Identification of Mental Architectures in Face Perception Using the Systems Factorial Technology

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The Goals of the Talk

1. What is a **procedural operational definition** of holistic face processing and what is it's weakness?

2. What is a **mental architecture**?

3. Why we should consider a mental architecture to understand holistic face perception?

"Little Red Riding Hood." © 1991 Susan Gustafson. All rights reserved

The holistic hypothesis: Objects are perceived as whole entities and not as a sum of independent features

Analytic, or feature-based perception, is conducted on individual features that make up an object.

Signatures of Holistic perception

- Gestalt laws: proximity similarity by inducing perceptual effects (Sarris; Overvliet, Krampe & Wagemans)
- Pop-out effect (Pomerantz; Eidels)
- Part to whole paradigm (Donnelli; Tanaka & Farah; Bierman)
- Garner Task (Kimchi)
- Superiority effects (Pomerantz)
- Thatcher faces illusion: Grotesqueness (Wenger)
- Face inversion (Bartlett, Innes-Ker)
- Unitization (Goldstone, Lightfoot & Shiffrin, Blaha)
- Scrambled faces vs Normal
- Neural Responses (Peterson, Palmeri)
- Context effect (Palmer, Kimchi)
- **Super capacity index** (Townsend, Eidels, Blaha)
- **Coactivation signature** (Colonius, Little, Fific, Nosofsky, Townsend; Houpt)

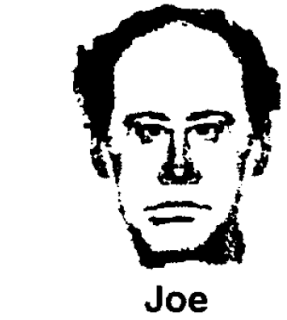
Goal 1

1. What is a **procedural operational definition** of holistic face processing and what is it's weakness?

2. What is a **mental architecture**?

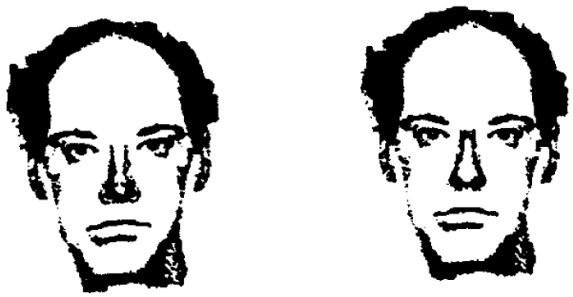
3. Why we should consider a mental architecture to understand holistic face perception?

The *part-to-whole paradigm*



Joe

Which is Joe's nose?



Which is Joe's nose?
(in a new configuration)

Old Configuraton

Isolation

New Configuration

Tanaka & Sengco, 1997

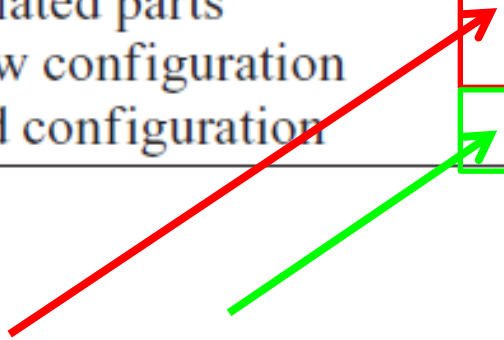
Failure of selective attention

- The *part-to-whole paradigm:* explores whether it is possible to attend selectively to a facial feature (a “part”) under different face contexts

The failure of selective attention

Percent Correct Recognition for Eyes, Nose, and Mouth Features Shown in Isolation, in a New Configuration, and in the Old Configuration

	Features			
	Eyes	Nose	Mouth	*M*
Isolated parts	61	63	70	65
New configuration	73	70	74	72
Old configuration	79	72	81	77



"FAILS"

Strong Holistic Hypothesis

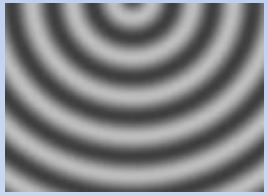
OLD CONFIGURATION

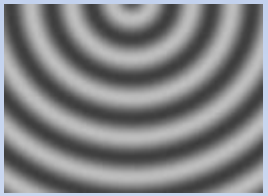
ISOLATION

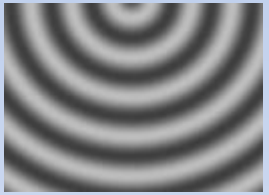
NEW CONFIGURATION

Cognitive Representation

Matching







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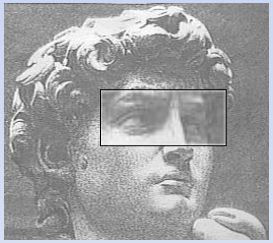
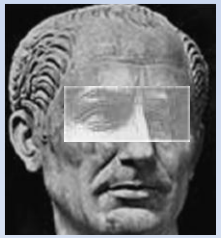
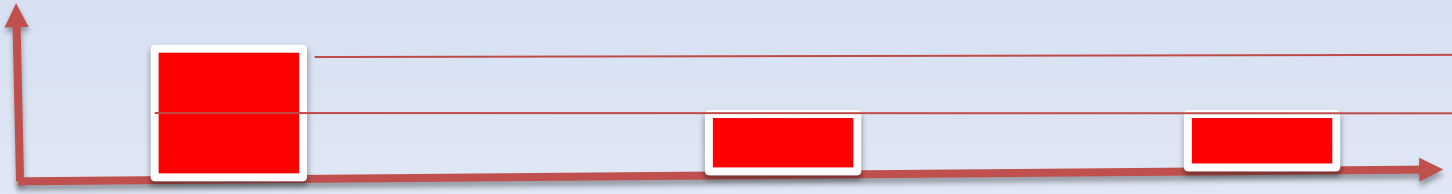




P(Accuracy of detection)



Failure of Selective attention

The Analytic Hypothesis

OLD CONFIGURATION

ISOLATION

NEW CONFIGURATION

Cognitive Representation

Matching

Displayed

P(Accuracy of detection)

A procedural operational definition of holistic face perception

Holism= failure of selectively attend to attend a facial feature regardless of a feature's context.

The failure of selective attention

- () has provided an important clue to understanding the holistic properties of face perception, but what we can learn from this failure is limited.
- We claim that although the failure of selective attention is a necessary component of holistic perception, in itself it is not sufficient to explain it.
- **The part-to-whole paradigm and its focus on the failure of selective attention ignores the cognitive properties that are a natural part of information-processing systems.**

The missing part

- **Operational definition through cognitive processes:**

Mental Architectures

Goal 2

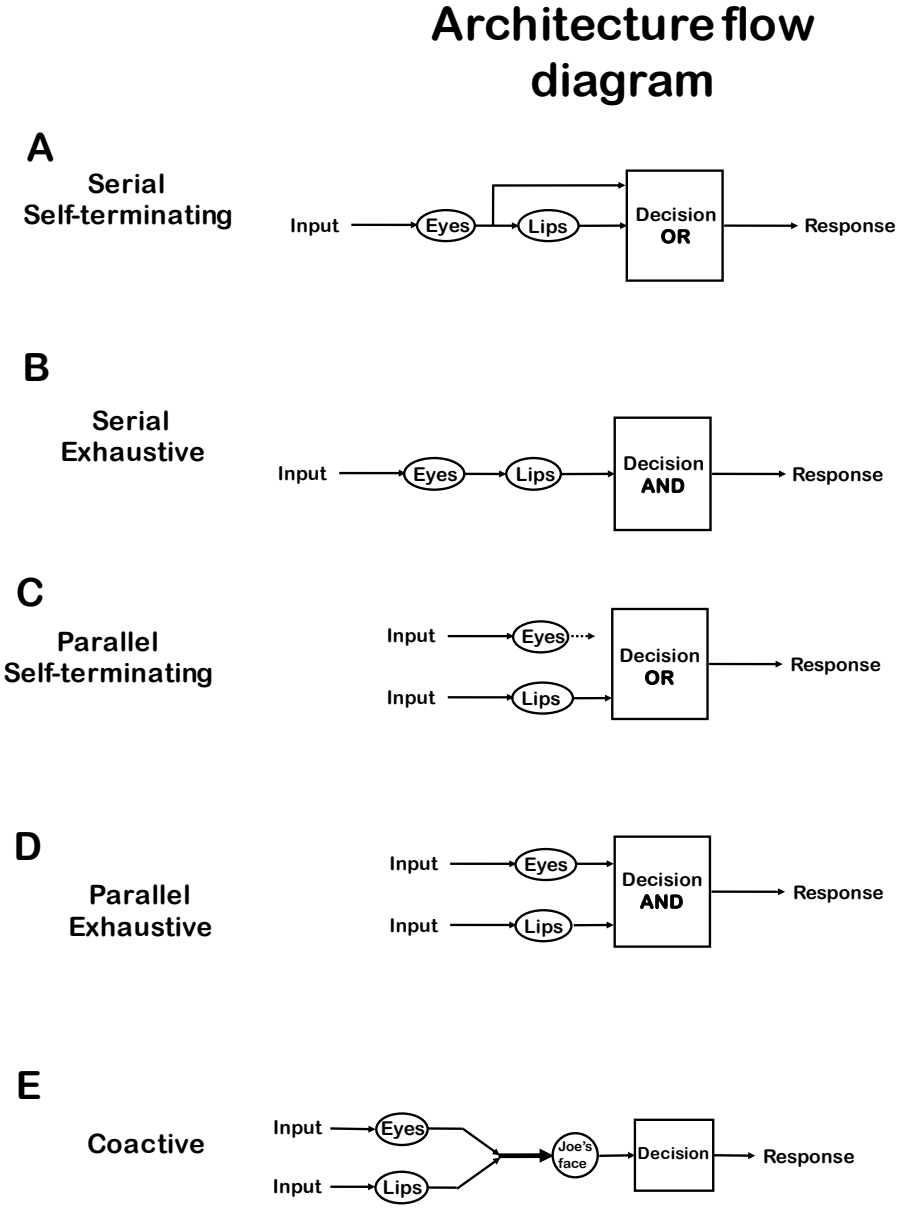
1. What is a **procedural operational definition** of holistic face processing and what is it's weakness?
2. What is a **mental architecture**?
3. Why we should consider a mental architecture to understand holistic face perception?

Fundamental properties of cognitive processes. Definitions

- Processing order
  - Serial
  - Parallel
  - Coactive
- Stopping Rule
  - Self terminating
  - Exhaustive
- Interdependency
  - Facilitatory
  - Inhibitory
- Capacity
  - Limited
  - Unlimited
  - Super

(Schweickert, 1985; Schweickert, Giorgini, & Dzhafarov, 2000; Townsend & Ashby, 1983; Townsend & Nozawa, 1995; Townsend & Wenger, 2004)

A catalog of mental architectures



Defining a **strong holism** in terms of processing characteristics

- Dependent features
- Coactive, parallel architectures
- Mandatory exhaustive stopping rule
- Interdependencies between feature detectors (“glued”)

Defining **analytic processing** in terms of processing characteristics

- Independent features
- Serial , Parallel architectures
- Terminating stopping rule
- Non-dependent feature detectors (“not glued”)

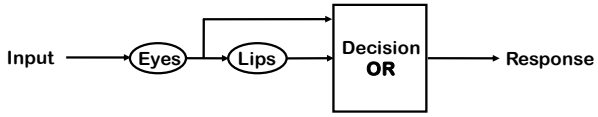
(Wenger & Townsend, 2000; Innes-Ker, A. H. K., 2003; Fific 2006; Wenger & Townsend, 2006; Fific, Nosofsky, Townsend, 2008)

A catalog of mental architectures

Architecture flow diagram

A

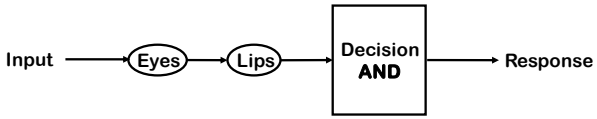
Serial
Self-terminating



Analitic

B

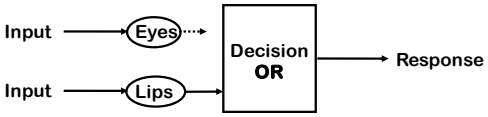
Serial
Exhaustive



Analitic

C

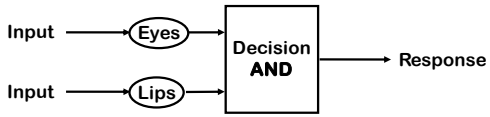
Parallel
Self-terminating



Analitic

D

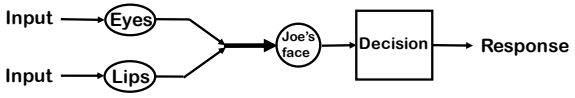
Parallel
Exhaustive



Analytic/ Holstic

E

Coactive

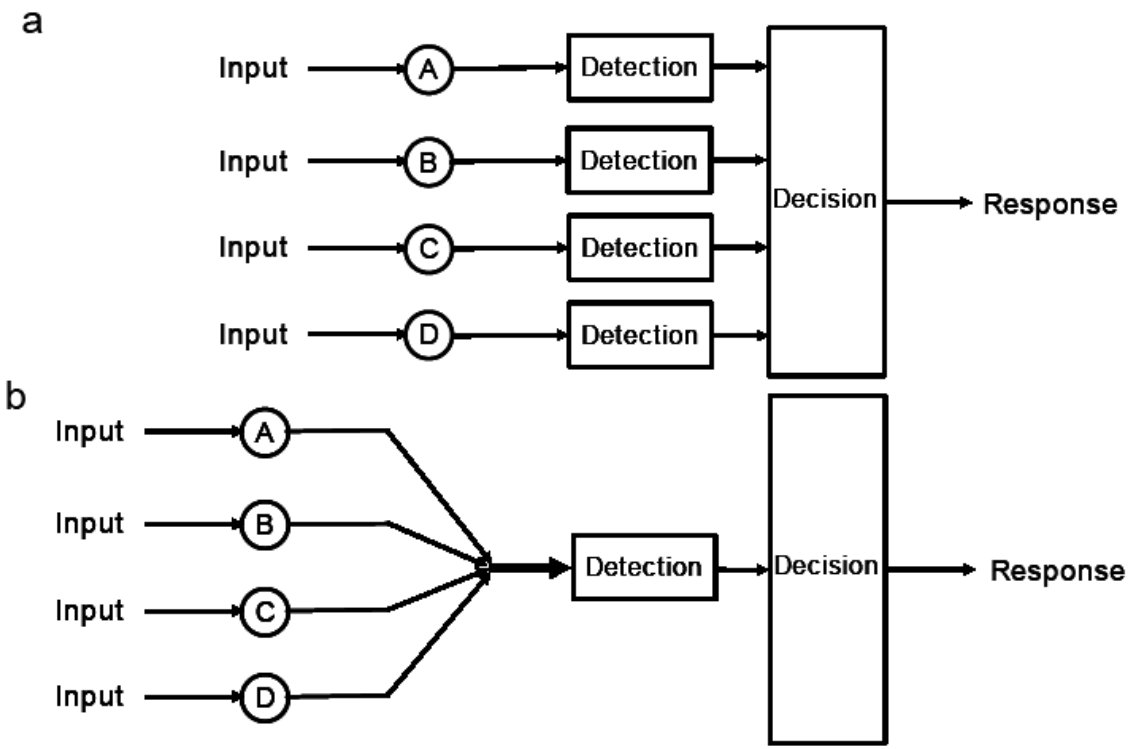


Strong Holstic

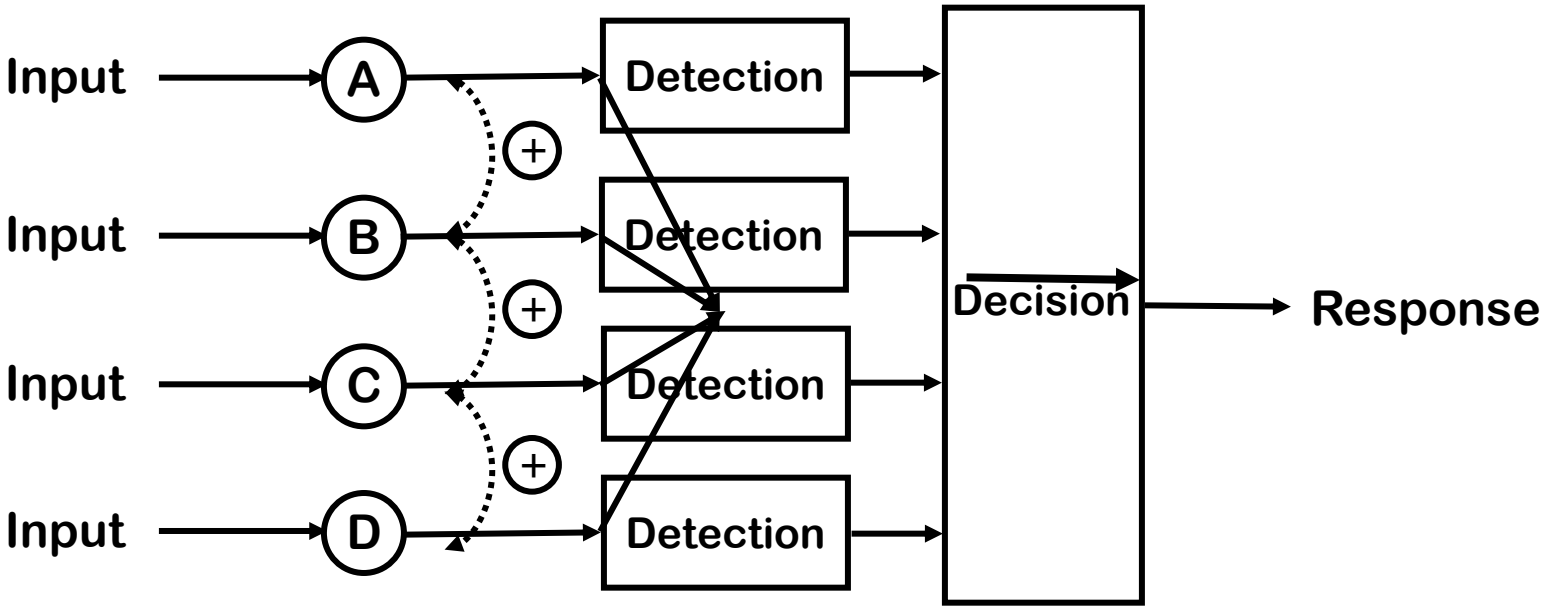
Coactive mental architecture

Parallel

Coactivation



Coactivation is a special case of parallel dependent processing



A cognitive process-based operational definition of holistic face perception

Holism= the coactive mental architecture

General issue: how to identify different mental architectures?

- Systems factorial technology (SFT) is a suite of methodologies that permits the assessment of a set of critical properties of an information-processing system.

Systems factorial technology (SFT)

- 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 (Fific, 2006; Townsend & Fific, 2004; Fific, Nosofsky, Townsend, 2008; Fific, Townsend & Eidels, 2008)

A crash course in SFT approach

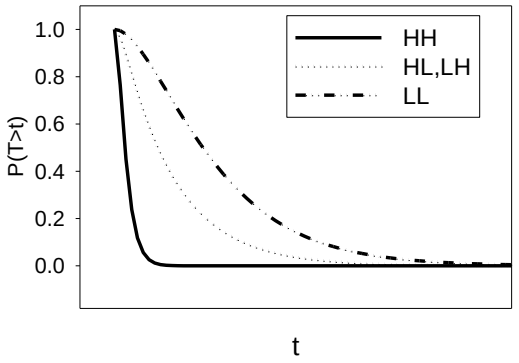
- 1. Non-parametric, factorial method
- 2. Uses RT distribution data to get the diagnostic Signatures
- 3. Identifies different mental architectures based on observed signatures

A diagnostic tool: Survivor interaction contrast function (SIC)

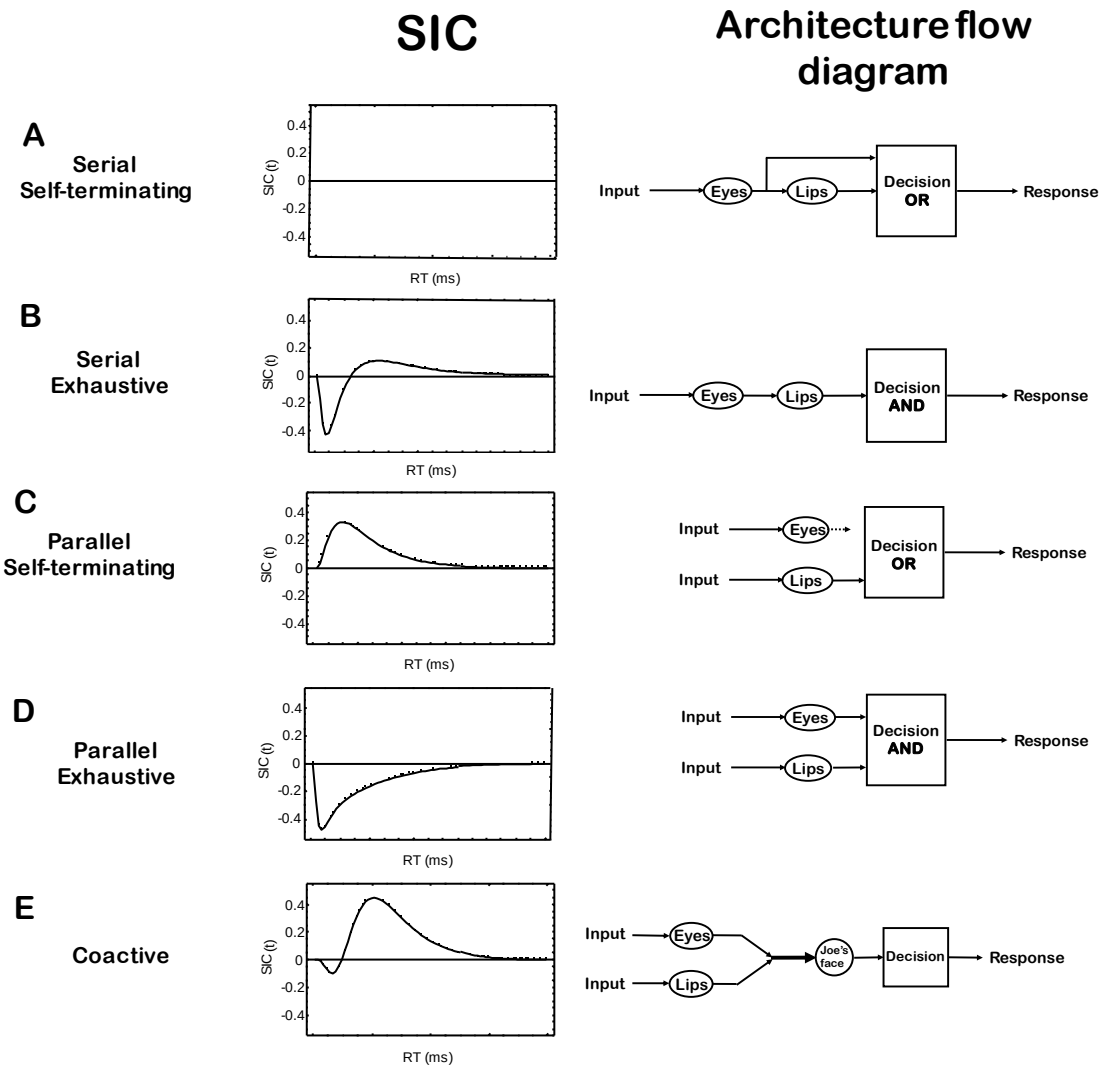
$$SIC(t) = S_{ll}(t) - S_{lh}(t) - (S_{hl}(t) - S_{hh}(t))$$

SURVIVOR FUNCTIONS

$$S(t) = P(T > t)$$



The diagnostic signatures: Survivor interaction contrast function (SIC)

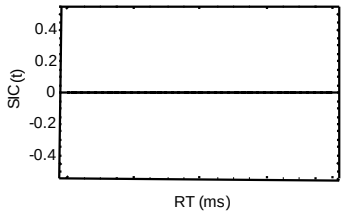


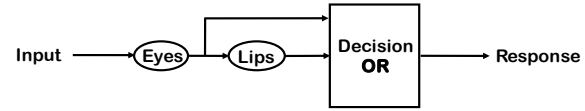
SIC predictions

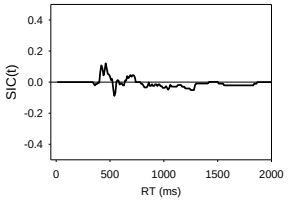
Observed signatures
(Townsend & Fific 2004; Fific & Towsned, 2010)

SIC | **Architecture flow diagram**

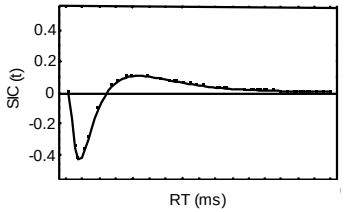
A Serial Self-terminating

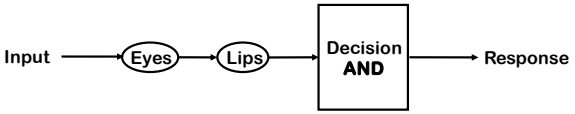


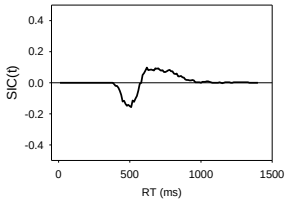




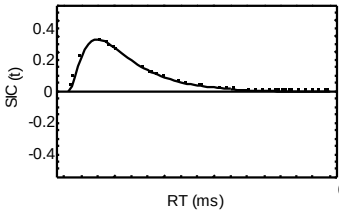
B Serial Exhaustive

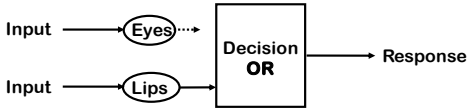


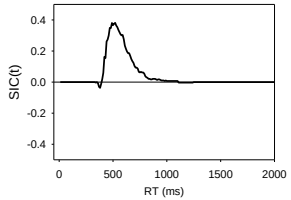




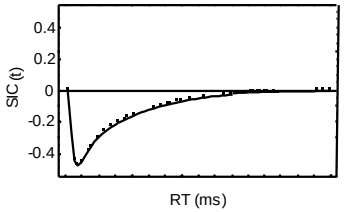
C Parallel Self-terminating

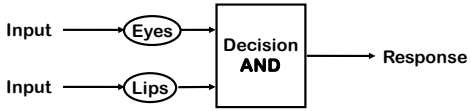


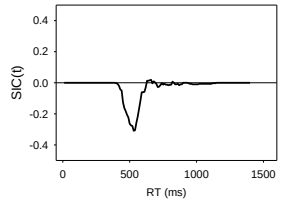




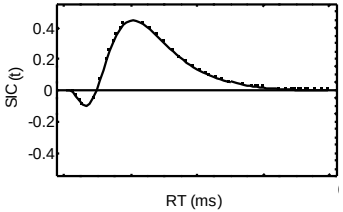
D Parallel Exhaustive

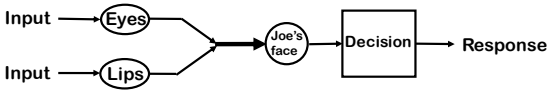


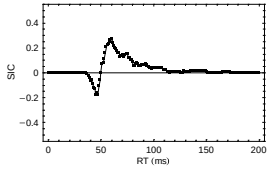




E Coactive







Goal 3

1. What is a **procedural operational definition** of holistic face processing and what is it's weakness?
2. What is a **mental architecture**?
3. Why we should consider a mental architecture to understand holistic face perception?

Information-Processing Systems and the Failure of Selective Attention

- Which one of the catalogued mental architectures can predict the failure of selective attention in the part-to-whole paradigm?

OR

- Does it exist an analytic mental architecture that can predict the failure of selective attention?

Minimum-time (self-terminating) Parallel Model

- A Horse race model

- e.g., Eidels, Townsend, & Algom, 2010; LaBerge, 1962; Marley & Colonius, 1992; Pike, 1973; Townsend & Ashby, 1983; Van Zandt, Colonius, & Proctor, 2000; Vickers, 1970

A horse-race model

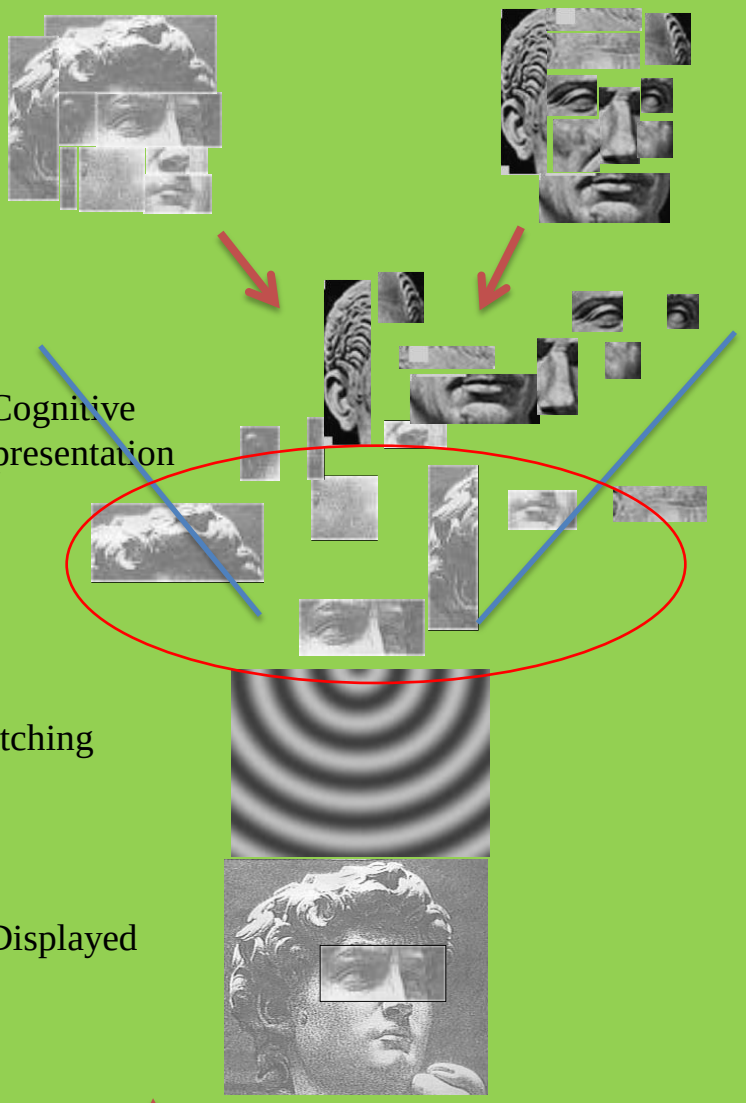
- *All* facial features (including *both* Joe's and Bob's) are stored as noisy memory representations
- *All* of these features race to be recognized
- The first-to-be-recognized feature is used to make an overall decision
- Errors occur because "incorrect" feature finishes first

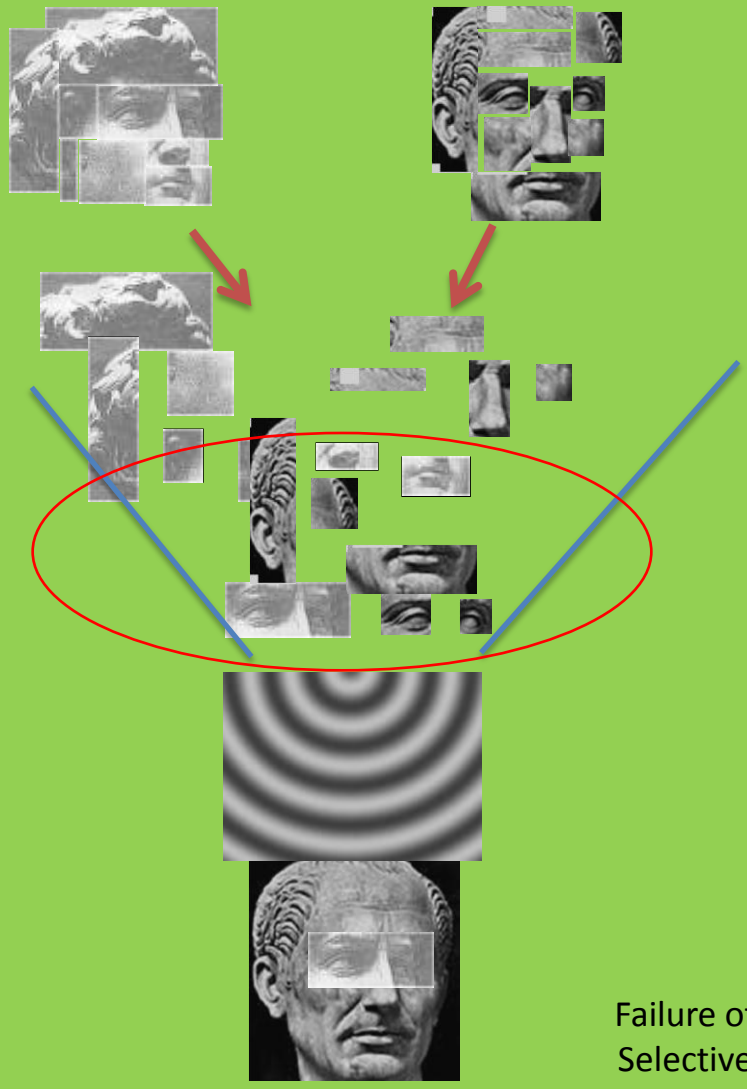
Horse race

Cognitive Representation

Matching

Displayed



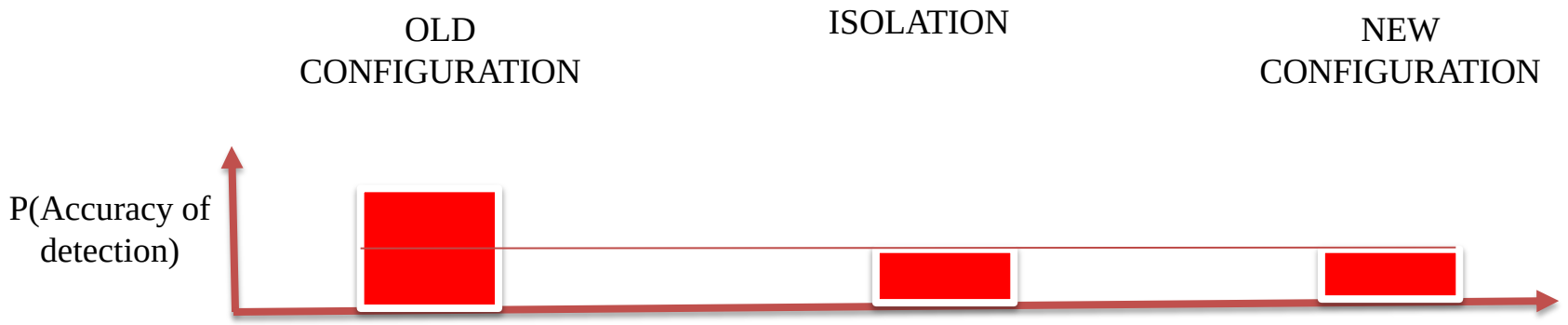


Failure of Selective attention

P(Accuracy of detection)

Simulation results

Context	Feature activation levels			
	Joe's eyes	Joe's lips	Bob's eyes	Bob's lips
OLD CONFIGURATION	**.97**	**.87**	.30	.05
NEW CONFIGURATION	**.97**	.16	.30	**.95**
ISOLATION	**.97**	.16	.30	.05



Is a horse-race model (aka first-terminating parallel architecture) realistic?

- Yes
- Evidence from face categorization (Fific, 2006)
- Detection (Townsend & Nozawa 1995)
- The Stroop effect (Eidels, Townsend, & Algom, in press)
- Global-Local Matching (Johnson, Blaha, Houpt, Townsend, 2009)

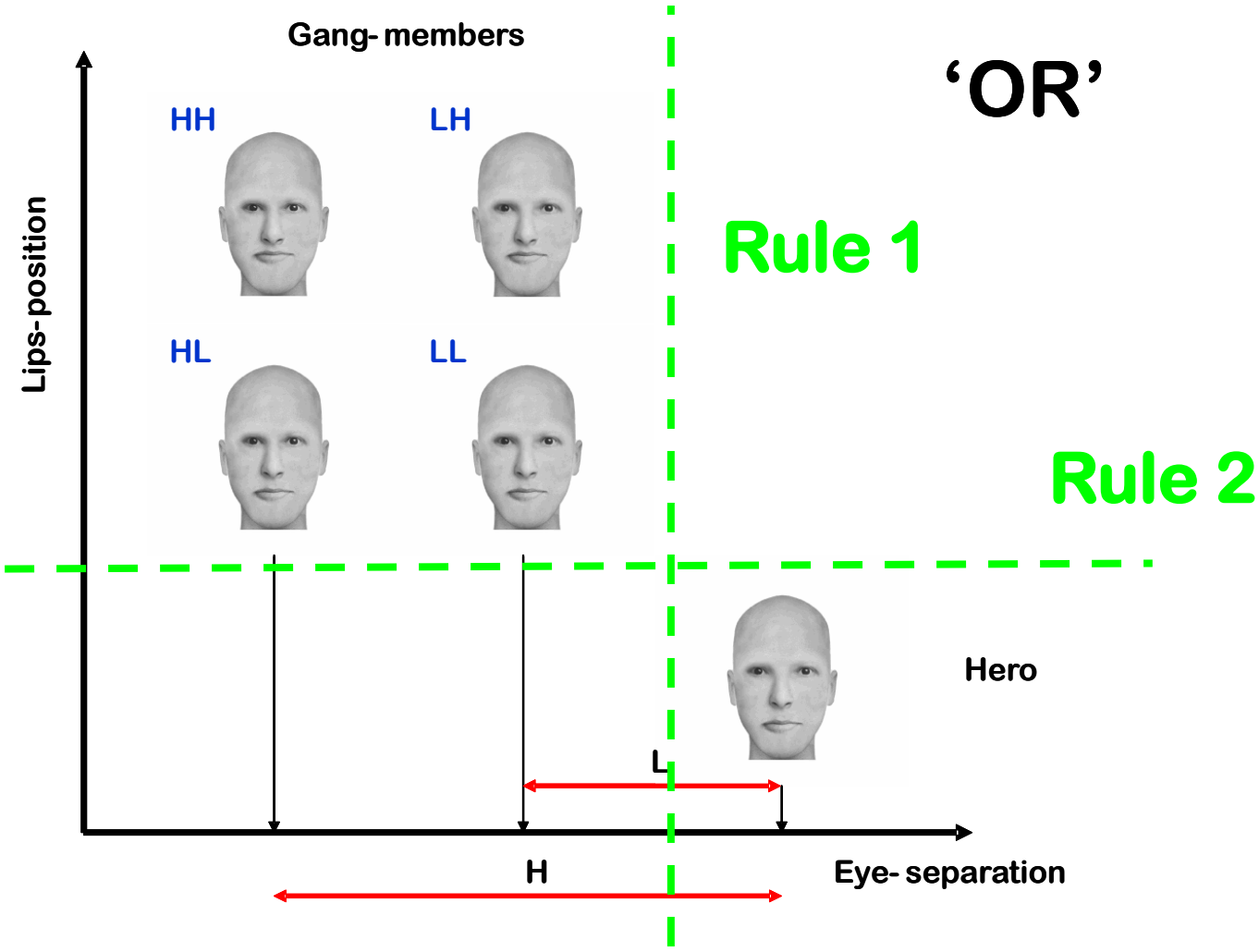
The empirical evidence the SFT “OR” task: a disjunctive rule face classification task

Configurally Altered (new) face

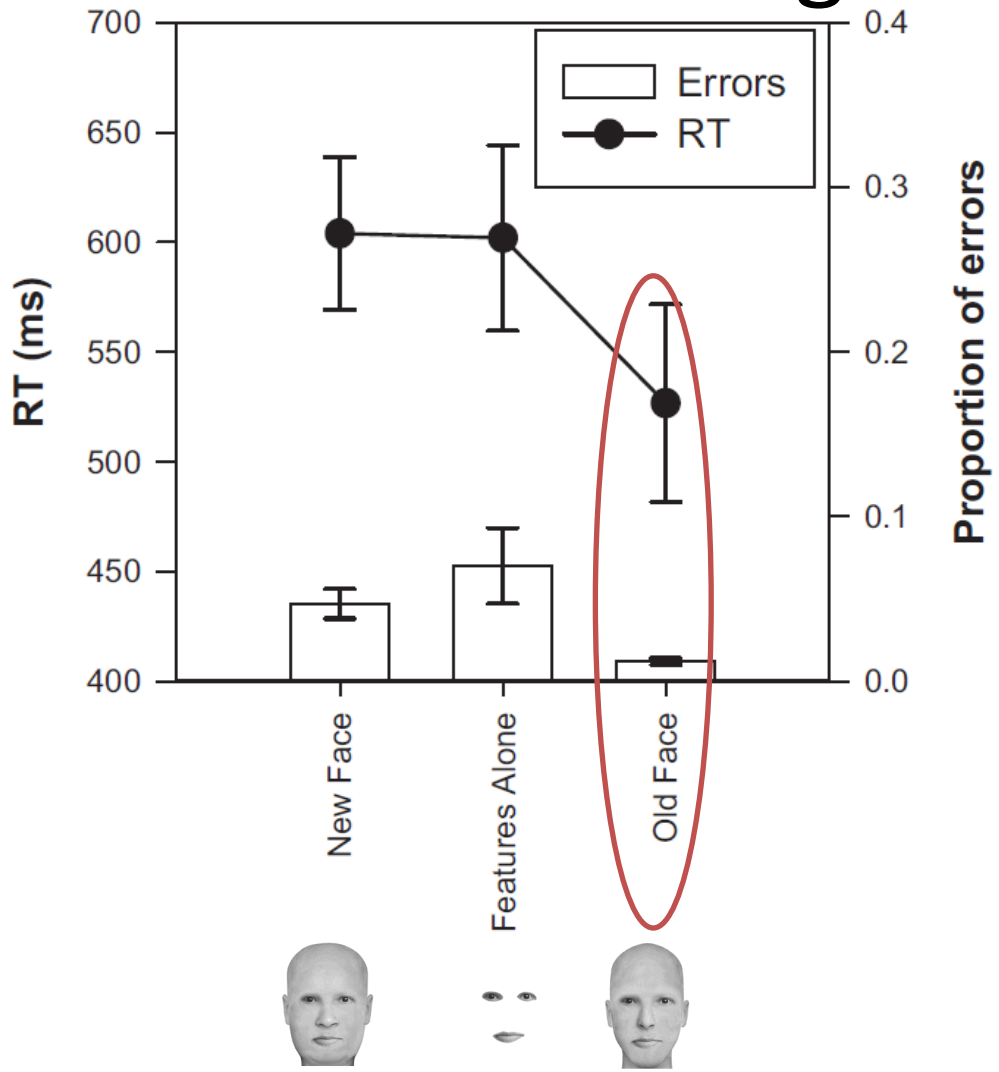
Features only

Old face

The empirical evidence the SFT "OR" task: a disjunctive-rule face classification task

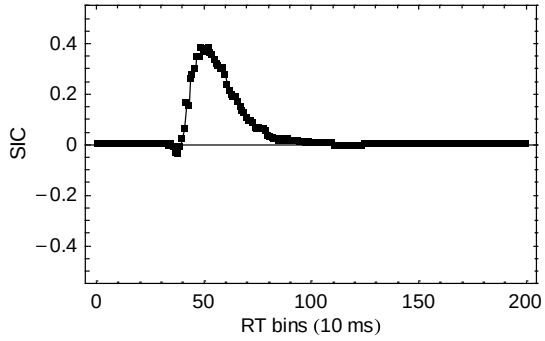


The empirical evidence:
Standard approach: face categorization
RTs and accuracies categorization

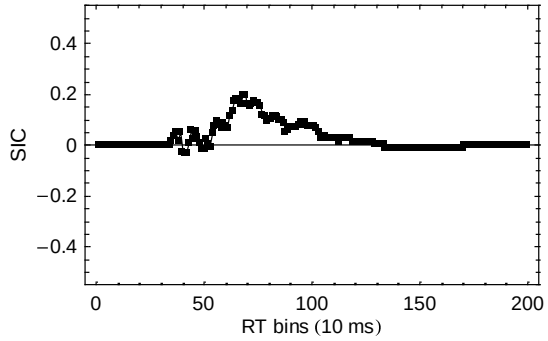


The empirical evidence: The SFT findings

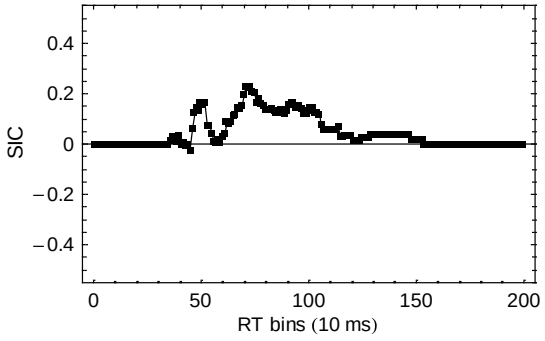
Old face



Configurally Altered (new) face



Features only



RT < RT ≈ RT

The Goals of the Talk

1. What is a **procedural operational definition** of holistic face processing and what is it's weakness? vs. A **cognitive process-based operational definition** of holistic face perception
2. What is a **mental architecture**?
3. Why we should consider a mental architecture to understand holistic face perception?

Conclusions

- An analytic model (nonholistic), based on a parallel mental architecture and a self-terminating stopping rule, can predict failure of selective attention
- Test for presence of Holism must include the test for mental architectures.
- Systems factorial technology provides such a test
- SFT approach is non parametric and based on Individual subject analysis.