

# Control and association in categorization

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Dizziness and Skin Rash → Jominy fever (common)  
Dizziness and Back Pain → Phipp's syndrome (rare)

### Skin Rash and Back Pain

Is the patient more likely to have:  
Jominy fever or Phipp's syndrome ?

# Inverse base-rate effect

Dizziness and Skin Rash → Jominy fever (common)

Dizziness and Back Pain → Phipp's syndrome (rare)

## Skin Rash and Back Pain

Is the patient more likely to have:  
Jominy fever or Phipp's syndrome

- In the experimental context, skin rash perfectly predicts Jominy fever, and back pain perfectly predicts Phipp's syndrome. Jominy fever is more common, so the rational answer is "Jominy".
- Across a number of experiments (Medin & Edelson, 1998; Kruschke, 1996; Juslin et al., 2001; Kruschke, 2001) the rare disease (Phipps) is chosen.

Why?

# Eliminative inference explanation

$2 \times AB \rightarrow 1$

$1 \times AC \rightarrow 2$

BC?

- (a) Eliminative inference: “When faced with a novel situation, produce a novel response”.
- (b) As  $AC \rightarrow 2$  is rarer than  $AB \rightarrow 1$ , participants are more likely to forget  $C \rightarrow 2$  than  $B \rightarrow 1$ .
- (c) If  $C \rightarrow 2$  is forgotten, then the familiar response for BC is 1 (from  $B \rightarrow 1$ ). Hence under eliminative inference, they respond “2”.

Juslin et al. (2001).

# Prediction of Eliminative inference

The inverse base-rate effect should not be dependent on the presence of a common symptom.

2 x DB  $\rightarrow$  1                  1 x EC  $\rightarrow$  2                  BC?

- (a) Eliminative inference: “When faced with a novel situation, produce a novel response”.
- (b) As EC  $\rightarrow$  2 is rarer than DB  $\rightarrow$  1, participants are more likely to forget C  $\rightarrow$  2 than B  $\rightarrow$  1.
- (c) If C  $\rightarrow$  2 is forgotten, then the familiar response for BC is 1 (from B  $\rightarrow$  1). Hence under eliminative inference, they respond “2

Kruschke (2001)

# Error-correcting attention

2 x AB → 1                      1 x AC → 2  
BC?

- AB → 1 is learned first (because it is more common).
- On seeing AC, participant tends to predict 1 because they have learned A → 1.
- In order to reduce future error, attention to C (the perfect predictor of 2) is increased.

Kruschke (1996)

# Design

## *Phase 1*

2 x AB → Disease 1

1 x AC → Disease 2

2 x FD → Disease 1

1 x GE → Disease 2

## *Phase 2*

As phase 1, plus:

2 x [ B?, C?, D?, E? ]

1 x [ A?, BC?, DE? ]

# Procedure

<u>Phase 1</u>	<u>Phase 2</u>
2 x AB → 1	As phase 1, plus:
1 x AC → 2	2 x [ B?, C?, D?, E? ]
2 x FD → 1	1 x [ A?, BC?, DE? ]
1 x GE → 2	



1 sec



RESPONSE



1.5 sec

- Cell bodies in blood samples.
- Each letter in the design instantiated in three “cell bodies”.
- Cell bodies randomly allocated to letters for each participant.
- 20 blocks in phase 1 (18 trials per block)
- 8 blocks in phase 2 (51 trials per block)

# EEG

<u>Phase 1</u>	<u>Phase 2</u>
2 x AB → 1	As phase 1, plus:
1 x AC → 2	2 x [ B?, C?, D?, E? ]
2 x FD → 1	1 x [ A?, BC?, DE? ]
1 x GE → 2	

- 58 scalp electrodes. 500 Hz sample rate.
- Low-pass filtered (40Hz)
- Segmented by stimulus onset (-100ms to +500ms)
- Assess B, C, D, and E during phase 2.
- Attentional selection by stimulus features is commonly associated with a posterior selection negativity and also sometimes an anterior selection positivity (Hillyard & Anllo-Vento, 1998).
- Selection negativity previously seen in a forward cue competition design (Wills, Lavric, Croft & Hodgson, 2007)

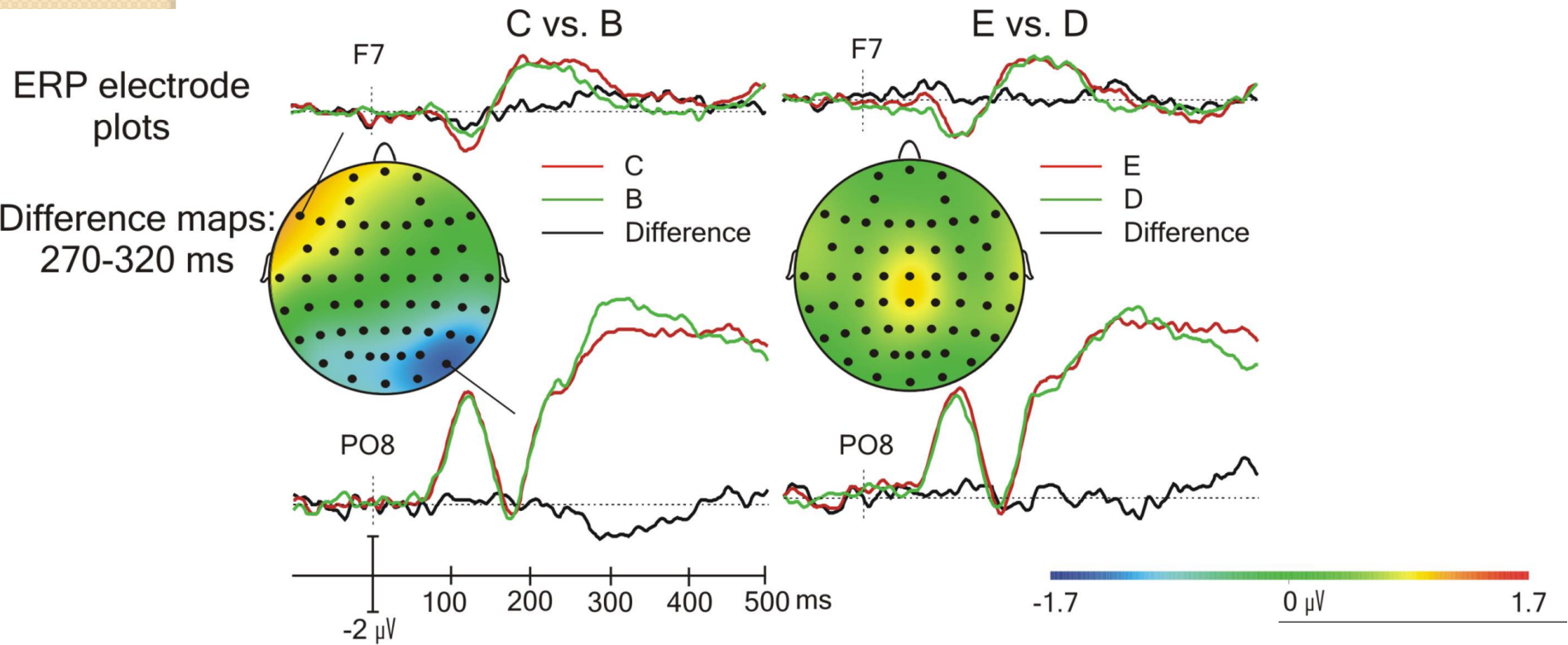
# Results

<u>Phase 1</u>	<u>Phase 2</u>
2 x AB → 1	As phase 1, plus:
1 x AC → 2	2 x [ B?, C?, D?, E? ]
2 x FD → 1	1 x [ A?, BC?, DE? ]
1 x GE → 2	

	<u>A→1</u>	<u>B→1</u>	<u>C→2</u>	<u>D→1</u>	<u>E→2</u>	<u>BC→1</u>	<u>DE→1</u>
<i>Prob</i>	0.69	0.88	0.67	0.87	0.56	0.36	0.95
<i>RT</i>	835	732	763	711	755	917	785

- Inverse base-rate effect ( $BCI < 0.5$ ).
- Eliminative inference account ruled out ( $DEI > 0.5$ ).
- Associative strength account ruled out ( $BI > C2$ ).

- TANOVA and permutation-based correction used to identify significant time windows in the scalp distribution.
- 270-320ms revealed in C – B comparison. None revealed in E – D.
- (C-B) vs. (E-D) comparison is significant in this time window.
- Posterior selection negativity to C (compared to B)
- Anterior selection positivity to C (compared to B)
- Absence of effect in E – D comparison rules out explanation in terms of differential frequency.



# Modal model of cognition

Analytic

Nonanalytic

*Brooks (1978)*

Computation

Retrieval

*Logan (1988)*

Verbal reasoning

Procedural learning

*COVIS*  
*Ashby et al. (1998)*

# COVIS

## Explicit system

- Logical reasoning.
- Verbal description.
- Rule selection & switching.
- Incremental learning of rule salience and decision criteria.
- Prefrontal cortex, anterior cingulate.

## Implicit system

- Motor component
- Radial basis, feedforward, prediction error.
- No selective attention.
- Sensory cortex, striatum, premotor cortex.

High initial weight

Low initial weight

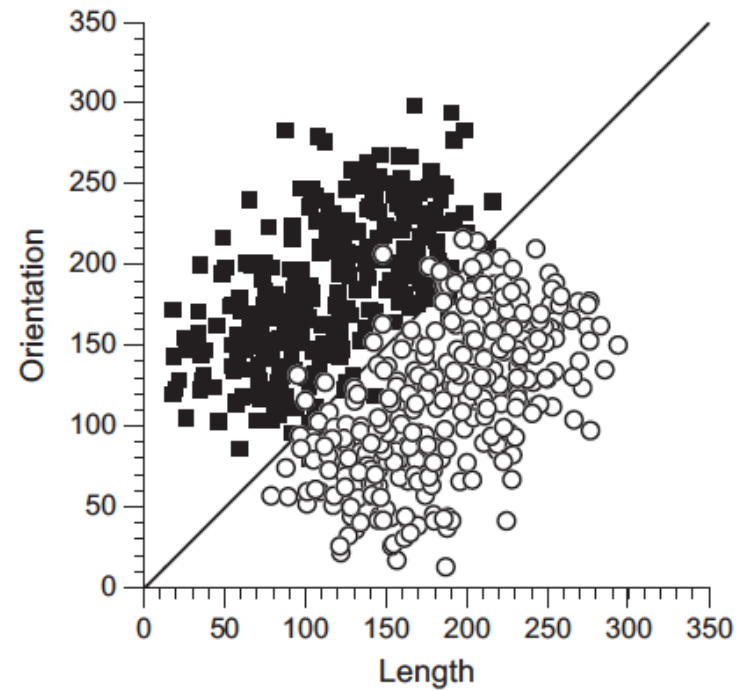
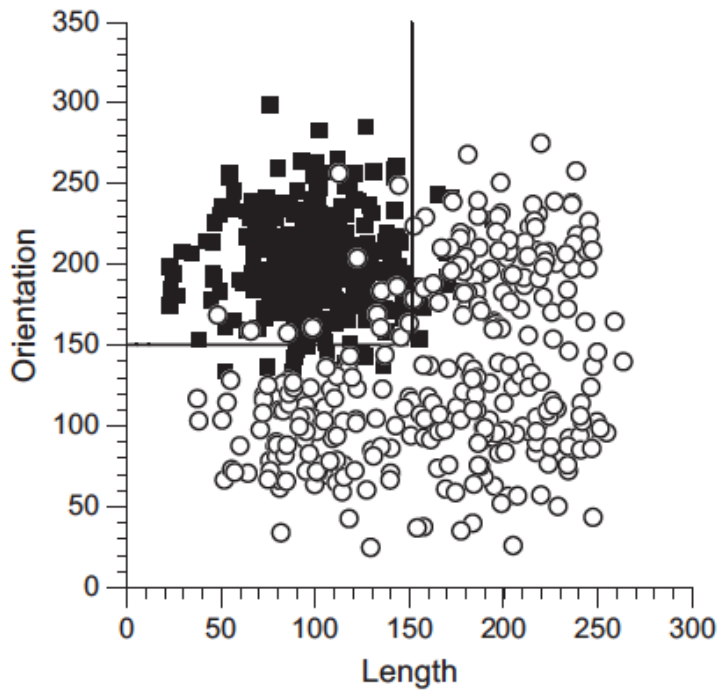
## Competition resolution

- Success-based trust

RESPONSE



# RB and II categories

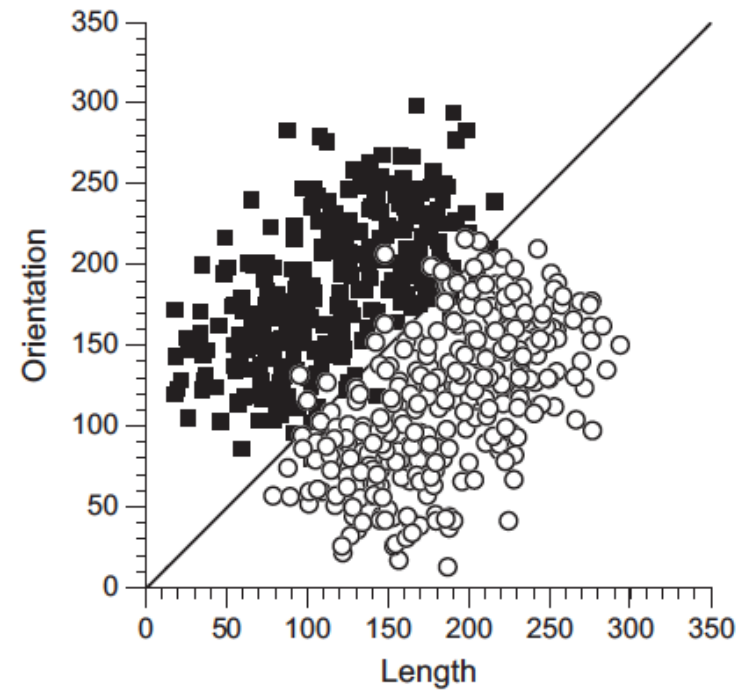
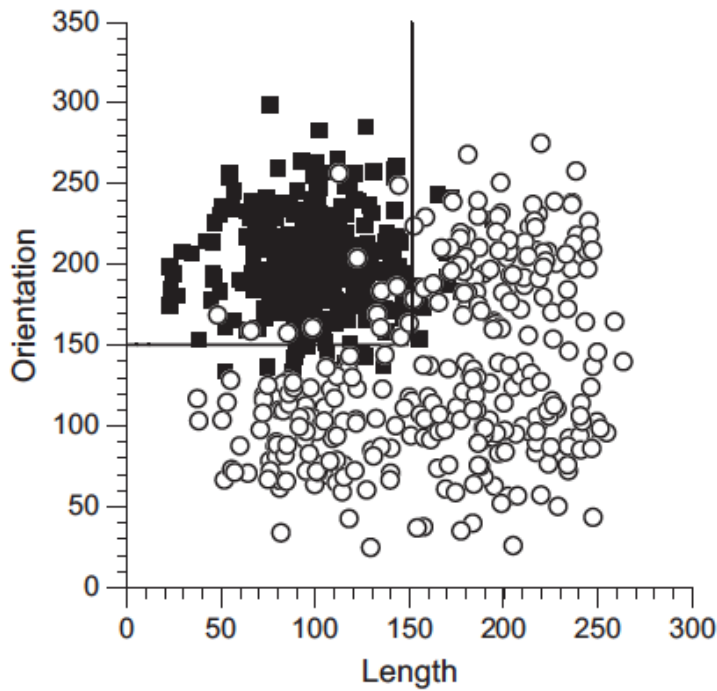


# COVIS

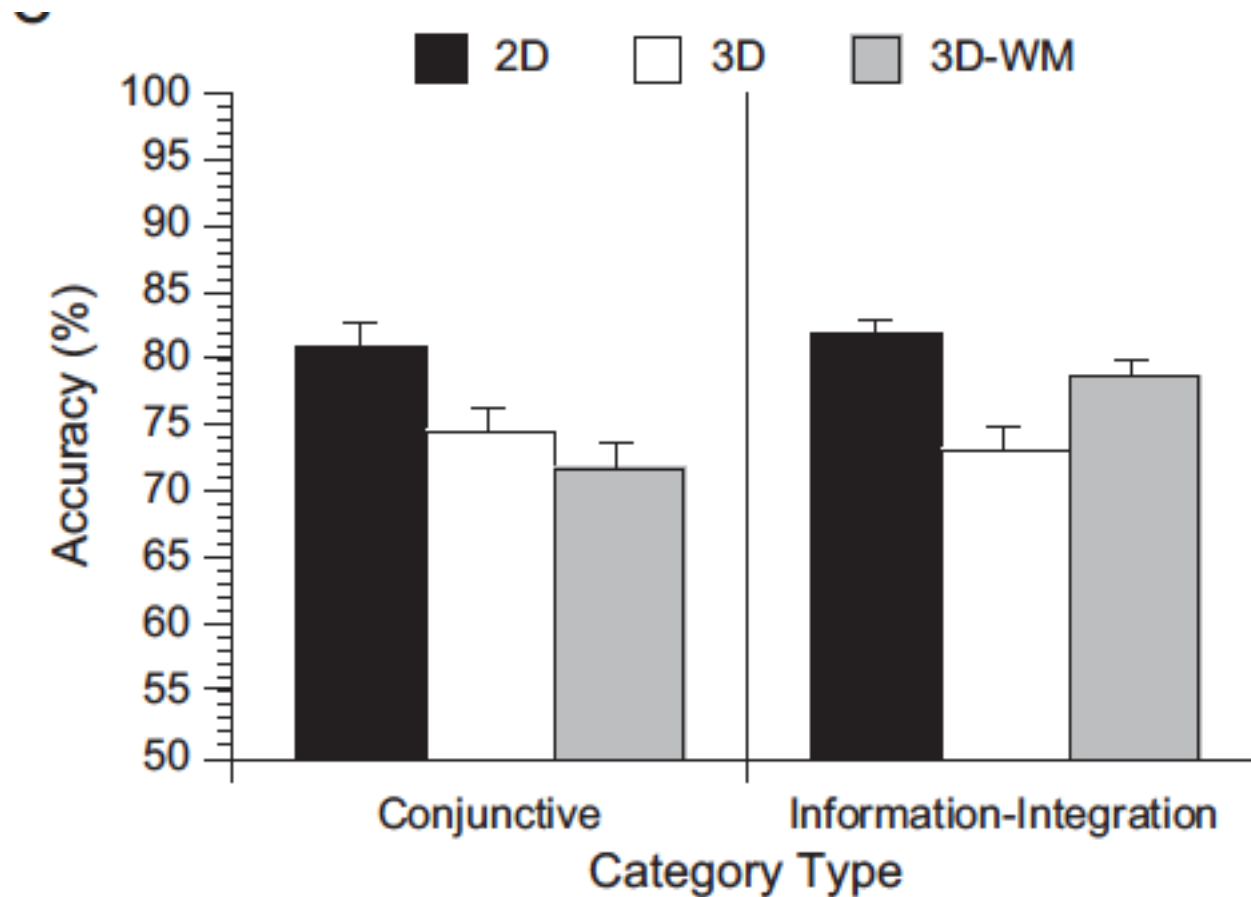
- Problems with COVIS:
  - Concurrent load affects RB but not II categorization (Waldron & Ashby, 2001; Zeithamova & Maddox, 2006).
  - Feedback delay (Maddox & Ing, 2005), category -> response key reversal (Ashby et al., 2003), affects II but not RB.
  - State trace analysis indicates these experiments are consistent with a single-process model (Newell, Dunn & Kalish, 2011).
- What about Filoteo et al. (2010)?
  - Concurrent load has ordinally opposite effects on easy-to-verbalize (“RB”) and harder-to-verbalize (“II”) category structures.



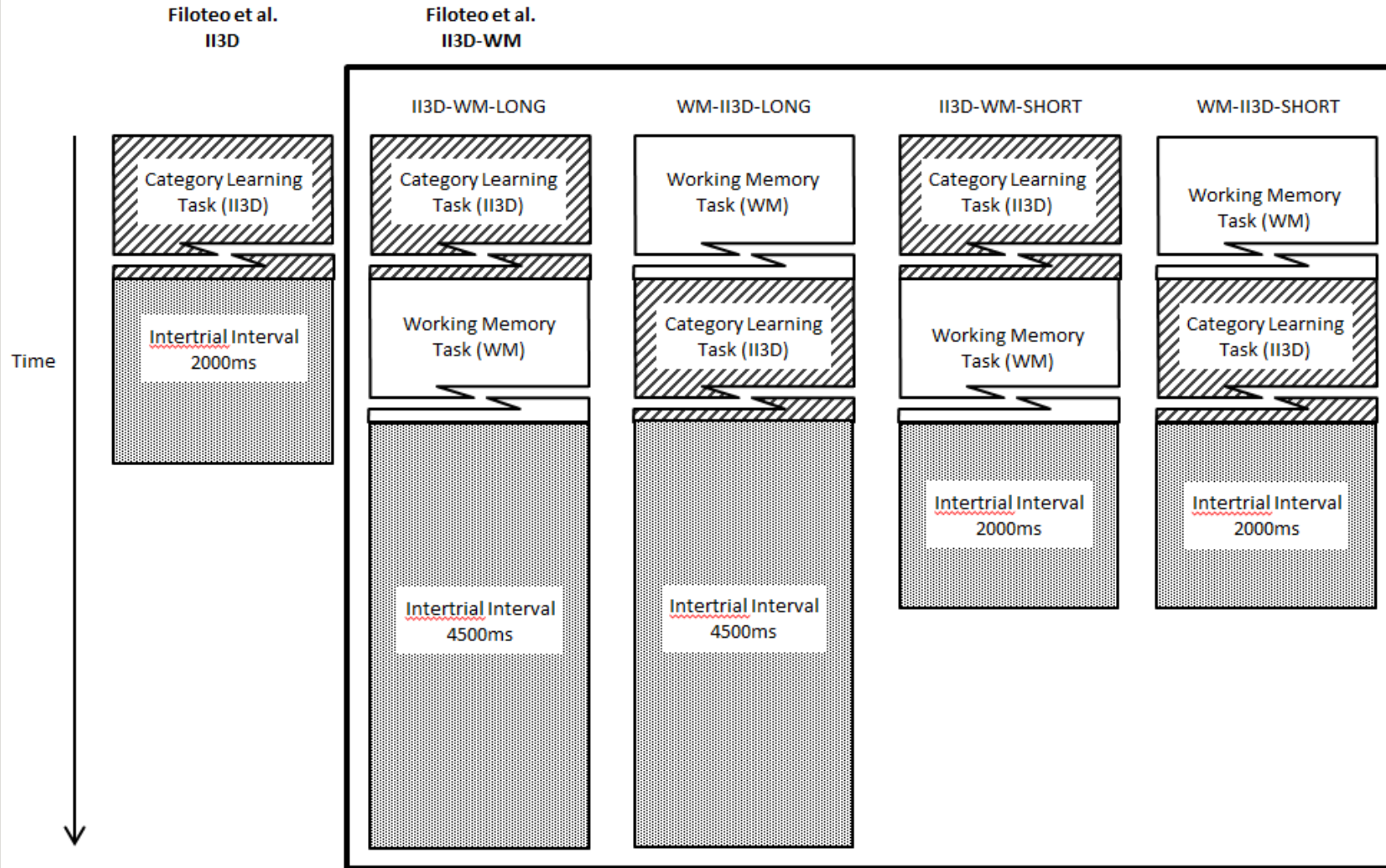
# Filoteo et al. (2010): Stimuli



# Filoteo et al. (2010): Results



# Confound and resolution



# Our results

