Self-Regulation of the Anterior Insula using Neural Feedback:
Pilot Data and Future Directions

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BACKGROUND

• Developments in fMRI now allow rapid data transfer/analysis within a few seconds.

• "Real time" fMRI (rt-fMRI) is a novel brain-computer interface useful for neurofeedback.

• This method has already been shown to have clinical promise. For instance, 8 chronic pain patients report 64% pain reduction after neural feedback[1].

• Studies from healthy controls suggest the right anterior insula (RAI) amenable to regulation[2], a region implicated in affective & interoceptive processing[3], and hypoactive in some psychiatric conditions[4].

AIMS

• To regulate the RAI using neurofeedback from our GE MRI system.
• To test a mindfulness based body scan strategy, alongside standardised emotion recall strategies.
• To investigate whether RAI regulation impacts on response to affective stimuli.

METHODS

• 2 x 2 mixed design:
• Group1: 'Real' RAI feedback & Group 2: 'Sham' feedback from another brain area.
• Condition 1: **Increase** brain activation & Condition 2: **Decrease** brain activation.

Participants

Mean & SD	Age	M:F	Verbal IQ+	Mindfulness*
Real n = 8	28 ± 6.2	1:1	117.5 ± 7.5	33.4 ± 6
Sham n = 8	27.6 ± 3.5	1:1	116.9 ± 5.7	37.3 ± 6.9

+ National Adult Reading Test   * Freiberg Mindfulness Inventory

PARADIGMS

Affective Probes: Probe 1: Start & Probe 2: End of training. Includes 6 positive, 6 negative, 6 neutral images: International Affective Picture System (Lang et al, 2005).

9 Decrease and 9 Increase blocks

38s pre-baseline   22s decrease   8s   22s increase   → time

Regulation Training: Runs x 4

5 Decrease and 5 Increase blocks

38s pre-baseline   30s decrease   30s increase   → time

IMAGING PARAMETERS

• 3T GE scanner using GE's standard 8 channel head coil.
• 38 2.3mm slices, 1mm gap, 22cm FOV, 64x64 matrix.Optimised excitation flip angle of 75 degrees with 2s TR and parallel imaging ('ASSET') speed up factor of 2.
• Customised Perl script from NIMH, US. accesses images as soon as they are constructed, and preprocessed using AFNI[5].
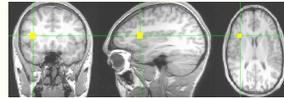
• ROI selected using neuro-anatomical criteria.

NEURAL FEEDBACK

• Global brain effects, e.g. respiration, controlled by subtraction of activation from a large control ROI from experimental ROI:

$$ROI_{EXP} (BOLD_{INC} - BOLD_{DEC}) - ROI_{CTRL} (BOLD_{INC} - BOLD_{DEC})$$

• New brain volume acquired every 2s, new values calculated to generate a running time series for the feedback signal.

COGNITIVE STRATEGIES

Increase Bloodflow:

"Recall and relive personal memories of situations and events in which you were very physically aroused. These could be pleasant and unpleasant"

"Become aware of are the tension of the muscles in your face, or limbs, the sensations created by the noise and vibration of the scanner, heartbeat or breathing rate. Do not spend too long focussing on any one sensation, but just continue to move your attention around your body."

Participants free to vary body/memory strategy across runs. 50% of real group chose body focus as their main strategy.

Decrease Bloodflow:
Count back from 100 in 3s.

REFERENCES & ACKNOWLEDGEMENTS
[1] DeCharms, R., 2008 Nature Reviews Neuroscience. 9:720-729.
[2] Caria, A., et al., 2007 NeuroImage. 35:1238-1246.
[3] Craig, B., 2009 Nature Reviews Neuroscience. 10:59-70.
[4] Phillips, M.L., et al., 2001 Psych Res: Neuroimaging. 108:145-160.
[5] Cox, R., 1996 Computers & Biomed Res. 29:162-173.
[6] Brammer, M., et al., 1997 Magnetic Resonance Imaging. 15:763-770.
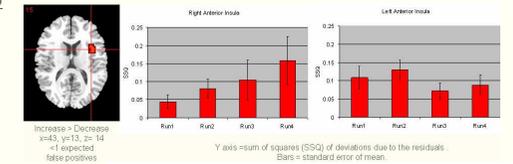This project was funded by a Psychiatry Research Trust grant.
We would also like to thank Dr Schoenberg & Dr Sierra for help with design, and Dr Jerzy Bodurka, NIH, for real-time scripts.

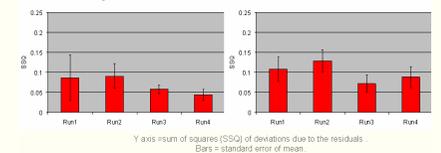## RESULTS: REGULATION TRAINING
Linear Trend Analyses

Real Feedback Group
Monotonic rise in RAI activation. Increase>Decrease. No monotonic rise in the LAI.
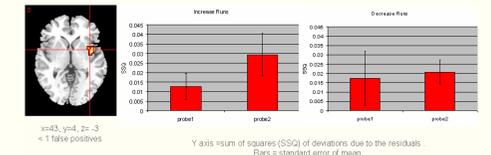

Sham Feedback group
No monotonic rise in Left or Right AI Increase>Decrease.

RESULTS: AFFECTIVE PROBES

Real Feedback Group
RAI activation Probe 2>Probe 1. Positive IAPS after Increase but not Decrease runs.

No RAI difference to negative IAPS after Increase: Probe 2>Probe 1.

Sham Feedback Group
No RAI difference to negative or positive IAPS after Increase : Probe 2>Probe 1.

CONCLUSIONS

• Data indicate it is possible to regulate the RAI, and lack of regulation in the sham group suggests this is not simply a general effect of cognitive strategy nor non-specific feedback from the brain.
• RAI regulation leads to > RAI activation to positive probes.
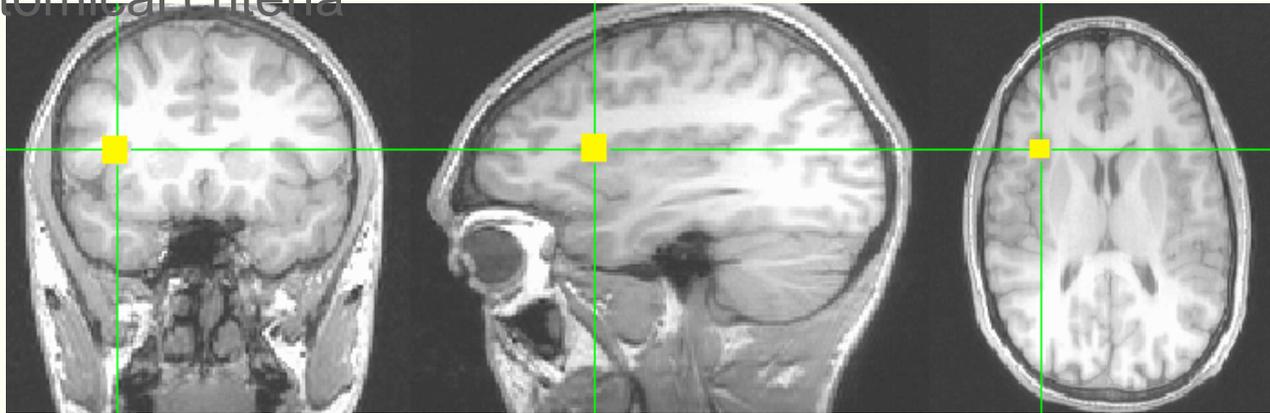• Body sensation strategy likely to be useful for modulating RAI.

FUTURE DIRECTIONS

• Is RAI regulation useful as a therapeutic intervention – behavioural effects?
• Do the effects of neurofeedback persist over time?
• Would composite feedback from functionally connected brain regions be more effective?
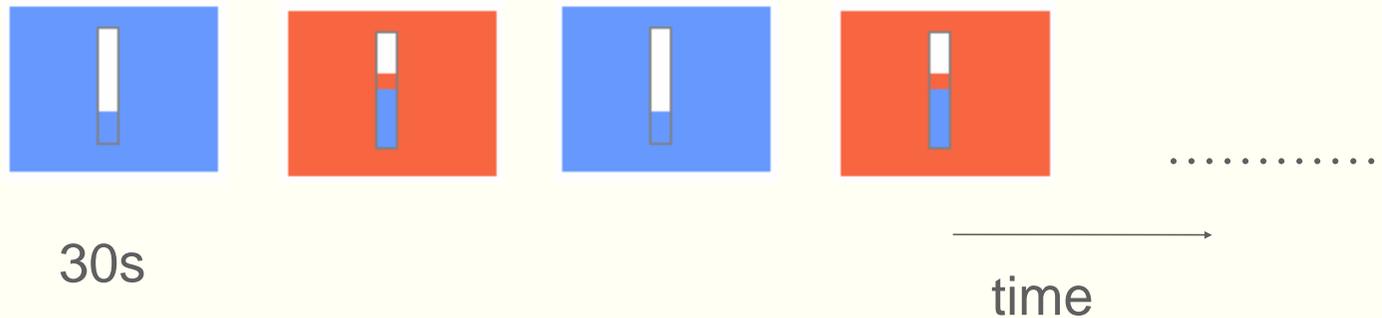
Task Parameters

- Right anterior insula is selected using anatomical criteria

- Blood flow to this region is calculated and shown to participants in the fMRI scanner using a visual gauge.
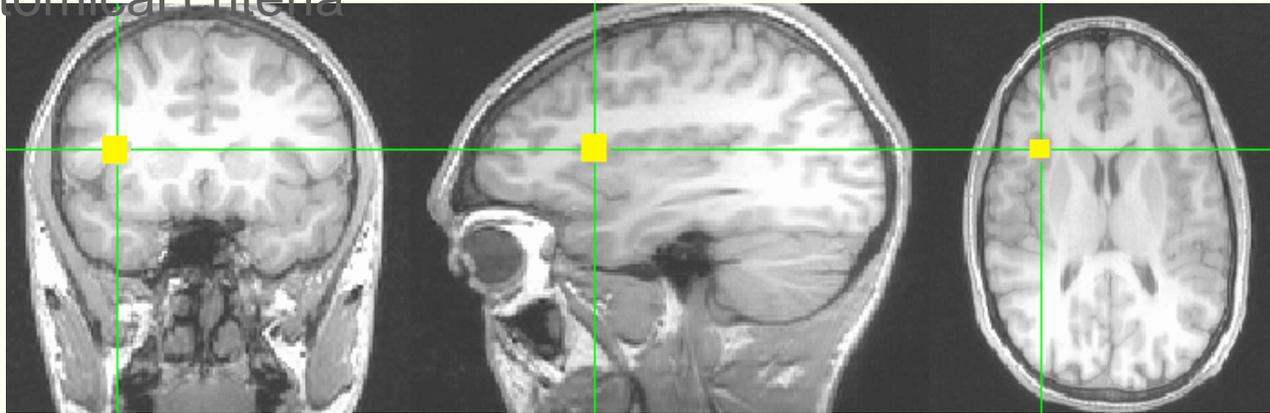
5 interleaved decrease and 5 increase trials

30s

time

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