Neurocognitive Mechanisms of Reasoning Ability

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Working Memory

Working memory has been defined as the system which actively holds information in the mind to do verbal and nonverbal tasks such as reasoning and comprehension, and to make it available for further information processing (Becker & Morris, 1999).

Primary memory (PM, focus of attention) — a highly active and accessible part of working memory (Cowan, 2001; Oberauer, Süß, Wilhelm, & Sander, 2007).

Fluid Intelligence

Fluid Intelligence or fluid reasoning is the capacity to think logically and solve problems in novel situations, independent of acquired knowledge. It is the ability to analyze novel problems, identify patterns and relationships that underpin these problems and the extrapolation of these using logic. It is necessary for all logical problem solving, especially scientific, mathematical and technical problem solving. Fluid reasoning includes inductive reasoning and deductive reasoning (http://en.wikipedia.org/wiki/Fluid_and_crystallized_intelligence).

What is intelligence?

What is intelligence?

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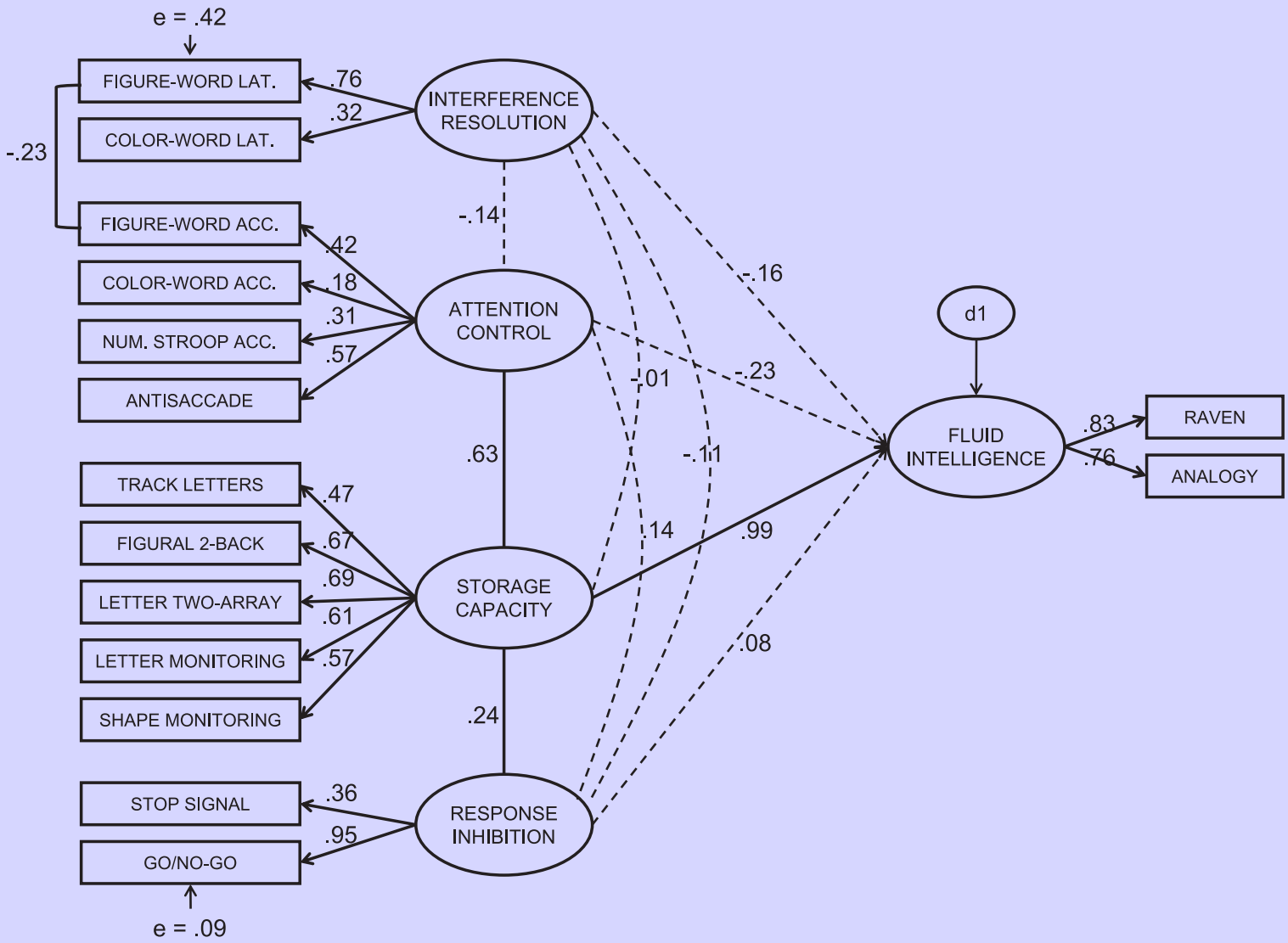
What is intelligence?
(as a mechanism)

Two hypotheses:

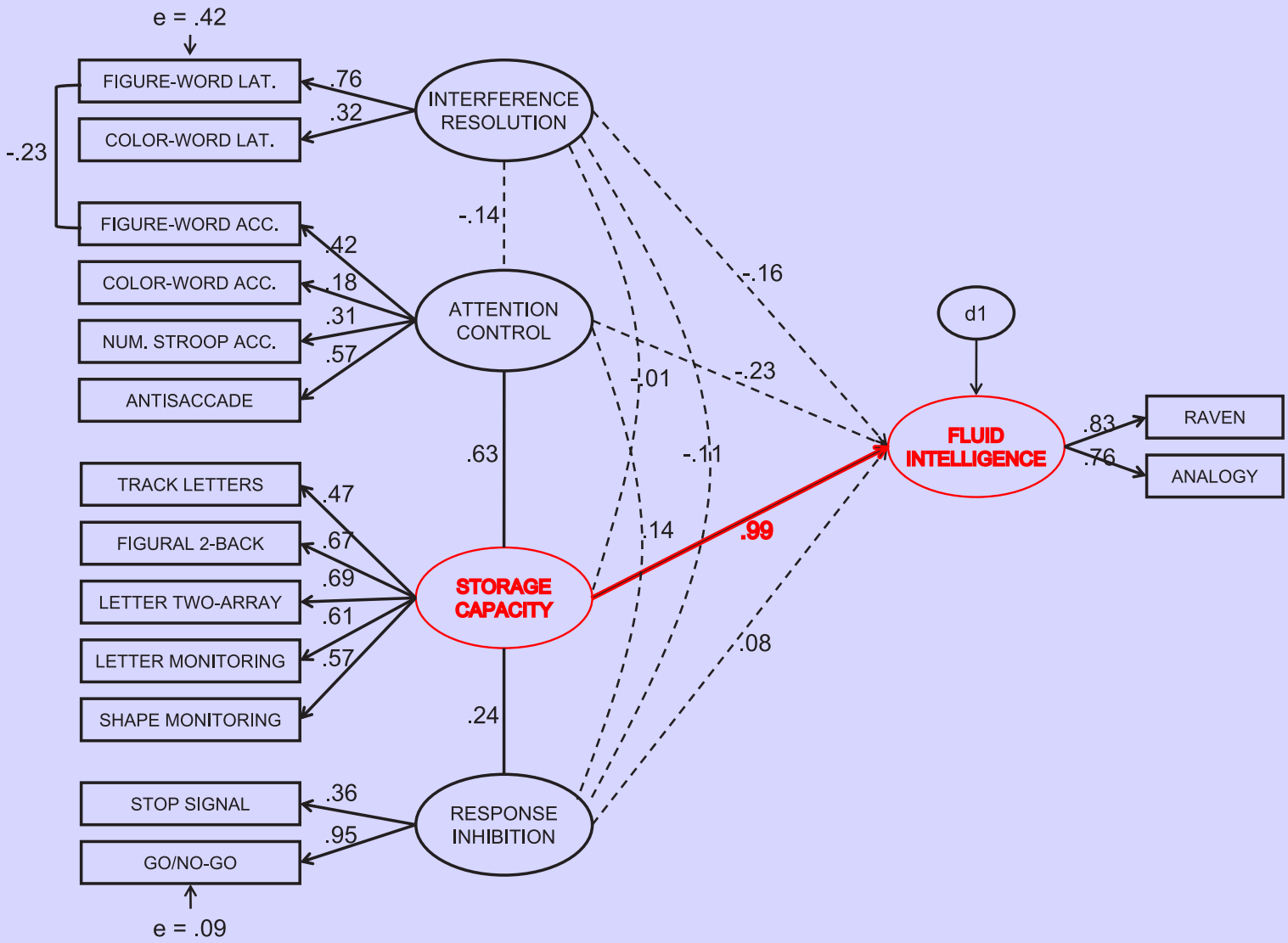
1. Intelligence is determined by the number of information chunk simultaneously stored in working memory.
2. Intelligence depends on one's ability to control information processing.

Primary Memory and Intelligence



(Chuderski, Taraday, Nęcka, & Smolen, 2012)

Primary Memory and Intelligence



(Chuderski, Taraday, Nęcka, & Smolen, 2012)

Primary Memory and Intelligence

Correlation studies

. . . show that PM capacity is the strongest intelligence predictor known,
. . . give "bird's-eye view" on intelligence components,

but they do not answer two important questions.

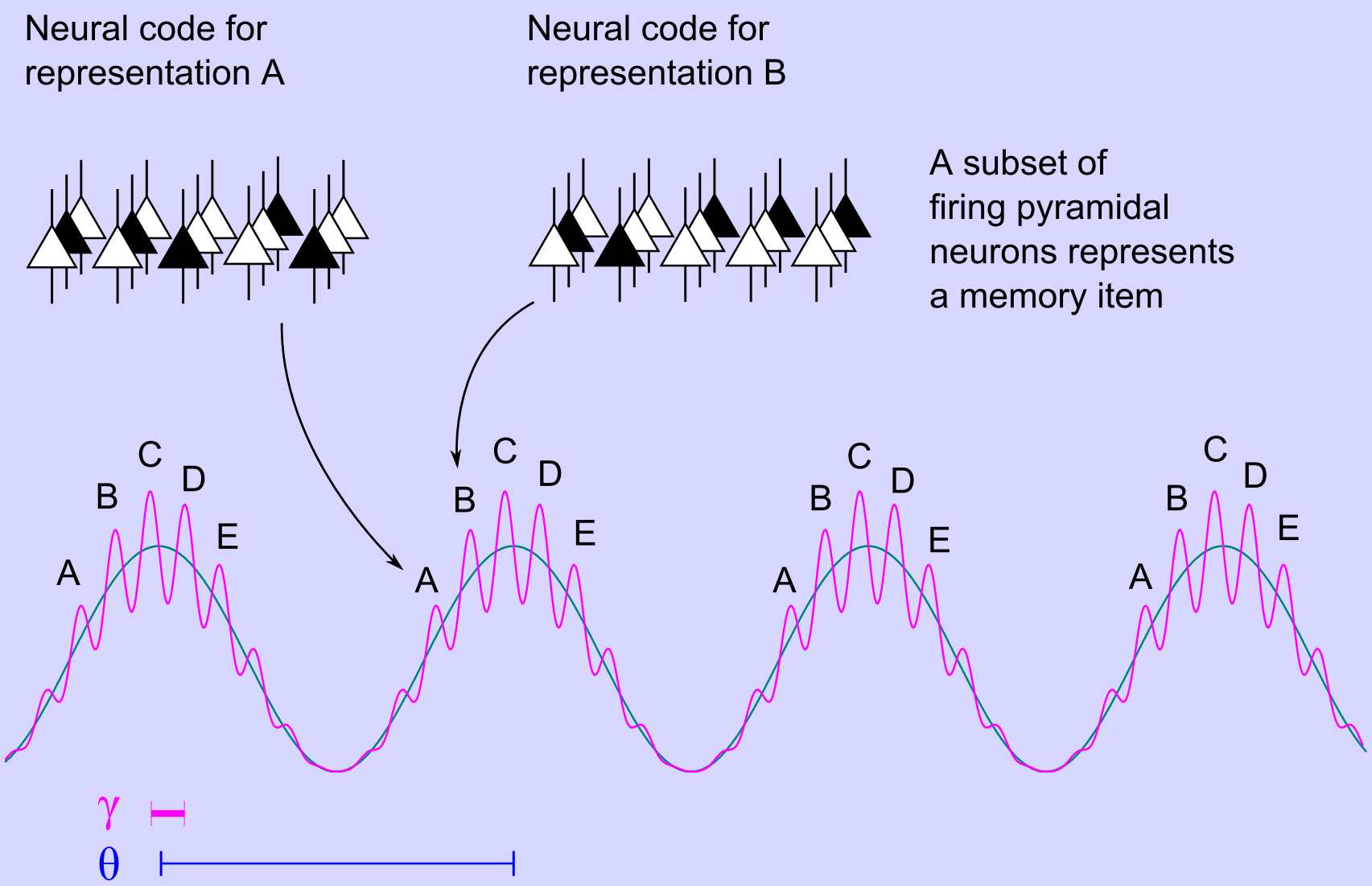
Primary Memory and Intelligence

1. Why is PM capacity is so limited?

Primary Memory and Intelligence

1. Why is PM capacity is so limited?
2. Why people differ in PM capacity?

Oscillatory Models



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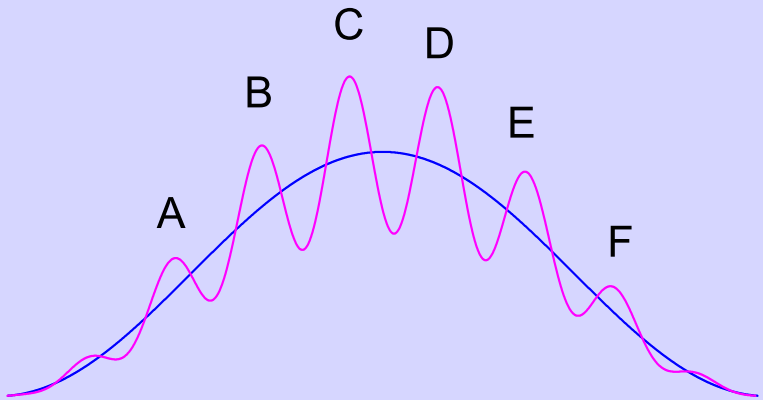

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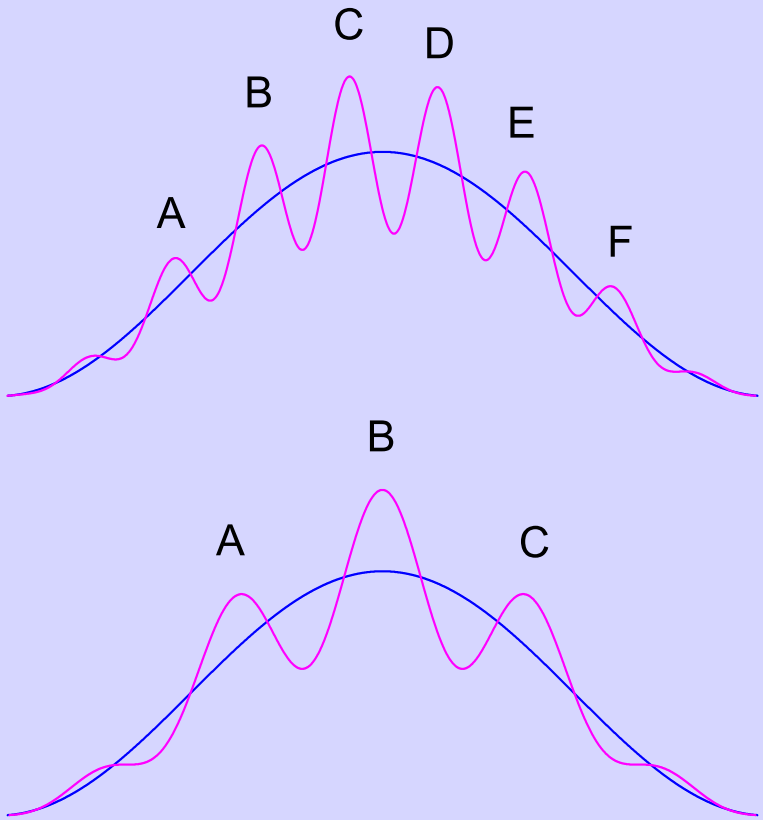

Why People Differ in PM Capacity?

1. Under what conditions the model exhibits the highest capacity?
2. Which parameters of the model allow for replication of the distribution of capacity observed in the population?
3. Are the differences in capacity related to differences in frequency of the gamma and theta cycles?

The model

Output of the element i

$$y_i(t) = \frac{1}{1 + \exp(-\delta(x_i(t) - \frac{1}{2}))}$$

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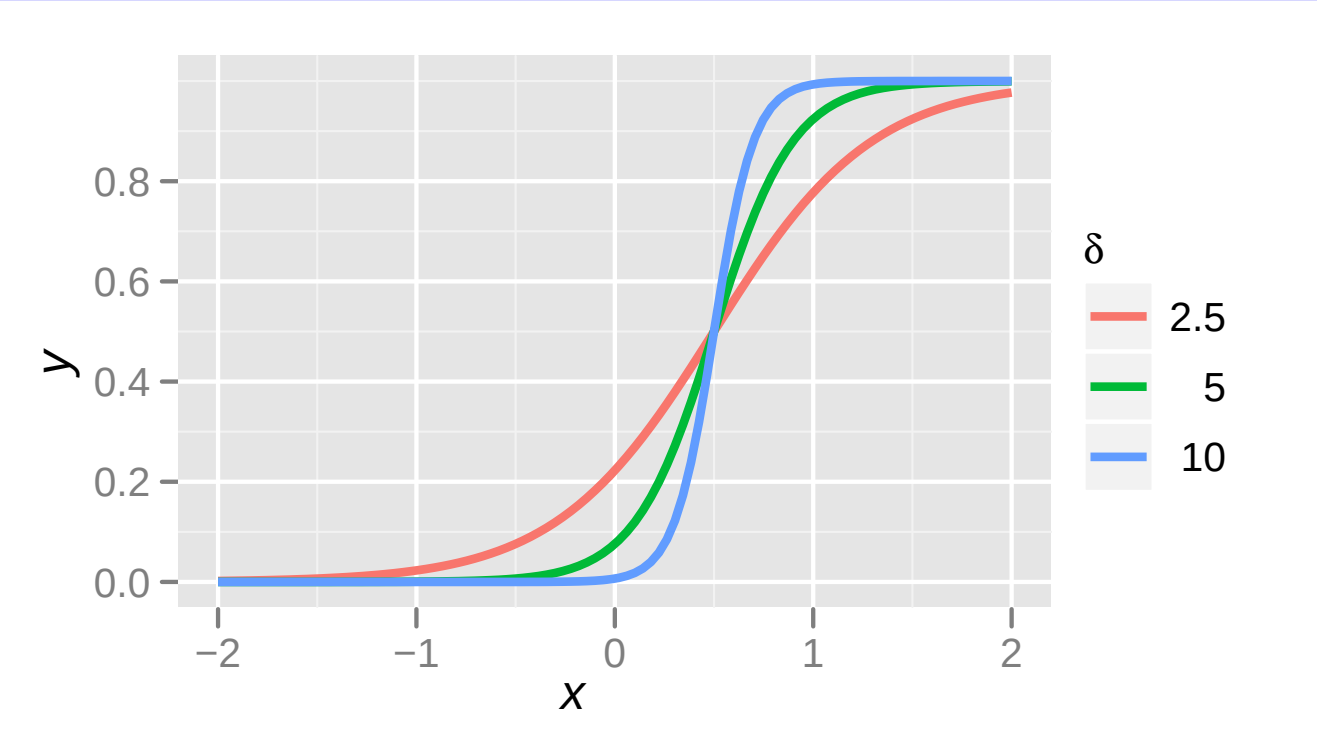

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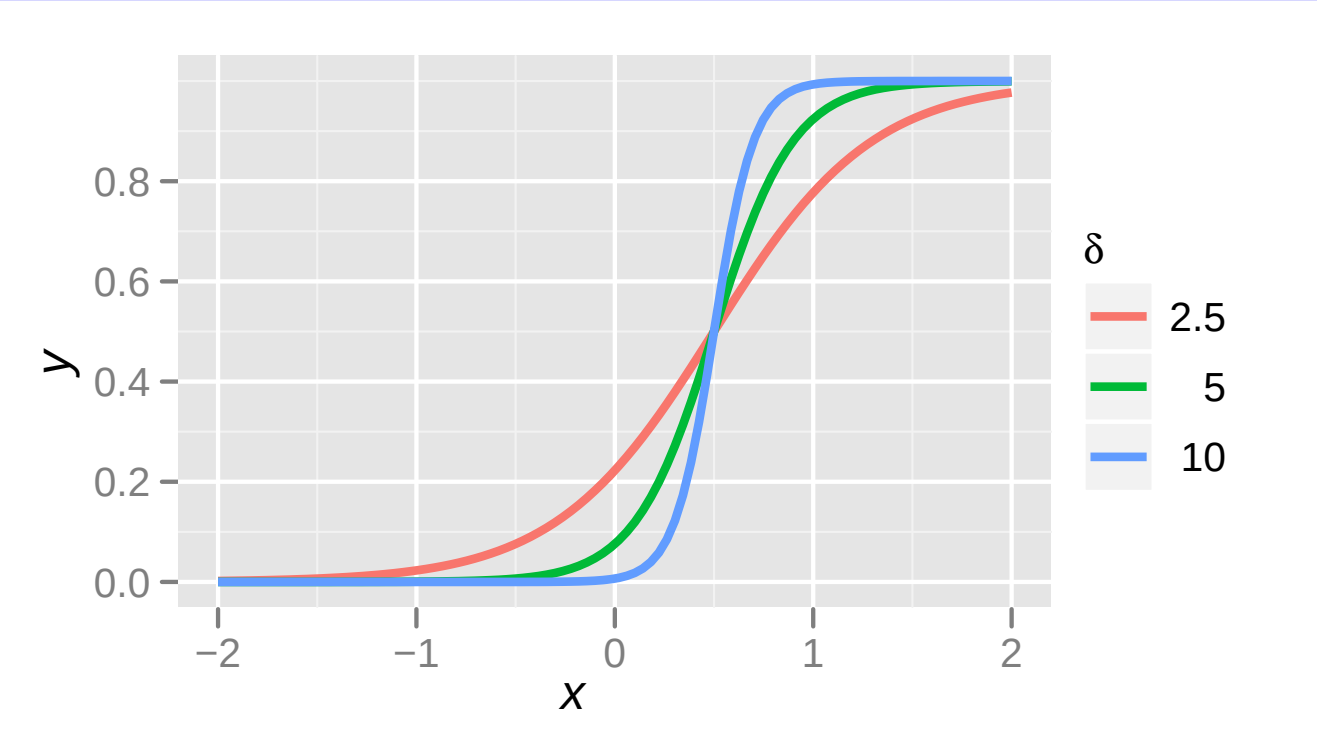

The Model

Internal activation of i

$$
\begin{aligned}
x_i(t) = \quad & x_i(t-1) + \frac{\lambda}{1 + y_i(t-1)} \\
& + \alpha \sum_k \exp(y_k(t-1) - y_i(t-1)) \\
& - \beta \sum_j \exp(y_j(t-1) - y_i(t-1)) + \varepsilon(n)
\end{aligned}
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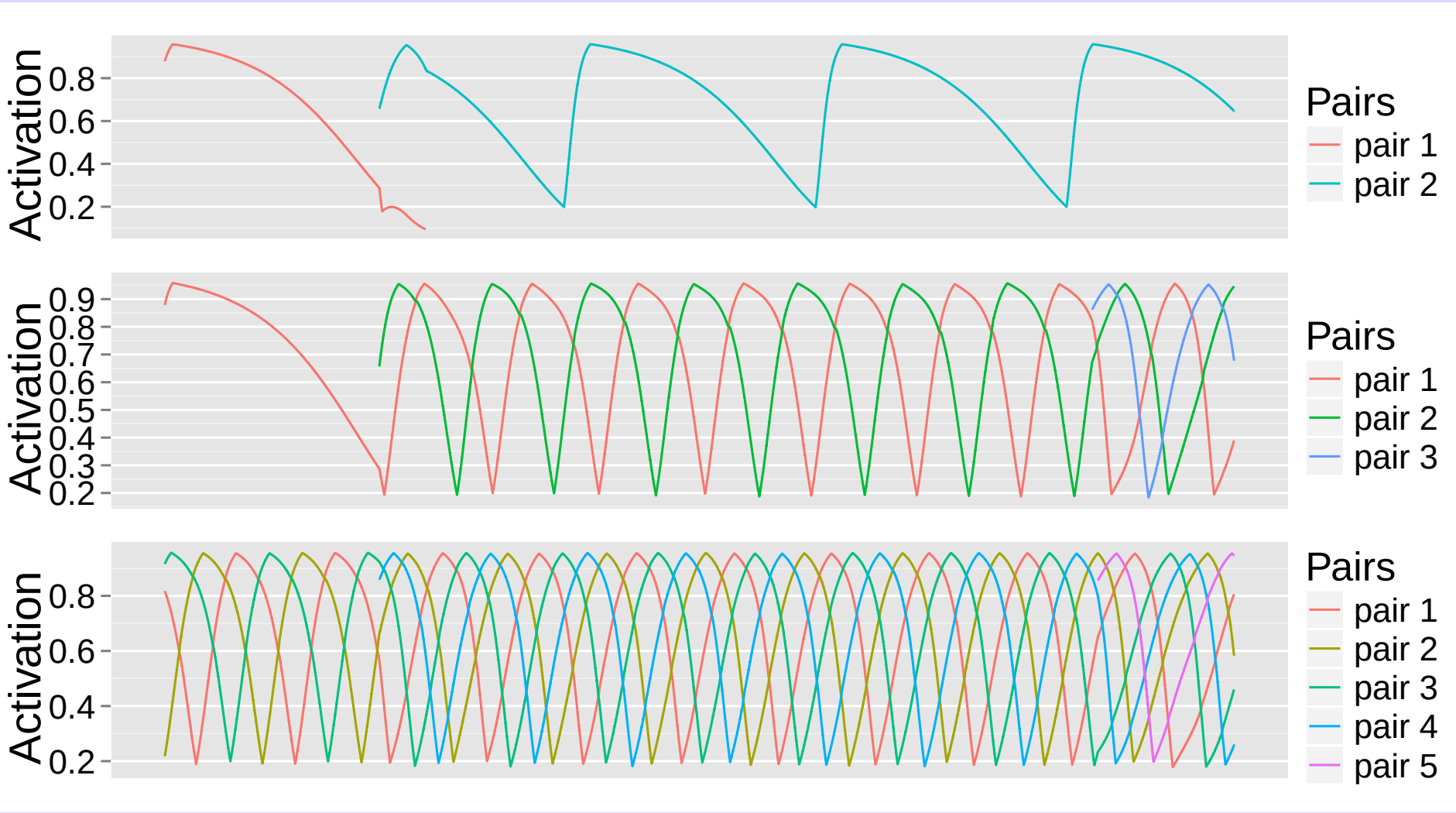
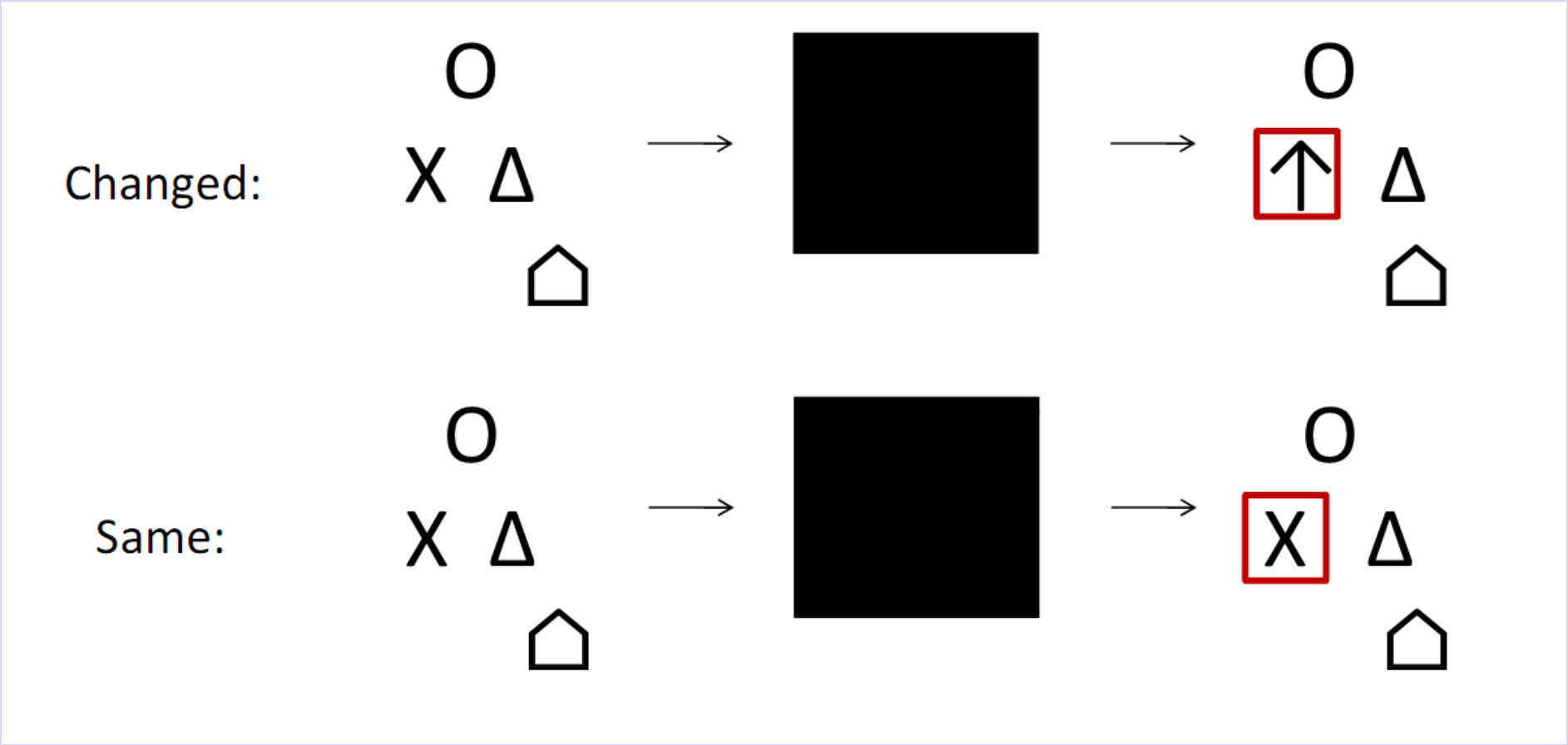
Model's Working



Primary Memory Capacity Task



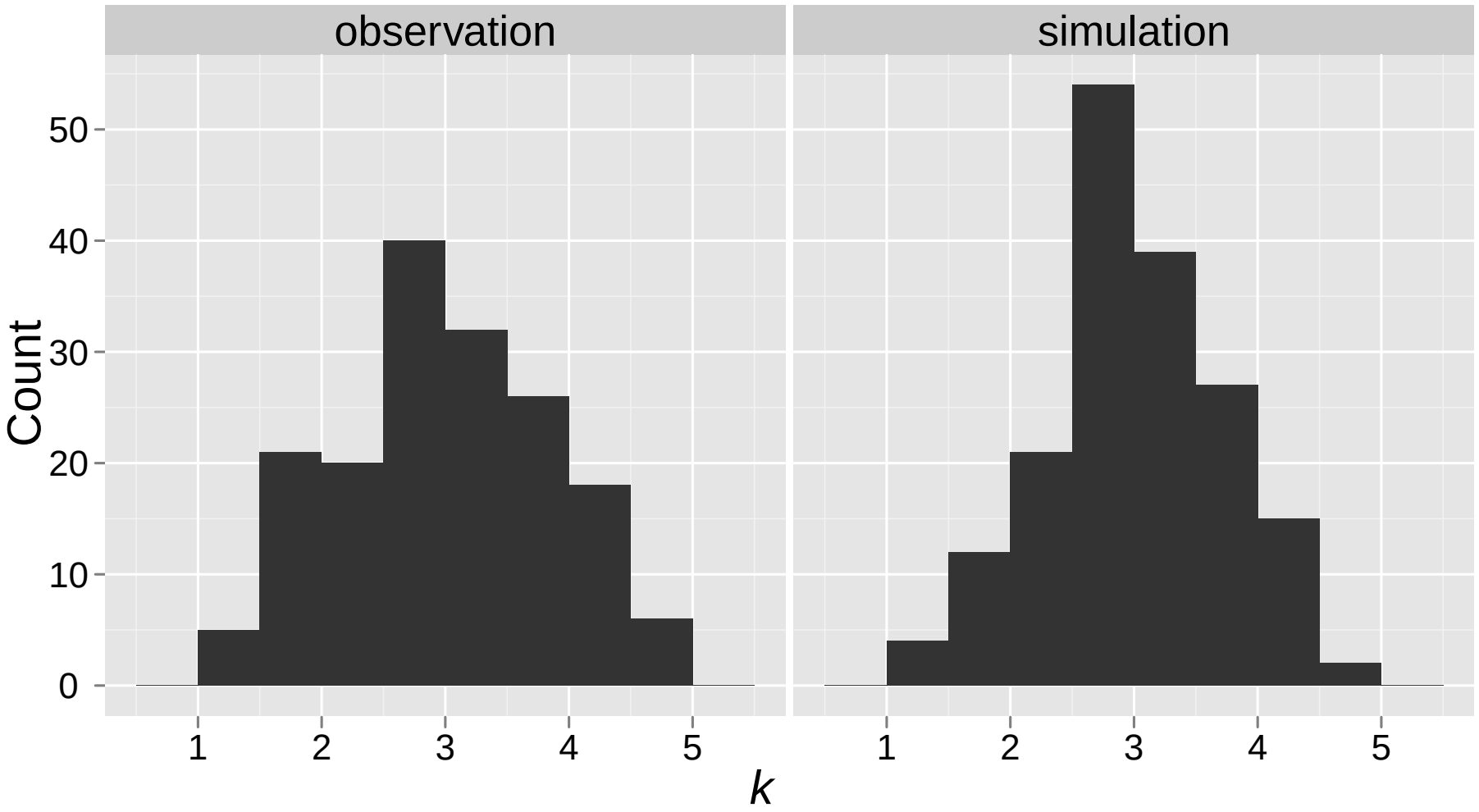
Primary Memory Capacity Task

PM Capacity Estimation

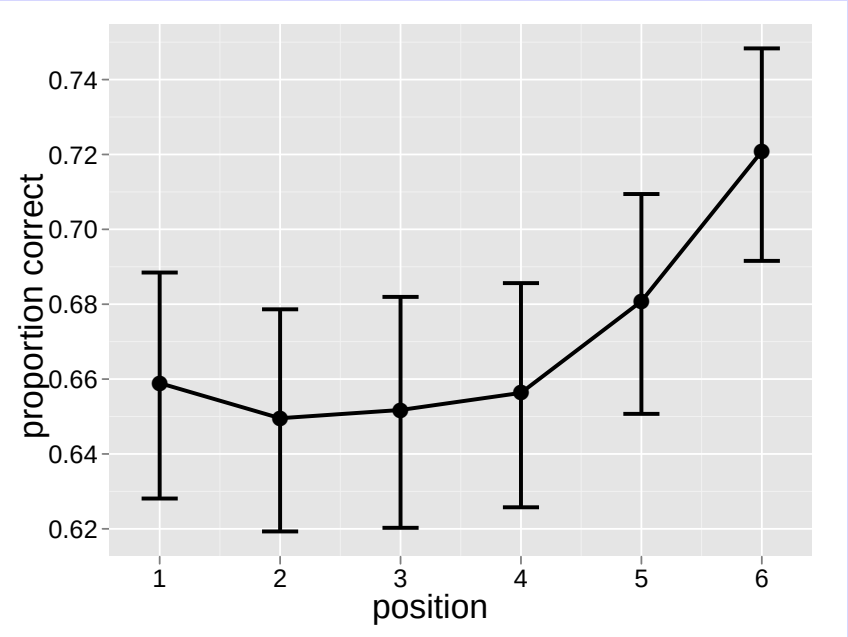
$$k = N(H - F)$$

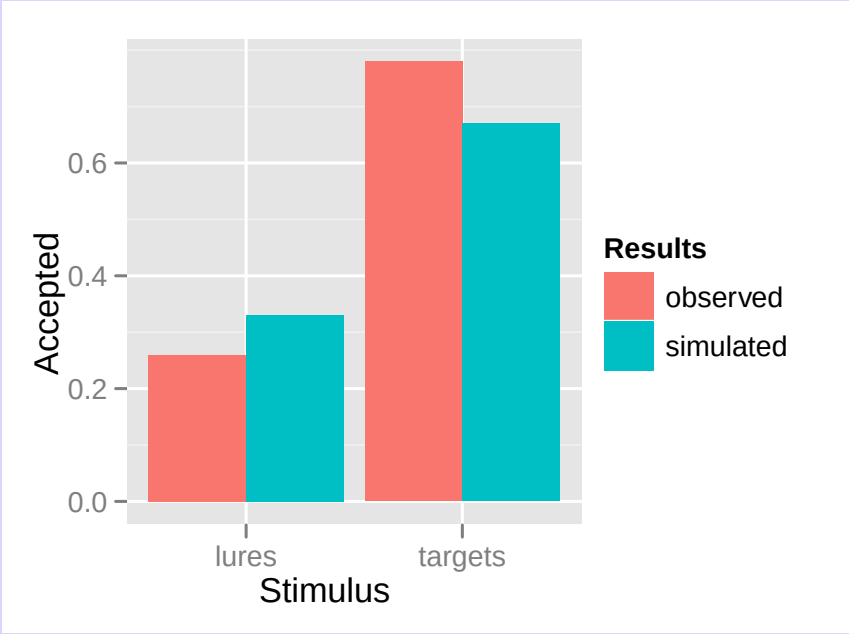
N — Set size
H — Hits
F — False alarms

Primary Memory Capacity



Other Results





(Andrelczyk, Smolen, & Chuderski, 2012)

Relation Monitoring Task

MO DO BU
NE TA RU
CA KO SI

Relation Monitoring Task

MO	DO	BU		MO	DO	SO
NE	TA	RU	$\longrightarrow$	NE	TA	RU
CA	KO	SI		CA	KO	SI

Relation Monitoring Task

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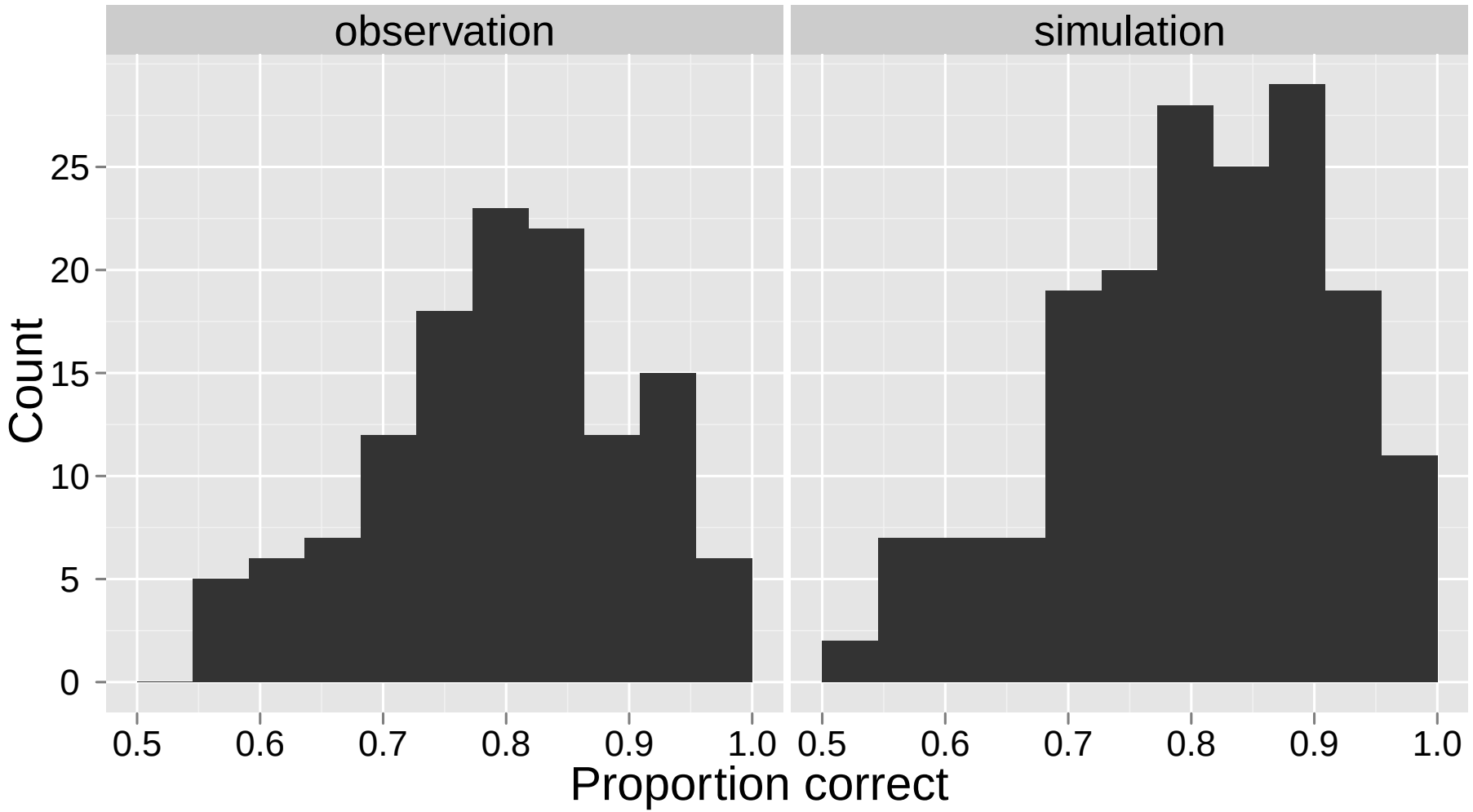
Relational Integration



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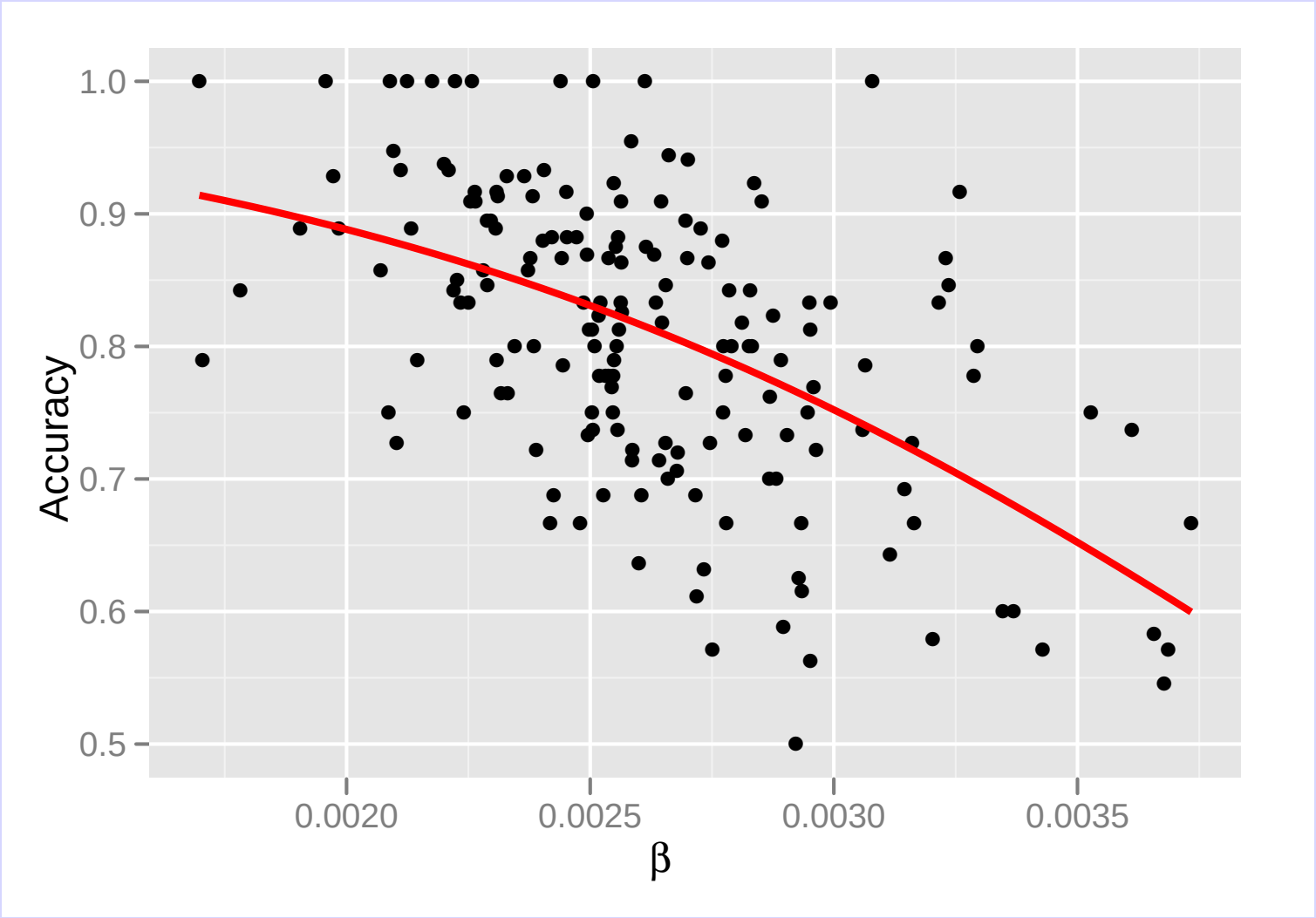
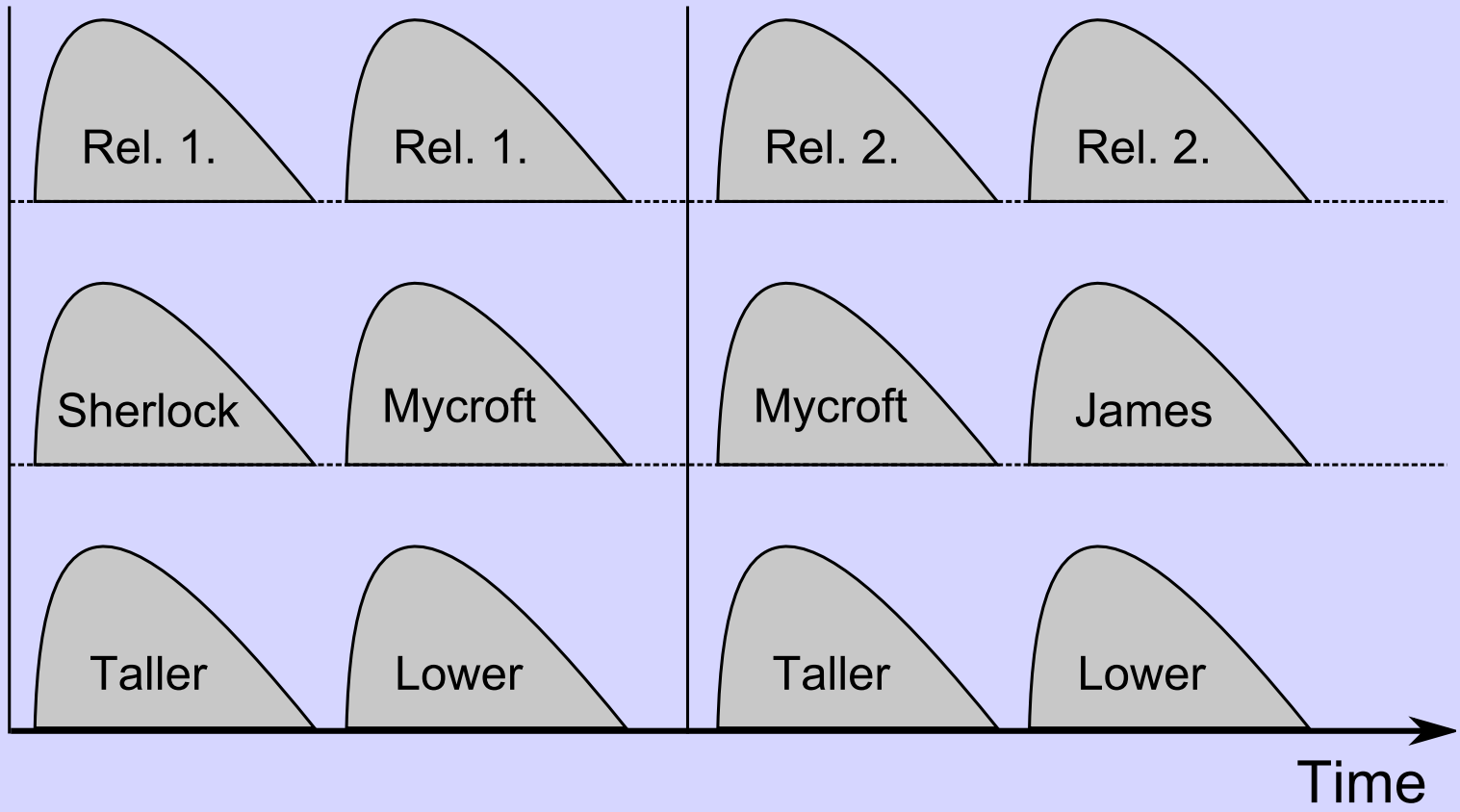


Null deviance: 2818.4 (df: 2895), residual deviance: 2756.8 (df: 2894)

Why Does PM Capacity Matter?

Sherlock is taller than Mycroft.
Mycroft is taller than James.
Is Sherlock taller than James?

Why Does PM Capacity Matter?



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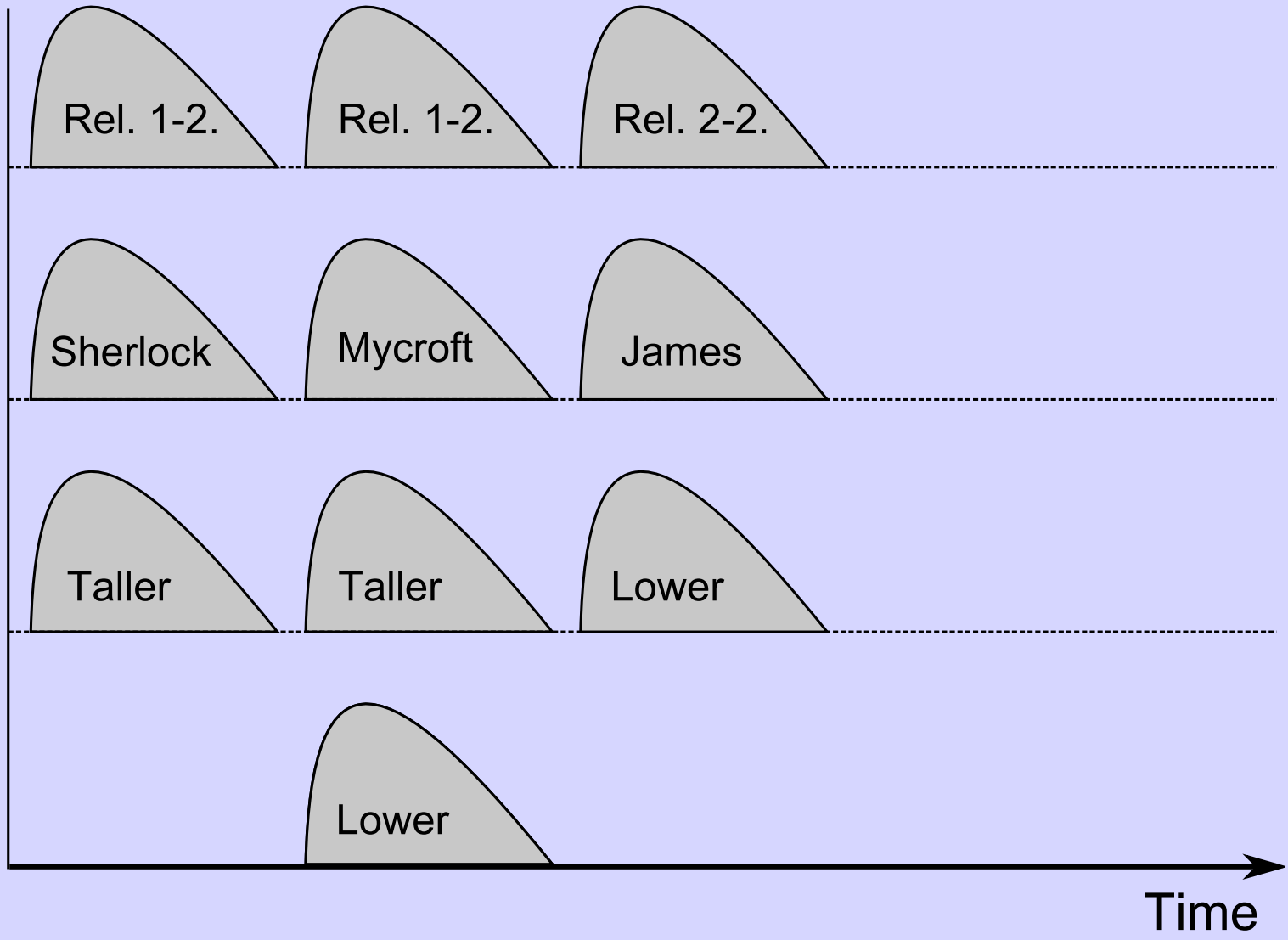

Summary

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- The problem "What is reasoning" can be solved.

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- It is probable that cognitive base of reasoning is identical to relational integration ability.

Thank You for Your Attention

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