

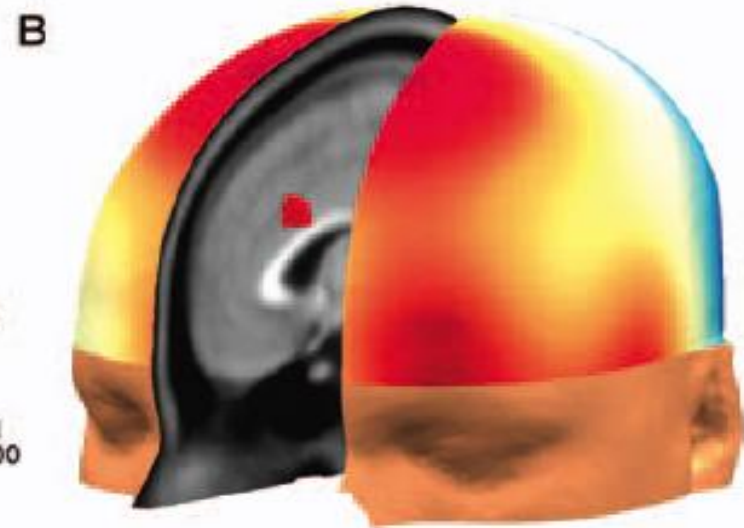
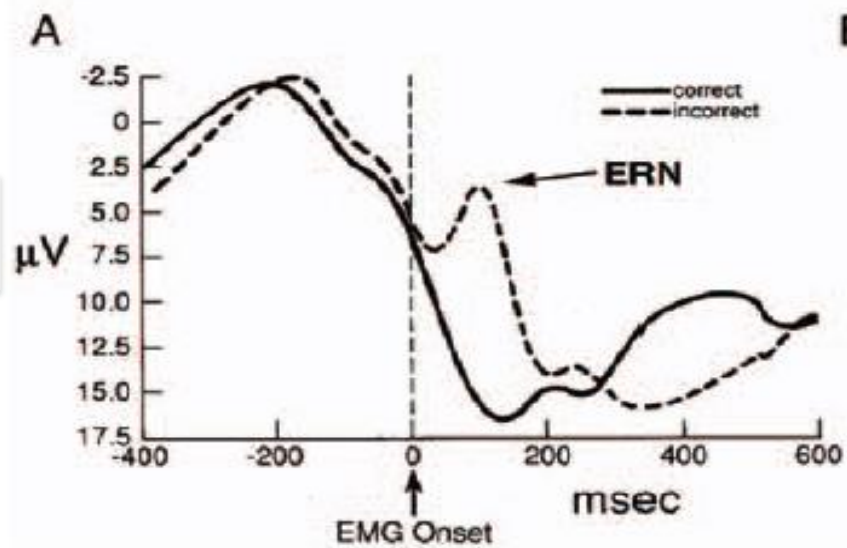
# Learning from errors: The role of the dorsal cingulate in feedback-based adaptive behaviour

Rob Hester

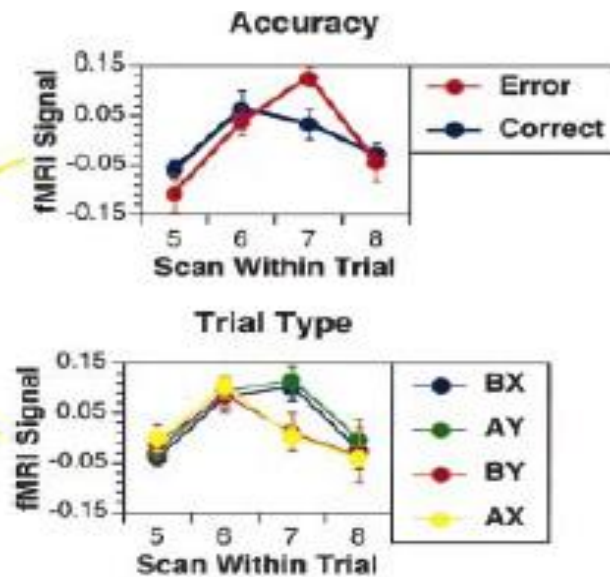
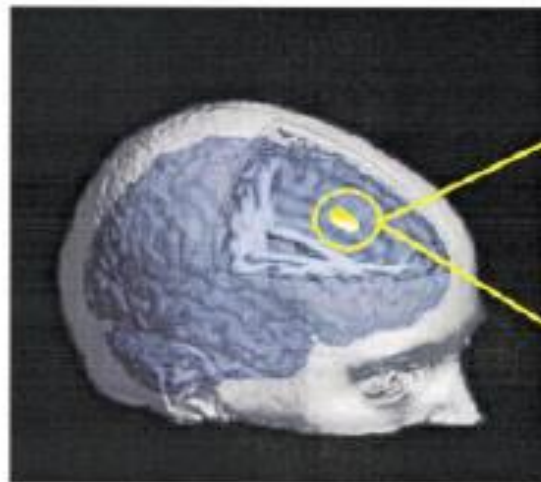
ARC Future Fellow and A/Prof  
School of Psychological Sciences  
University of Melbourne



Gehring et al  
1994



Carter et al.  
1998



# Hypoactive error-related neural activity



Neurobiology of Aging 24 (2003) 675–685

NEUROBIOLOGY  
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## Response-monitoring dysfunction in aging and Alzheimer's disease: an event-related potential study

Daniel H. Mathalon<sup>a,b,\*</sup>, Amy Bennett<sup>b,c,1</sup>, Nusha Askari<sup>b,c,2</sup>, E. Max Gray<sup>b,c</sup>,  
Margaret J. Rosenbloom<sup>b</sup>, Judith M. Ford<sup>b,c</sup>



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Journal of Psychiatric Research xxx (2005) xxx–xxx

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www.elsevier.com/locate/jpsychires

## Neural correlates of impulsive responding in borderline personality disorder: ERP evidence for reduced action monitoring

Ellen R.A. de Bruijn<sup>a,\*</sup>, Koen P. Grootens<sup>b</sup>, Robbert J. Verkes<sup>b</sup>, Verena Buchholz<sup>a</sup>,  
Jacobus W. Hummelen<sup>b,d</sup>, Wouter Hulstijn<sup>a,c</sup>

<sup>a</sup> Nijmegen Institute for Cognition and Information (NICI), Radboud University, P.O. Box 9104, 6500 HE Nijmegen, The Netherlands

<sup>b</sup> Unit for Clinical Psychopharmacology and Neuropsychiatry, University Medical Centre Nijmegen, Nijmegen, The Netherlands

<sup>c</sup> Collaborative Antwerp Psychiatric Research Institute (CAPRI), University of Antwerp, Antwerp, Belgium

<sup>d</sup> Spatie, Centre for Mental Health, Apeldoorn, The Netherlands

## Alcohol Consumption Impairs Detection of Performance Errors in Medial Frontal Cortex

K. Richard Ridderinkhof<sup>1,2\*</sup>, Yolande de Vlugt<sup>1</sup>, Aldo Bramlage<sup>1</sup>,  
Marcus Spaan<sup>1</sup>, Martin Elton<sup>1</sup>, Jan Snel<sup>1</sup>, Guido P. H. Band<sup>2</sup>

The Journal of Neuroscience, August 27, 2003 • 23(21):7838–7843 • 7839

### Brief Communication

## Cingulate Hypoactivity in Cocaine Users During a GO–NOGO Task as Revealed by Event-Related Functional Magnetic Resonance Imaging

Jacqueline N. Kaufman<sup>1</sup>, Thomas J. Ross<sup>1</sup>, Elliot A. Stein<sup>1</sup>, and Hugh Garavan<sup>1,2</sup>

<sup>1</sup>Medical College of Wisconsin, Department of Psychiatry, Milwaukee, Wisconsin 53226, and <sup>2</sup>Trinity College, Department of Psychology and Institute of Neuroscience, Dublin 2, Ireland

## Abnormal Brain Activation During Inhibition and Error Detection in Medication-Naïve Adolescents With ADHD

Katya Rubia, Ph.D.

(*Am J Psychiatry* 2005; 162:1067–1075)

Anna B. Smith, Ph.D.

Michael J. Brammer, Ph.D.

Brian Toone, Ph.D.

Eric Taylor, M.D., Ph.D.



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# The Neural Basis of Human Error Processing: Reinforcement Learning, Dopamine, and the Error-Related Negativity

Psychological Review  
2002, Vol. 109, No. 4, 679–709

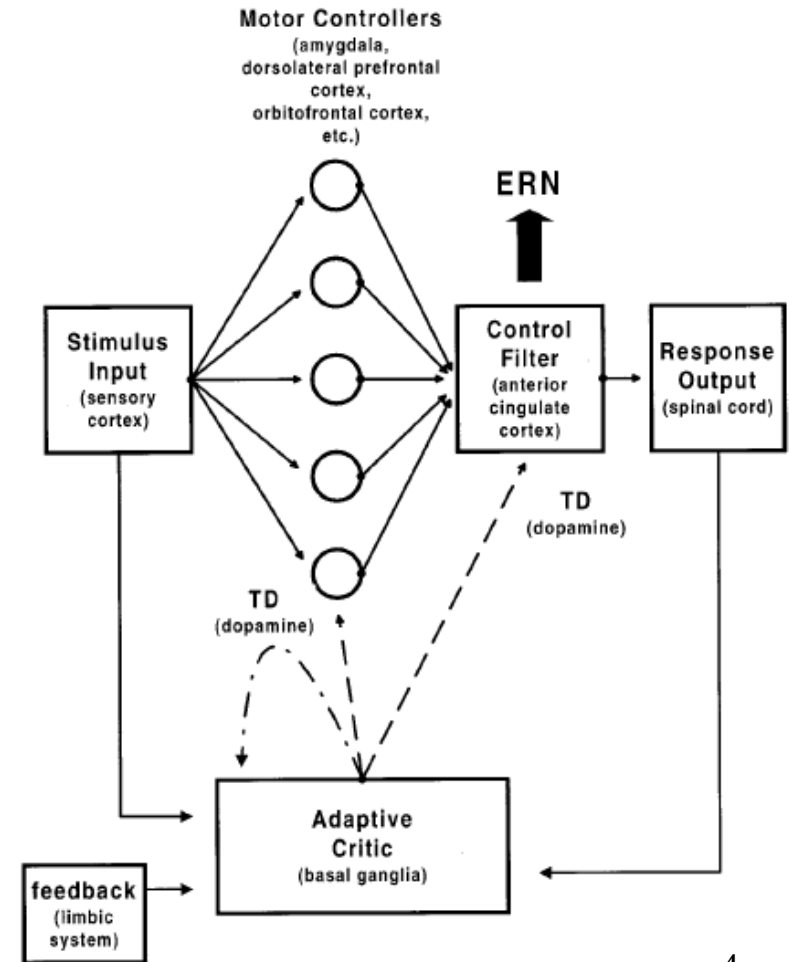
Clay B. Holroyd  
University of Illinois at Urbana–Champaign

Michael G. H. Coles  
University of Illinois at Urbana–Champaign  
and F. C. Donders Centre for Cognitive Neuroimaging

Error related ACC activity reflects a phasic decrease in midbrain dopamine activity that is modulated by the basal ganglia

Correct responses induce phasic increases in dopaminergic activity

The ACC transmits the value of the response to regions critical to the behaviour (e.g., dlPFC for response inhibition, or hippocampus for learning)



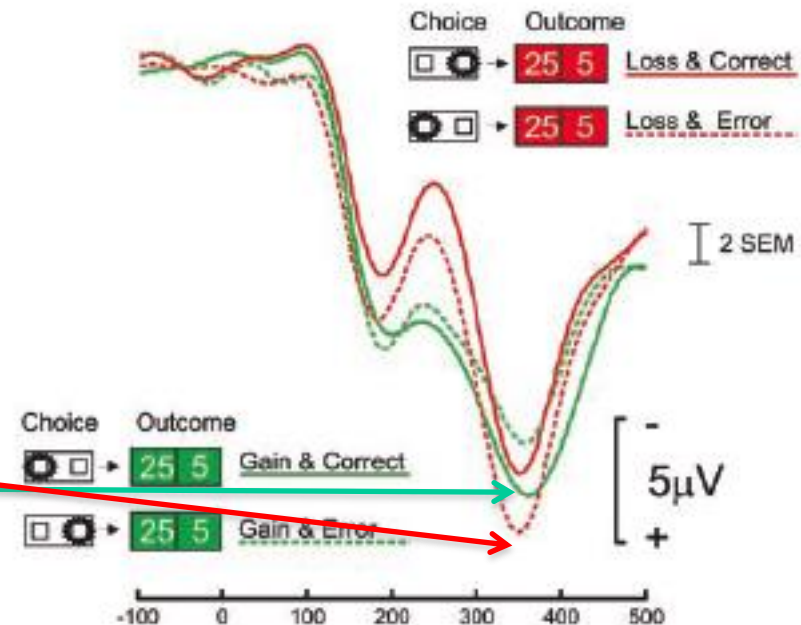
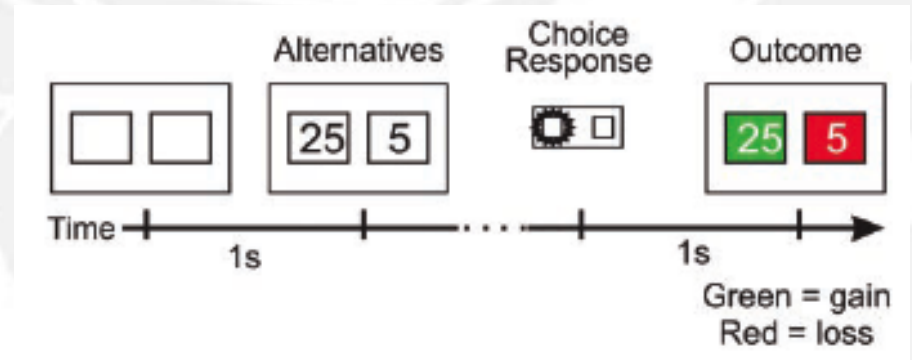


# Prediction error

- Using the reward prediction error model for learning as its guide, theories from Holroyd and others suggested that ACC activity reflected outcome relative to prediction, or expectation
- Gehring tested this hypothesis with a gambling task
- The magnitude of the ERN (or CRN) was influenced more by relative loss/gain, than whether a participant was correct/incorrect
- Two biggest responses are for outcomes that were better than expected
  - Loss & error
  - Gain & correct

## The Medial Frontal Cortex and the Rapid Processing of Monetary Gains and Losses

William J. Gehring\* and Adrian R. Willoughby  
SCIENCE VOL 295 22 MARCH 2002

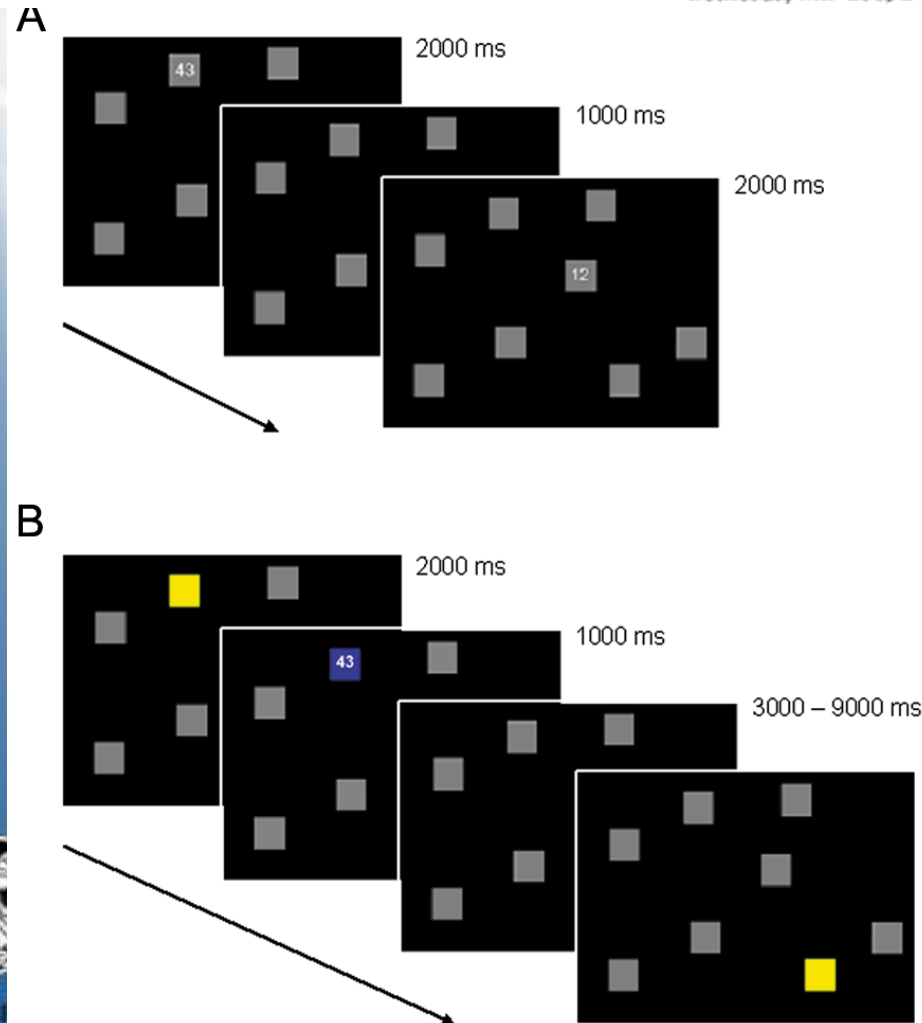


# Human Medial Frontal Cortex Activity Predicts Learning from Errors

Cerebral Cortex August 2008;18:1933-1940

Robert Hester<sup>1</sup>, Natalie Barre<sup>2</sup>, Kevin Murphy<sup>3</sup>, Tim J. Silk<sup>1</sup> and Jason B. Mattingley<sup>1</sup>

<sup>1</sup>Cognitive Neuroscience Laboratory, Queensland Brain Institute and School of Psychology, University of Queensland, St Lucia, Queensland 4072, Australia, <sup>2</sup>School of Behavioural Science, University of Melbourne, Melbourne 3010, Australia and <sup>3</sup>Section on Functional Imaging Methods, Laboratory of Brain and Cognition, National Institute of Mental Health, Bethesda, MD 20892-1148, USA



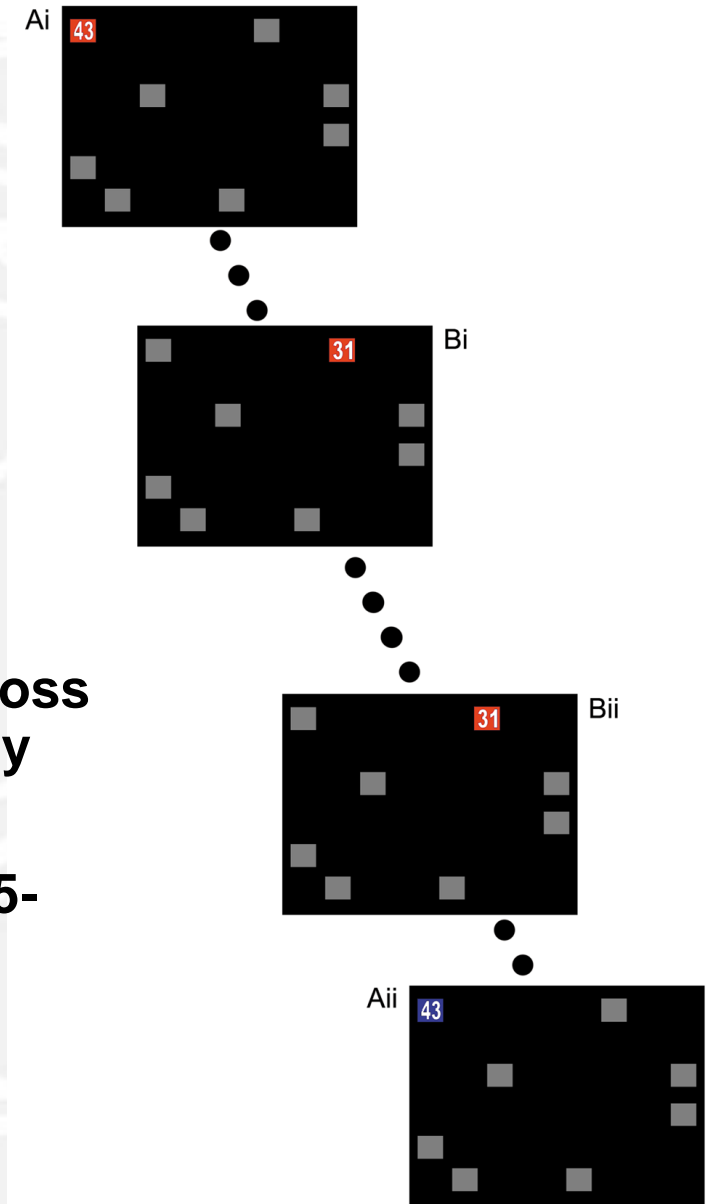
Encoding

Recall



Stimuli:	12	32	24	44	41	31	11	23	24	31	..	..
Accuracy:	x	x	x	✓	x	x	x	✓	x	✓		

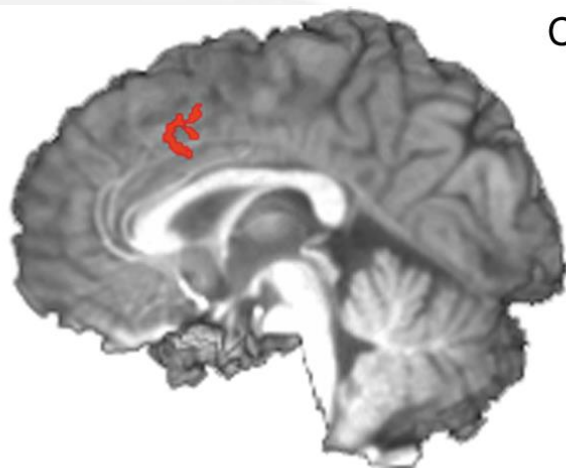
First round of eight trials      Second round of eight trials



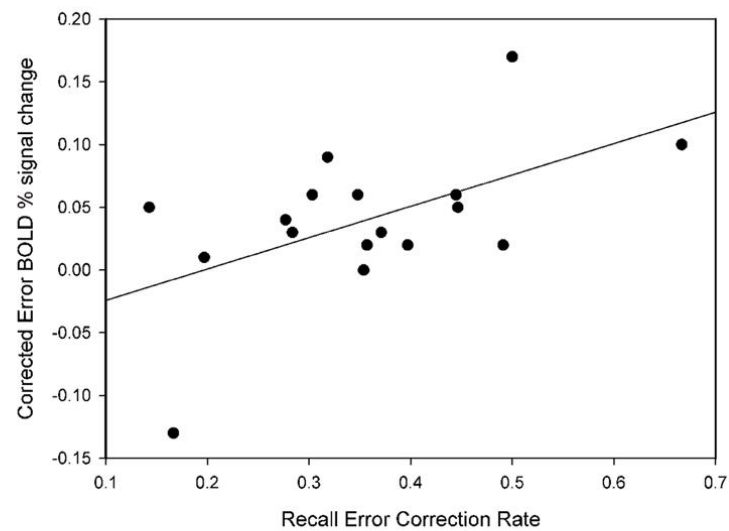
- Behavioural performance indicated learning across the 3 rounds of location presentations (Accuracy Rnd1: 33%, Rnd2: 47%, Rnd3: 58%).
- On average, subjects corrected 38% (Range = 15-66%) of Rnd 1 and 2 errors.



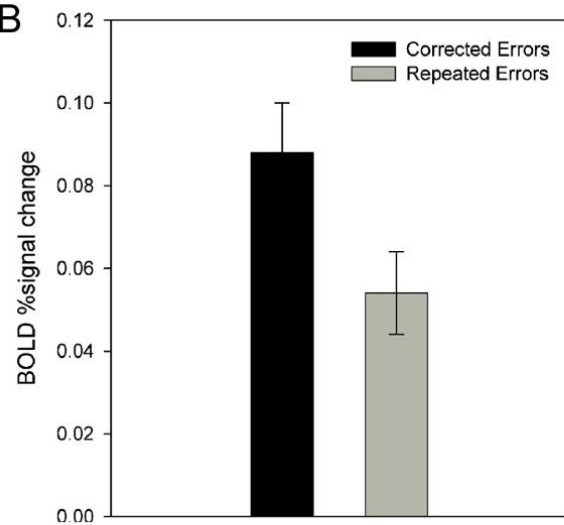
A



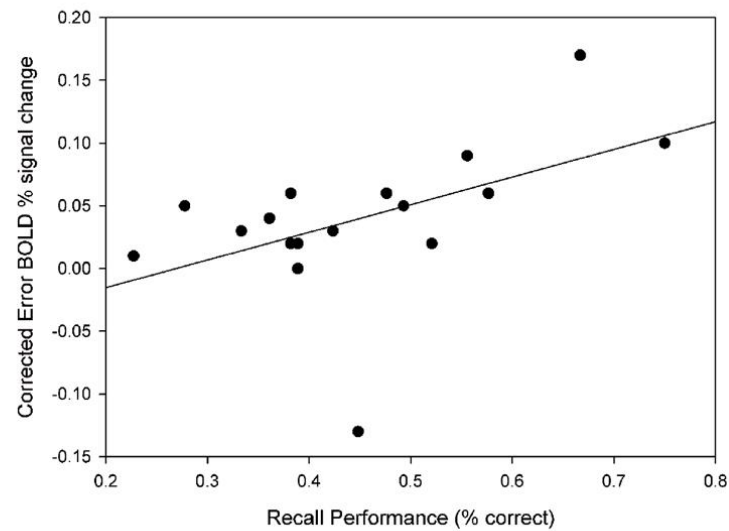
C


 $r = .57$ 

B

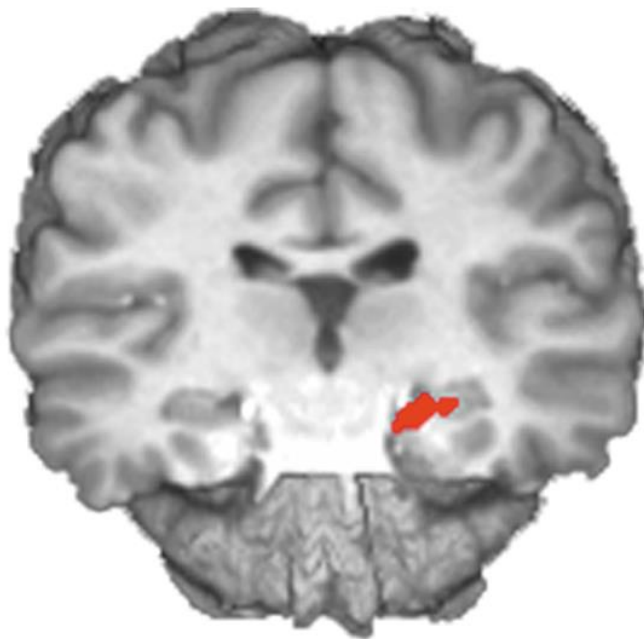


D

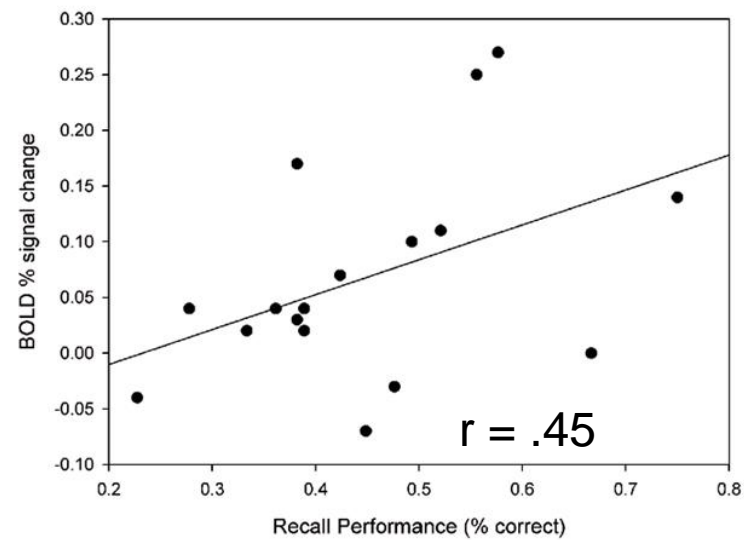

 $r = .51$ 



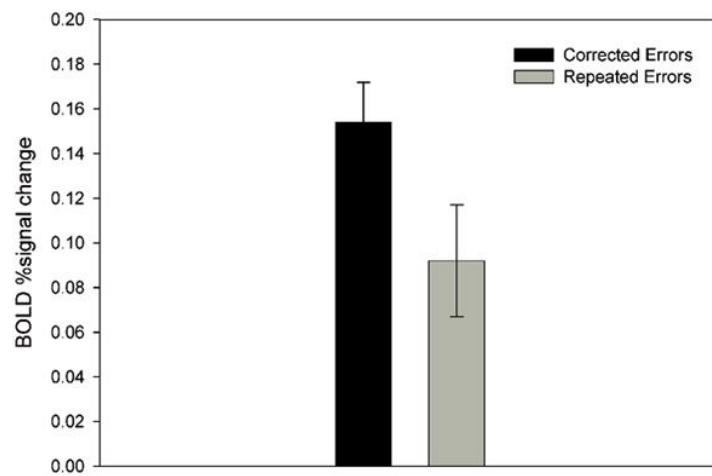

A



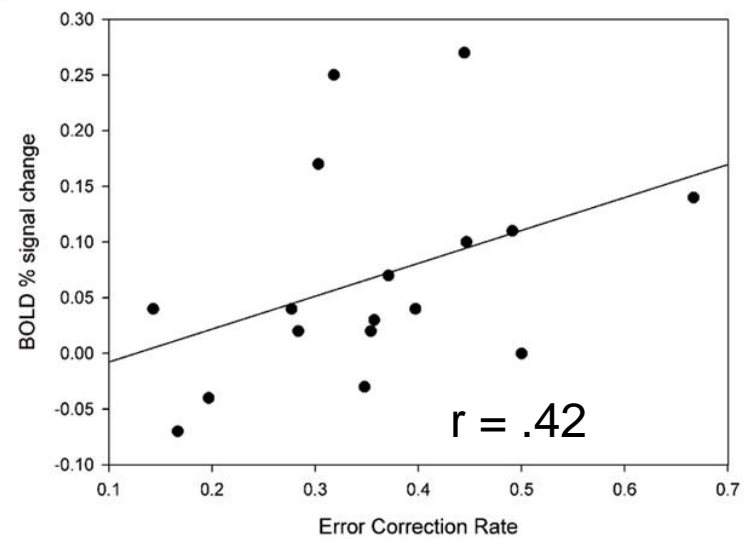
C

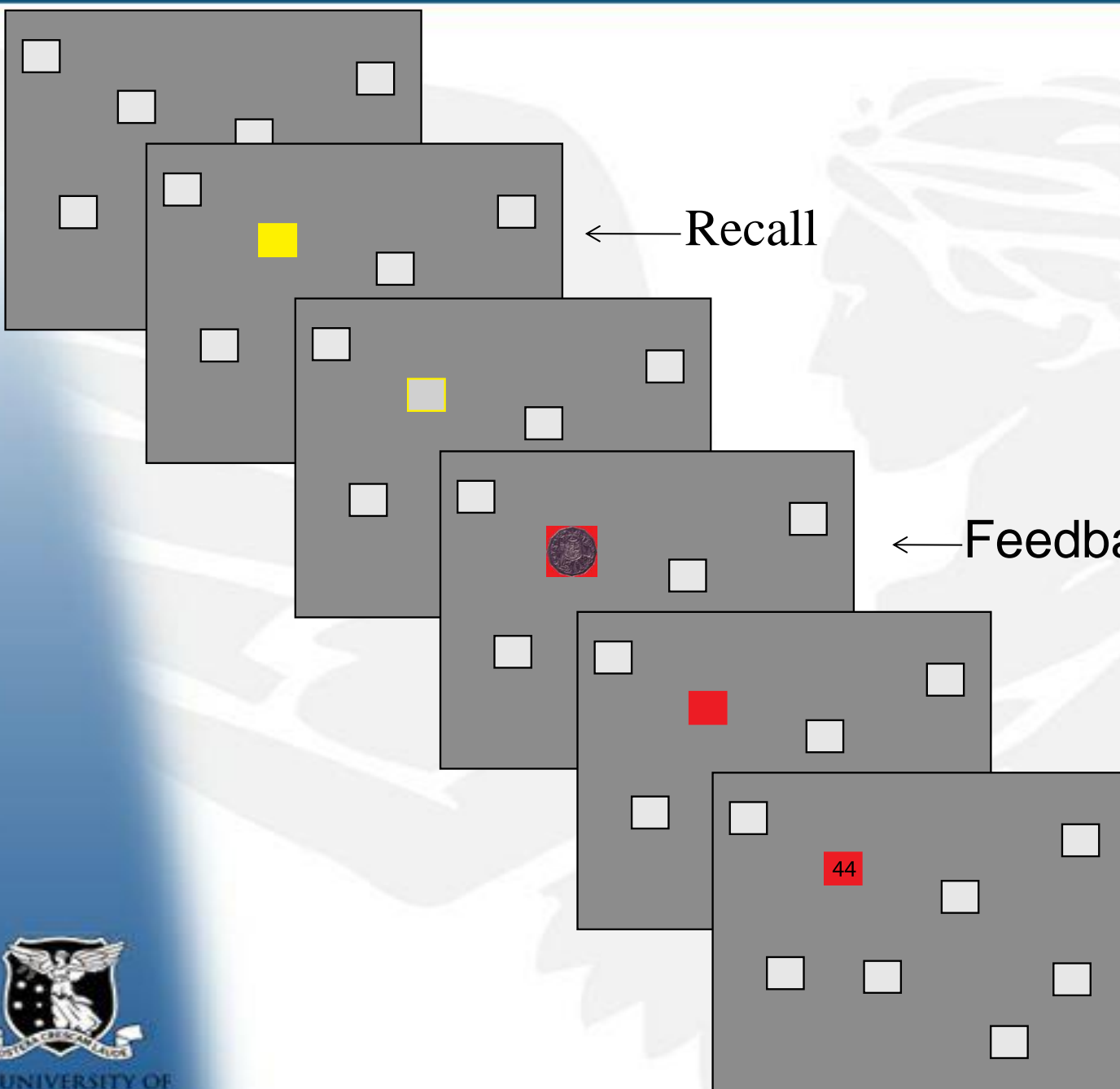


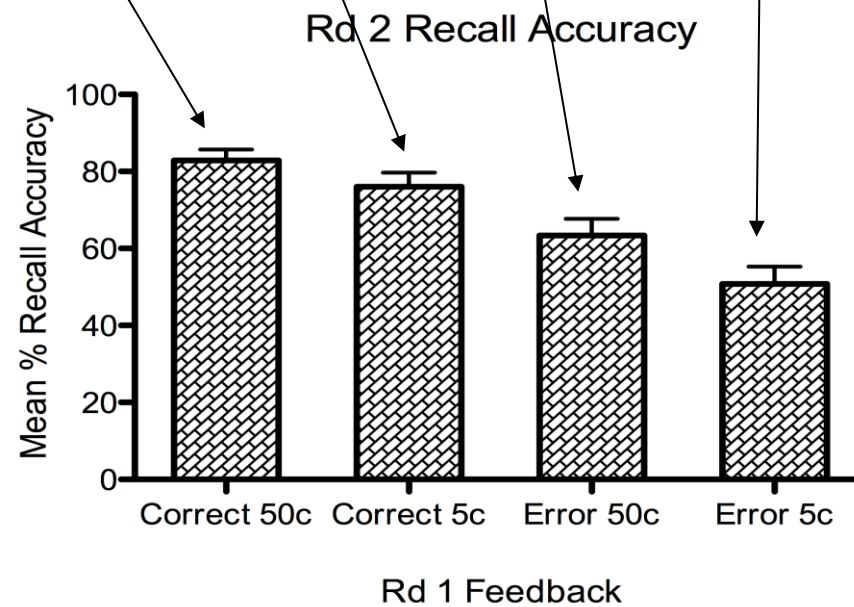
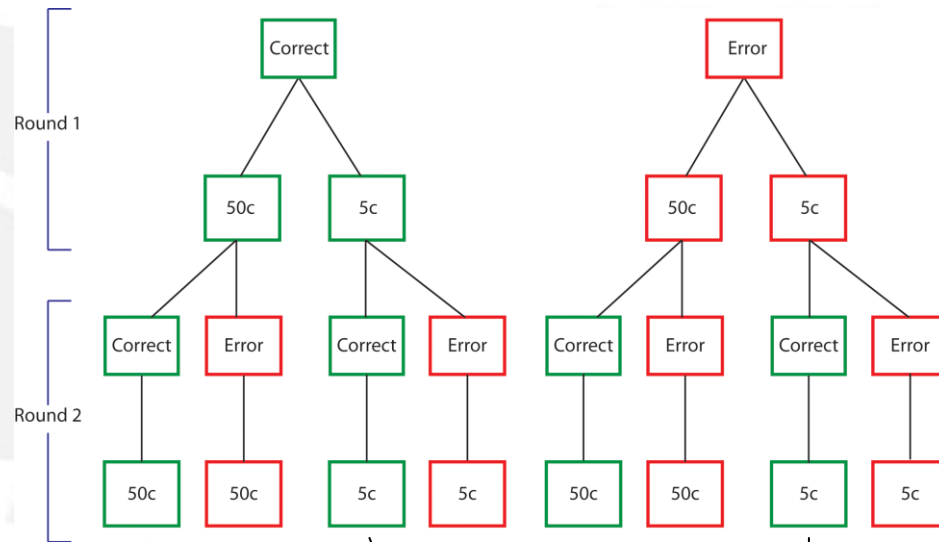
B



D





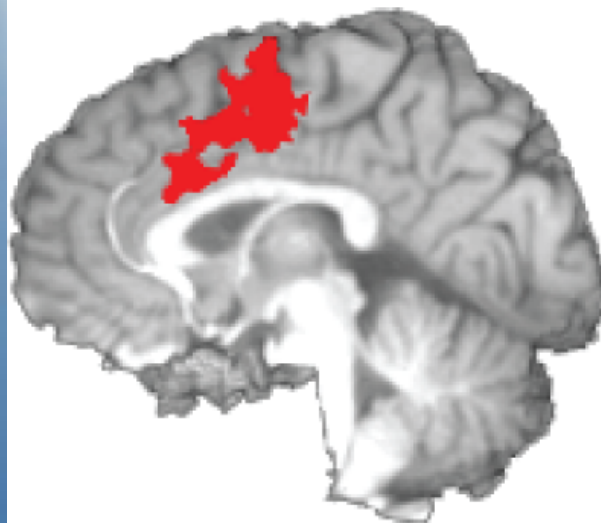


# Punishing an Error Improves Learning: The Influence of Punishment Magnitude on Error-Related Neural Activity and Subsequent Learning

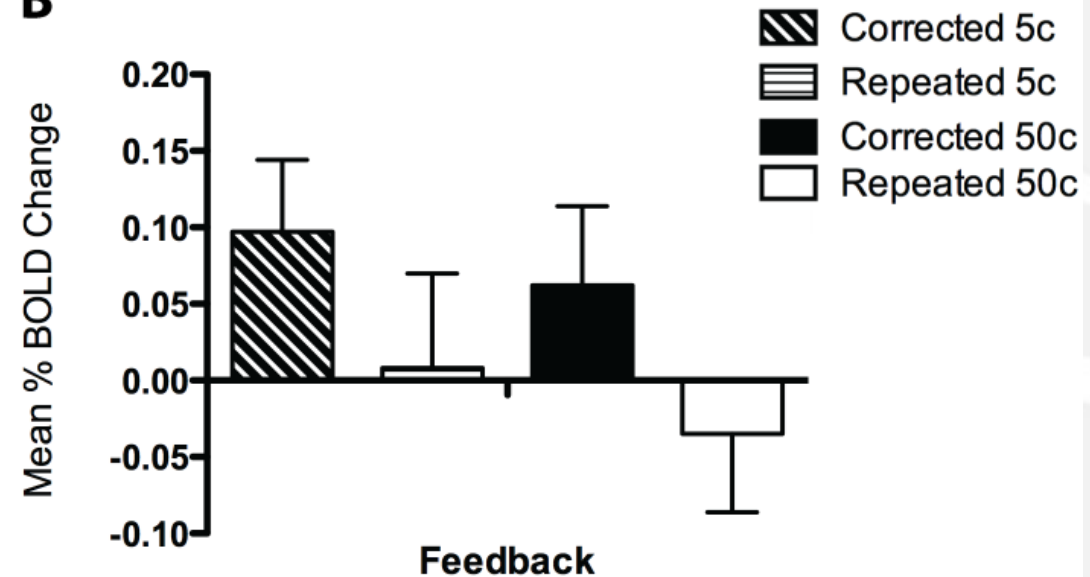
Robert Hester,<sup>1</sup> Kevin Murphy,<sup>2</sup> Felicity L. Brown,<sup>3</sup> and Ashley J. Skilleter<sup>3</sup>

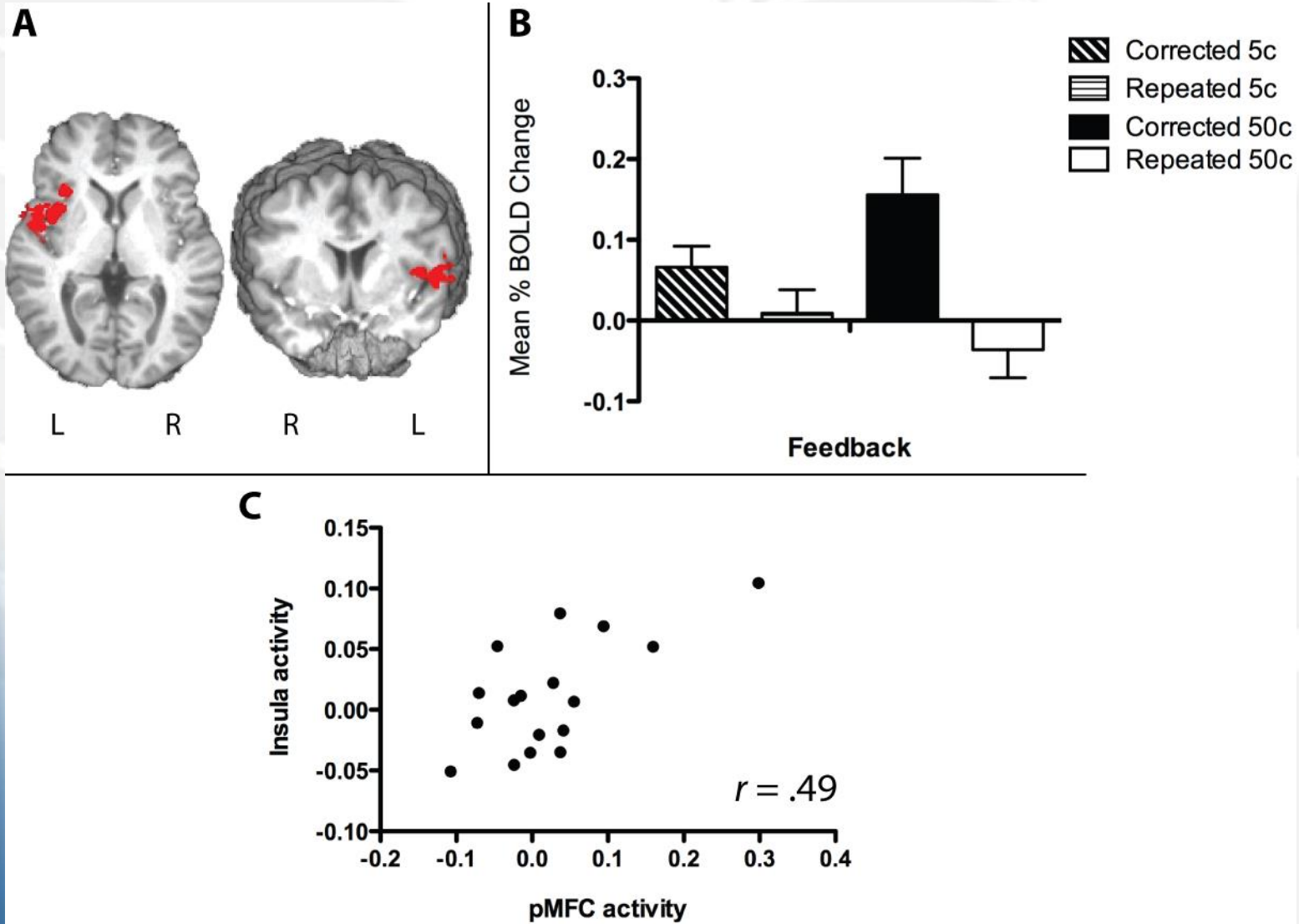
The Journal of Neuroscience, November 17, 2010 • 30(46):15600–15607

**A**



**B**







# Choice, uncertainty and value in prefrontal and cingulate cortex

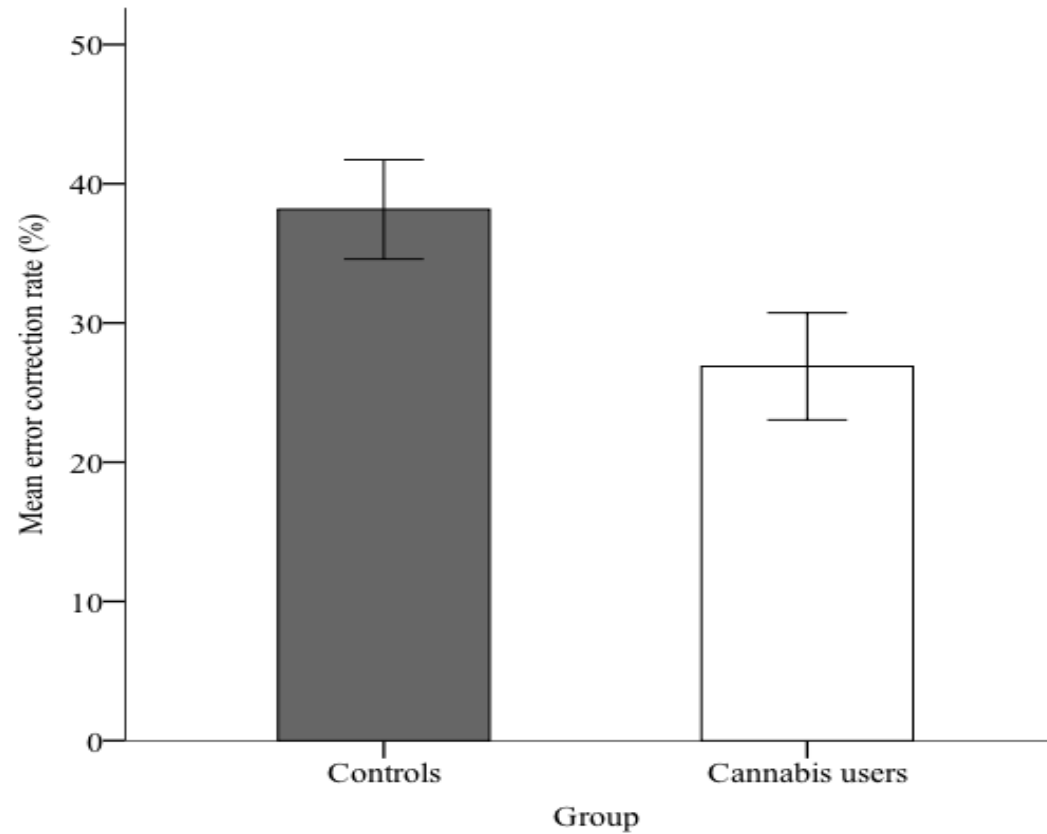
Matthew F S Rushworth & Timothy E J Behrens

NATURE NEUROSCIENCE VOLUME 11 | NUMBER 4 | APRIL 2008

“ACC activity encodes the degree to which the resulting information should influence future decisions”

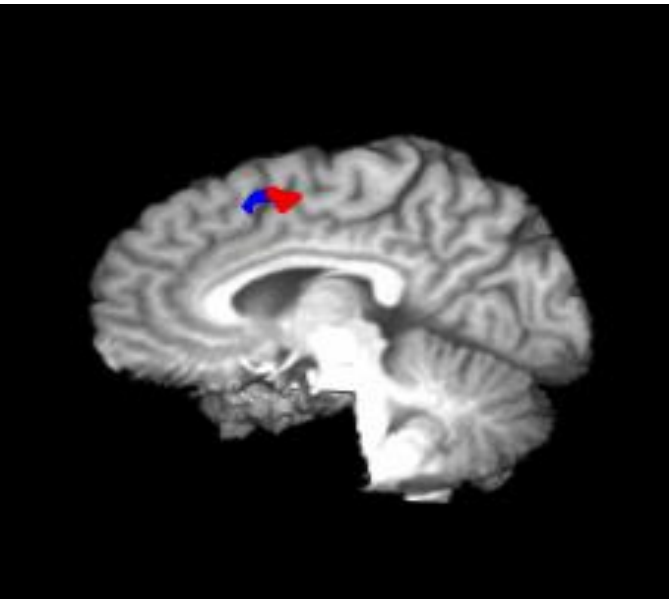
“when new information is observed (ACC activity) reflects the extent to which the current outcome should dictate future actions, or the value of information attained from the current outcome”



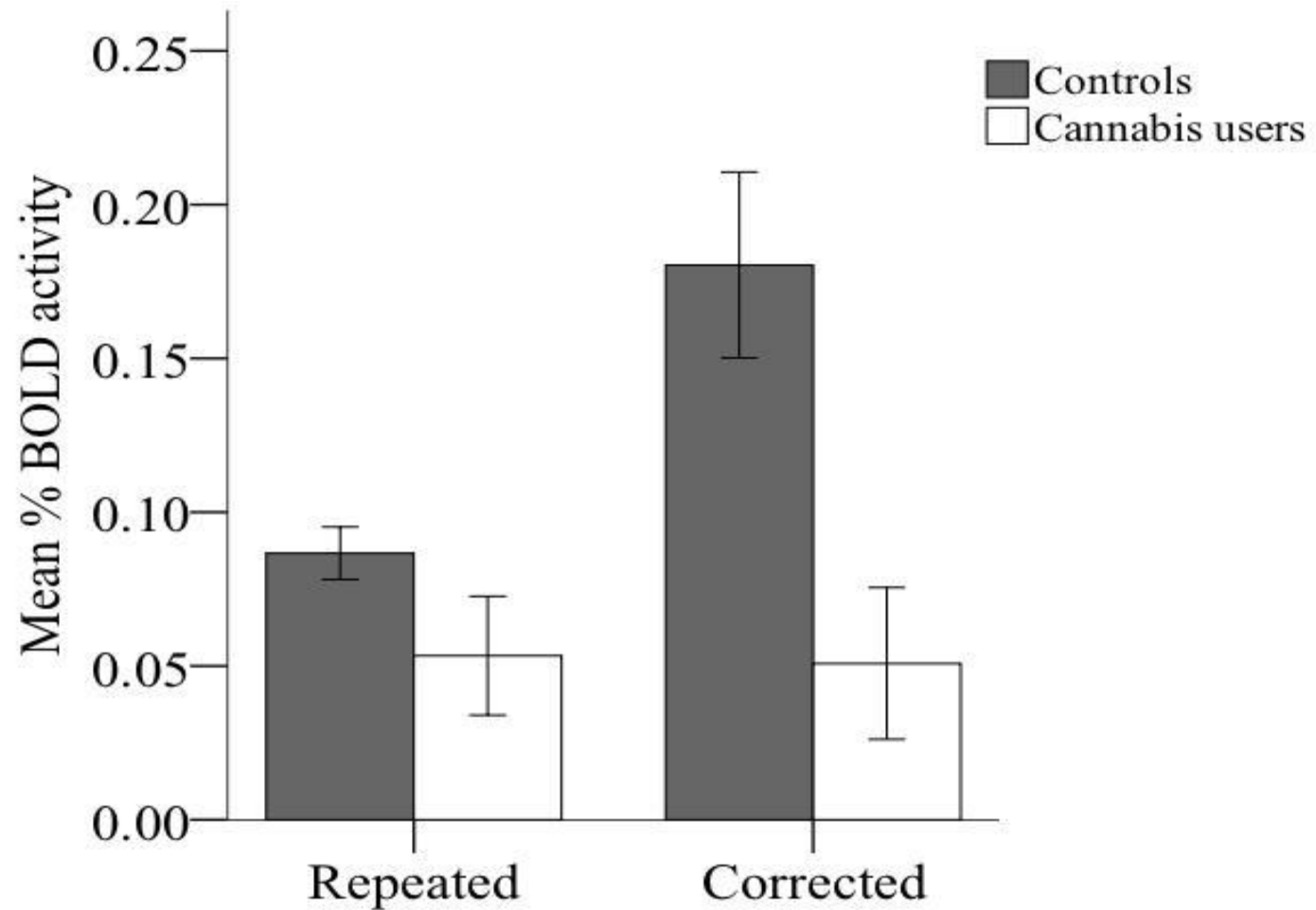


LFE task Mean error correction rates (expressed as a percentage of total errors in round 1 that were corrected in round 2) for control and cannabis groups (n=16).

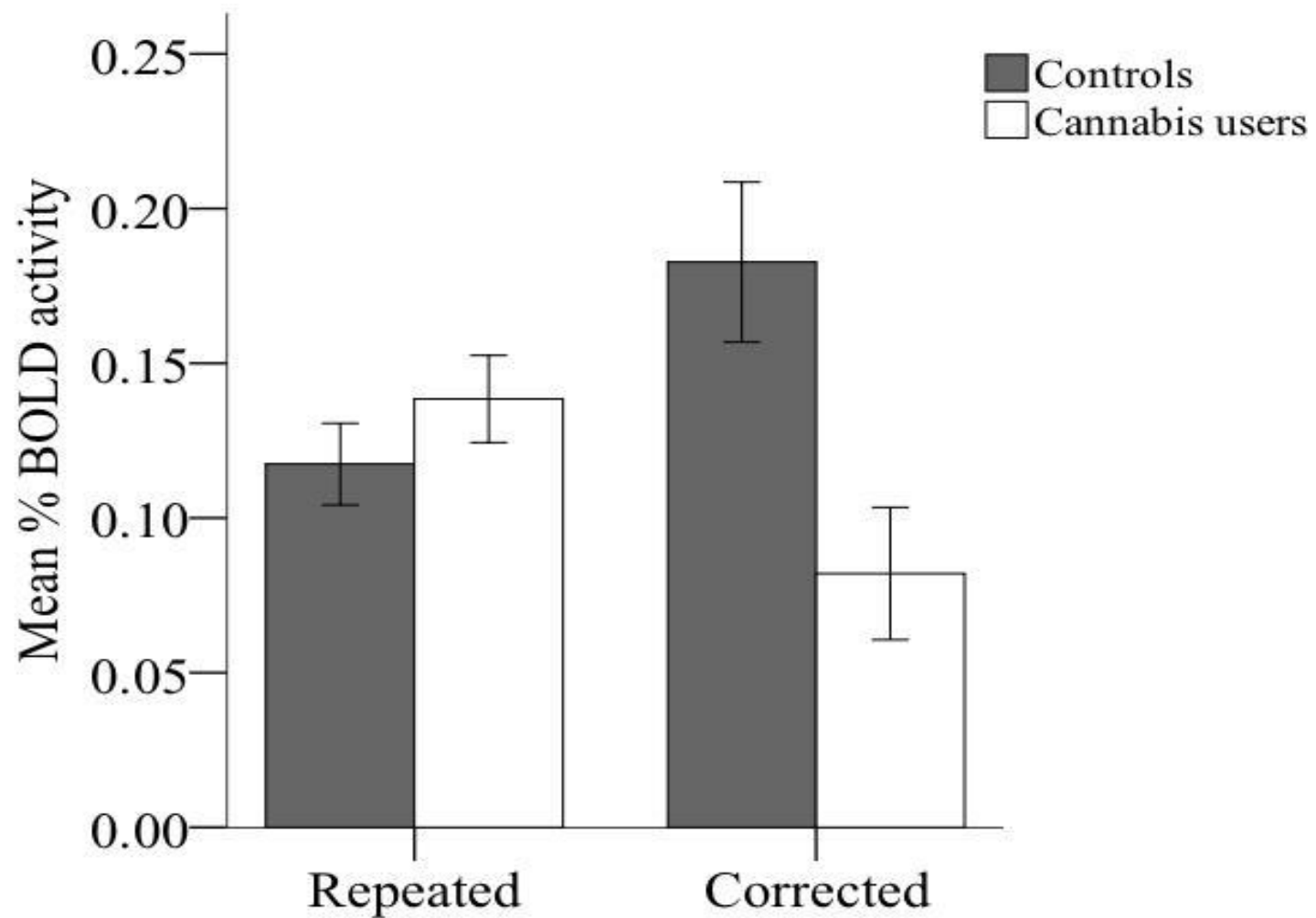
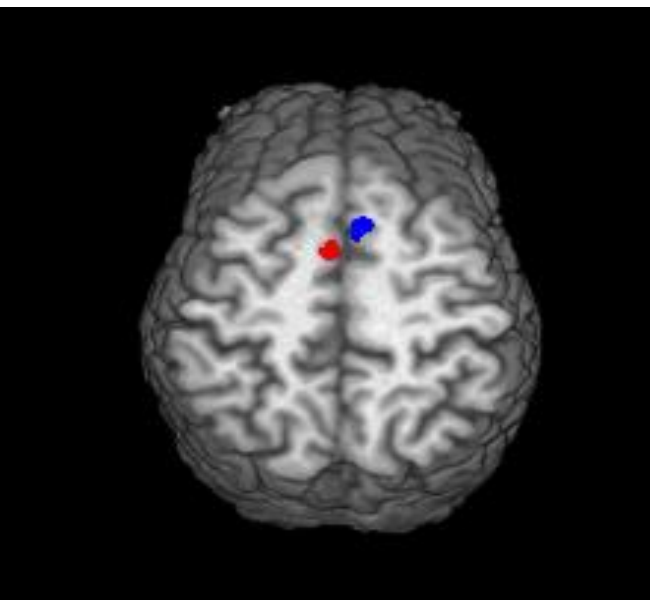
# Right dACC



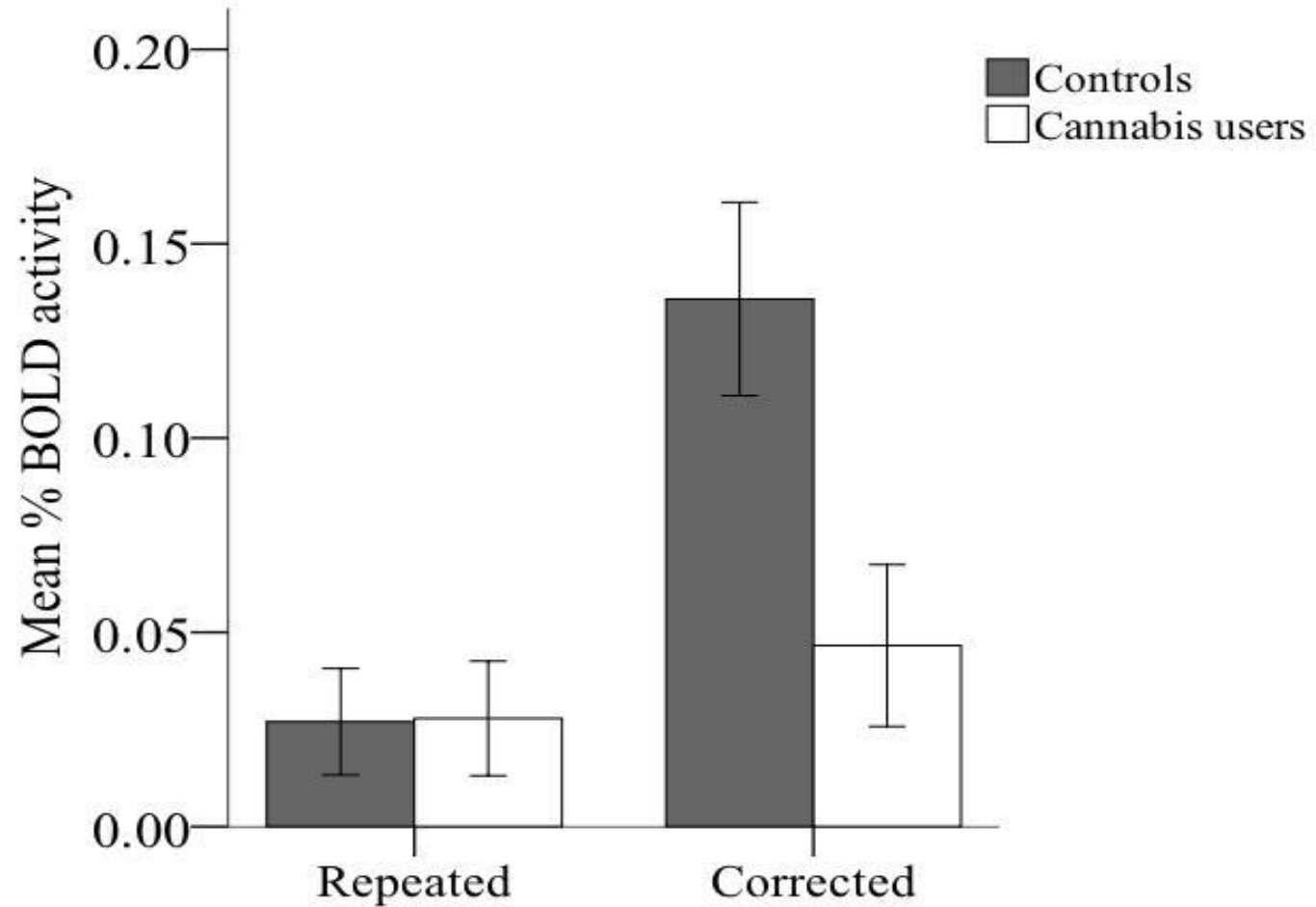
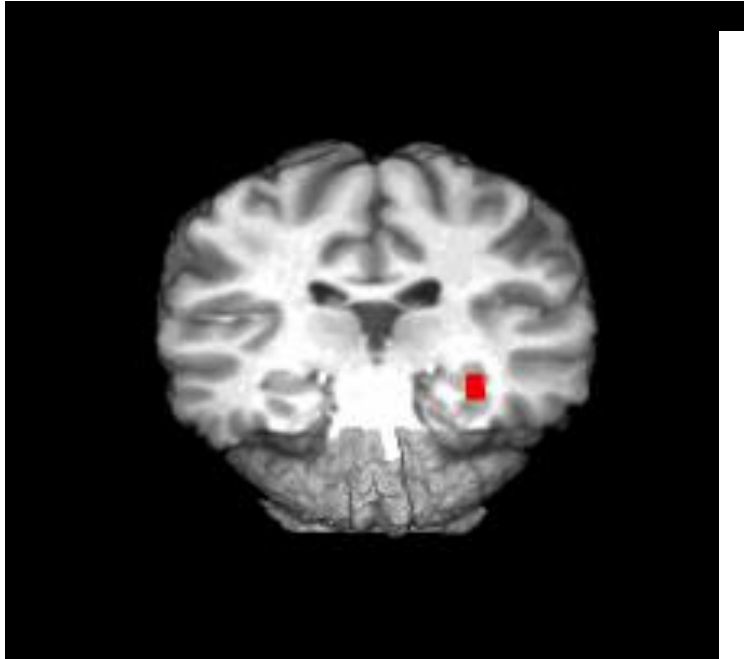
Blue = left, red = right



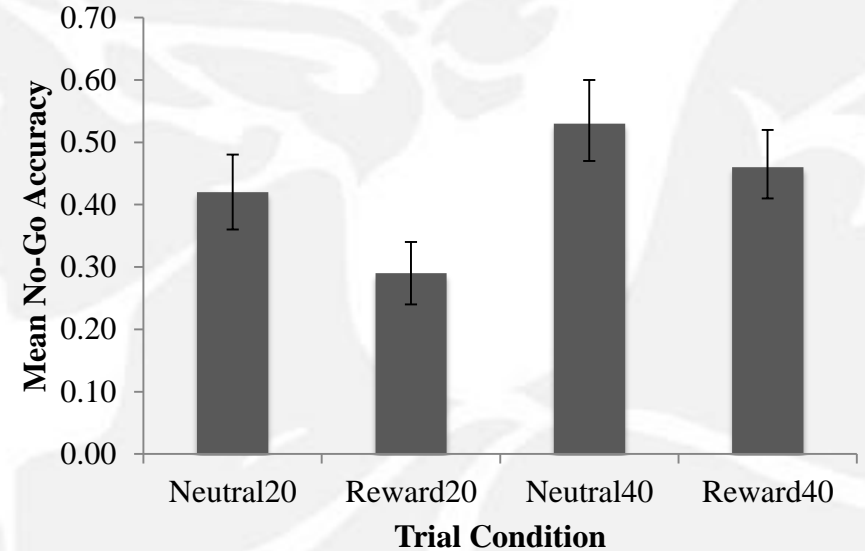
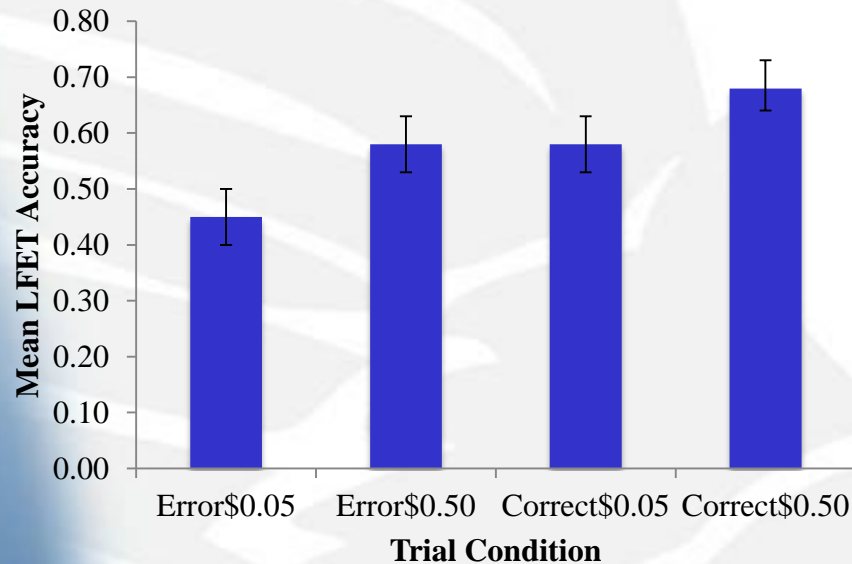
# Left dACC



# Left hippocampus

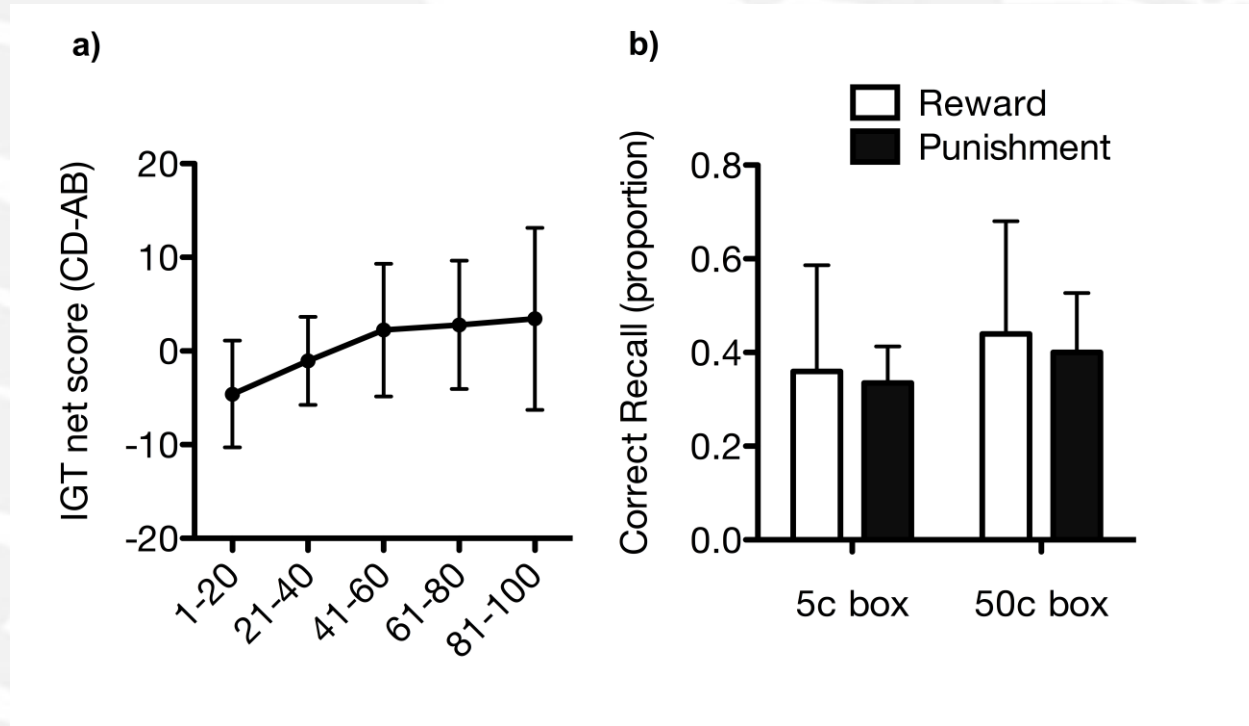






In a sample of 100 undergraduates, impulsiveness for reward correlated ( $r = .25$ ) with difference between learning from reward and punishment



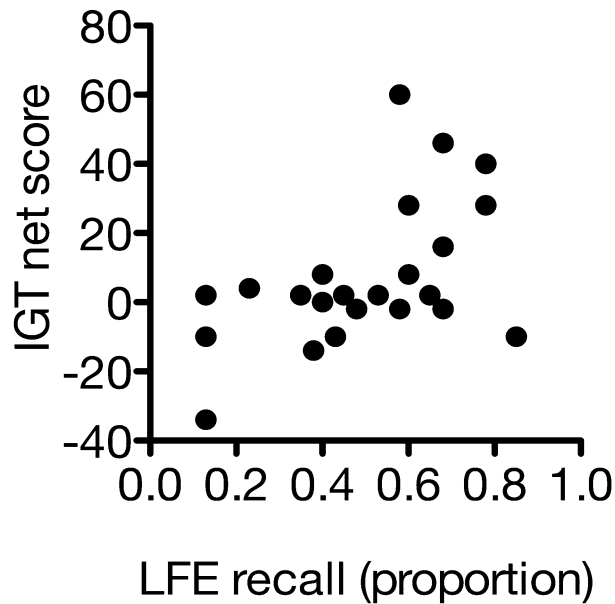


Dependent Opiate users (n = 25) show the typical pattern of impulsiveness for reward on the Iowa Gambling Task

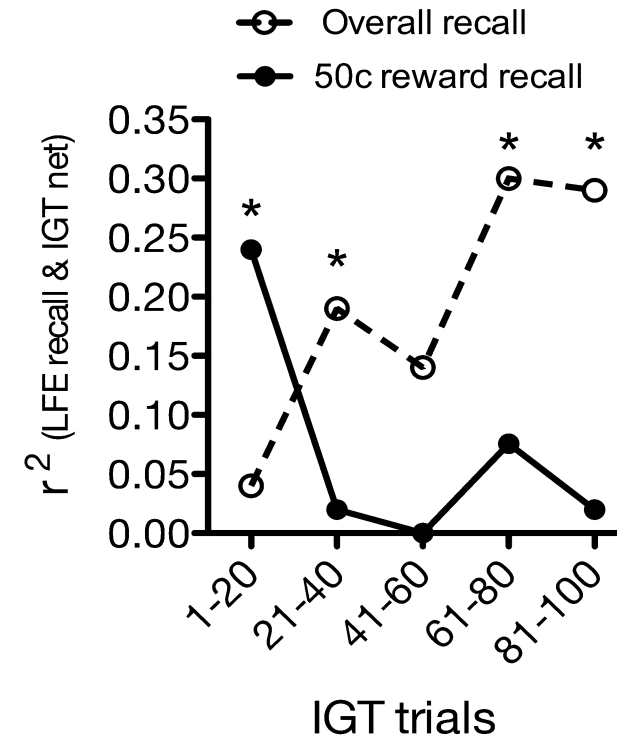


- Poster WCE018 Wednesday afternoon 4-6pm: Dr Dan Upton
- Poster MCE012 Monday 4-6pm: Ms Kathleen Charles-Walsh

a)



b)



- LFE recall performance correlates with less impulsive decision making
- Sensitivity to learning from reward correlates with greater impulsive decision making, especially during early IGT trials when contingencies are not yet known



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# Acknowledgements

Dr David O'Connor



Dr Catherine Orr



Dr Dan Upton



Kathleen Charles-Walker



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0973332



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