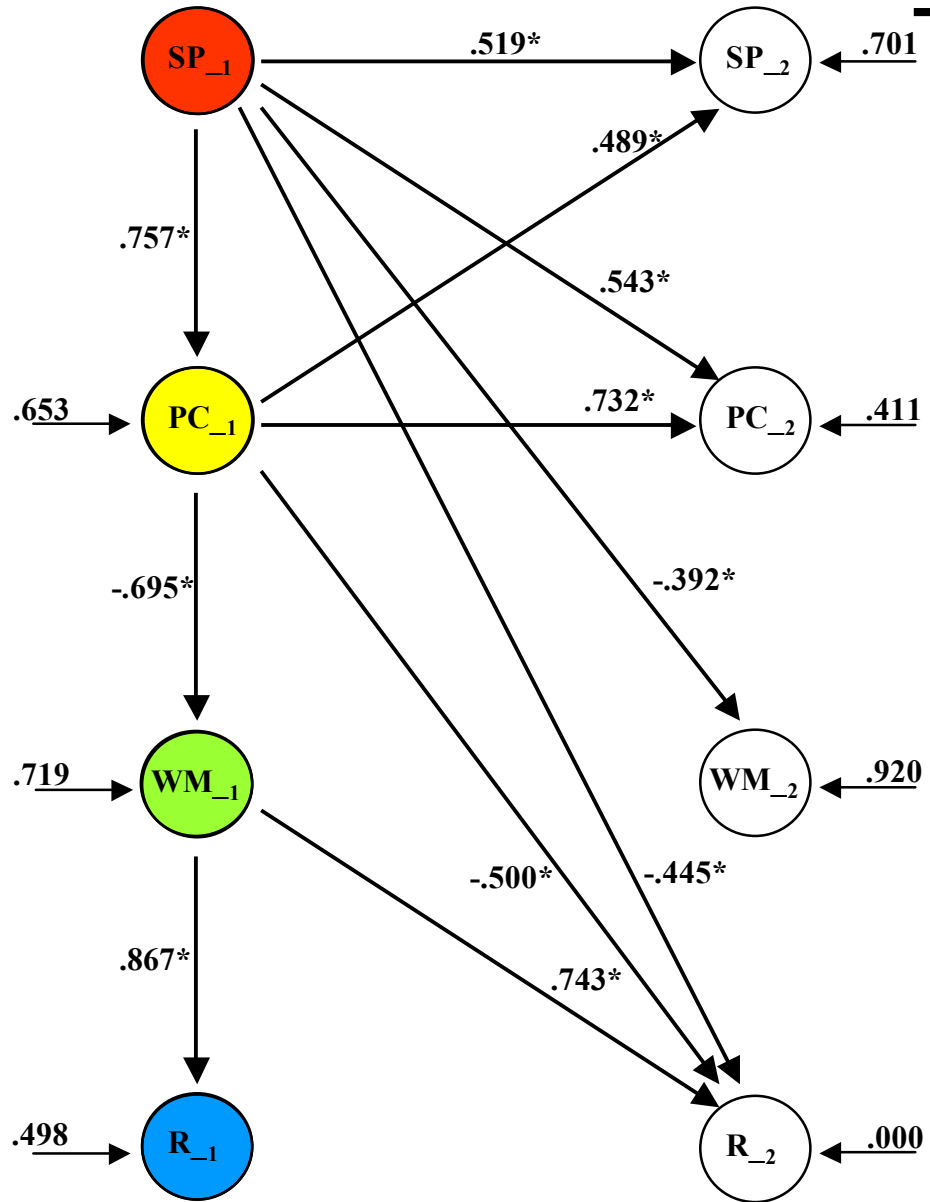
The cascade model



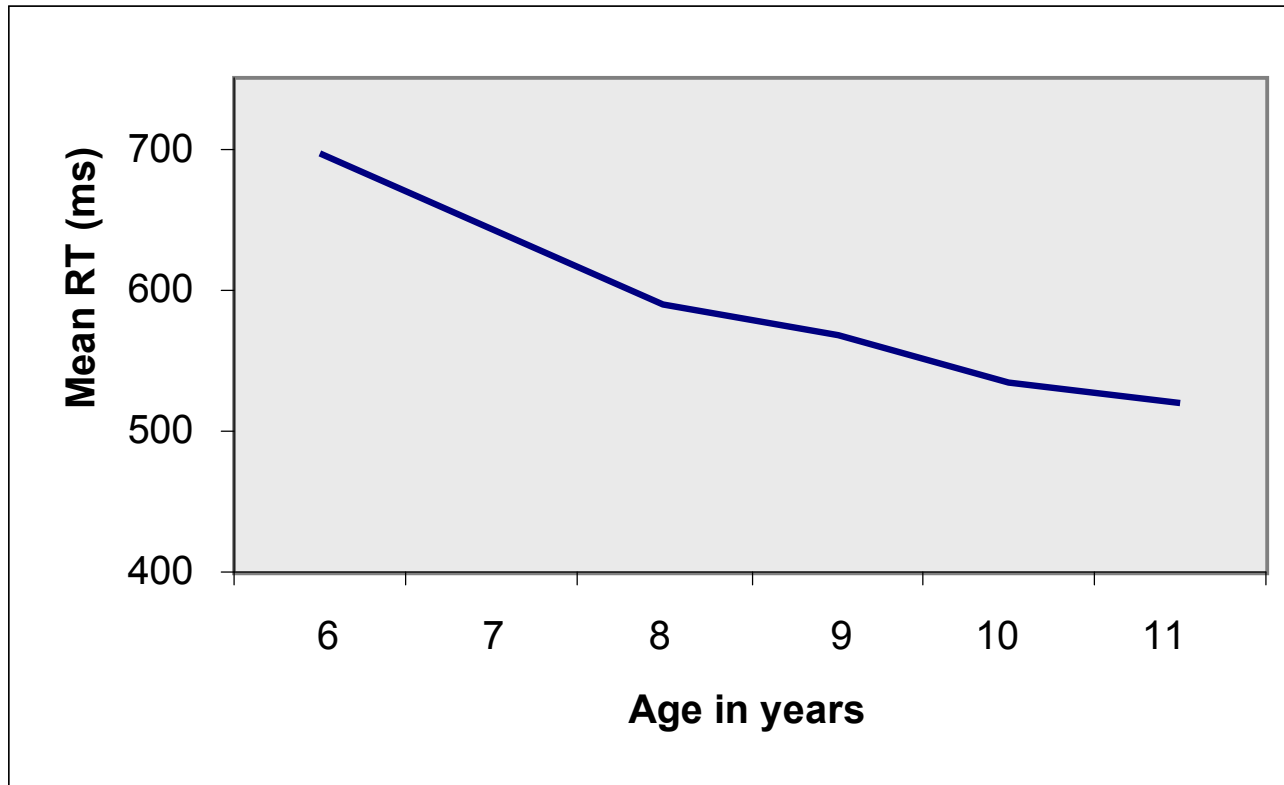
The parsimonious cascade model



The longitudinal model



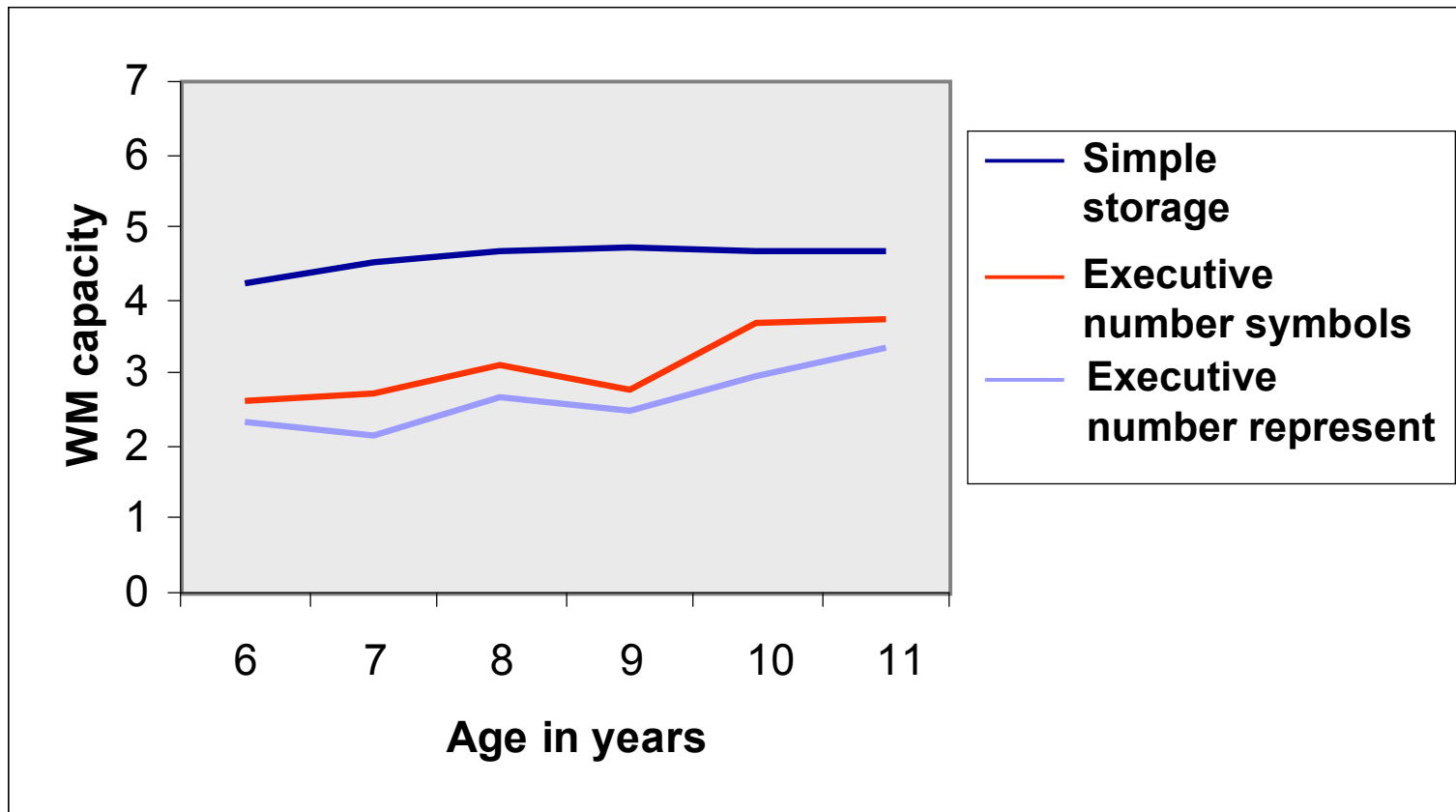
▣ The development of speed of processing



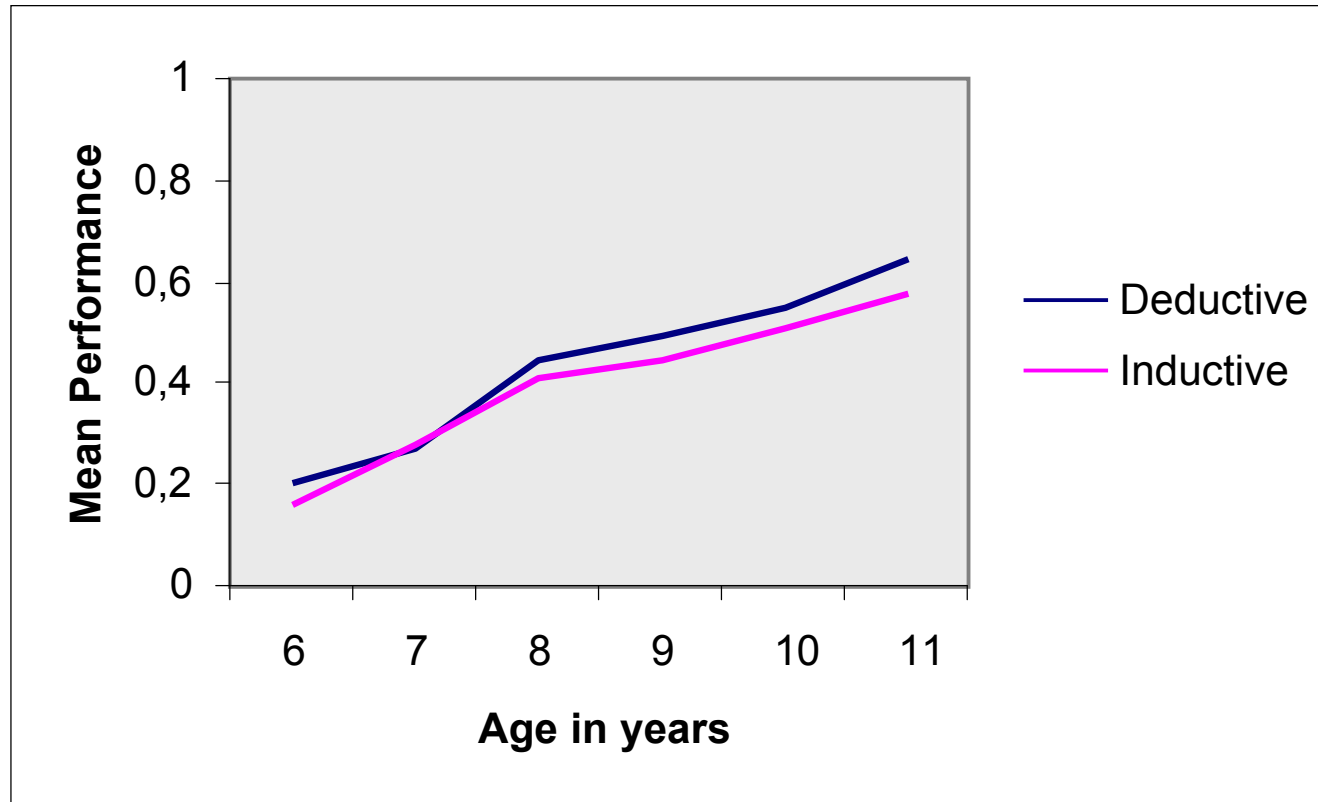
▣ The development of control of processing



▣ The development of working memory capacity

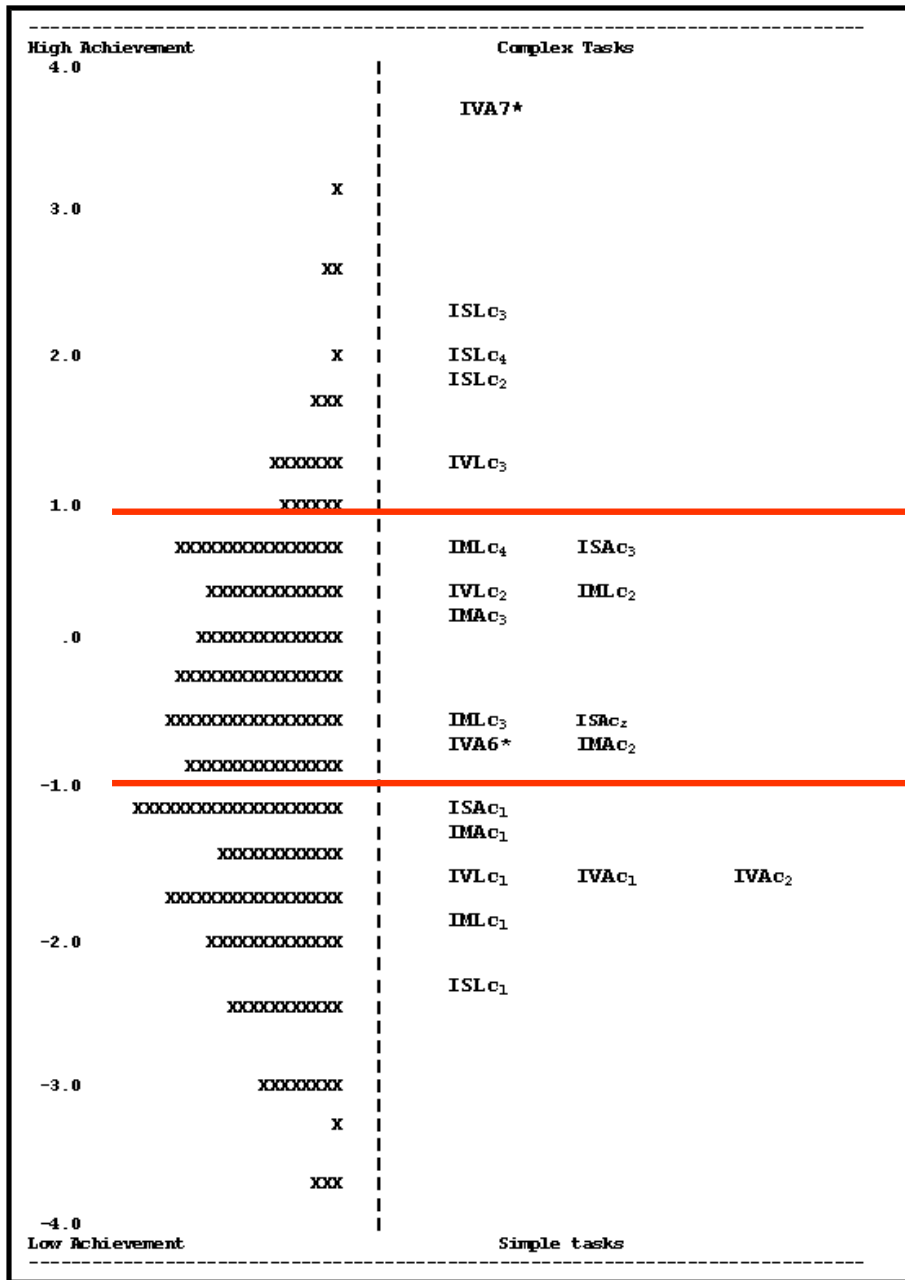


□ The development of reasoning ability



Scaling

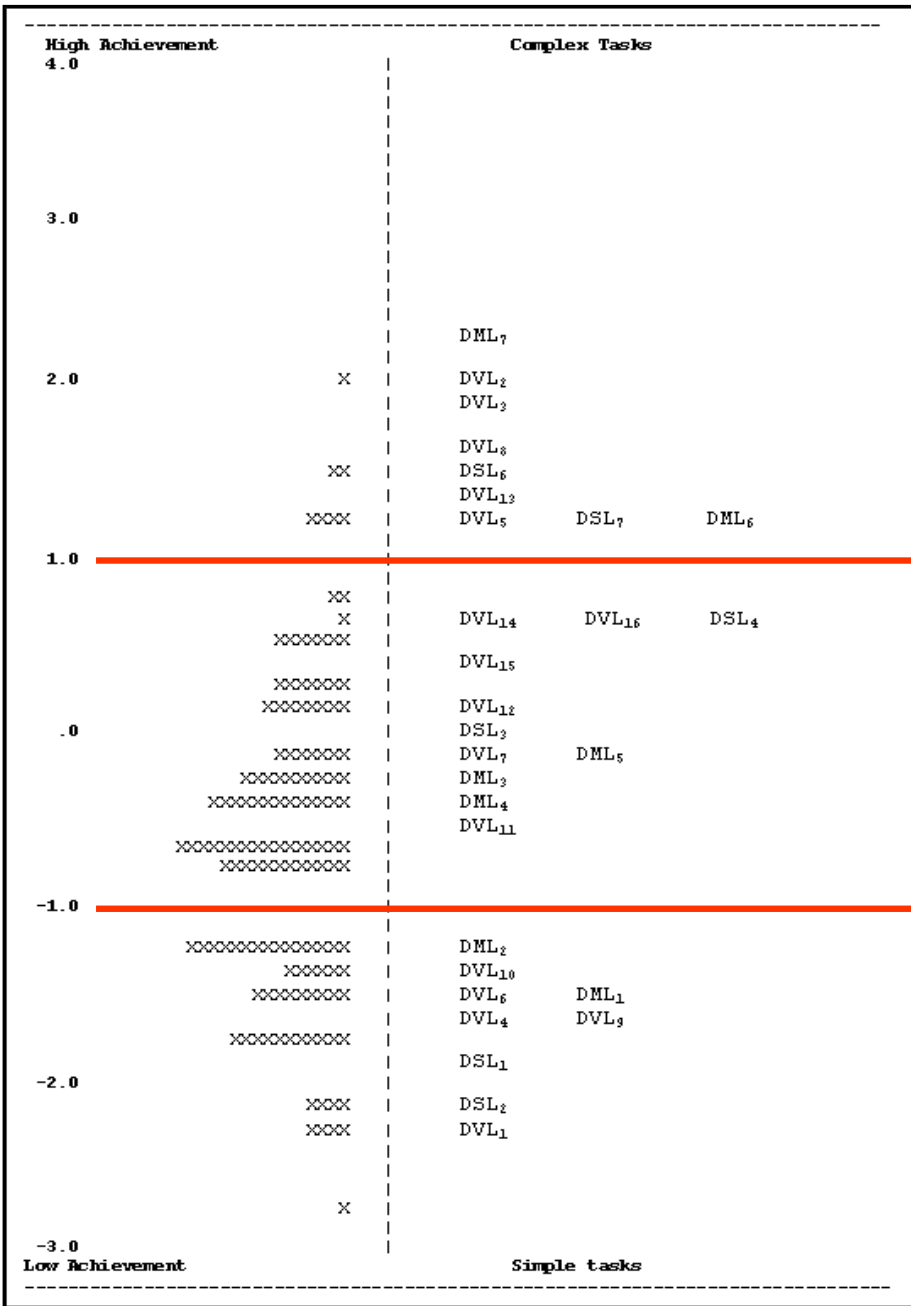
- Rasch and Saltus Scaling of the SCSs items showed a very reliable developmental scale involving four main levels with several sublevels within each



**Multi-dimensional relations
Generalizations
Abstract inferences**

**Two-dimensional analogical relations
Two transformations**

**Unidimensional analogical relations
Single transformation**

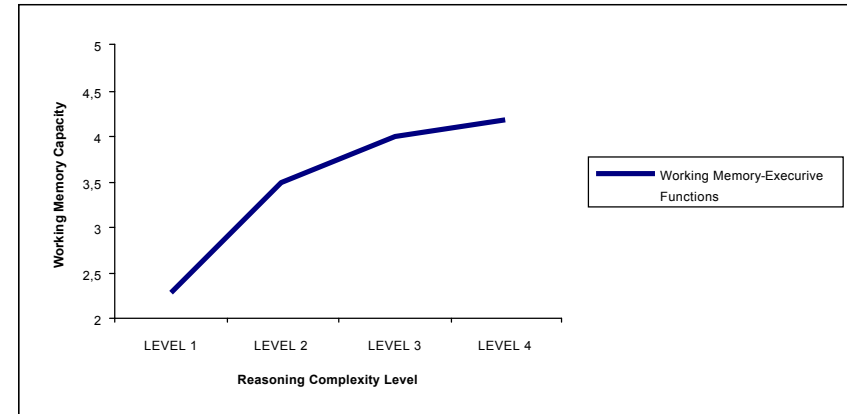
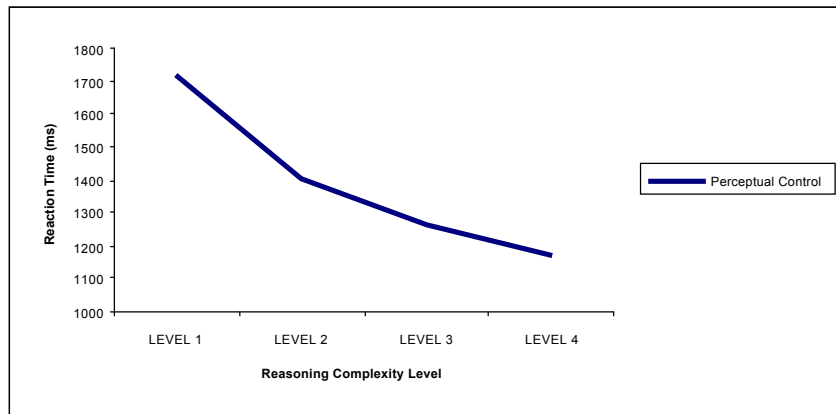
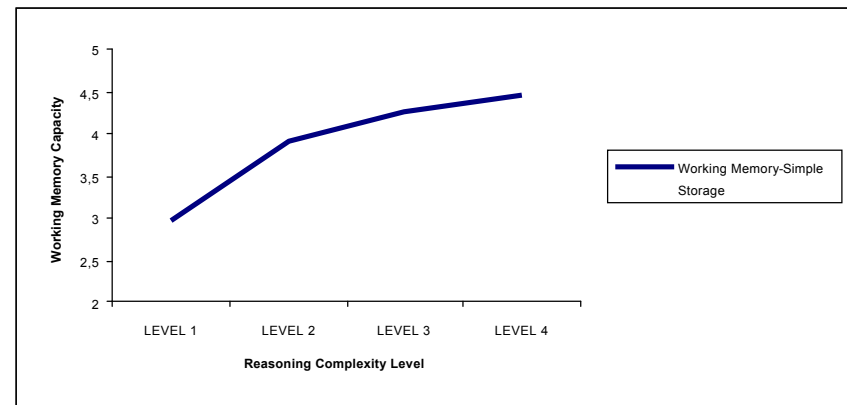
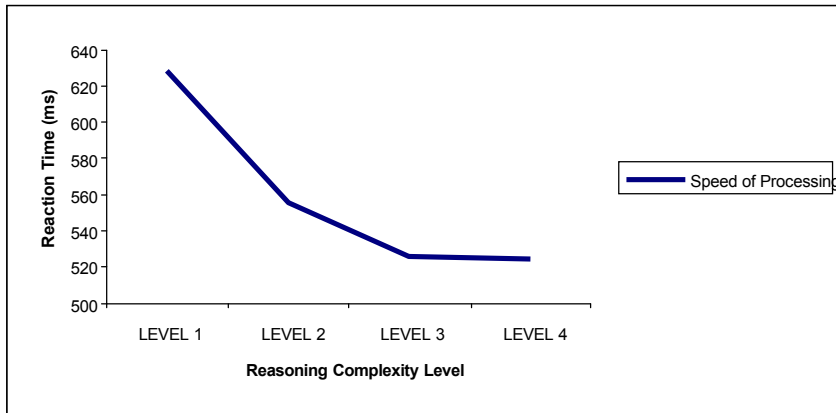


Logical fallacies
 “if p then q, -p, ...”
 “if p then q, q, ...”

Logically valid arguments: MT
 “if p then q, -q, therefore -p”
 Decidable conclusion
 Negation in premises

Logically valid arguments: MP
 “if p then q, p, therefore q”
 Decidable conclusion
 Affirmative premises

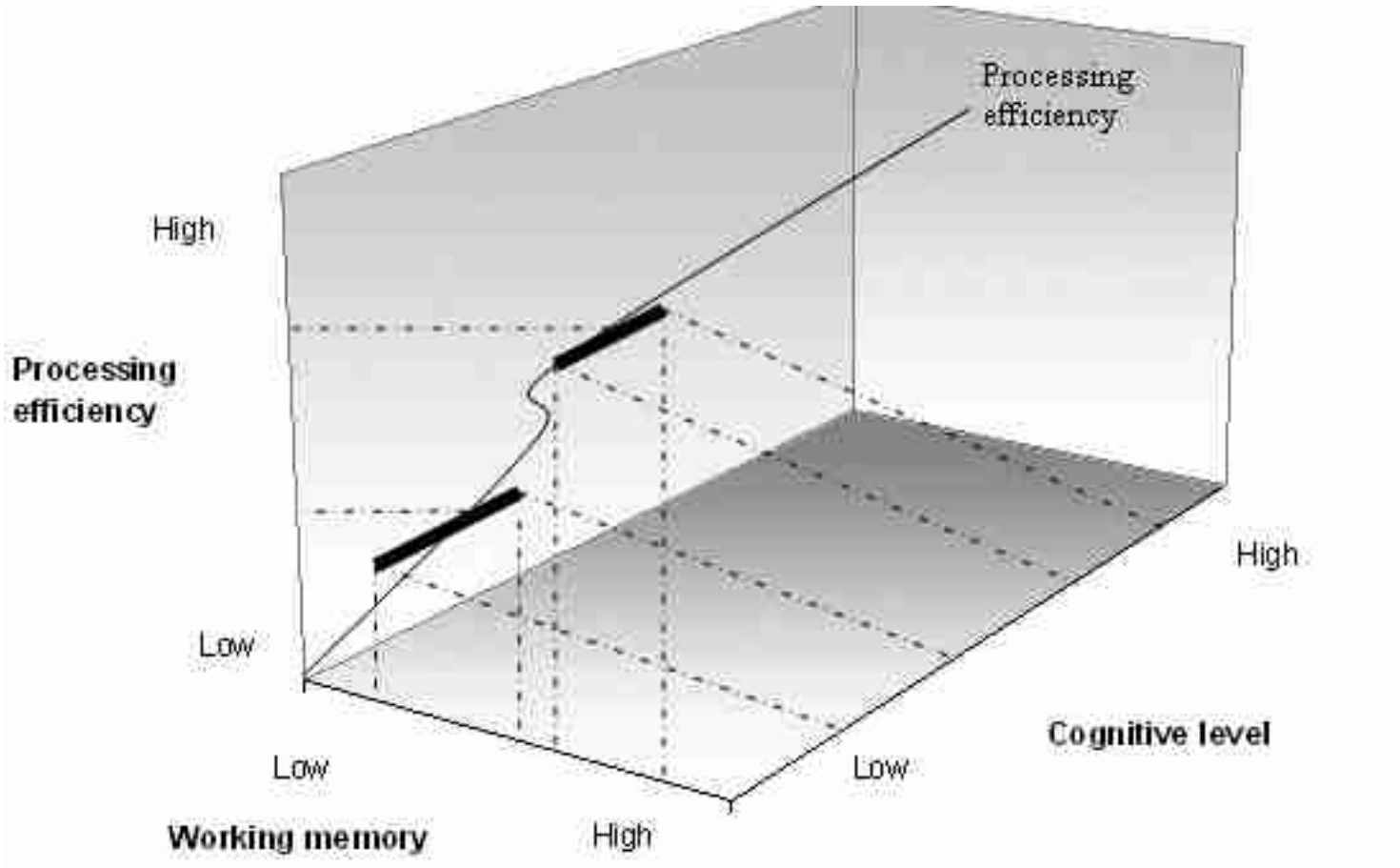
▣ The cognitive processes as a function of reasoning complexity level



▣ Identifying reasoning complexity levels in terms of their demand on cognitive resources

	Speed (ms)	Control (ms)	WM-storage	WM-executive
Level 1	630	1700	3,0	2,3
Level 2	550	1400	4,0	3,5
Level 3	525	1260	4,3	4,0
Level 4	525	1170	4,5	4,2

The relations between processing efficiency, working memory, and thinking



Is this Architecture Universal?

- Several studies compared populations from different countries, including
 - China
 - India
 - Nigeria
 - Pakistan

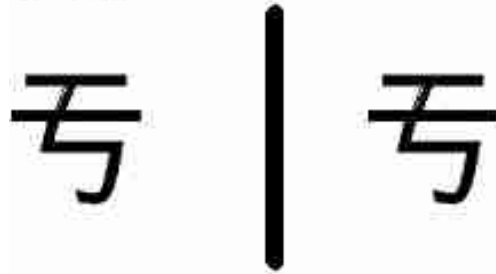
A Greek-Chinese Study

- 122 Greeks and 130 Chinese children from 4 to 7 yrs.
- With
 - Speed of processing tasks
 - RT tasks requiring to compare three types of characters: european, arabic, chinese
 - WM: verbal, arithmetic, spatial
 - Reasoning: verbal, arithmetic, spatial

Arabic



Chinese



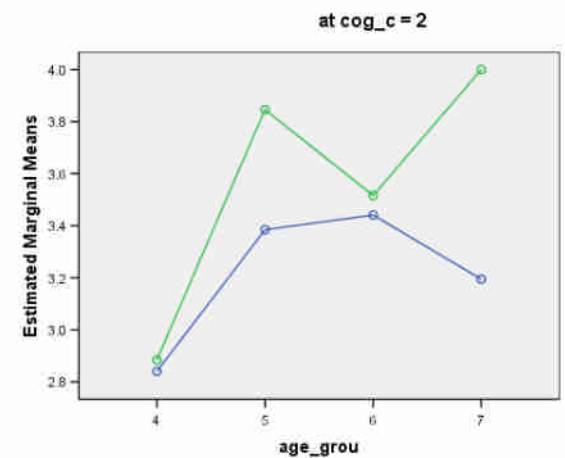
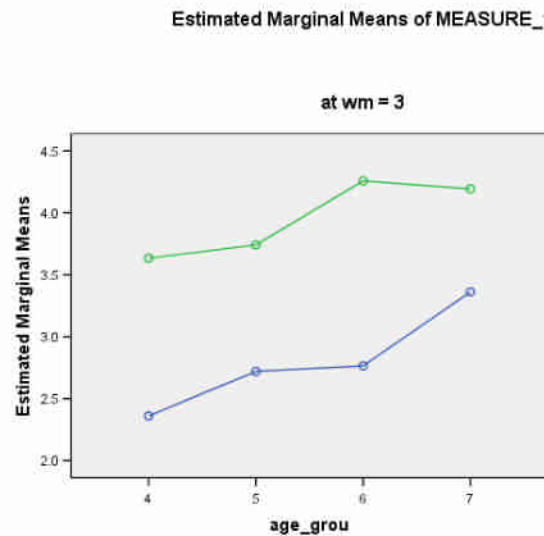
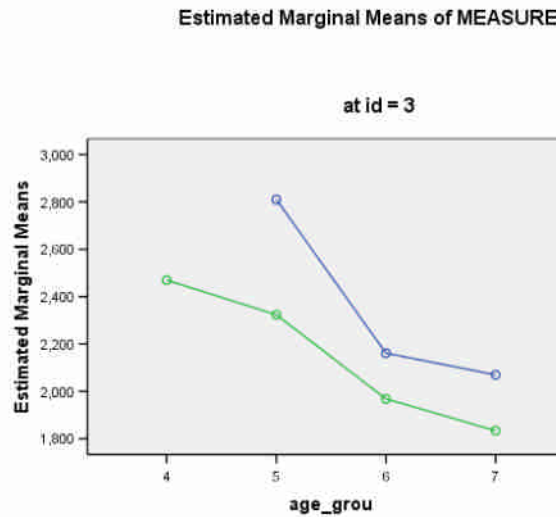
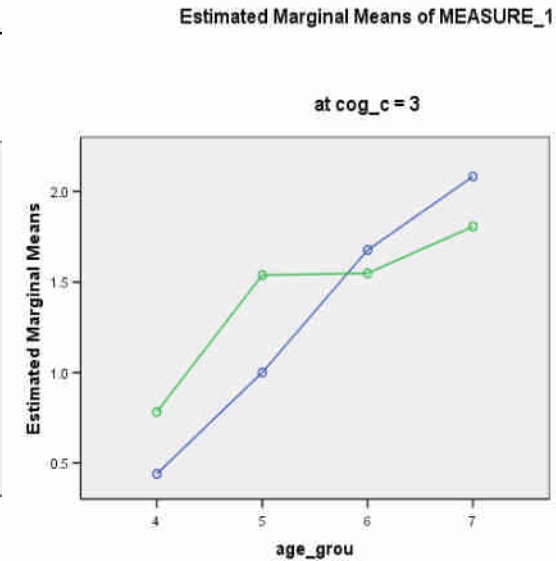
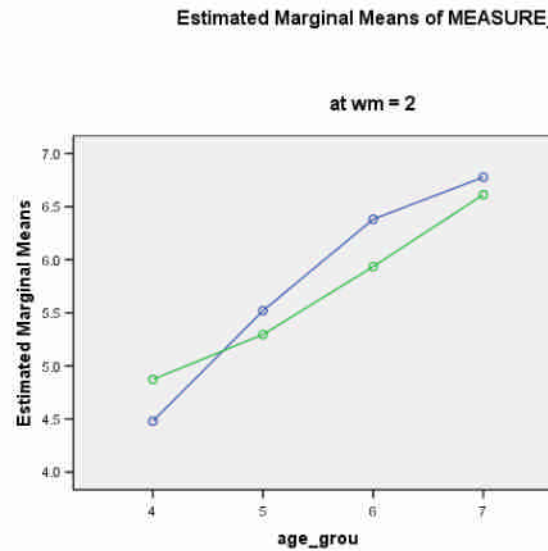
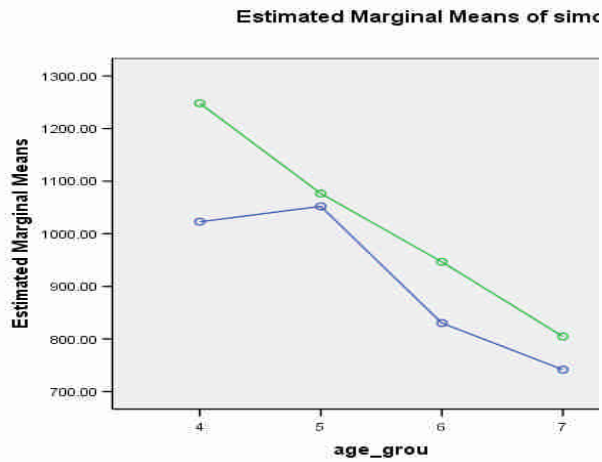
European



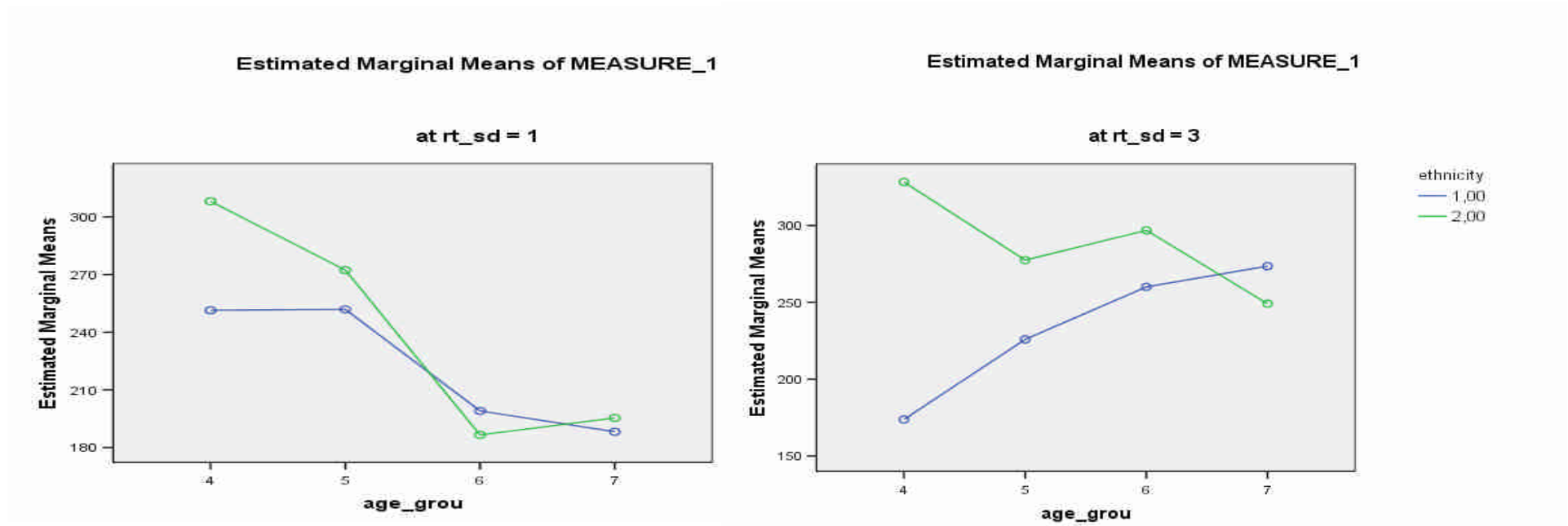
Speed

WM

Reasoning



Variability of RT across age, culture, and writing system



European

Chinese

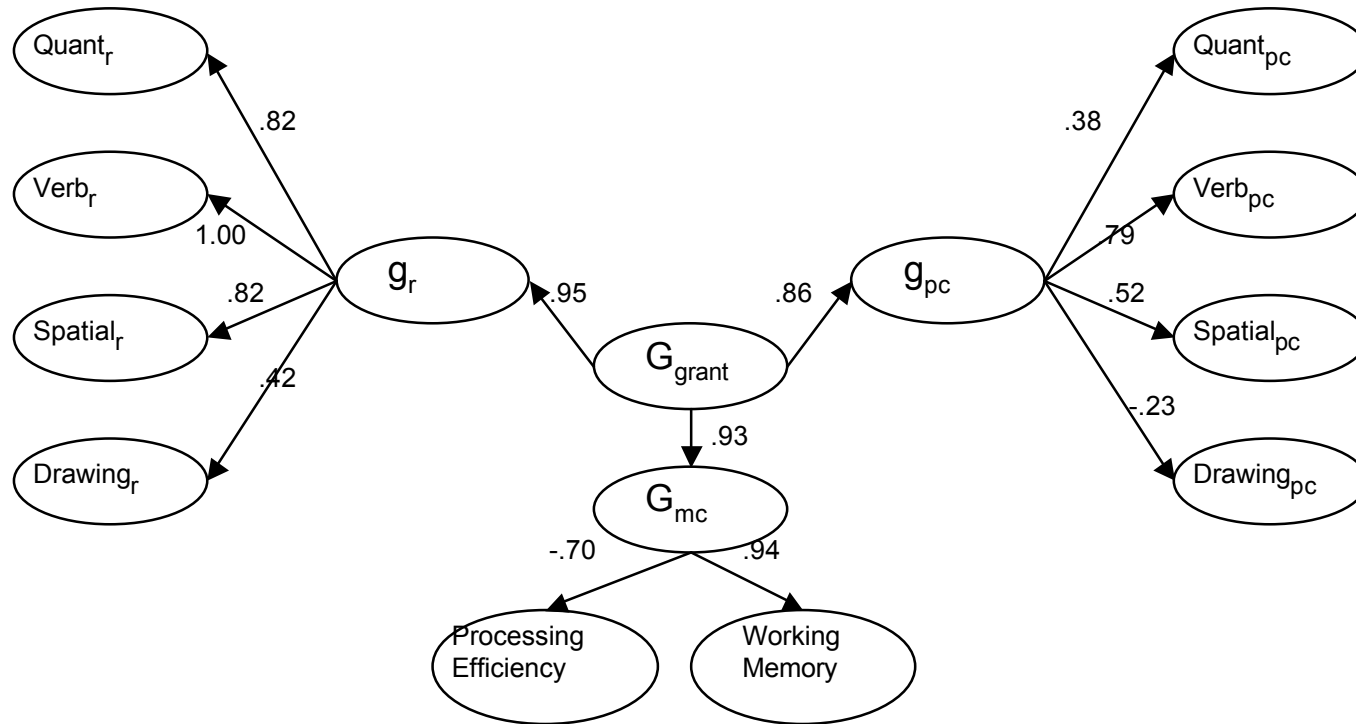


Cognitive self-representation

(scale: 1 – 7)

- I make decisions quickly
- I learn fast
- I can easily remember a new phone number
- I can easily monitor (or change) my thoughts (or emotions etc.)
- I can easily see the relation between things which appear unrelated
- I immediately solve everyday problems involving numbers
- When something I use spoils, I try to think of all the possible reasons that might have caused it
- To find out which of my guesses is correct, I proceed to methodically consider each time only the things my guess proposes
- I retain a very clear picture of things
- I orient myself easily in a strange place if I am given instructions
- I understand easily the intentions of others before they express them
- I am interested in understanding others' problems

The Model Involving Cognitive Systems, Cognitive Self-representations, and processing efficiency



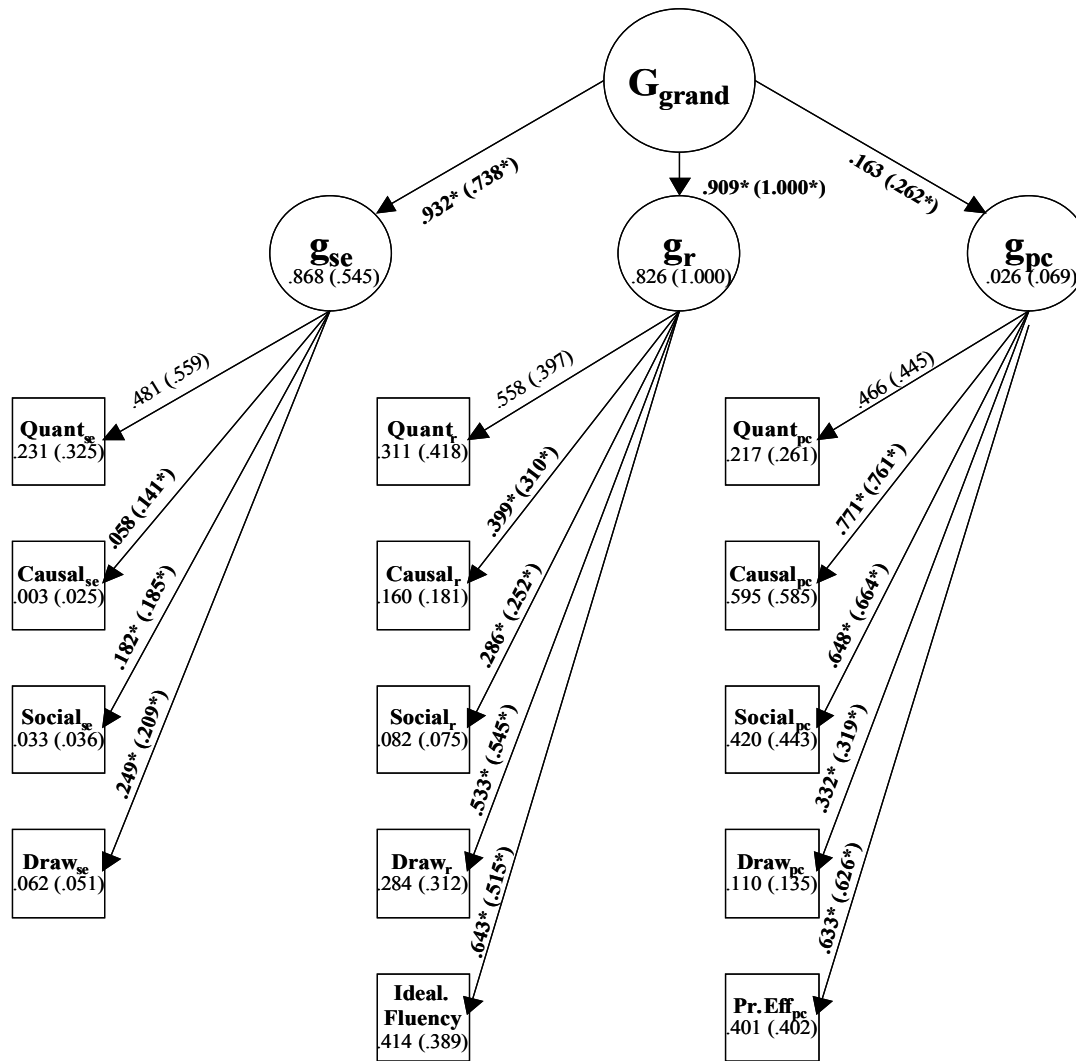


Figure 2: The confirmatory factor analysis model for cognitive performance, self-evaluation, and self-representation of the cognitive processes examined in Study 2.

Note: The first and the second coefficient in each pair represent relations before and after partialling out the effect of age. Free parameters are denoted by bold characters. Significant coefficients are denoted by asterisk. Numbers in squares and circles indicate variance accounted for.

Structural Relations Between Reasoning, Self-evaluation, and Self-concept as a Function of Age

	Reasoning	Self-evaluation
Self-evaluation		
11	.18	
12	.33*	
13	.78*	
14	.80*	
15	.97*	
Self-concept		
11	.00	.08
12	.06	.12
13	.01	-.10
14	.34*	-.30*
15	.54*	-.80*

Conclusions about PE, WM, Thought Relations

- Processing speed is the crucial developmental factor in concern to working memory and thinking. When it changes the other functions may also change.
- Working memory is the crucial individual differences factor for intelligence. Differences between individuals within ages or groups in WM explain their differences in performance on intellectual tasks.
- Changes in thinking may facilitate the functioning of information processing mechanisms, exerting top-down effects.

Conclusions cognitive- hypercognitive relations

- Processing efficiency, inferential (cognitive) processes and self-awareness (hypercognitive) processes are equipotent constituents of the mind. G is then a constrained, well mapped, self-aware supercontroller.
- Domains preserve their relative functional autonomy everywhere in the mind's architecture.
- Self-awareness is a recycling process that is gradually attained within each developmental phase by binding cognitive with self-monitoring and self-regulation processes

The Main Roads of Cognitive Development

1. The mind develops from being perceptually driven and action-bound to self-guidance, reflection and self-awareness.
2. The mind moves from fewer and reality-referenced to more and reciprocally referenced representations.
3. The mind evolves from global and less integrated to differentiated but better integrated mental operations.
4. With development, the mind becomes increasingly flexible and able to shift across perspectives

The More Intelligent one is ...

- The more mentally efficient (i.e, the faster and more focused on goal).
- Capable (i.e., the more information one can hold in mind at a given moment).
- Planfull and foresighted (i.e., the more clearly one can specify goals and plan how to achieve them).
- Flexible (i.e, the more one can introduce variations in the concepts and mental operations one already possesses)

This person is.

What is Environment Doing?

- At the same time, social, cultural, and historical influences set the frame in which the cognitive, differential, and developmental dynamics operate. Powerful cultural systems may shape powerful patterns of mental activity that cause strong cultural differences in mental performance and development

An overarching model of the mind that accommodates:

- basic intellectual functions and processes and their organization
- their real time operation as an integrated system
- the factors underlying their change and development
- the factors underlying intra- and inter-individual differences in regard to the attainment, operation, and development of these functions and processes.
- Tools for measuring all of these processes and dynamics for each individual vis-à-vis one's age and social group

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