Attention and the Inverse Base Rate Effect: Evidence From Event-Related Potentials.

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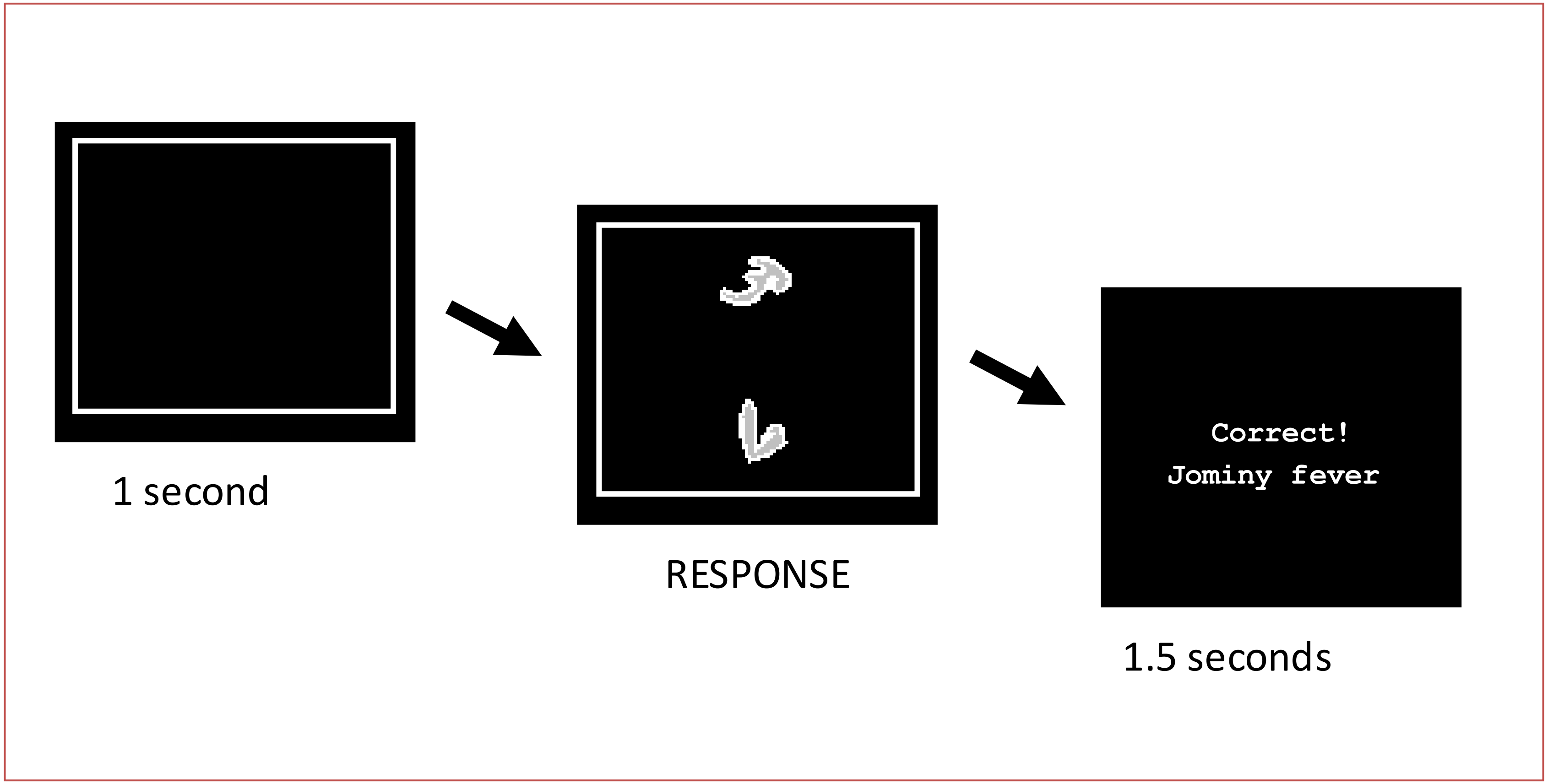
Cue competition

Phase 1	Phase 2	Test
A+	AX+	X?
B-	BY+	Y?
I-	IJ-	

- Deduction
- Error-driven learning
- Error-driven attention

Wills, Lavric, Croft & Hodgson (2007)



- 2 second time-out (0.3% trials terminated)

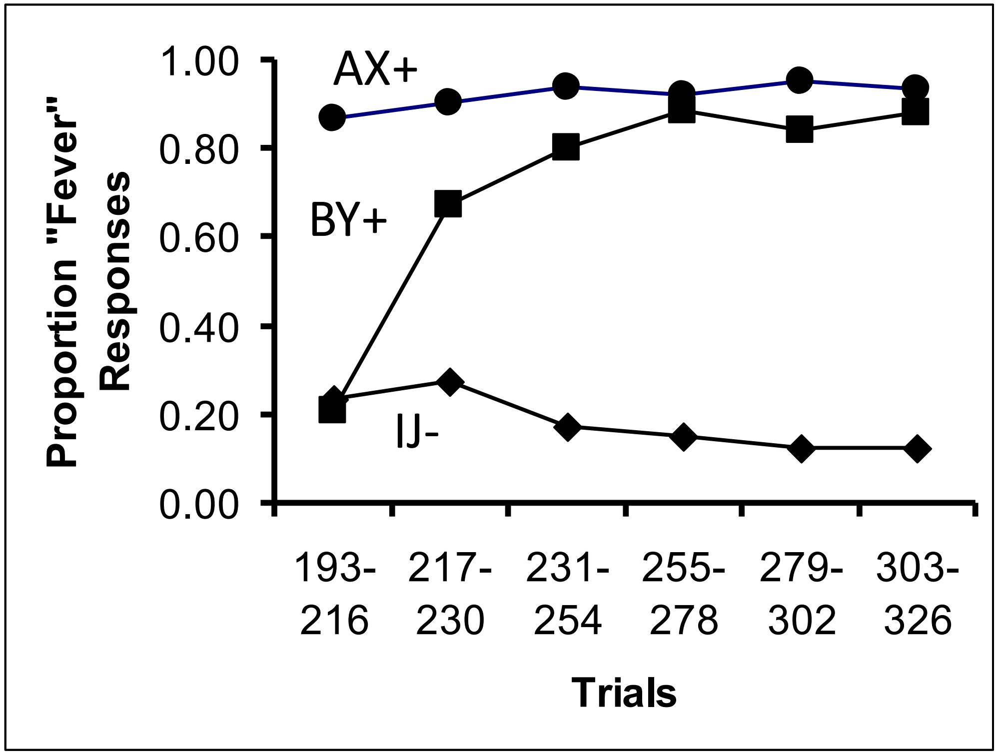
Behavioural results

Phase 1

A+ 0.90

B- 0.03

I- 0.03



Phase 3

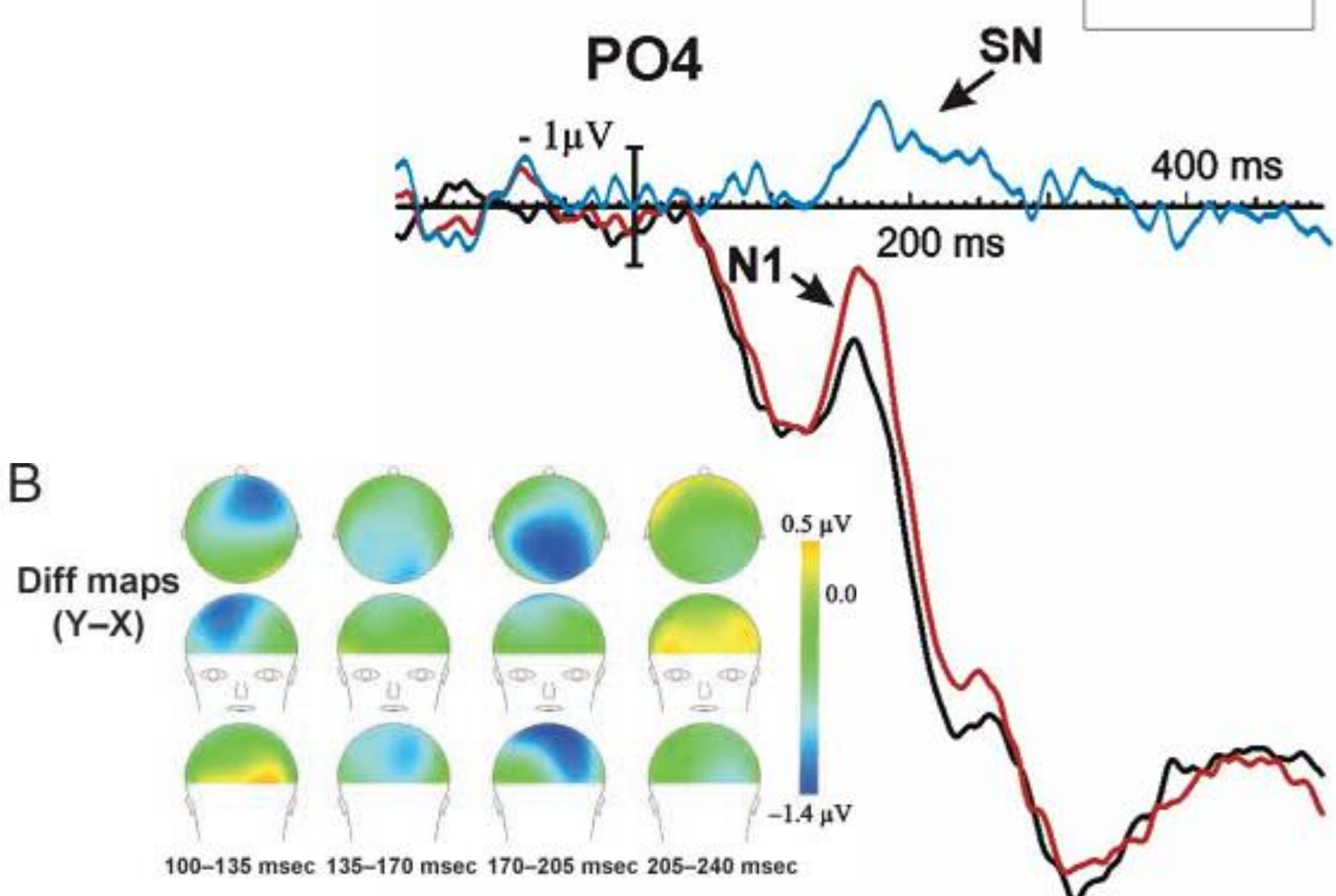
X – 0.45

(807ms)

Y – 0.72

(767ms)

- Other phase 3 trial types:
  A:0.96; AX: 0.98; BY: 0.91; B: 0.18



Attentional difference as cause or consequence?

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

?

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 x AB → 1   1 x AC → 2   BC?

(a) Eliminative inference: “When faced with a novel situation, produce a novel response”.
(b) As AC → 2 is rarer than AB → 1, participants are more likely to forget C →2 than B → 1.
(c) If C →2 is forgotten, then the familiar response for BC is 1 (from B →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 → 1   1 x EC → 2   BC?

(a) Eliminative inference: “When faced with a novel situation, produce a novel response”.

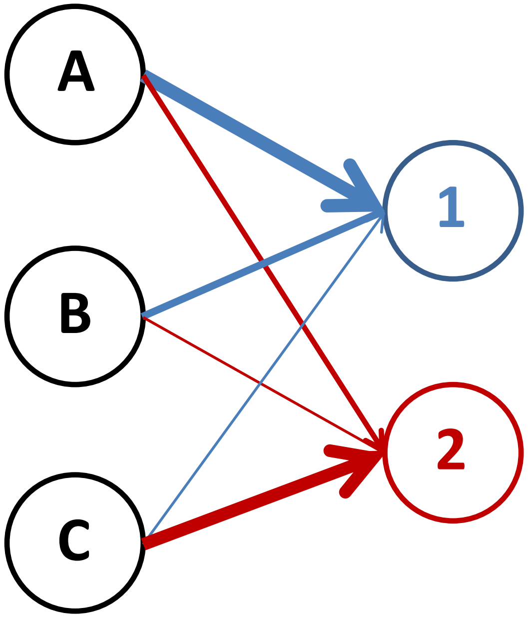
(b) As EC → 2 is rarer than DB → 1, participants are more likely to forget C →2 than B → 1.

(c) If C →2 is forgotten, then the familiar response for BC is 1 (from B →1). Hence under eliminative inference, they respond “2”.

Kruschke (2001)

Error-correcting learning

- Predicted by a simple error-correcting learning algorithm (delta rule / Rescorla-Wagner / temporal difference models).
  - A has greater associative strength to 1 than to 2.
  - Cues compete to predict outcomes.
  - So C →2 gains more associative strength than B →1.
- Prediction of this account:
  - C → 2 is greater than B → 1



2 x AB → 1 1 x AC → 2 BC?

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.

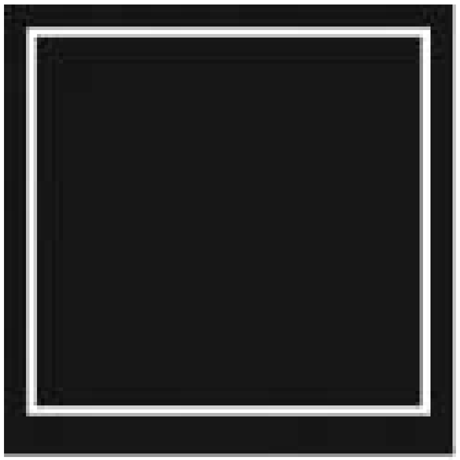
Kruschke (1996)

Design

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

Procedure

Phase 1	*Phase 2*
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

- 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)

Phase 1	*Phase 2*
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	

Results

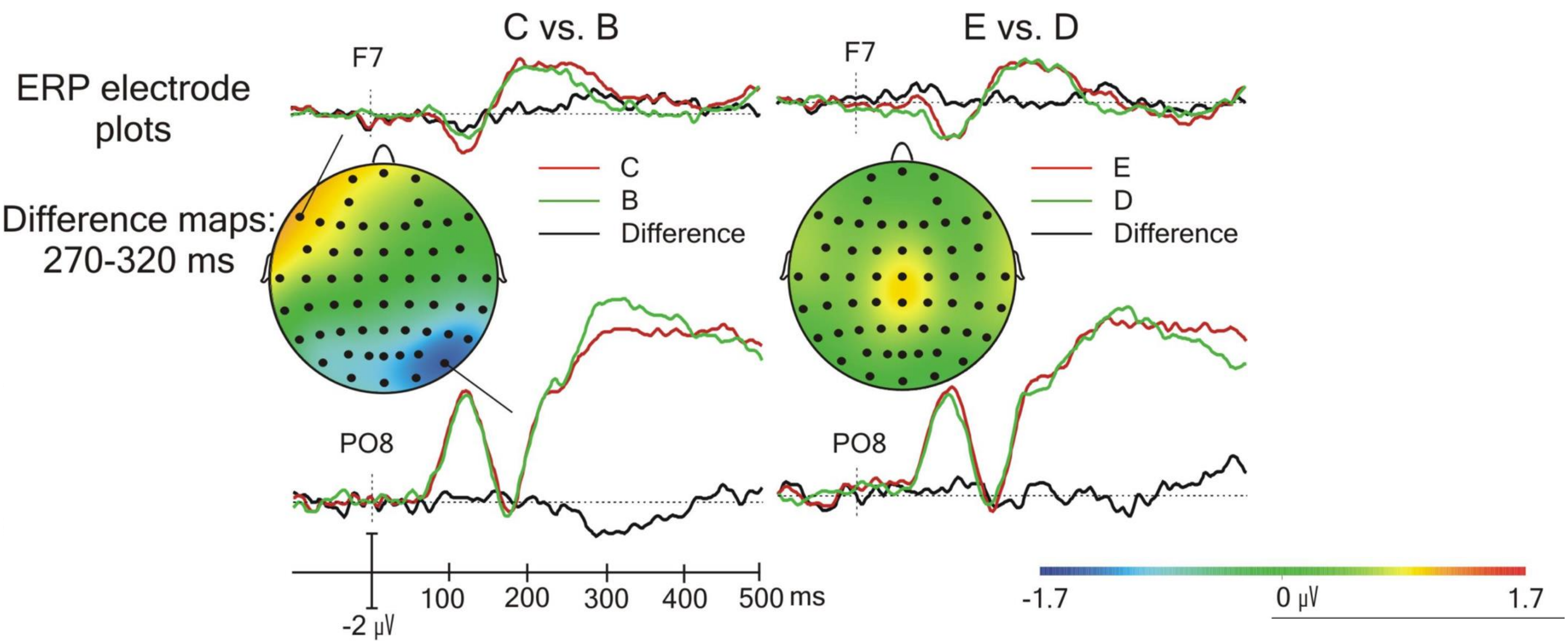
Phase 1	*Phase 2*
2 x AB → 1	As phase 1, plus:
1 x AC → 2	2 x [B?, C?, D?, E?]
2 x FD → 1	1 x [A?, BC?, DE?]
1 x GE → 2	

	A→1	B→1	C→2	D→1	E→2	BC→1	DE→1
Mean	0.69	0.88	0.67	0.87	0.56	0.36	0.95
SE	(0.04)	(0.03)	(0.06)	(0.04)	(0.06)	(0.06)	(0.02)
RT	835	732	763	711	755	917	785
SE	(54.9)	(37.3)	(37.8)	(35.0)	(35.4)	(37.3)	(41.0)

- Inverse base-rate effect (BC1 < 0.5).
- Eliminative inference account ruled out (DE1 > 0.5).
- Associative strength account ruled out (B1 > 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.

Phase 1	*Phase 2*
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	



Summary and Conclusions

- In the inverse base-rate effect phenomenon, participants make the apparently irrational decision that when two perfect predictors of two different outcomes co-occur, the *less* frequent outcome is more likely.
- At least in the current study, this is not due to a process of “eliminative inference” (no effect in absence of common element – see also Kruschke, 2001).
- Nor is it due to error-correcting learning (as B > C behaviourally).
- The remaining class of explanation – error-correcting attention – is supported by ERPs showing a selection negativity to C.
  - Commonly seen correlate of selective attention to features (Hillyard & Anllo-Vento, 1998)
  - Selection negativity previously reported in an EEG study of forward cue competition (Wills, Lavric, Croft & Hodgson, 2007).
  - However, in Wills et al. 2007, it was not possible to rule out an associative strength mediated effect.
  - In the current study, it was.