

A Neural System For Human Learning

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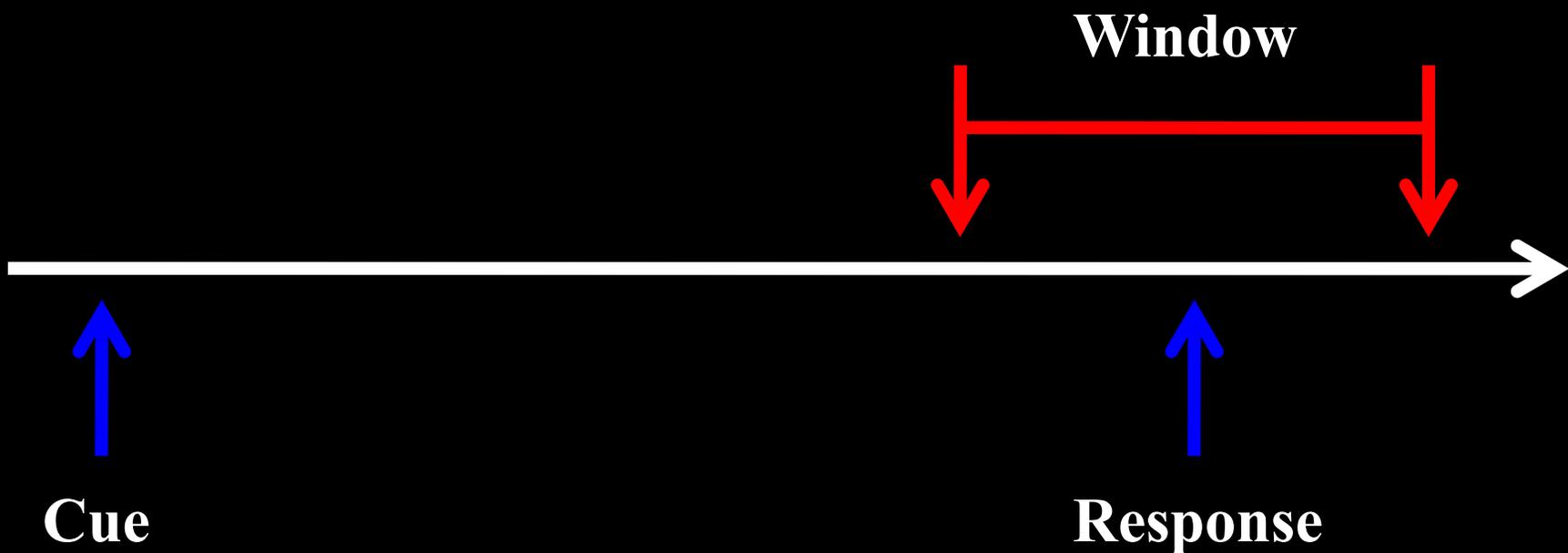
Are the neural signals that we measure in response to feedback simply sensitive to rewards and punishments or are they actually indicative and representative of a neural system that underlies human learning?

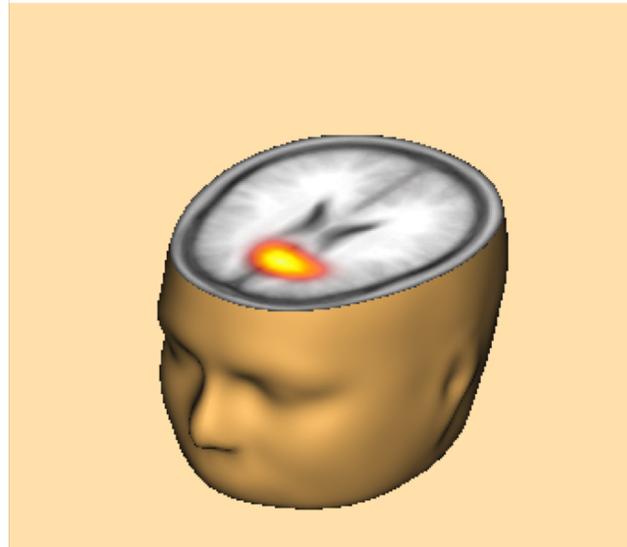
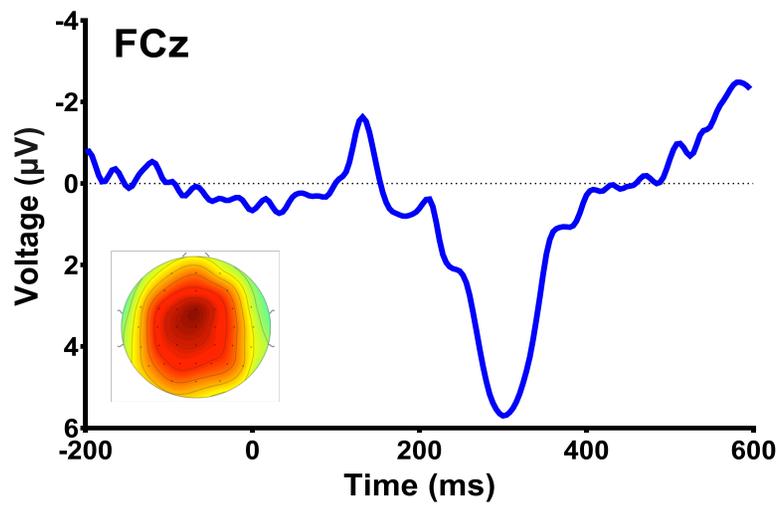
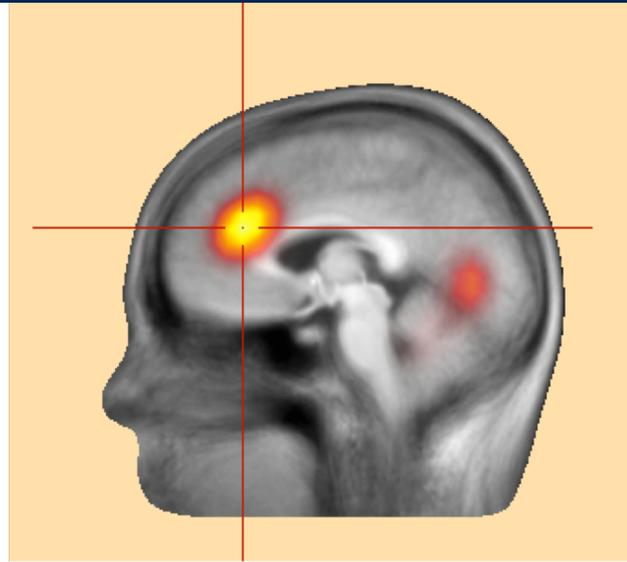
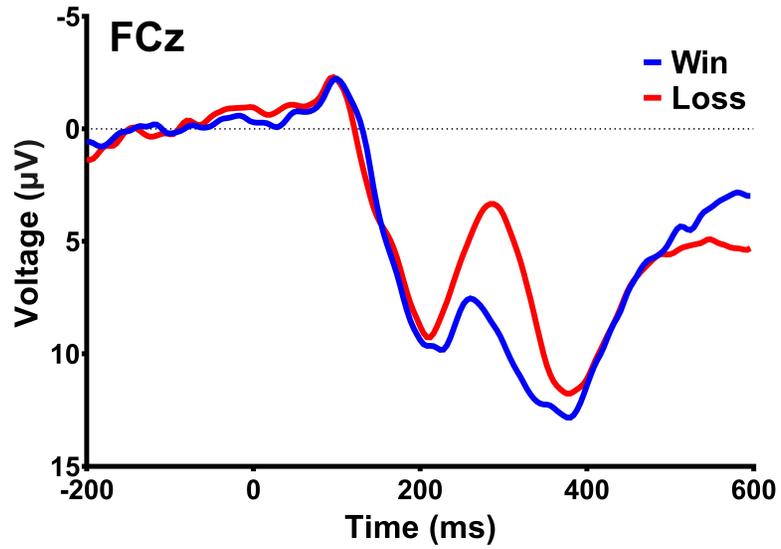
Part I. The Reward Positivity

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Correct!

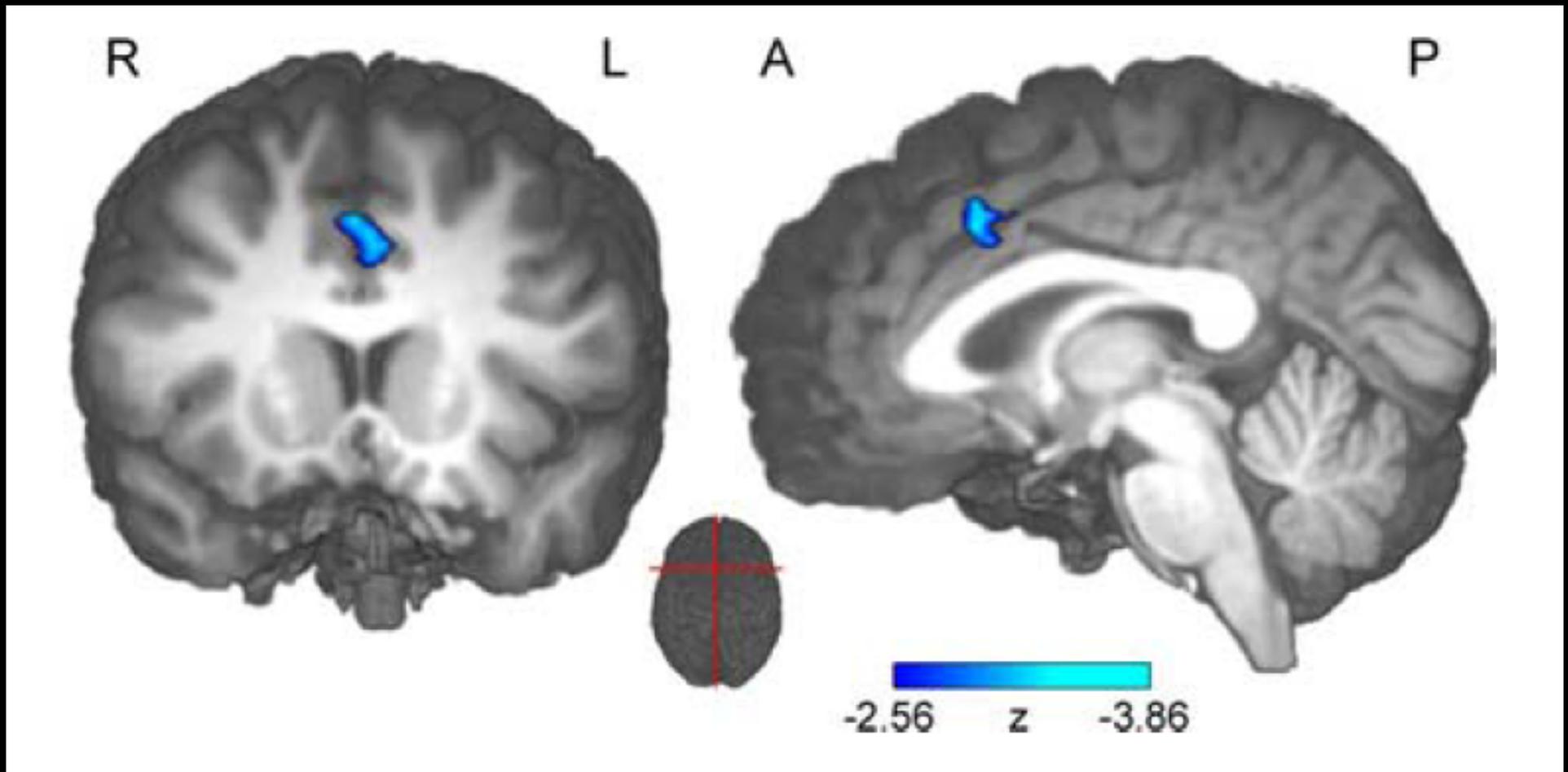






- Hands
 - Feet
 - Visual
 - Auditory
 - Somatosensory
- } error responses
- } error feedback

Miltner et al., 1997; Holroyd et al., 1998



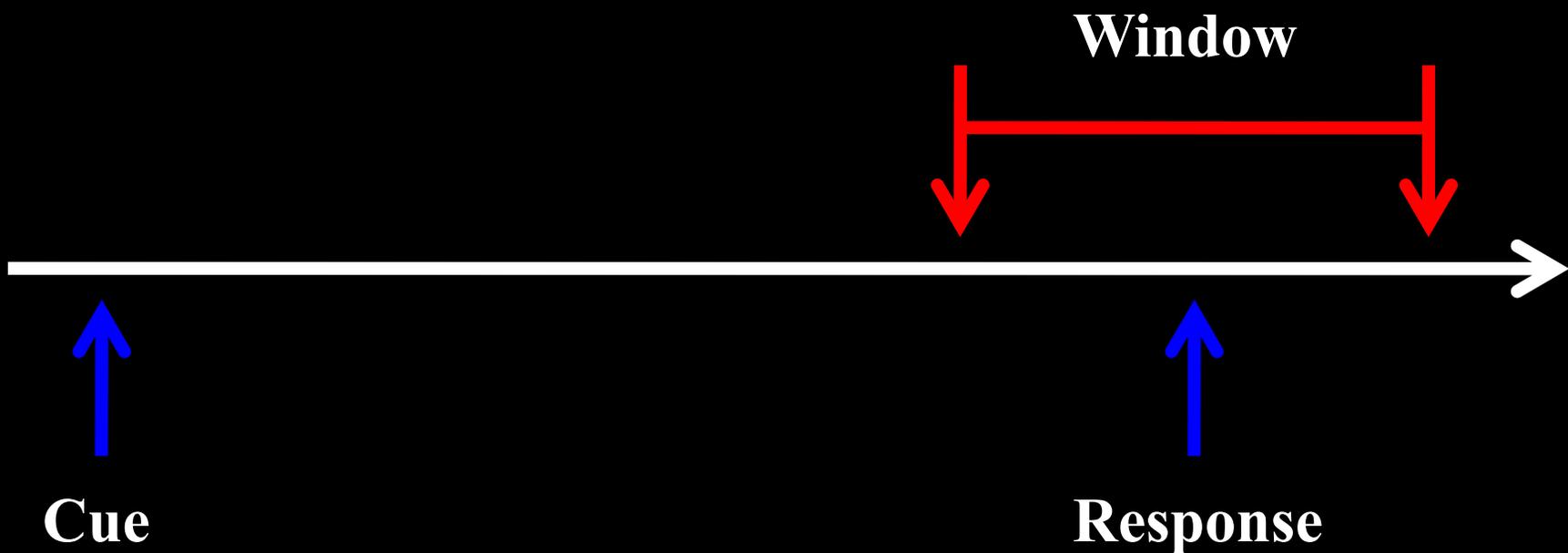
Anterior Cingulate Cortex is the probable source of the FRN

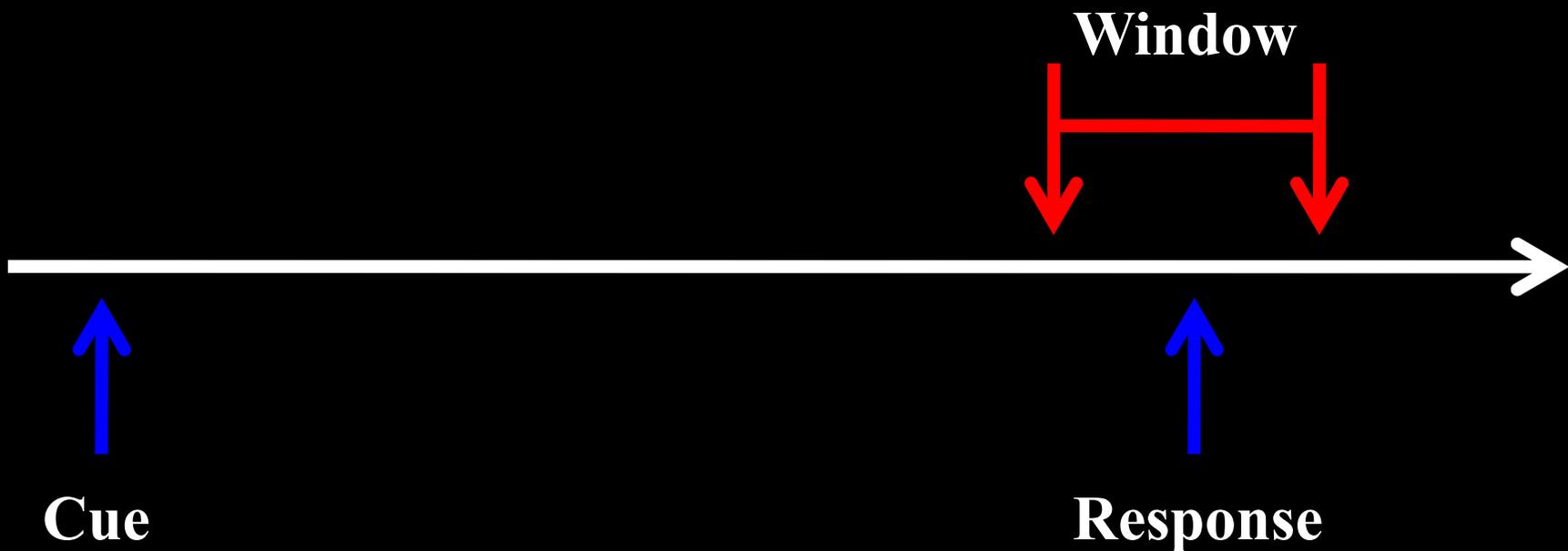
EEG/fMRI: Debener et al., 2005; Holroyd et al., 2004; Hauser et al., 2014

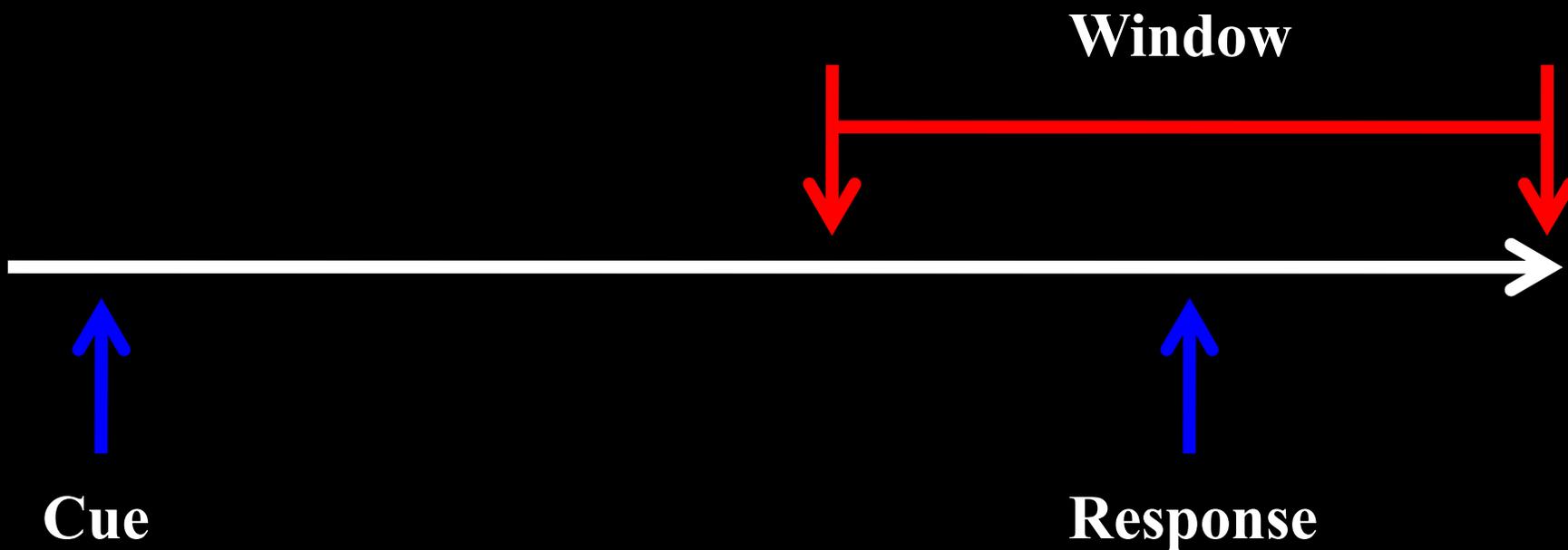
Monkey: Ito et al., 2003; Emeric et al., 2008 Rodent: Warren et al., 2014

Pre-Surgery: Williams et al., 2004

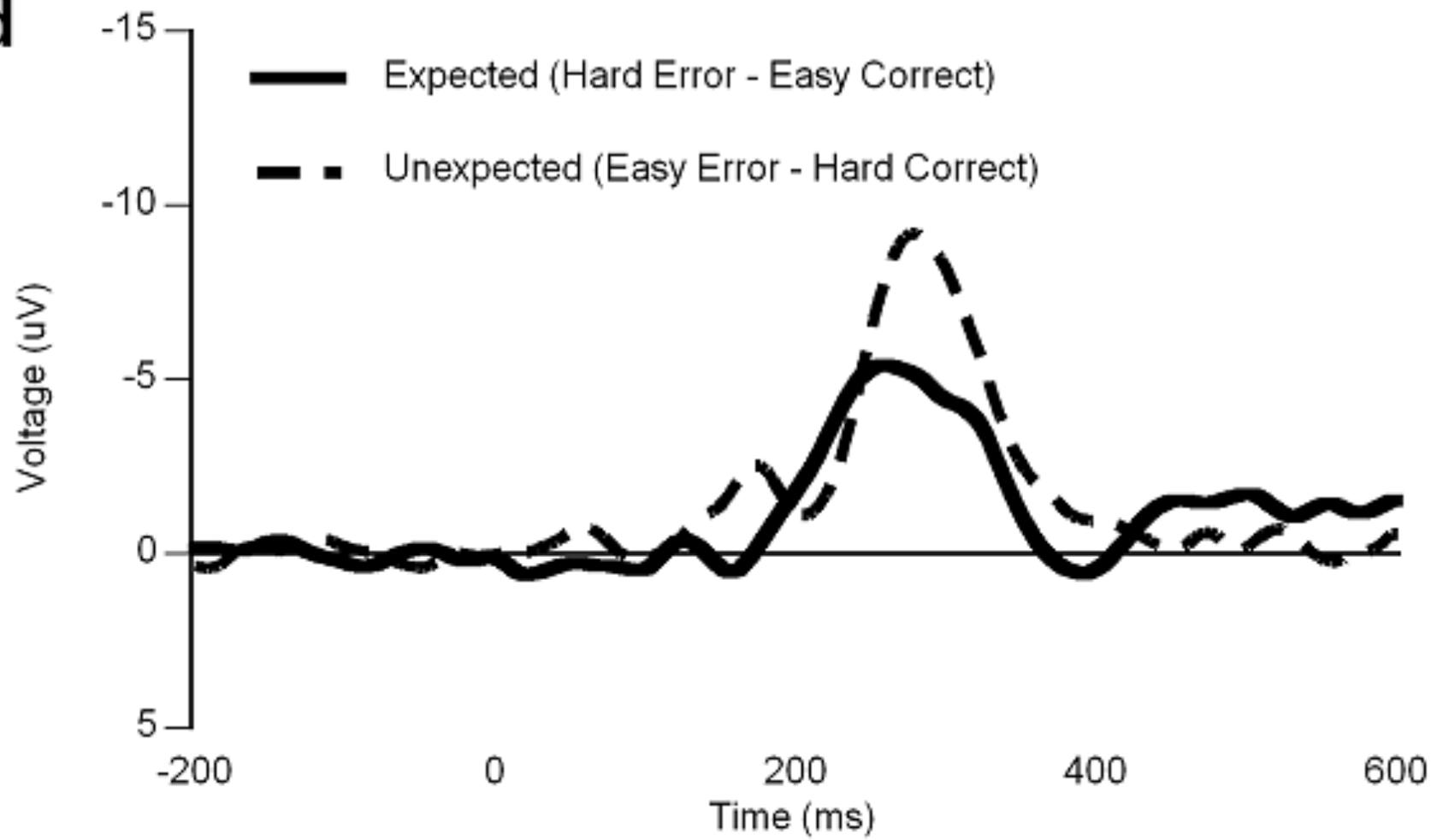
Part II. Theoretical Predictions

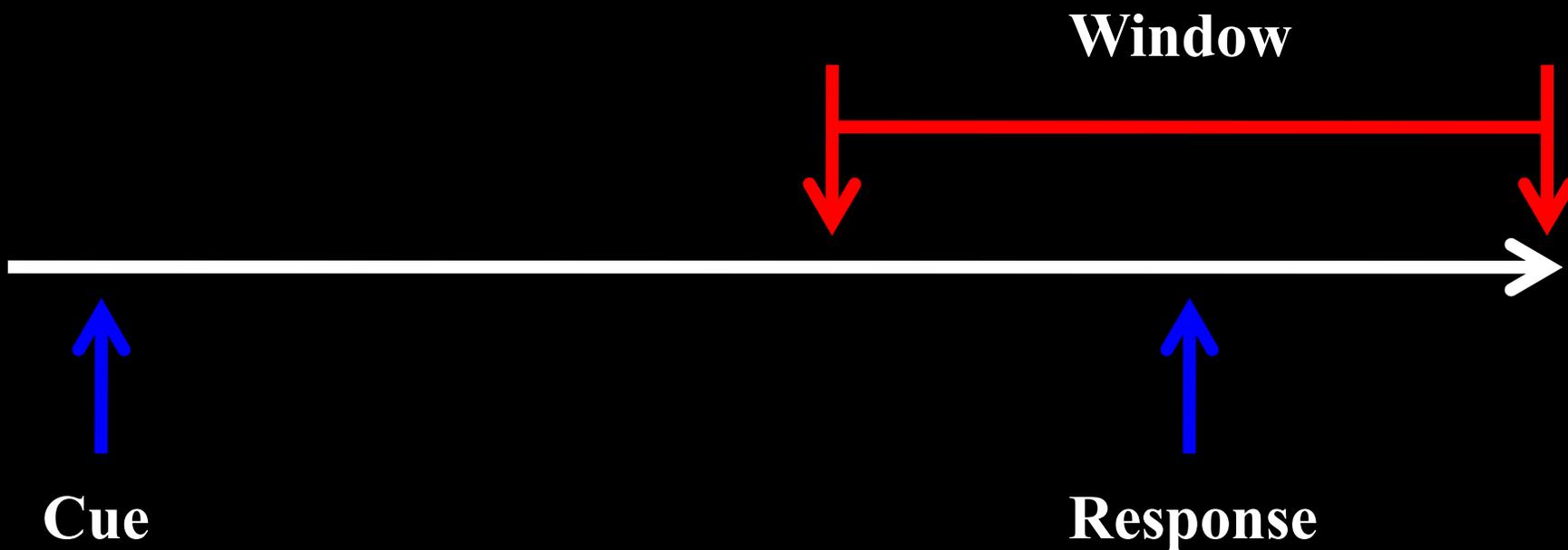




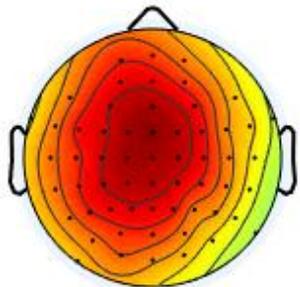


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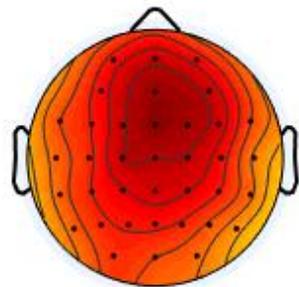




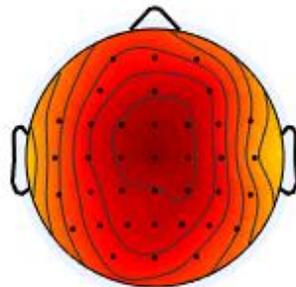
VERY EXPECTED



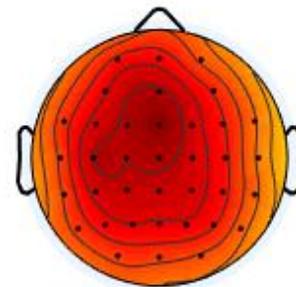
EXPECTED



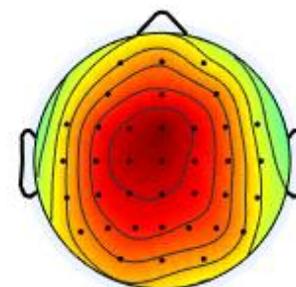
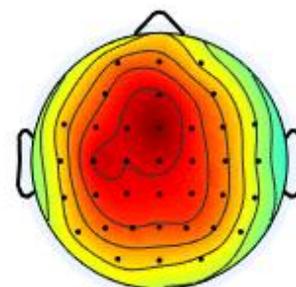
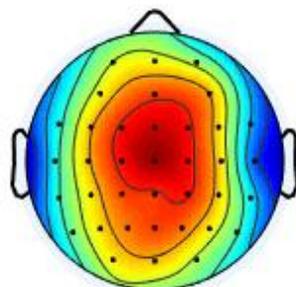
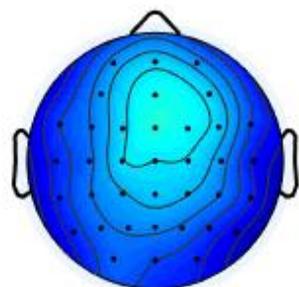
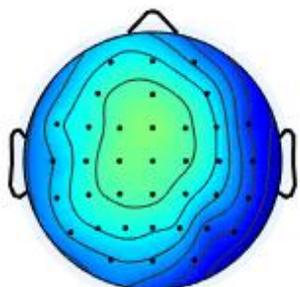
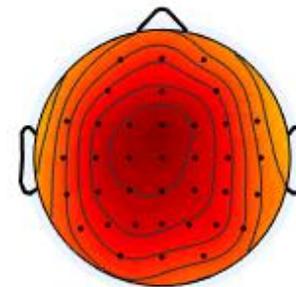
NORMAL

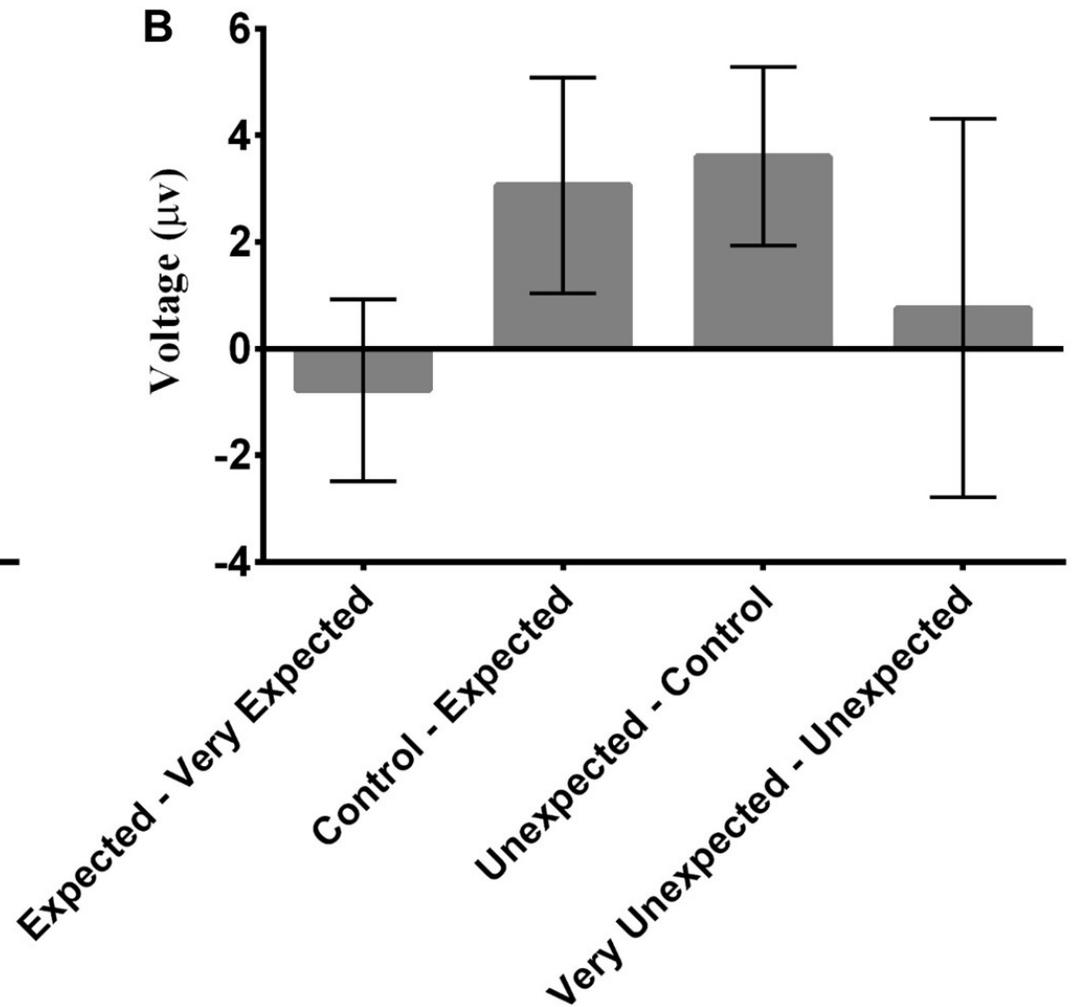
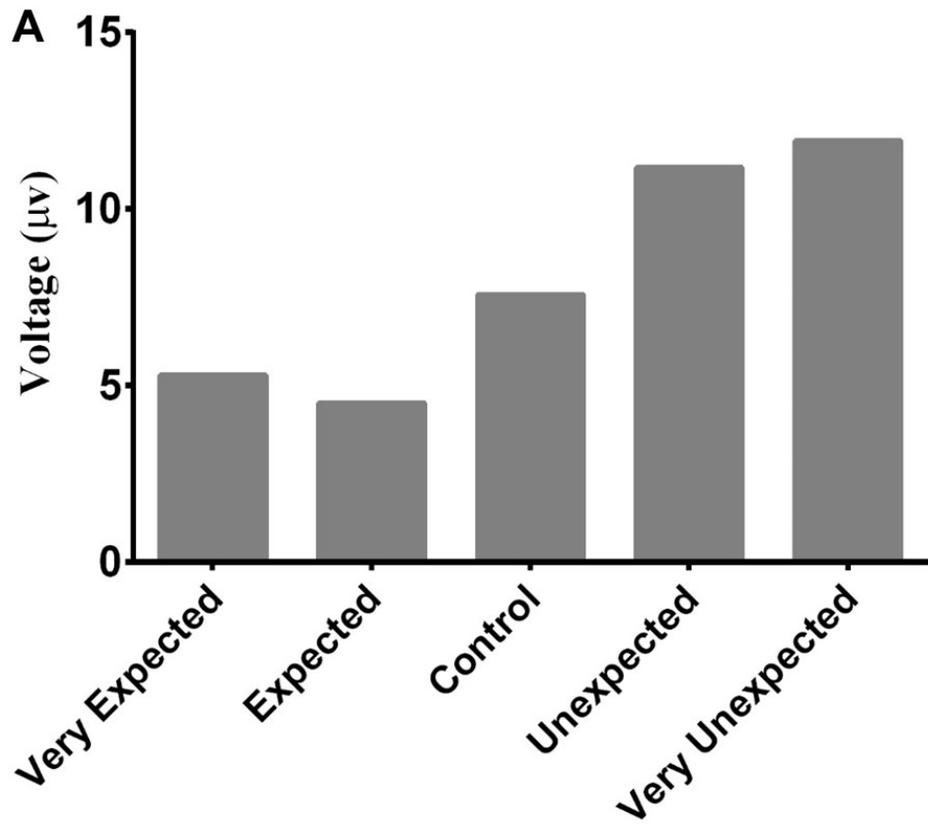


UNEXPECTED



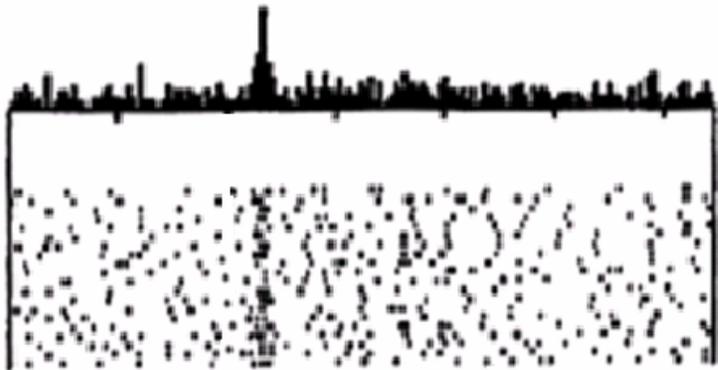
VERY UNEXPECTED





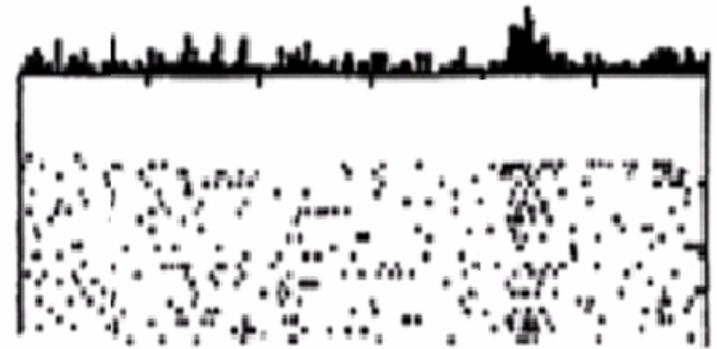
Propagation of Prediction Errors

Cue **Rew**



After Learning

Cue **Rew**



Before Learning

+





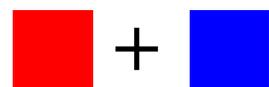
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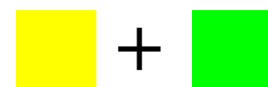
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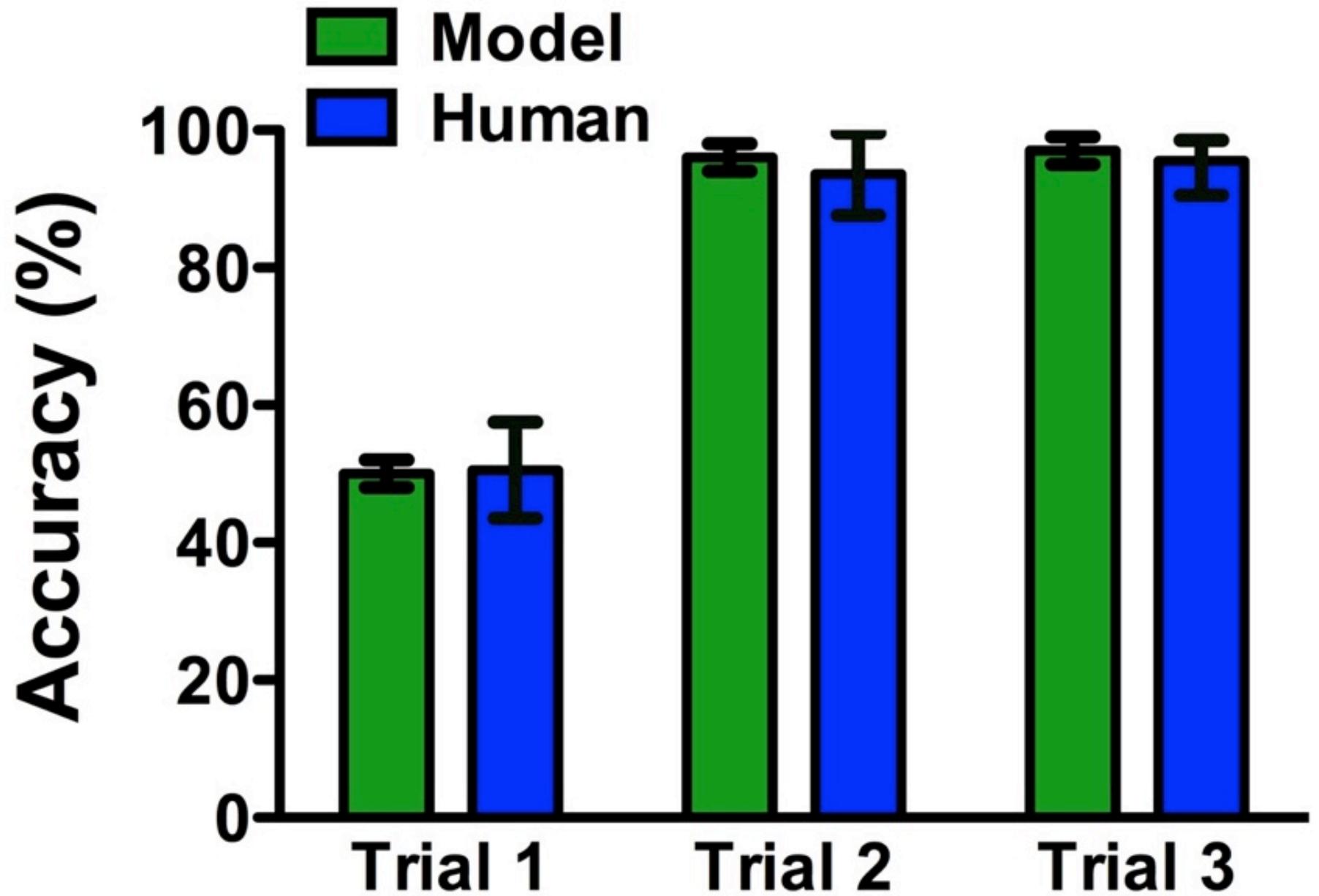


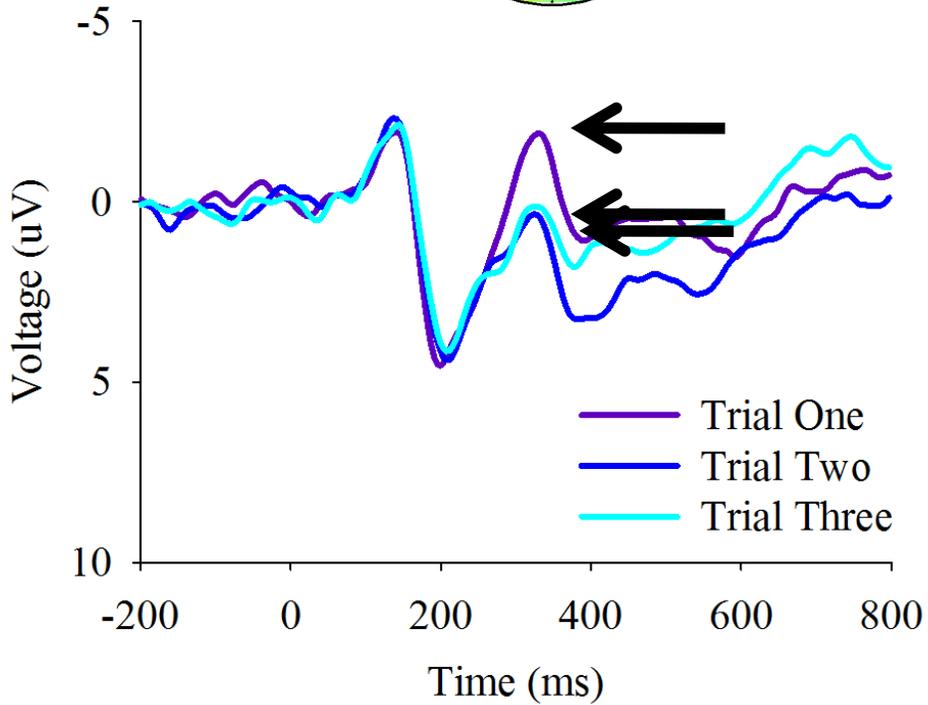
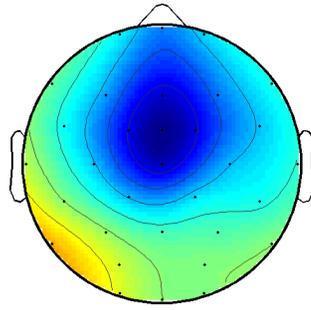
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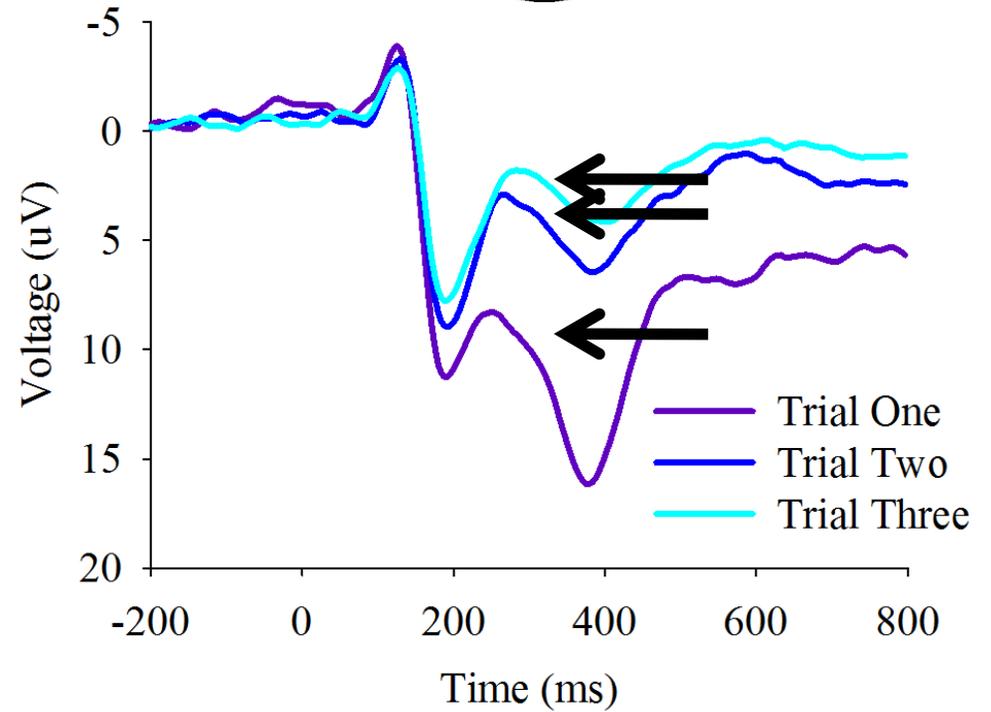
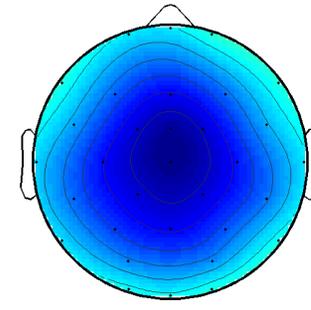
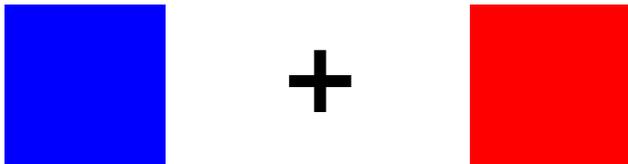
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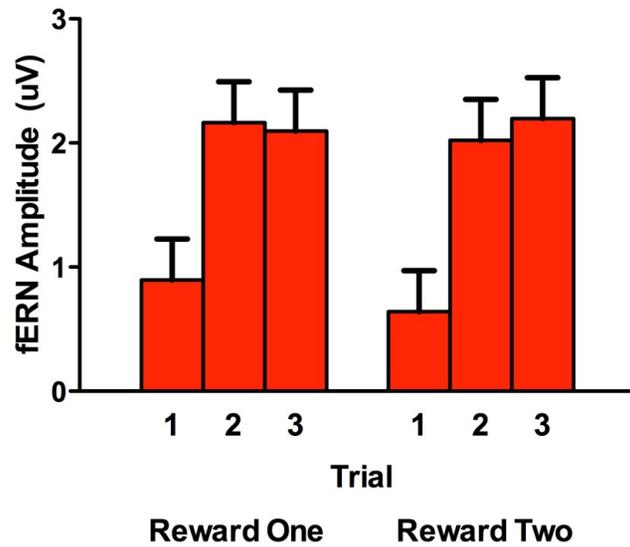
Stimulus Averaged
ERP Waveforms



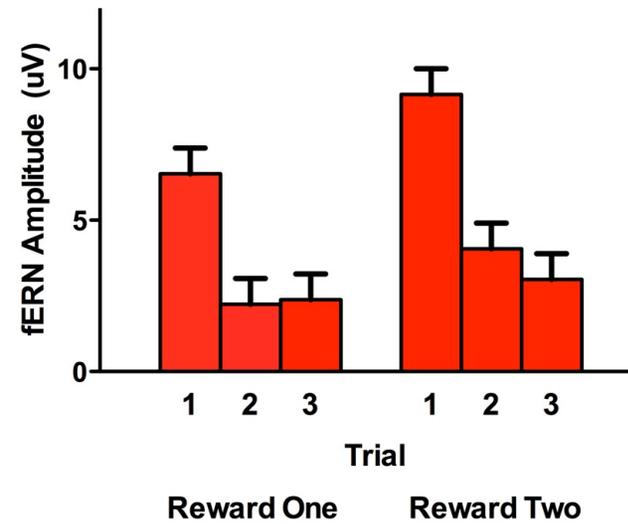
Feedback Averaged
ERP Waveforms



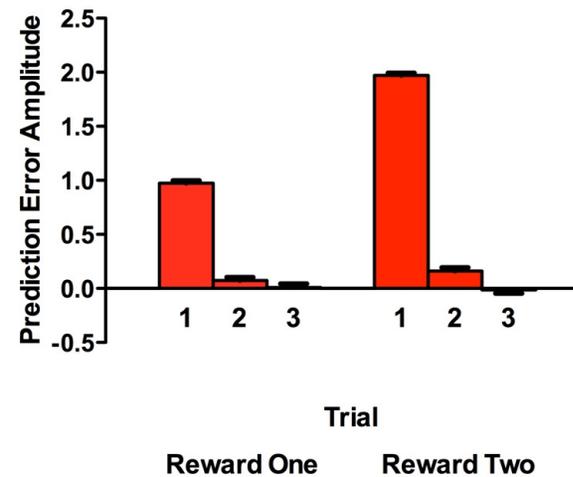
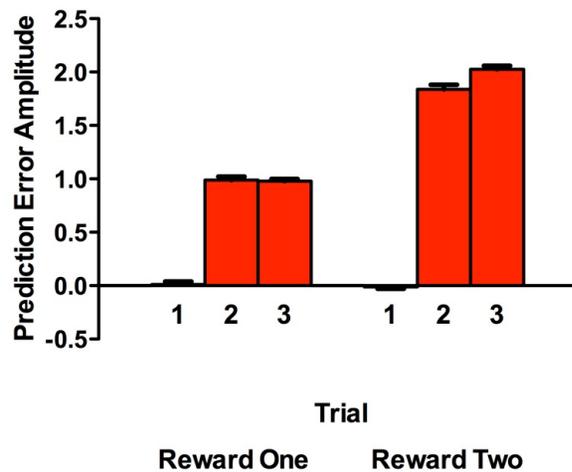
Choice Presentation



Reward Delivery



DATA



MODEL

Part III. Learning Effects

Blobs

+



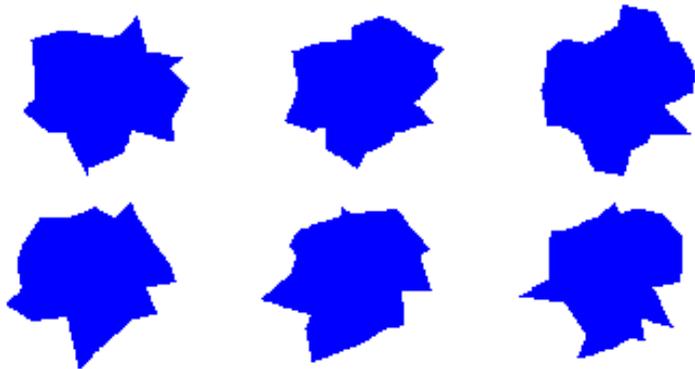


A

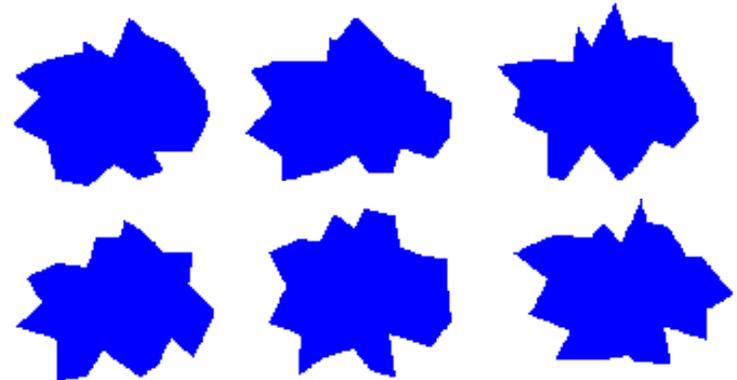
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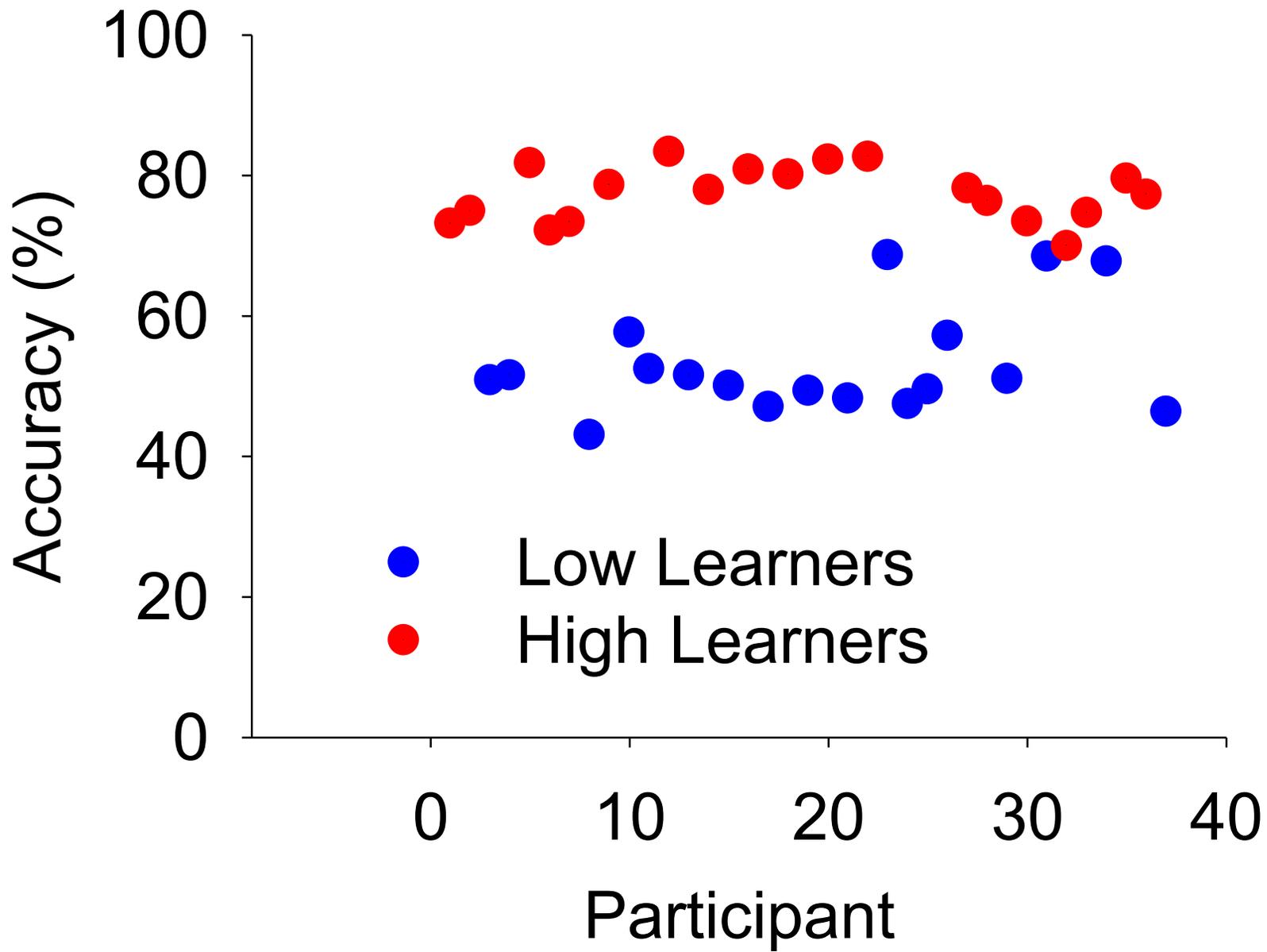
Correct!

A Family Blobs

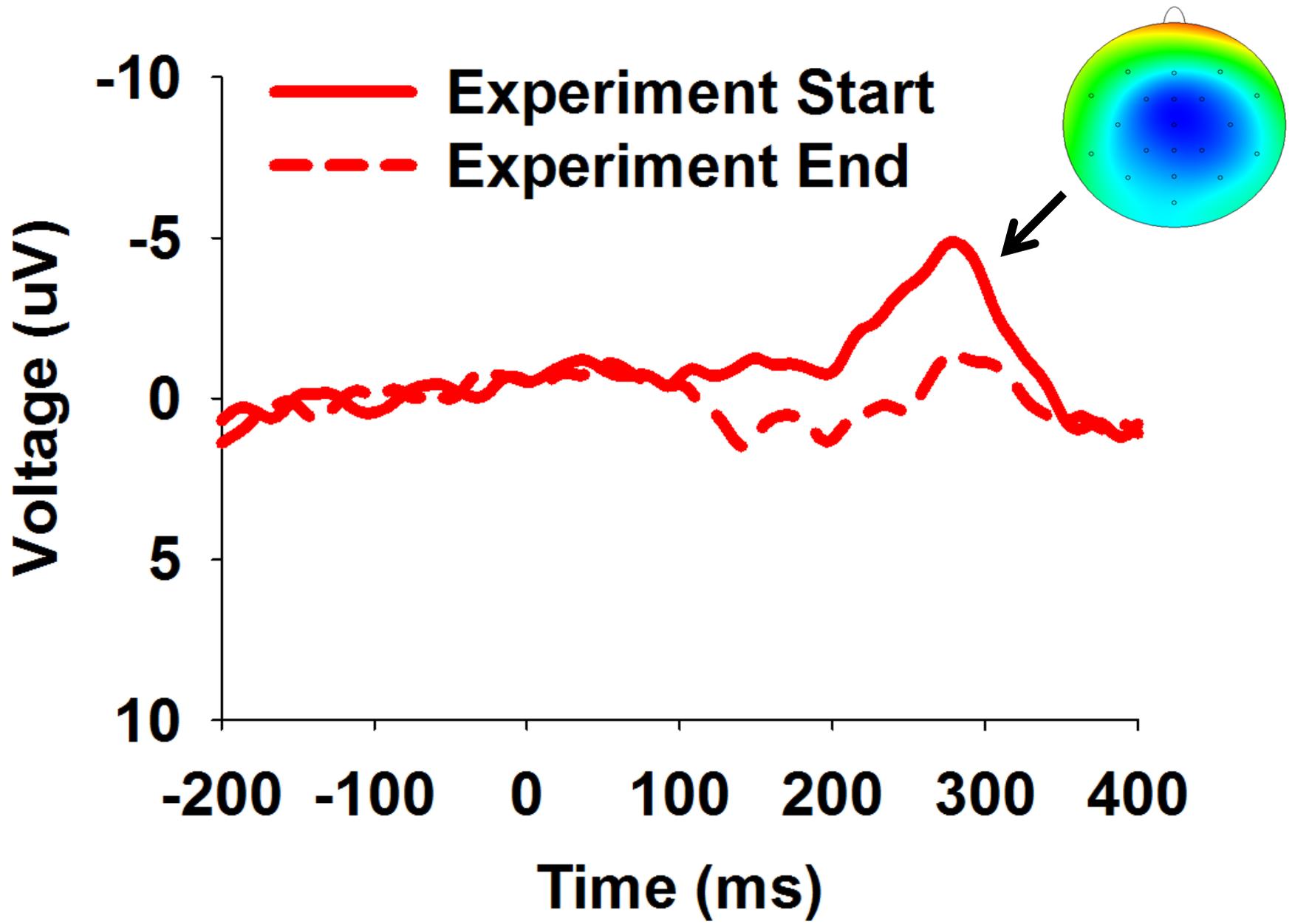


B Family Blobs

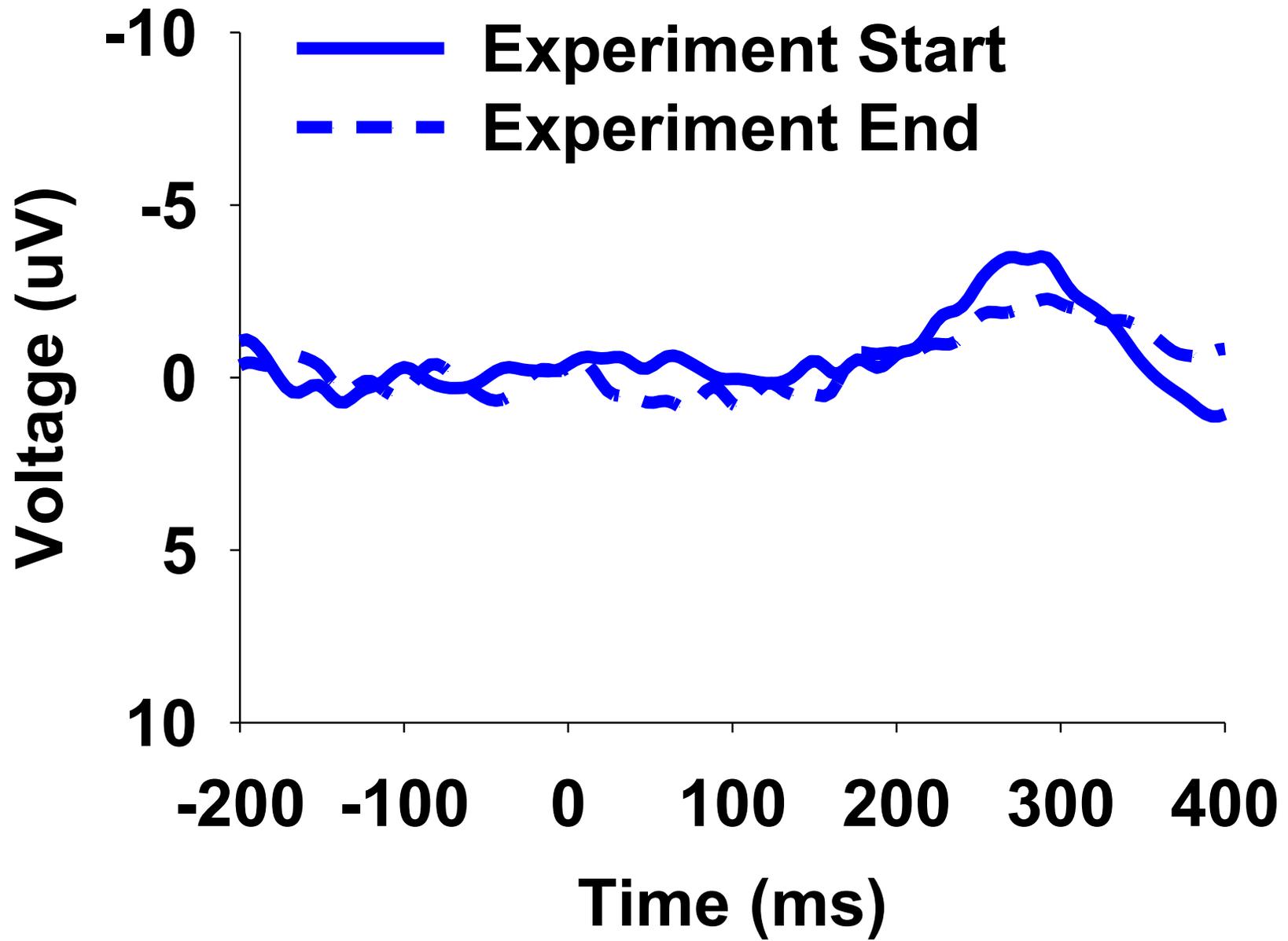




Correct!



High Learners

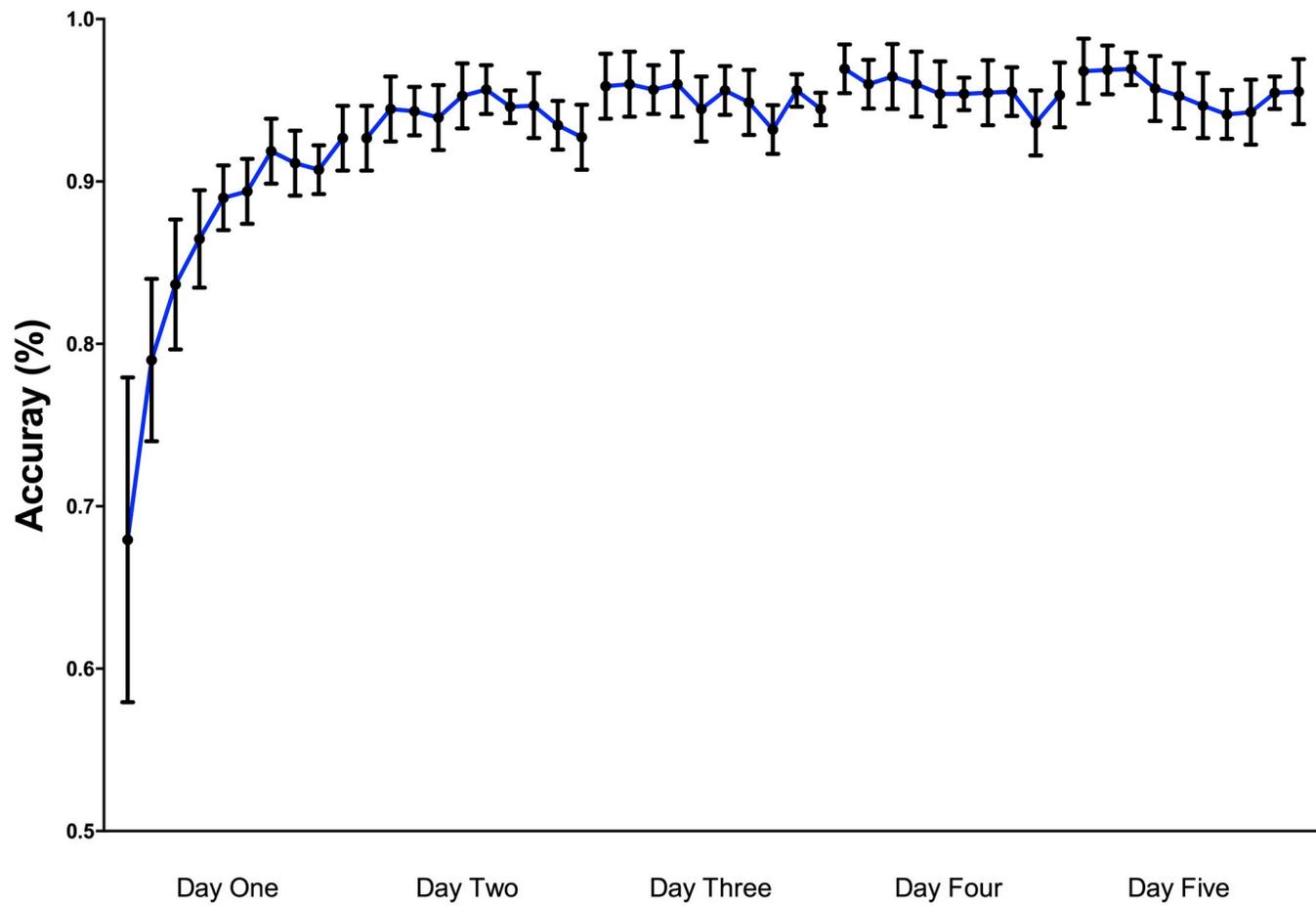


Low Learners

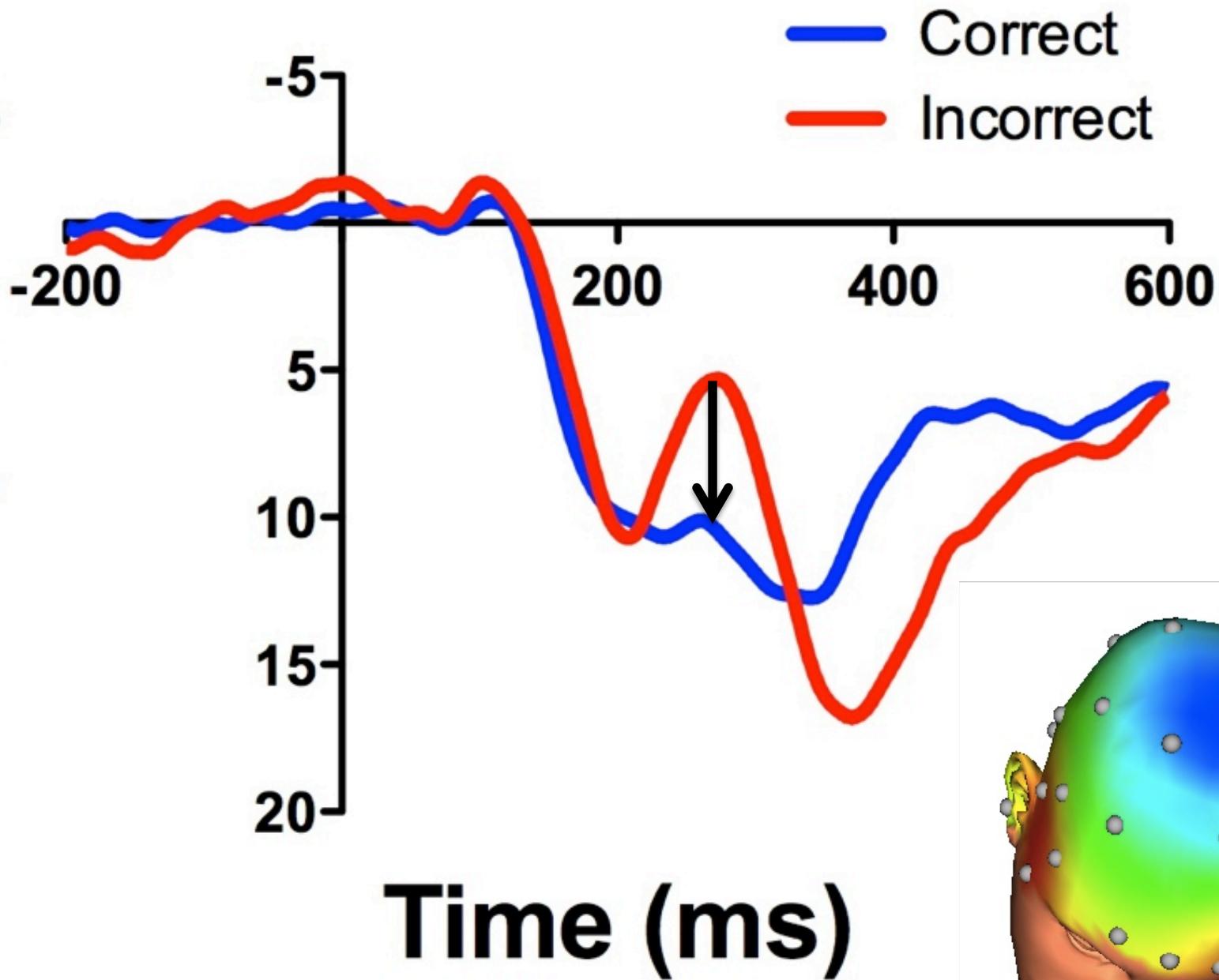
More Blobs

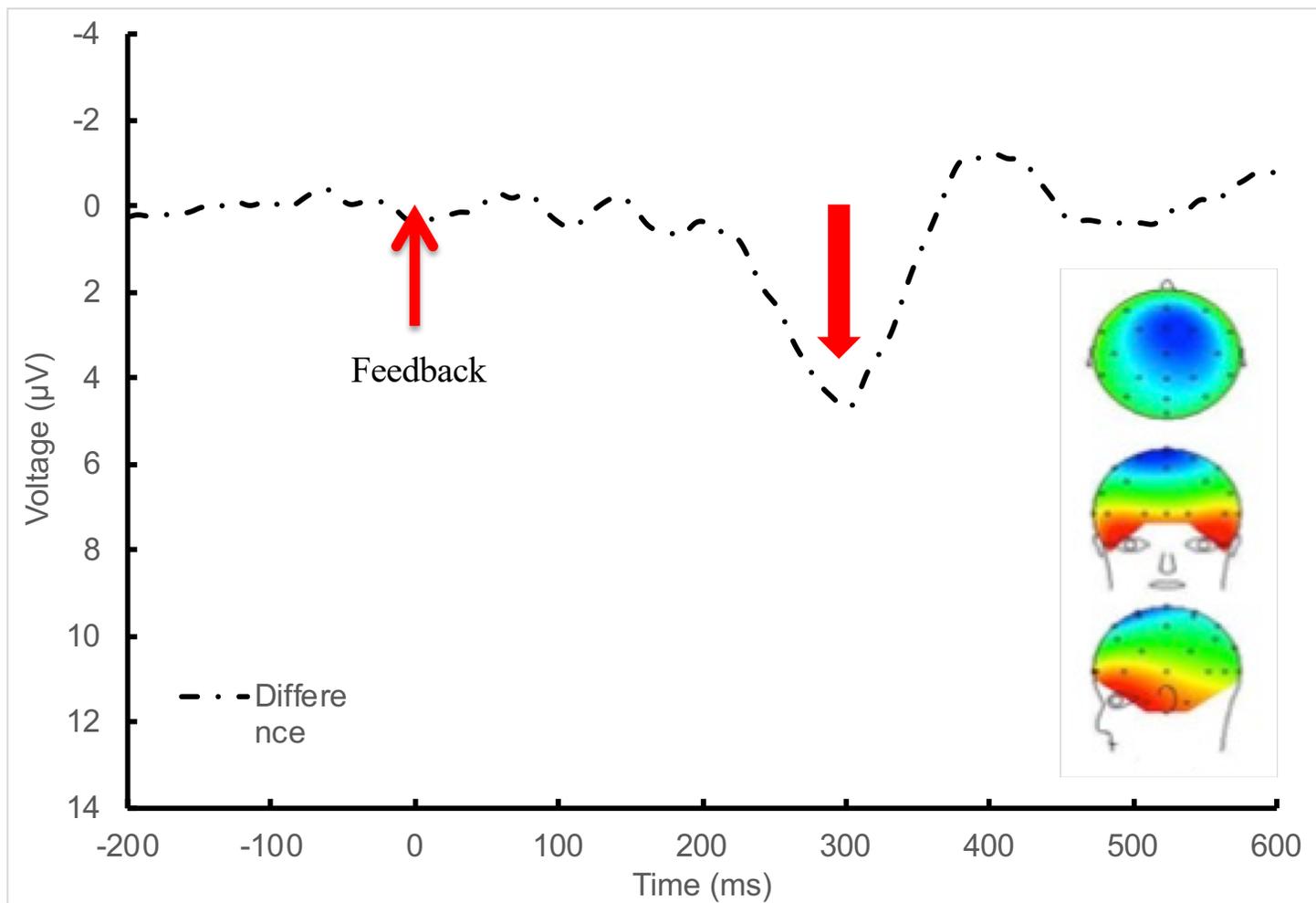


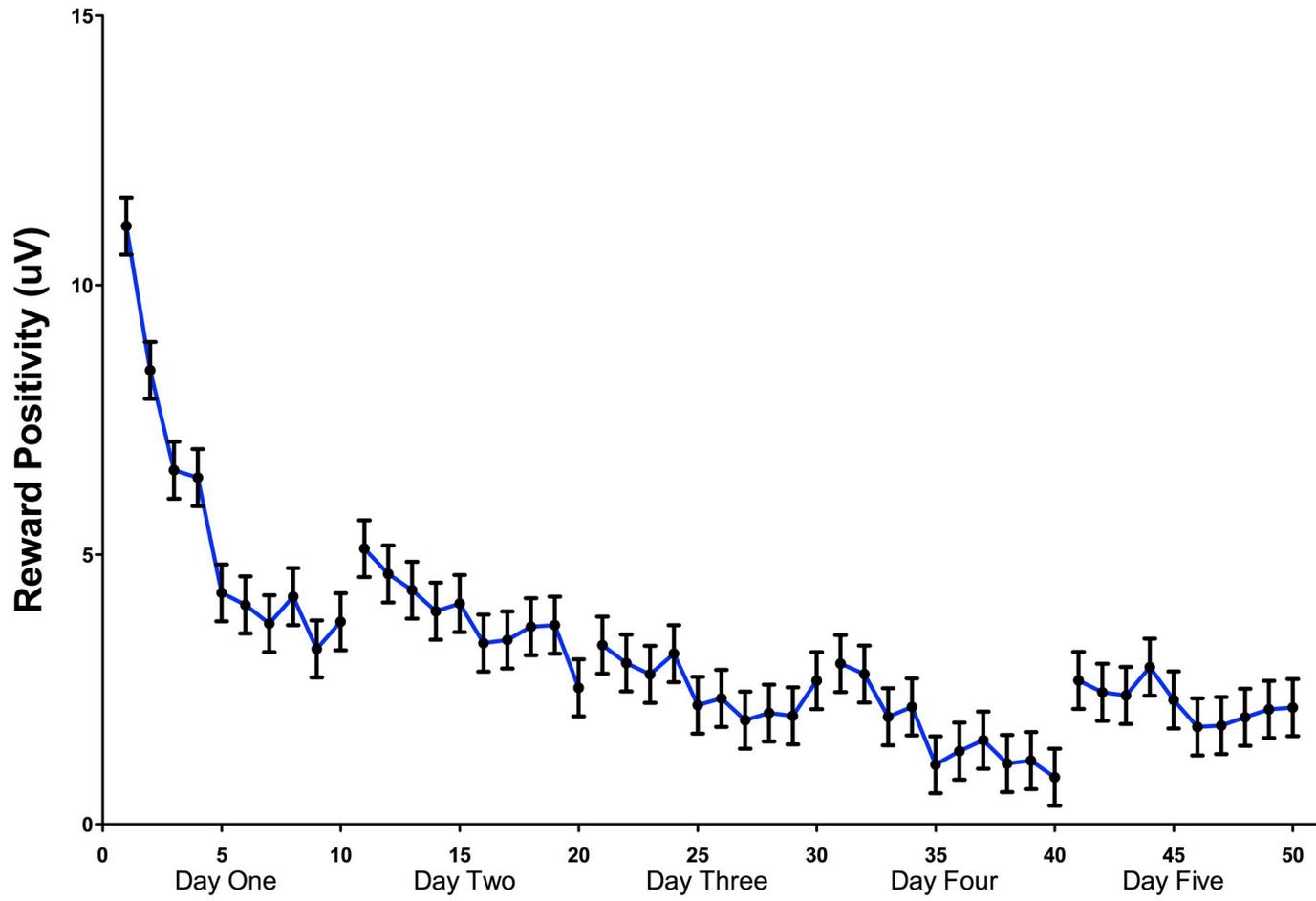
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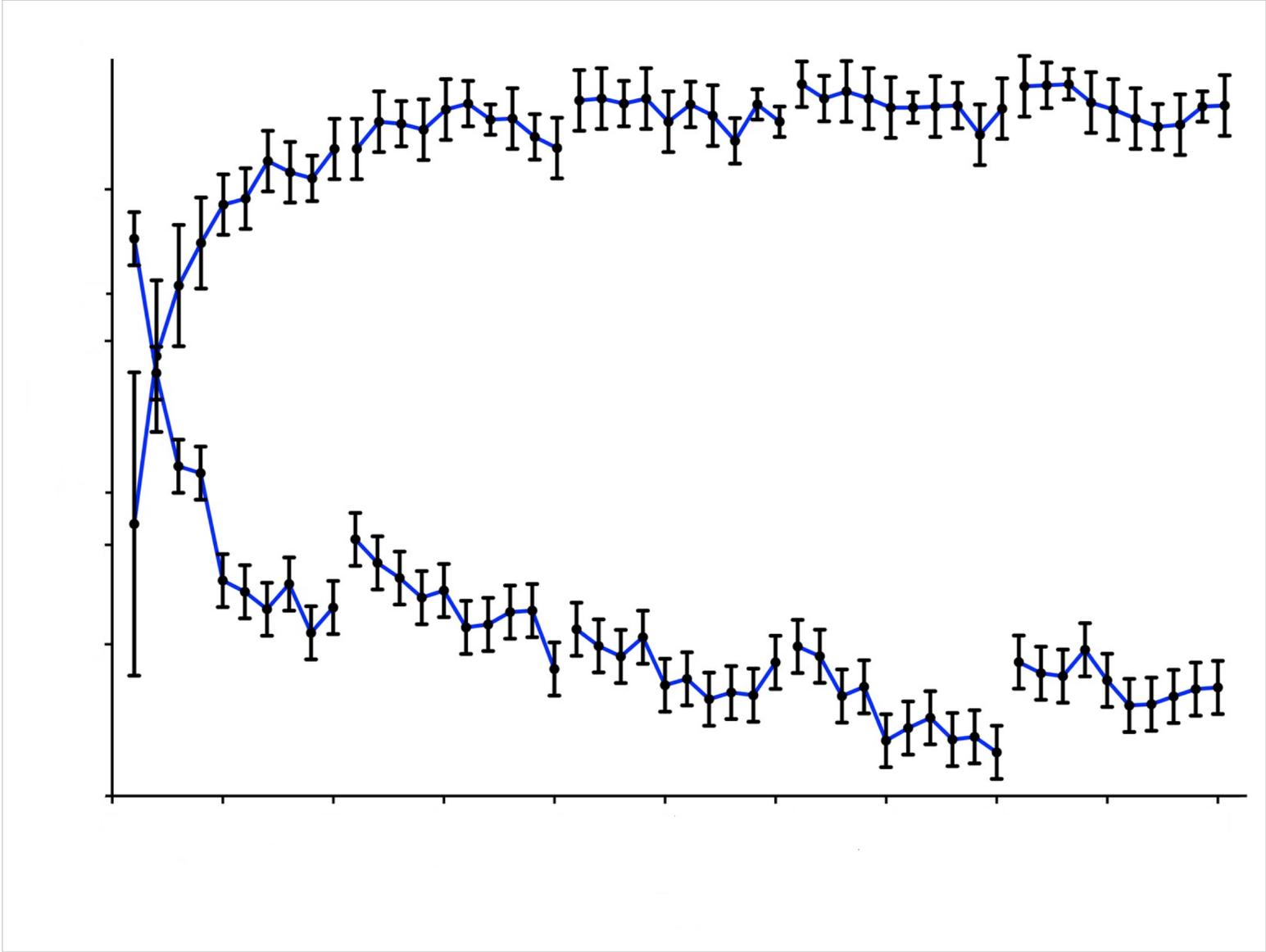


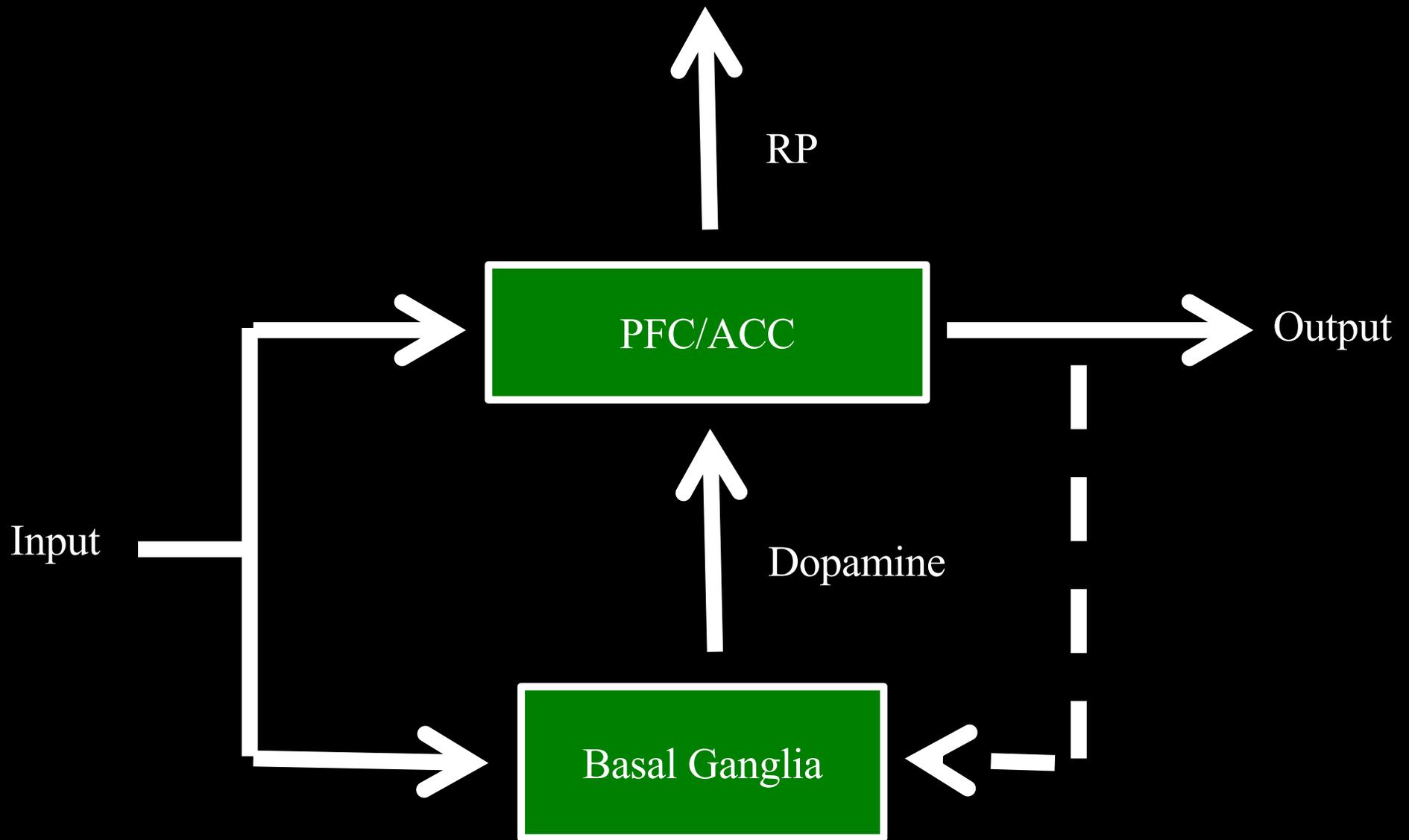
RP Amplitude (μV)











Part IV. Application



A Reinforcement-Based Learning Paradigm Increases Anatomical Learning and Retention—A Neuroeducation Study

Sarah J. Anderson^{1}, Kent G. Hecker^{1,2}, Olave E. Krigolson³ and Heather A. Jamniczky⁴*

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²Department of Veterinary Clinical Diagnostic Services, Faculty of Veterinary Medicine, University of Calgary, Calgary, AB,

Canada, ³Centre for Biomedical Research, University of Victoria, Victoria, BC, Canada, ⁴Department of Cell Biology and

Anatomy, Cumming School of Medicine, University of Calgary, Calgary, AB, Canada



Points: 643

- a. Prefrontal Cortex
- b. Anterior Cingulate Cortex
- c. Corpus Callosum
- d. Supplementary Motor Area

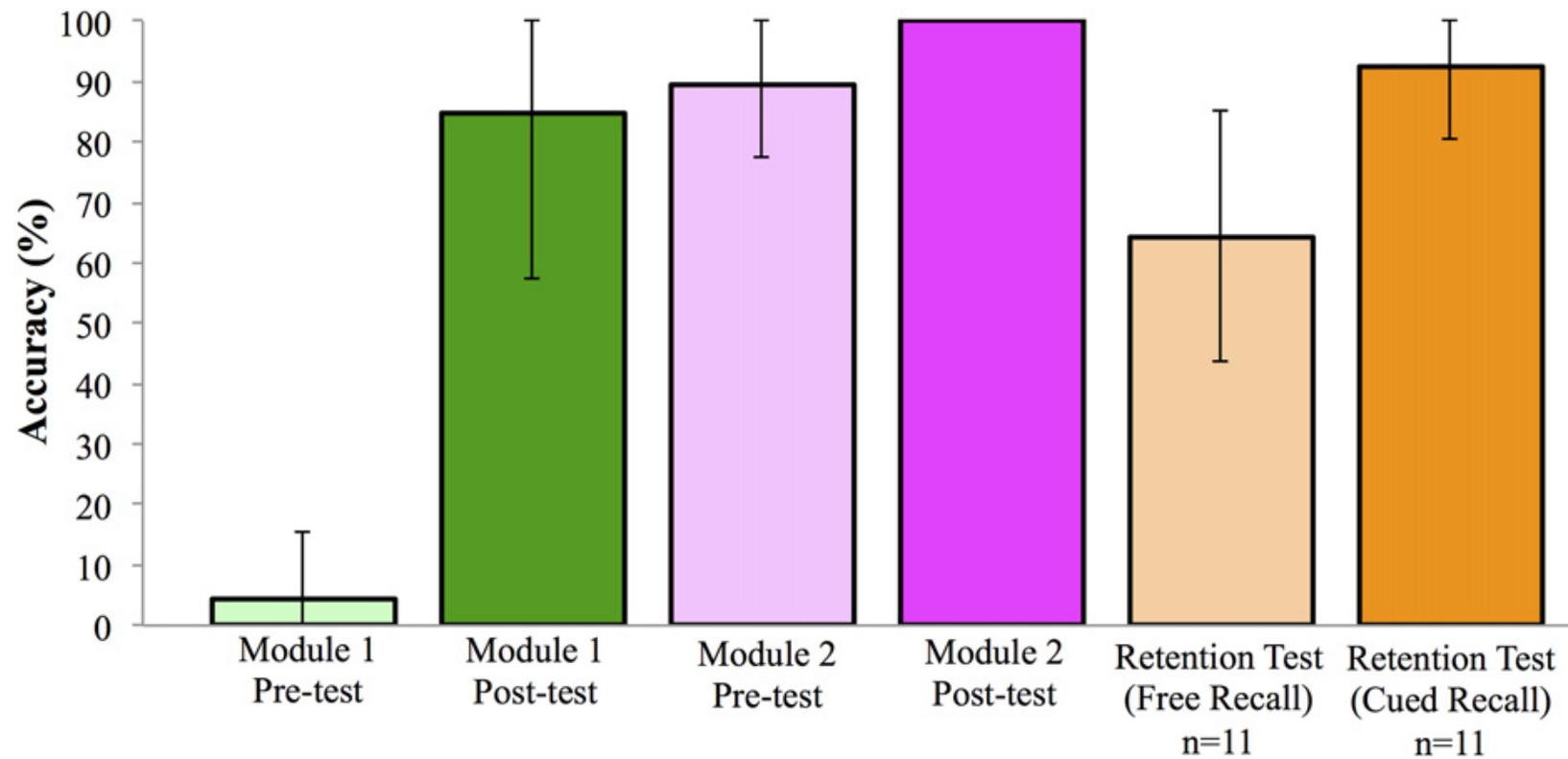
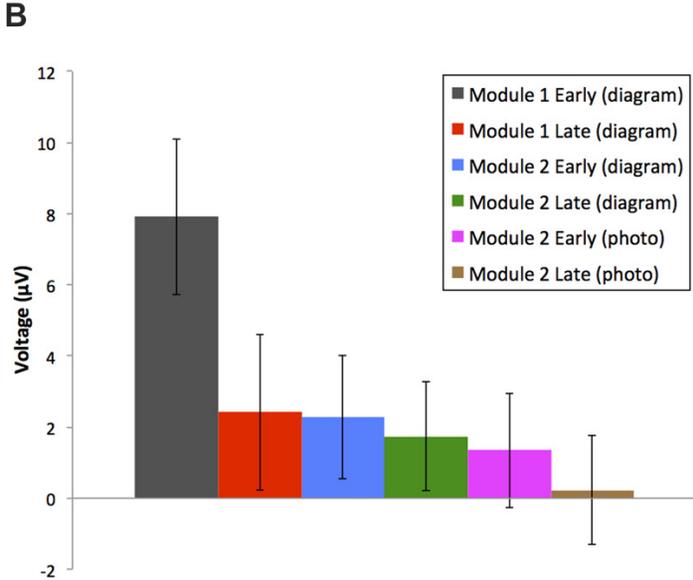
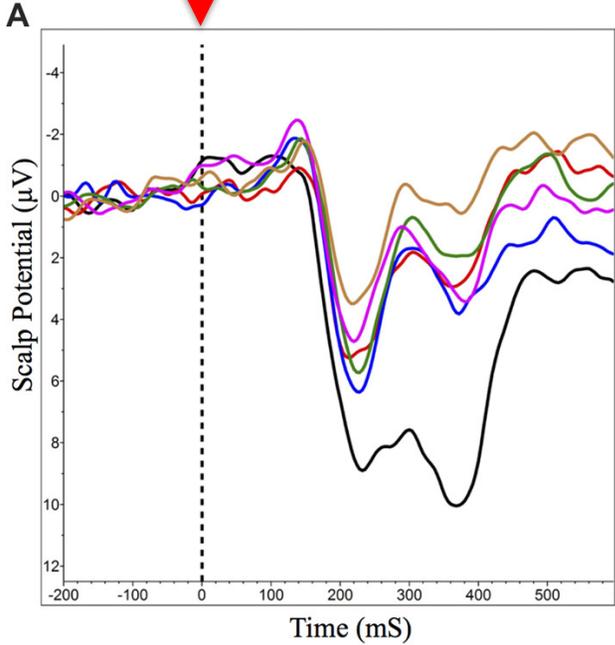


FIGURE 3 | Performance on knowledge test across learning events (\pm SD). Note: all participants achieved 100% in the Module 2 Post-test.

Correct!

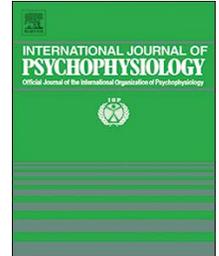




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The application of reward learning in the real world: Changes in the reward positivity amplitude reflect learning in a medical education context[☆]

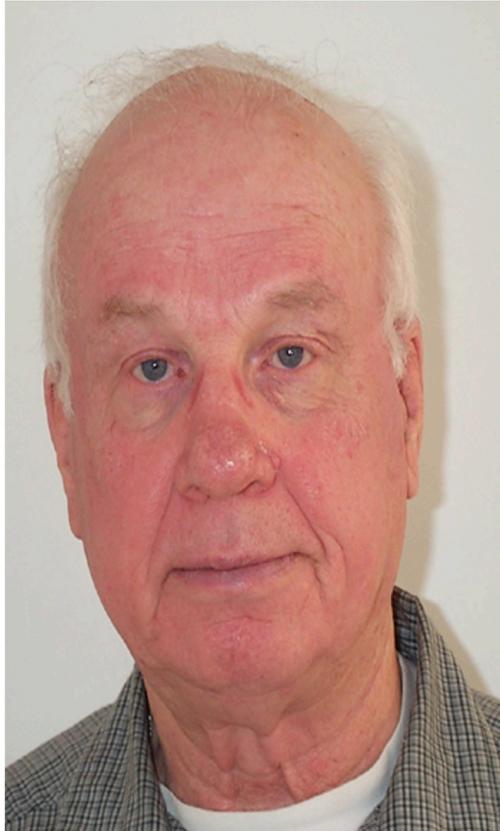
Chad C. Williams^{a,*}, Kent G. Hecker^{b,c}, Michael K. Paget^c, Sylvain P. Coderre^c, Kelly W. Burak^c, Bruce Wright^d, Olave E. Krigolson^a

^a Centre for Biomedical Research, University of Victoria, Canada

^b Faculty of Veterinary Medicine, University of Calgary, Canada

^c Cumming School of Medicine, University of Calgary, Canada

^d Division of Medical Science, University of Victoria, Canada



HR
79

SpO2
98

Temp
35.8

ALP
131

NBP
138/71

RR
12

Ultrasound
No abnormal

GGT
123

ALT
1030

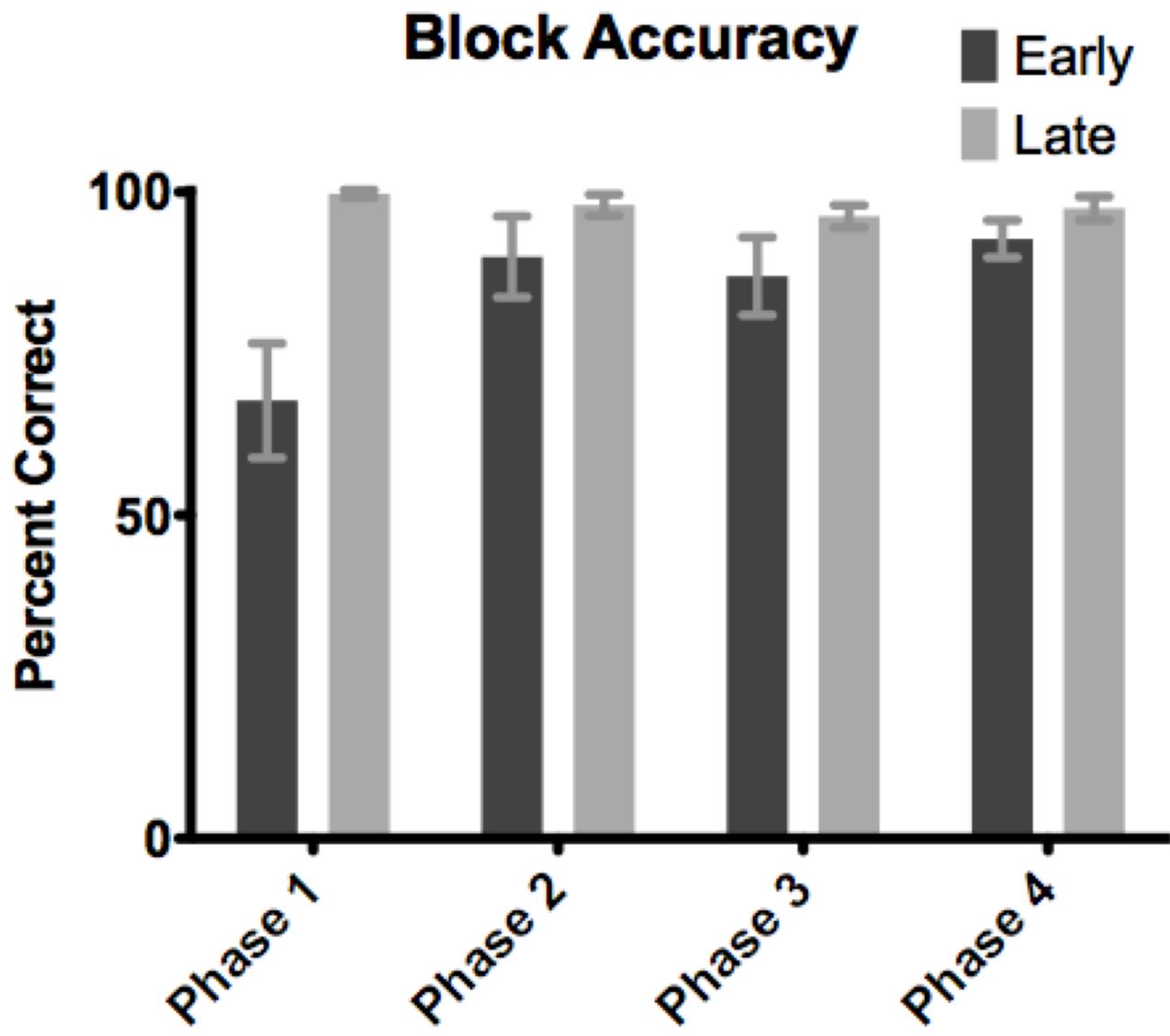
AST
744

Cholestatic
Extrahepatic

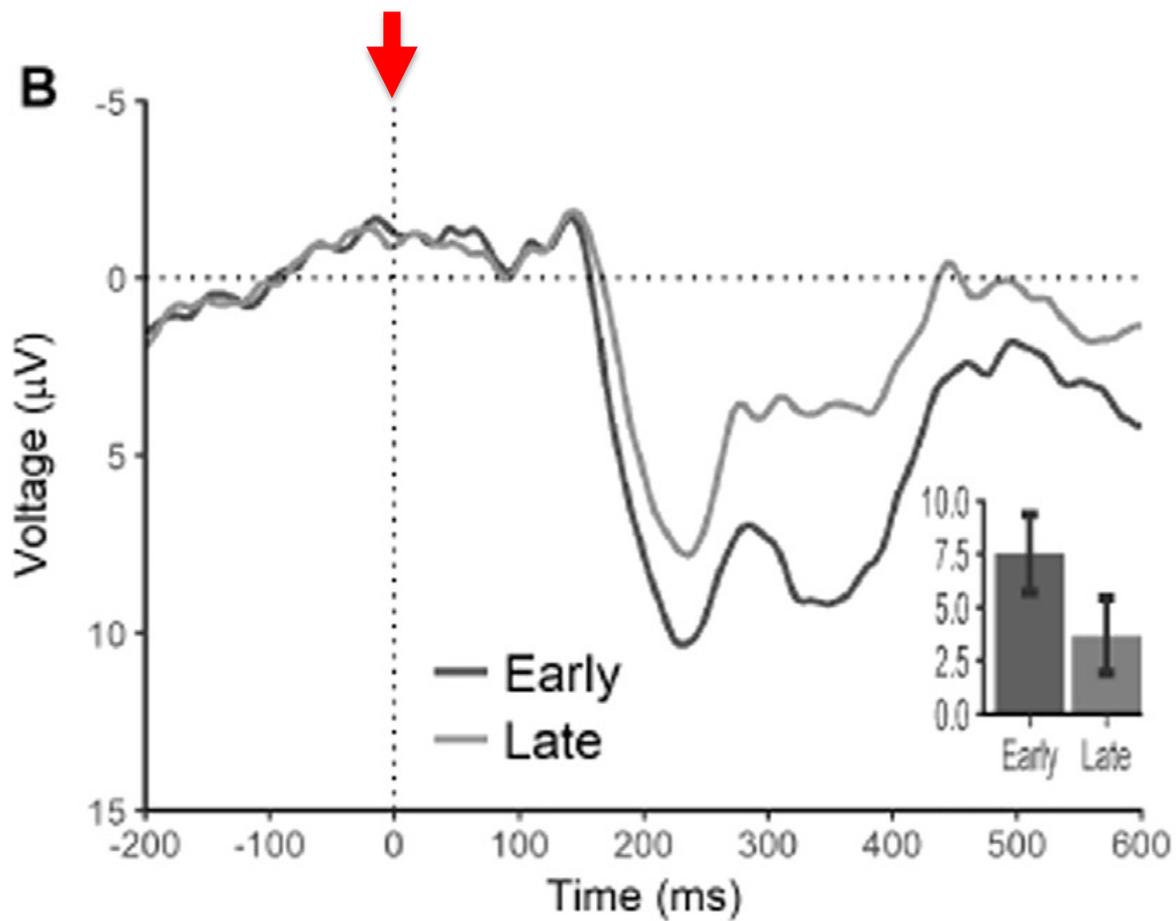
Cholestatic
Intrahepatic

Severe
Hepatocellular

Mild
Hepatocellular



Correct!



Two Week Retention Test

Accuracy: 92%

[87% 96%]



HRP	128/75	Ultrasound	No abnormal
Temp	36.1	SpO2	172
ALP	25	ALP	295
RR	15	HR	72
AST	24	SpO2	98



Temp	36.1	HRP	136/75
HR	77	RR	16
Ultrasound	No abnormal	ALT	1092
ALP	110	AST	724
SpO2	98	GGT	132



HR	17	HR	72
Ultrasound	No abnormal	HRP	128/79
Temp	36.5	AST	127
ALP	103	SpO2	98
ALT	147	GGT	314



HR	73	ALP	29
ALT	39	AST	337
Ultrasound	Dilated bile ducts	SpO2	98
Temp	36.2	HRP	138/75
GGT	371	HR	14