The Rosetta stone for cognitive and decision strategies

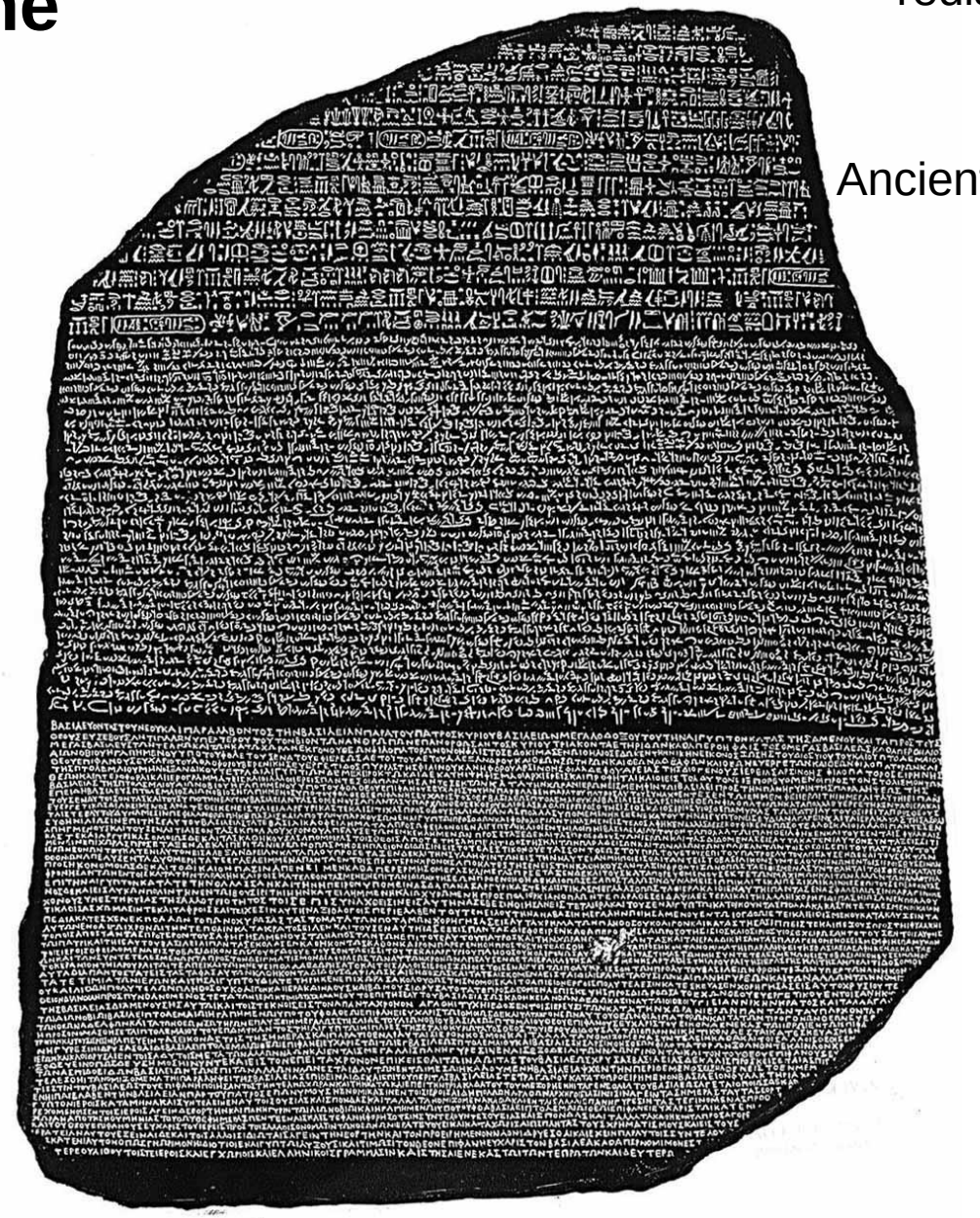
Mario Fifić
Grand Valley State University, Allendale, MI, USA
Max Planck Institute for Human Development, Berlin

Jörg Rieskamp
University of Basel

SJDM Conference 2012 , Minneapolis

Rosetta Stone

rediscovered in 1799



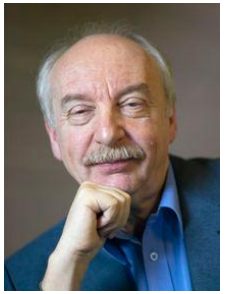
Ancient Egyptian hieroglyphs

Demotic script

Ancient Greek

Fast and Frugal Heuristics

- People often rely on fast and frugal heuristics for making judgments and decisions



Heuristics' characteristics:

- ***limited information search***
- ***sequential processing of information***

e.g. Gigerenzer & Gaissmaier, 2011, Annual Review of Psychology
Todd & Gigerenzer, 2000, Behavioral and Brain Sciences

Bayesian Models of Decision Making

- Bayesian models can often describe people's judgments and decisions quite well

Psychological plausibility

- ***exhaustive information search***
- ***parallel processing of information***

e.g. Griffiths, Chater, Kemp, Perfors, Tenenbaum, 2010, Trends in Cognitive Sciences

Exemplar Models of Decision Making

- Similarity as a core principle for judgment and decision making

Psychological plausibility

- parallel processing of activating exemplars from memory

- sequential judgment process of retrieved exemplars

Peter Juslin

e.g. Juslin & Persson, 2002, Cognitive Science
Bergert & Nosofsky, 2007, JEP:LMC

Research Question

How can we detect whether the cognitive process underlying a judgment or decision relies on

1. **exhaustive vs. limited information search**
   (stopping rule or amount of information)

2. **parallel vs. sequential processing of information**
   (processing order)

Classification of decision strategies

Processing order \ Stopping rule	Limited	Exhaustive
Serial	TTB	WADD
Parallel	Horse Race	Bayes

Research Question

If you decide to use Choice Preference

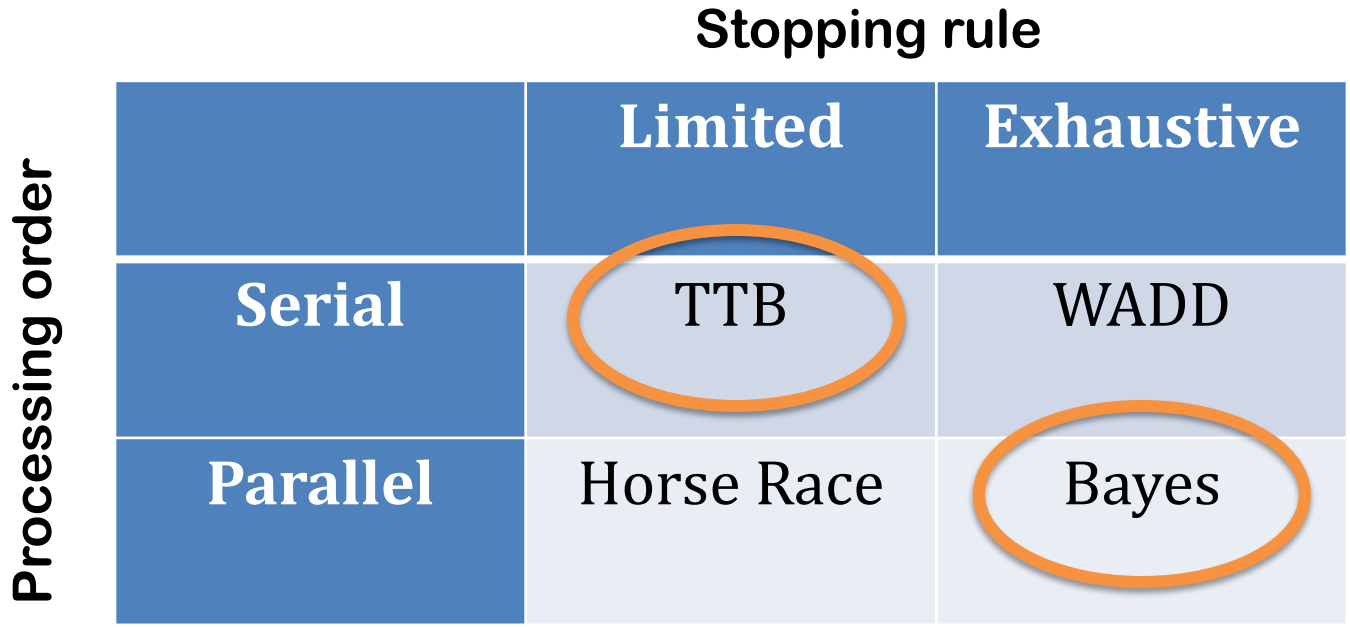
Classification of decision strategies

Stopping rule

Processing order	Limited	Exhaustive
Serial	TTB	WADD
Parallel	Horse Race	Bayes

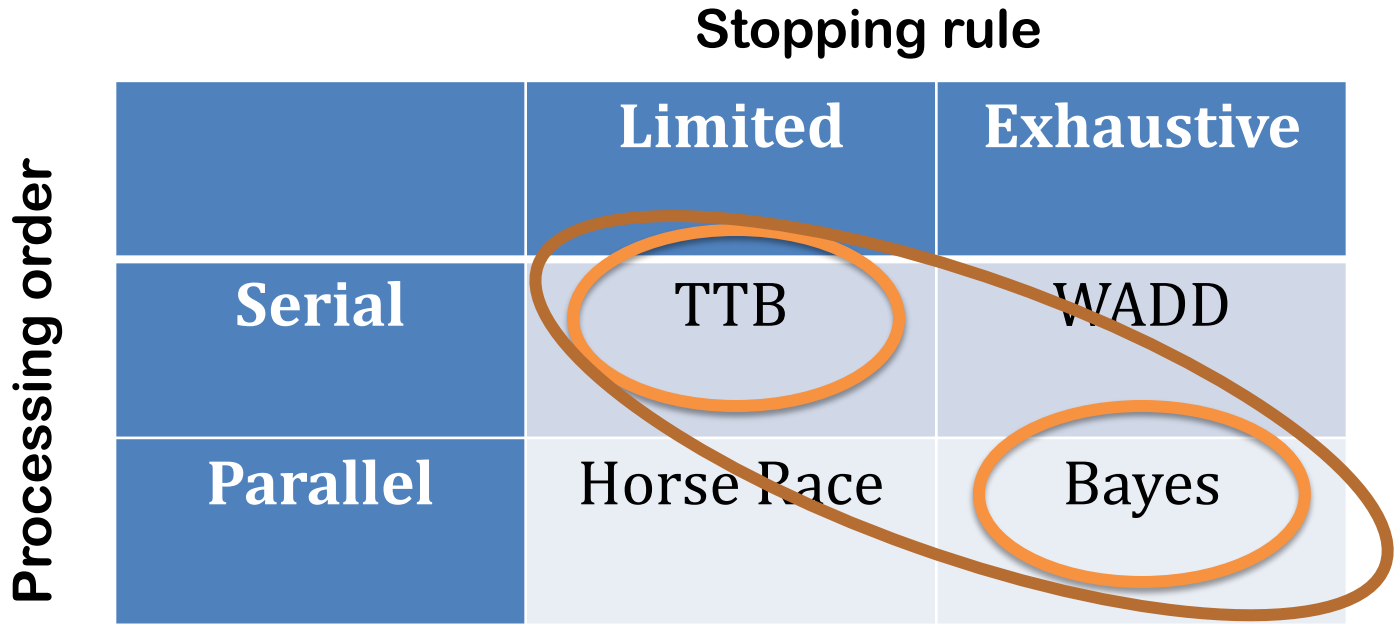
Using choice preferences

Classification of decision strategies



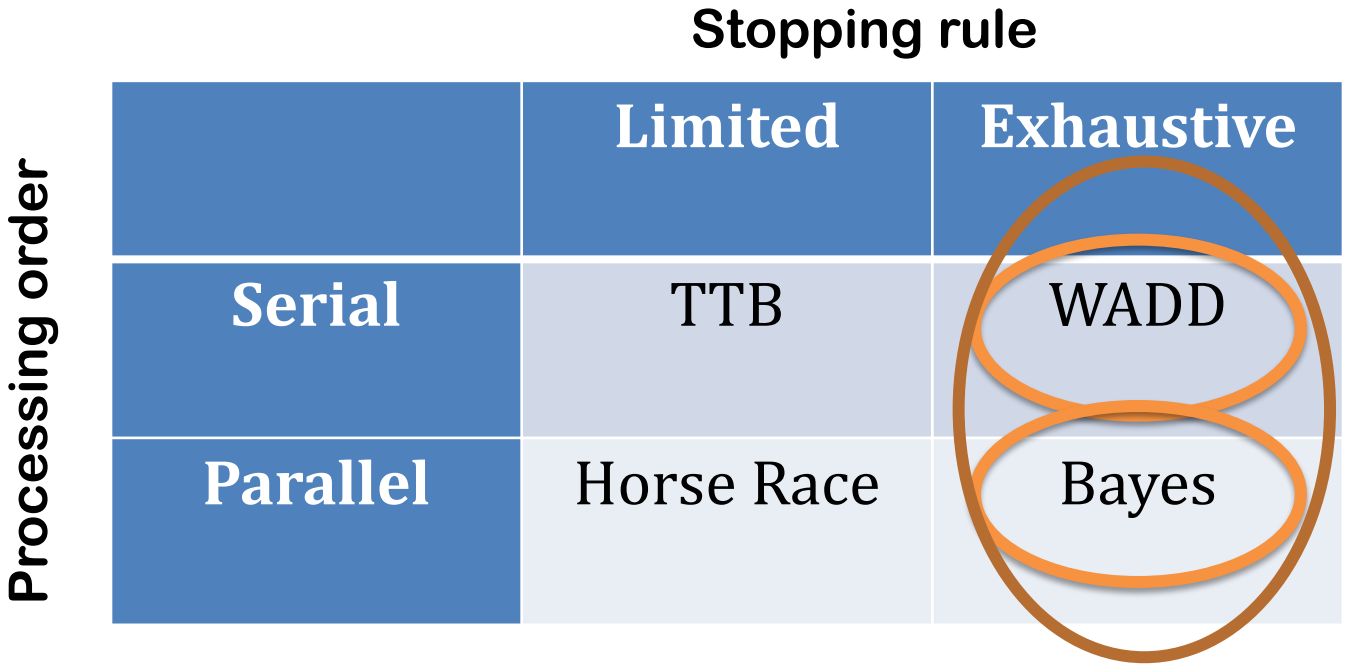
Using choice preferences

Classification of decision strategies



Using choice preferences

Classification of decision strategies



Using choice preferences

Research Question

If you decide to use mean Reaction Times

Mimicking Problem

- It is impossible to distinguish between ***serial*** and ***parallel*** processing only on examining mean response times
- Models assuming parallel processing of information can also predict an increase of response time as a function of the number of processed cues

Townsend & Ashby, 1983, *The stochastic modeling of elementary psychological processes*

Classification of decision strategies

Stopping rule

Processing order	Limited	Exhaustive
Serial	TTB	WADD
Parallel`	Horse Race	Bayes

Using simple Reaction Time

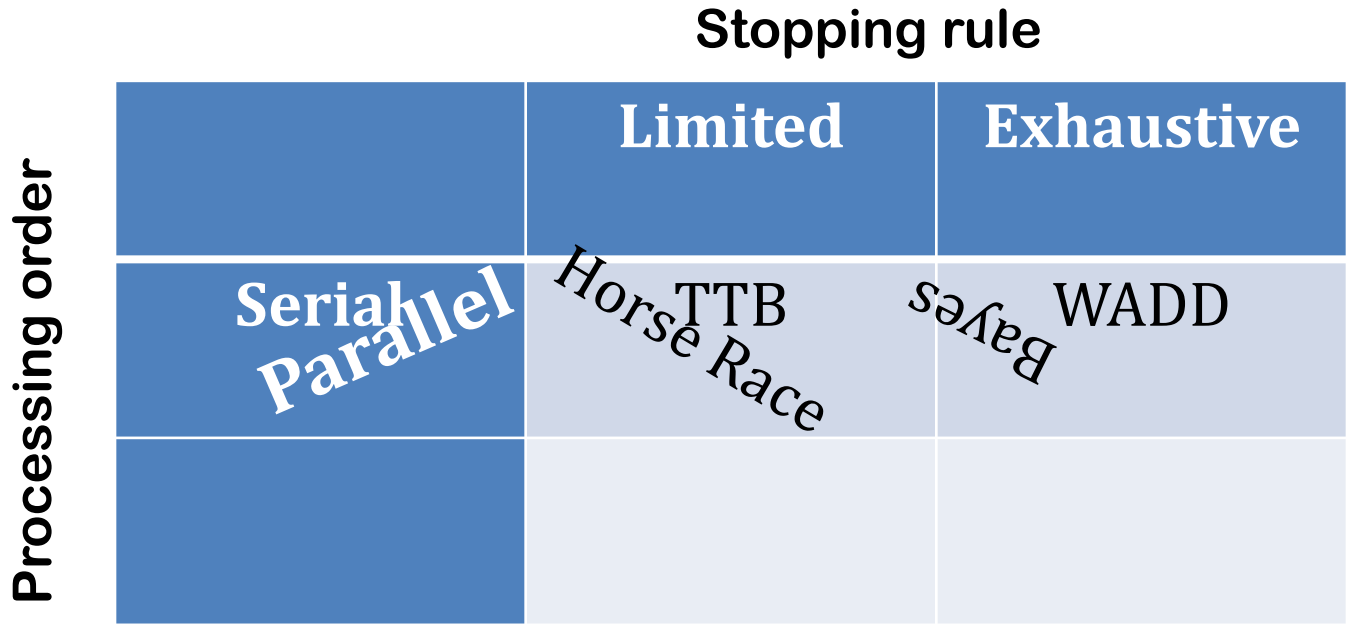
Classification of decision strategies

Stopping rule

Processing order	Limited	Exhaustive
Serial / Parallel	TTB	WADD
	Horse Race	Bayes

Using simple Reaction Time

Classification of decision strategies



Using simple Reaction Time

Solution: Systems factorial technology (SFT)

Antecedents

- Donders (1868), Subtraction method, pure insertion
- Sternberg – Additive factor method (1969)
- Development of mental networks (Schweickert, 1978, 1982), Townsend & Schweickert's trichotomy method (1985, '89), Schweickert, Georgini and Dzhafarov (2000).
- Townsend et al stochastic modeling theory (1984, 83, 95).

Validation and extensions of SFT

- Detection (Townsend & Nozawa, 1995)
- Visual and memory search tasks (Wenger & Townsend, 2001; Townsend & Fific, 2004; Fific, Townsend & Eidels, 2008; Sung, 2008; Egeth & Dagenbach, 1991; Wenger & Townsend, 2006)
- Face perception (Fific & Towsnend, 2010; Ingvalson & Wenger, 2005; Fific, 2006)
- Classification (Nosfosky & Little, 2011; Fific, Little, & Nosofsky, 2010; Fific, Nosofsky & Townsend, 2008; Eidels, Townsend, & Pomerantz, 2008)
- Global-local perception (Johnson, Blaha, Houpt, Townsend, 2009)

The task: Probabilistic Inference

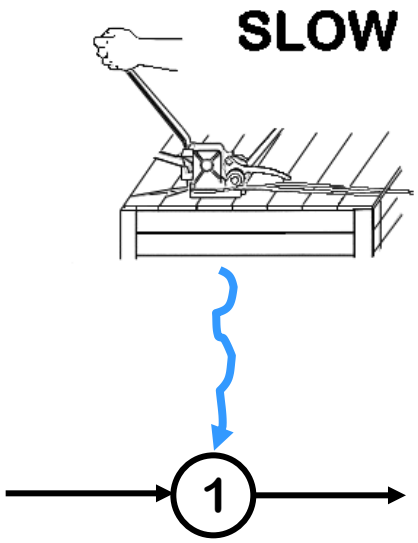
Inference: Which of two objects has a higher criterion value

Cues: Probabilistically related to the criterion

?  ?

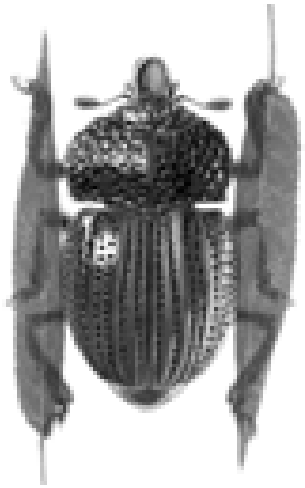
Essence of SFT

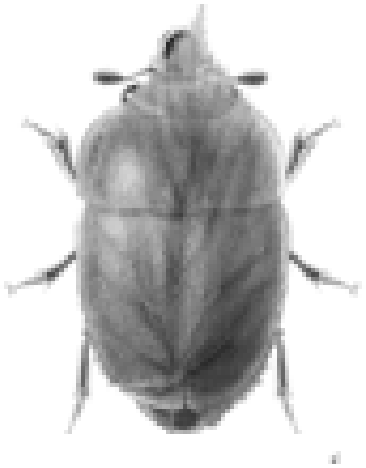
- Selective manipulation of speed of a certain process of interest



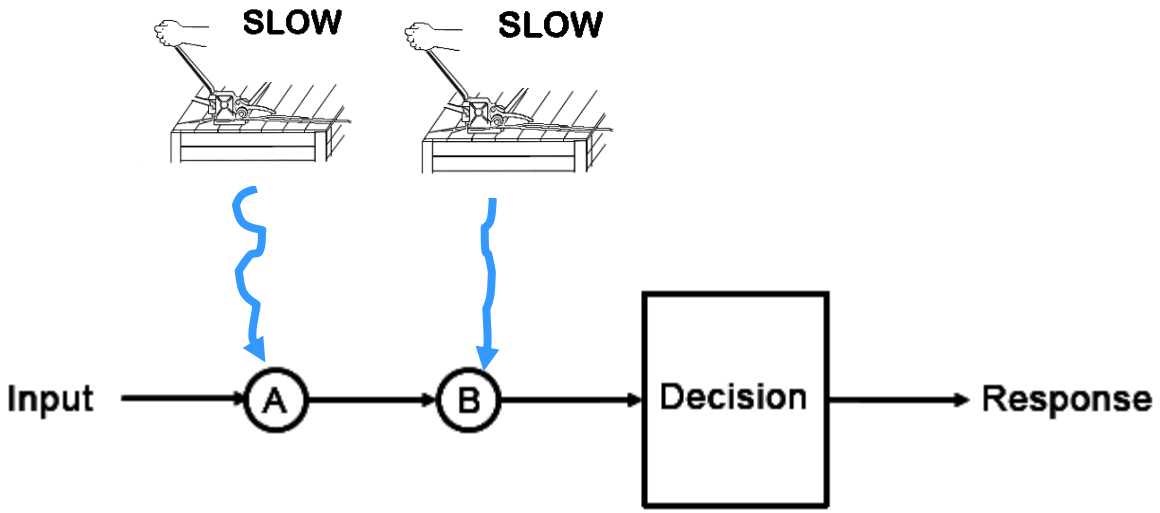
Mental Process

Manipulating Processing of Cues





Double Factorial Paradigm



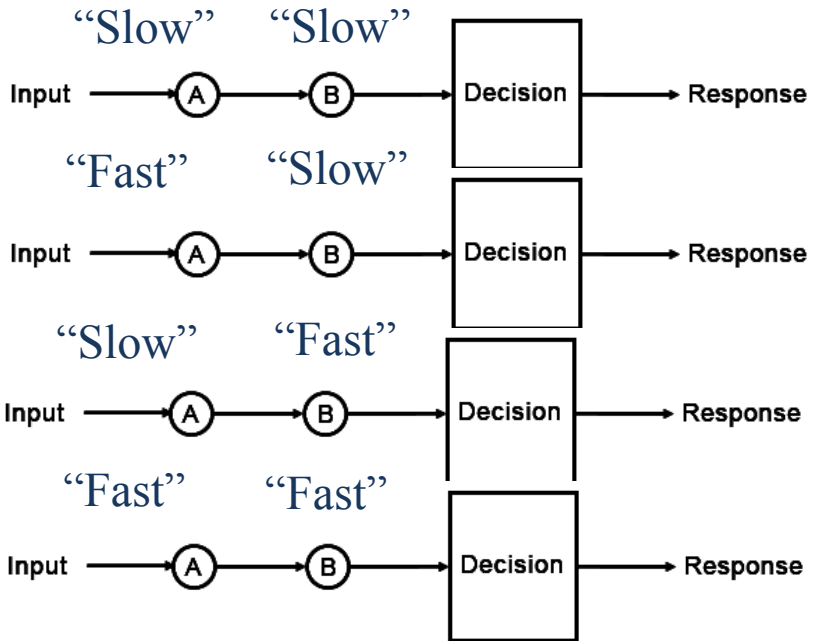
Factorial Conditions

SS

FS

SF

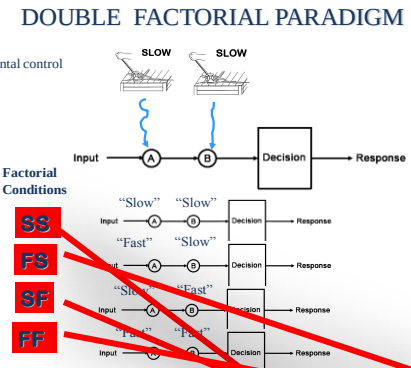
FF



Inference Strategies

- different inference strategies should lead to different patterns of reaction time data

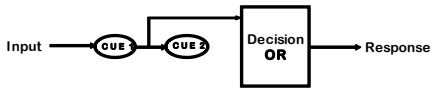
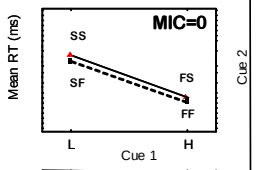
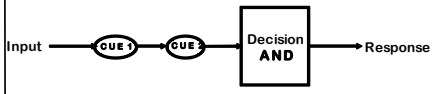
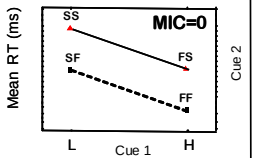
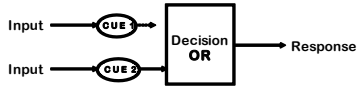
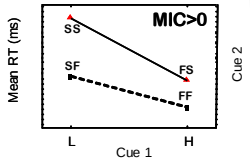
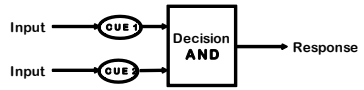
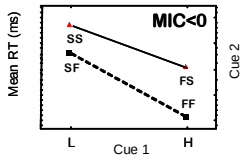
The Statistics: MIC



Mean Interaction Contrast

Mean of RTs

$$MIC = [RT_{SS} - RT_{SF}] - [RT_{FS} - RT_{FF}]$$

Cognitive strategies		SFT diagnostic tools			Decision strategies		
Mental Architecture	Architecture flow diagram	MIC Mean RT Signature	ANOVA	MIC	Information Search	Processing Order	Decision strategy
A Serial Self-terminating			Cue 1 ** Cue 2 Cue 1 x Cue 2	=0	Limited	Serial	TTB
B Serial Exhaustive			Cue 1 ** Cue 2 ** Cue 1 x Cue 2	=0	Exhaustive	Serial	WADD, TTB(2)
C Parallel Self-terminating (First–terminating)			Cue 1 ** Cue 2 ** Cue 1 x Cue 2 **	>0	Limited	Parallel	Horse Race
D Parallel Exhaustive			Cue 1 ** Cue 2 ** Cue 1 x Cue 2 **	<0	Exhaustive	Parallel	Naïve Bayes

Experimental Test

Learning Phase

- two environments: **Compensatory** and **Non-compensatory**
- 40 participants
- 3 independent cues
- validities: 71%; 70%; 68% vs. 80%; 59%; 53%)
- 3 sessions with a minimum of 200 trials with outcome feedback

Test Phase

- only two cues were factorially manipulated
- no feedback

Overall Results

In terms of the processing component

	Compensatory environment	**Non-Compensatory environment**

Overall Results

In terms of the processing component

	Compensatory environment	Non-Compensatory environment
Exhaustive	**.8**	.33
Limited	**-**	**.5**

Overall Results

In terms of the processing component

	Compensatory environment	Non-Compensatory environment
Exhaustive	**.8**	.33
Limited	-	**.5**
Serial	.6	**.83**
Parallel	.2	-

Overall Results

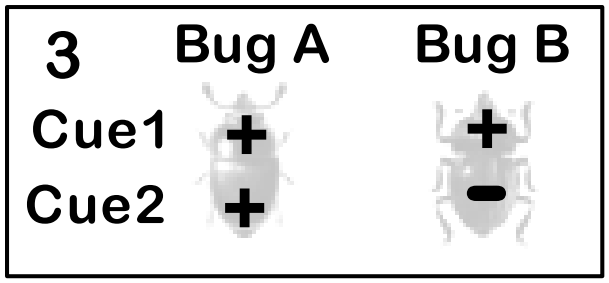
In terms of the models' identification

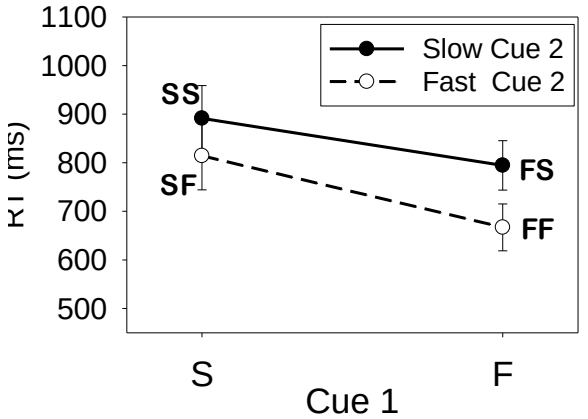
	Compensatory environment	Non-Compensatory environment
TTB	.2	**.5**
WADD	**.6**	.33
NB	.2	-
Horse Race	-	-
Unknown	.2	.17

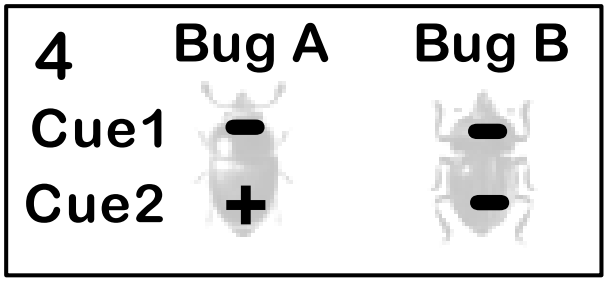
Reaction Time Pattern Compensatory Enviornment

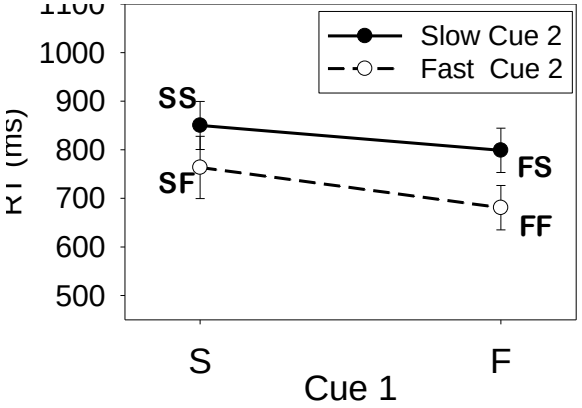
Stimulus Cue Configuration

Observed MIC



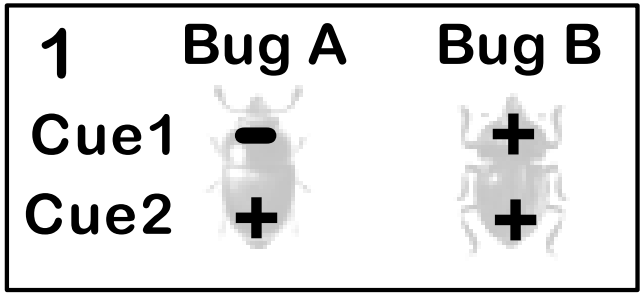


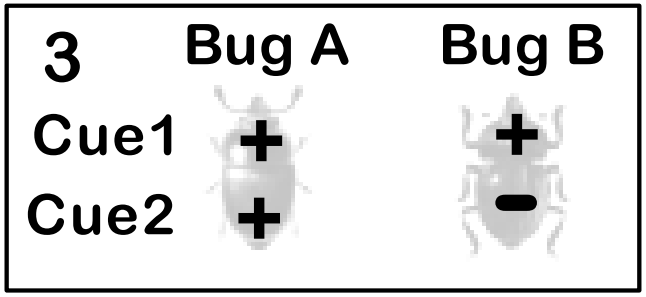




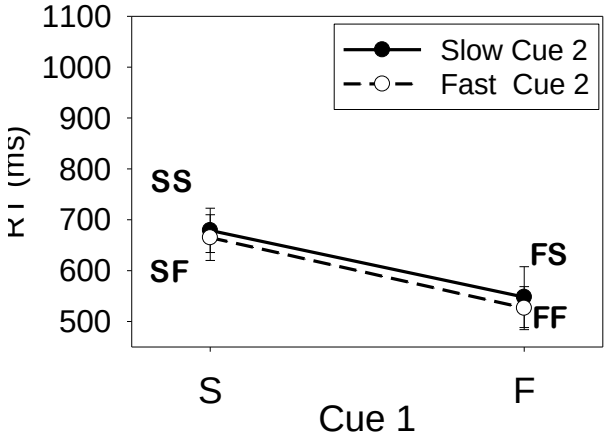
Reaction Time Pattern
Non-Compensatory Enviornment

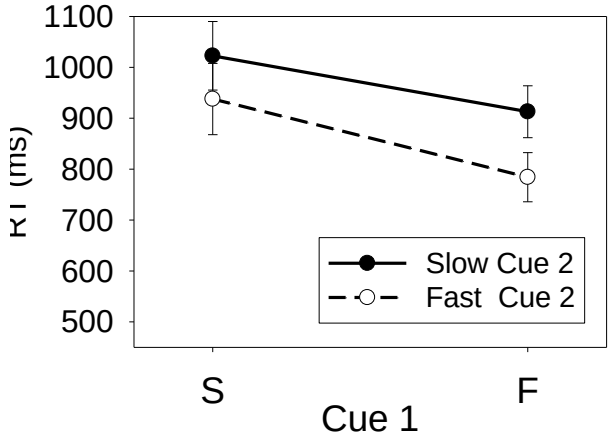
Stimulus Cue Configuration





Observed MIC





Conclusions

- The SFT approach was applied only to the limited set of decision making strategies.
- The SFT can be used to model selection and model falsification.
- Overall, participants showed different MIC patterns in the different environments
- Support for TTB and lexicographic decision making in the non-compensatory environment
- WADD and serial exhaustive cue processing in the compensatory environment.
- Method's costs are minimal: no optimization, no parameters, less assumptions
- The Rosetta Stone represents an important direction to better identification of processes engaged in decision making.

Contact:
mfific@gmail.com

References
Fific, Little, & Nosofsky, (2010) Psych Review
Gaissmaier, Fific, & Rieskamp, J. (2010)

Thank you for your attention!

Contact:
mfific@gmail.com

References

Fific, Little, & Nosofsky, (2010) Psych Review
Gaissmaier, Fific, & Rieskamp, J. (2010)