

ERP reveals early attentional effects in a human blocking study

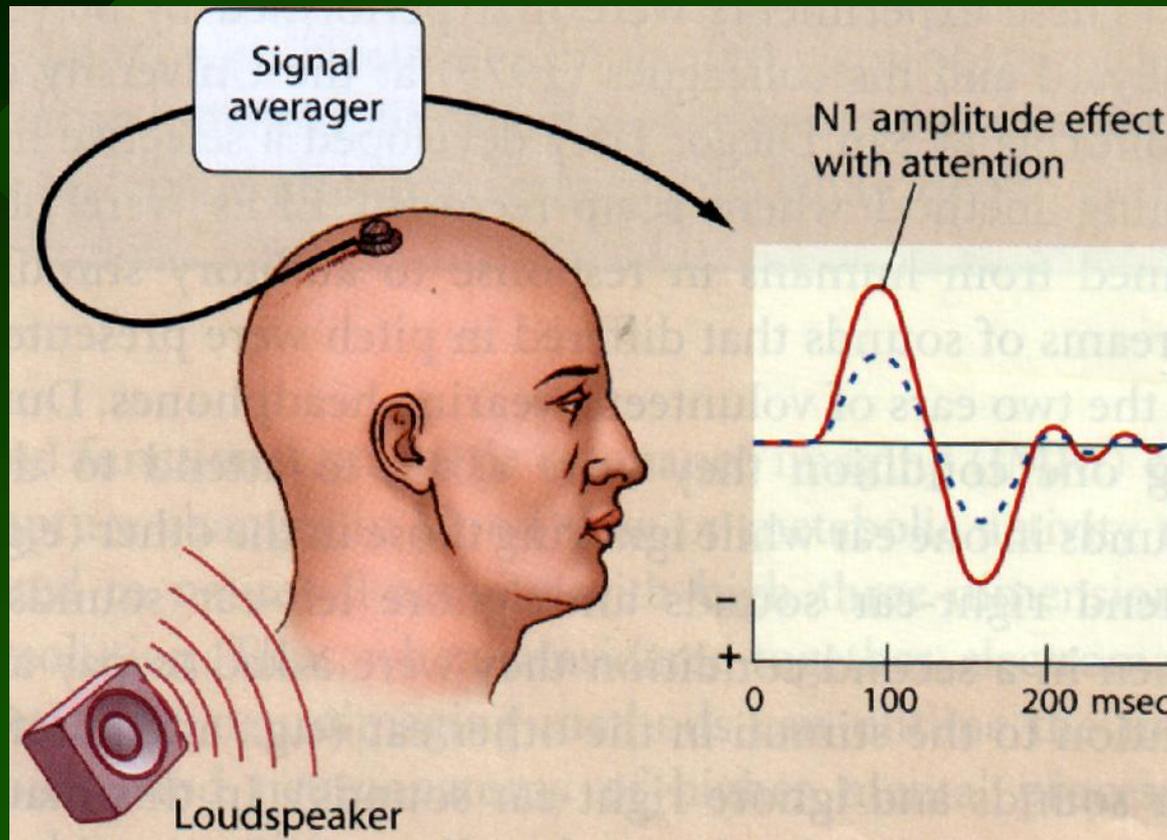
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Human associative learning: Non-exclusive classes of theory

- Direct learning with prediction errors
 - Rescorla-Wagner
- Learning via attention induced by prediction errors
 - Pearce-Hall; Mackintosh; Kruschke
- High-level reasoning processes
 - De Houwer, Lovibond

ERP and attention



- Hillyard et al. (1973) ... Luck *et al.* (2000)

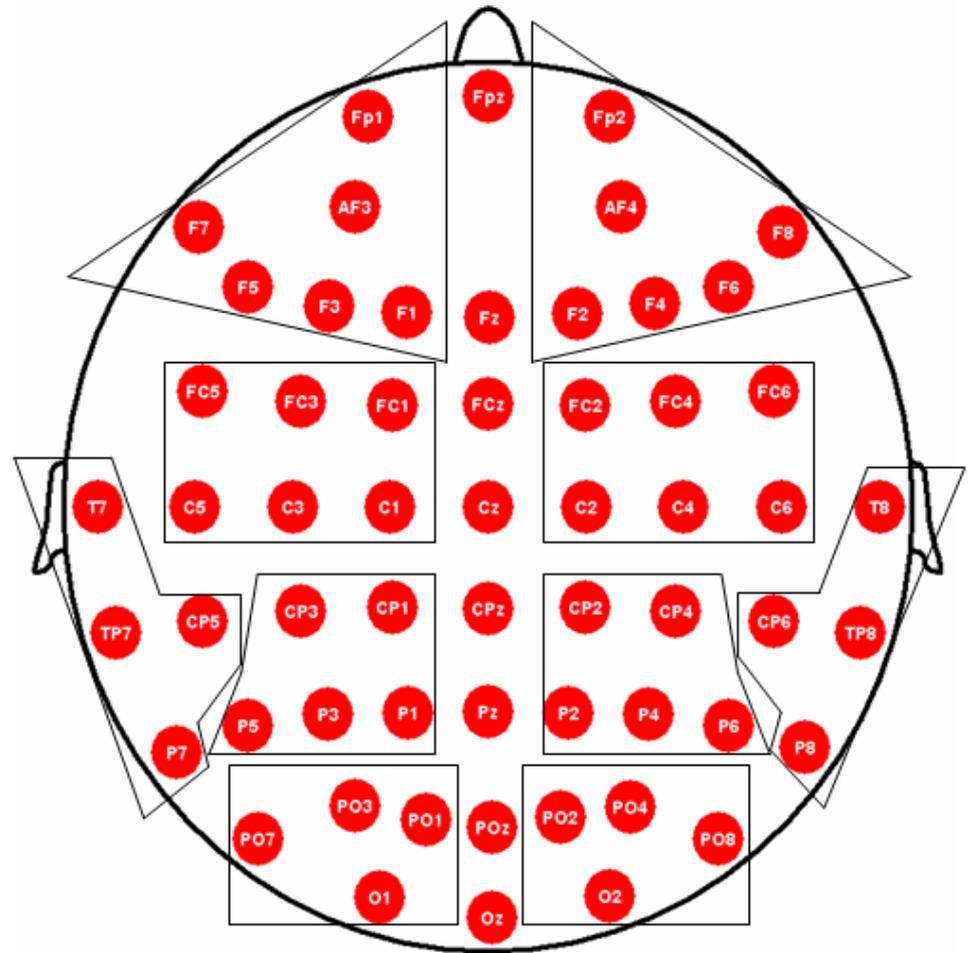
Experimental design

Phase 1	Phase 2	Phase 3
A+	AX+	X: “No data”
B-	BY+	Y: “No data”
I-	IJ-	A+, B-, AX+, BY+
(192)	(144)	(288)

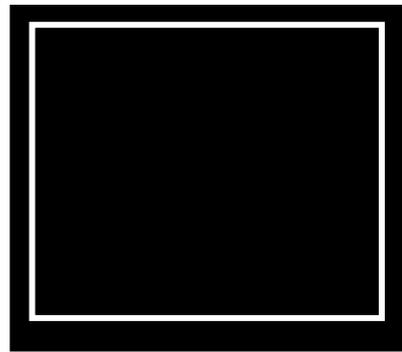
- Each letter represents 4 icons

Prediction

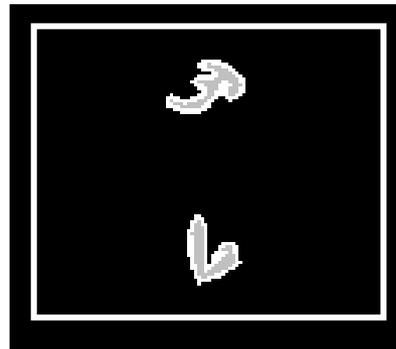
- Larger N1 for Y than for X
- High-density EEG array allows cortical localisation.



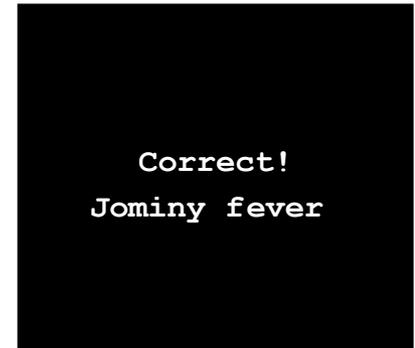
Trial structure



1 second



RESPONSE



1.5 seconds

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

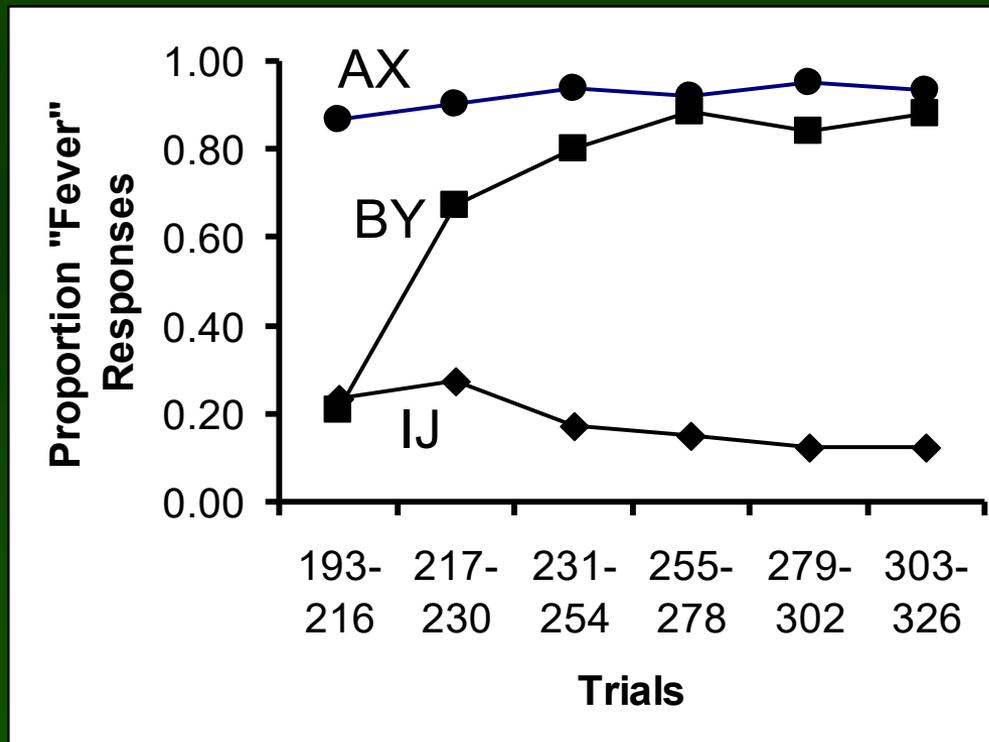
Behavioural results

Phase 1

A – 0.90

B – 0.03

I – 0.03



Phase 3

X – 0.45

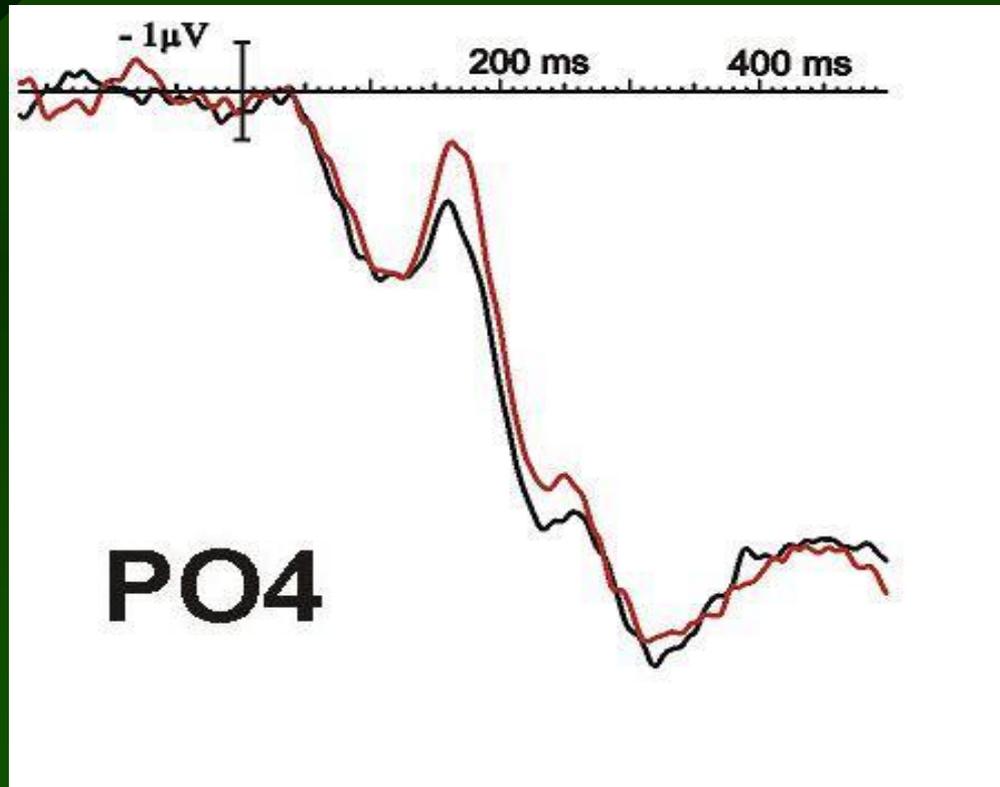
(807ms)

Y – 0.72

(767ms)

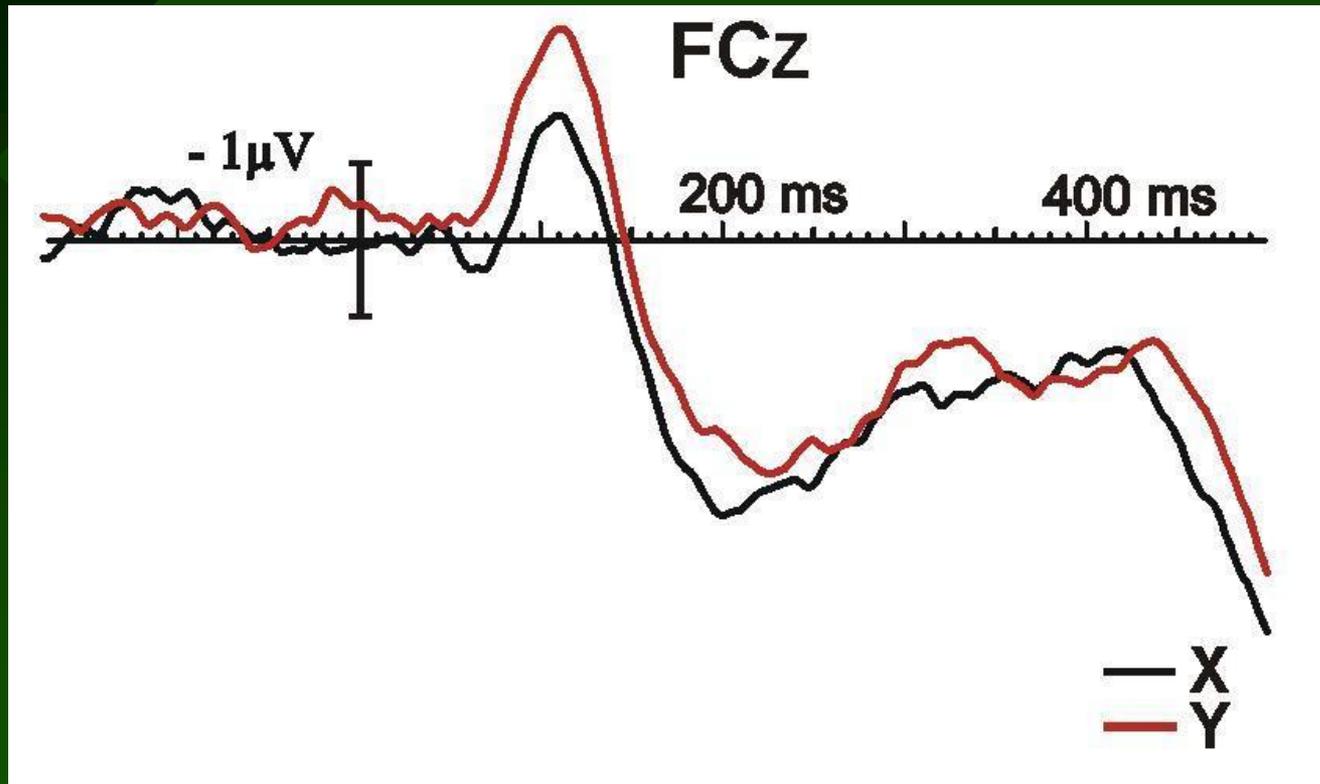
- Other phase 3 trial types:
A:0.96; AX: 0.98; BY: 0.91; B: 0.18

Predicted N1 difference



- Posterior scalp regions

Earlier AN1 difference



- Anterio-central scalp regions

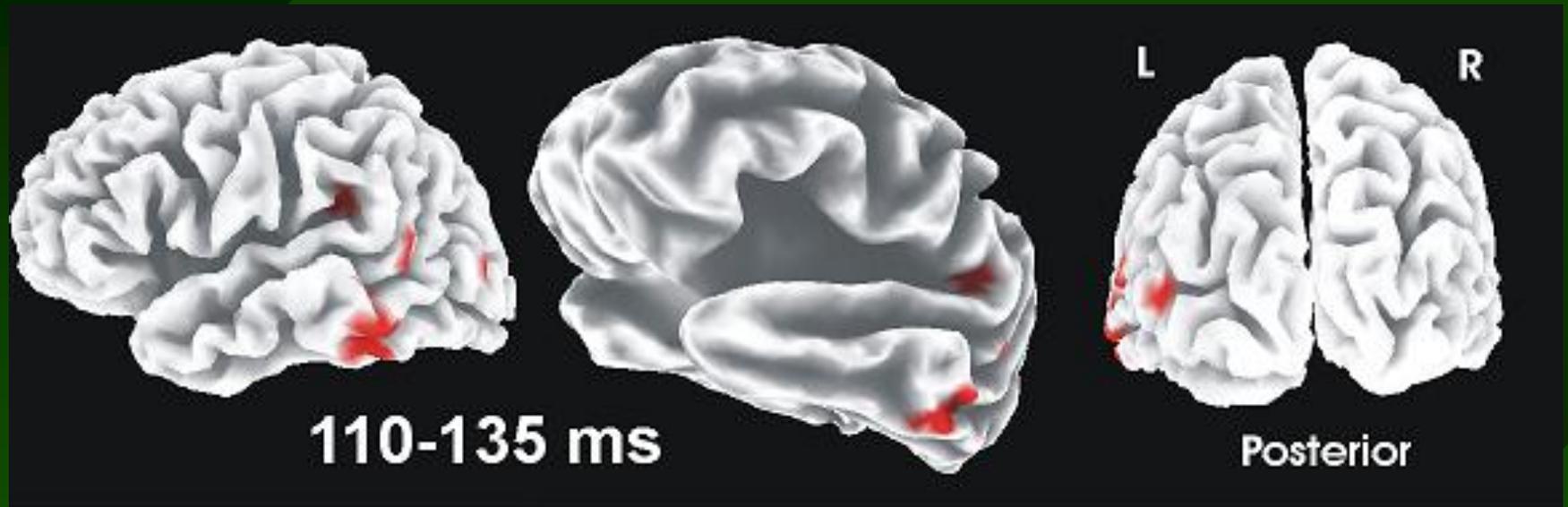
Cortical localisation

- **LOw-Resolution Electromagnetic Tomography Analysis**
 - “LORETA”
 - Computes 3D intracerebral current density
 - Solves the “inverse problem” through a smoothness assumption
 - Extensively validated
 - Computations restricted to cortical gray matter and hippocampi
 - Spatial resolution: 7mm

Localisation predictions

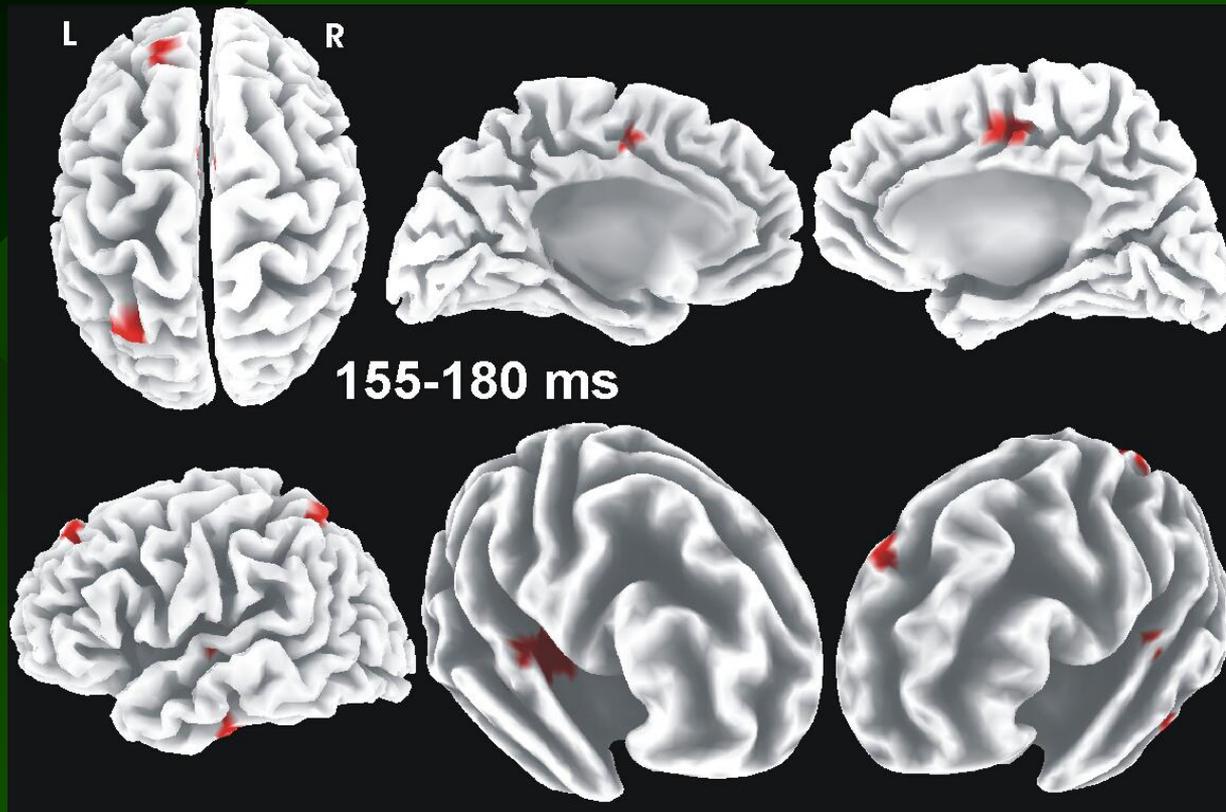
- AN1: Early attentional differentiation in perceptual identification areas
 - Inferior occipital and temporal cortices
- N1: Visual attention networks
 - Posterior parietal
 - Frontal eye fields
 - Supplementary eye fields
 - Anterior cingulate

AN1 time window



- Occipital
- Inferior temporal
- Posterior insula

N1 time window



- **Posterior parietal**
- **Posterior region of anterior cingulate**
- **Supplementary eye field**
- **Temporal (more anterior, inferior)**
- **Anterior insula**

Localisation summary

- Early time window
 - Temporal-occipital
 - Endogenous attention shifts (Kim et al. 1999)
- N1 time window
 - Posterior parietal, supplementary eye-fields
 - Selective visual analysis (Nobre et al. 2000)
 - Posterior region of anterior cingulate
 - Attention shifts (Kim et al. 1999)
- Insular activity
 - Attention? (Kim et al. ; Nobre et al)
 - Language processing? (Fylnn et al, 1999)

Conclusion

- Subjects distinguish very rapidly (135ms) between events that differ in their previous involvement in prediction errors.
- Nature and localisation of ERP differences implicates attentional processes.
- Human associative learning not entirely the product of high-level reasoning processes.