MANCHESTER 1824

The University of Manchester

Bilateral Brain Function Monitoring

Chris Pomfrett Ph.D (Clinical Scientist)

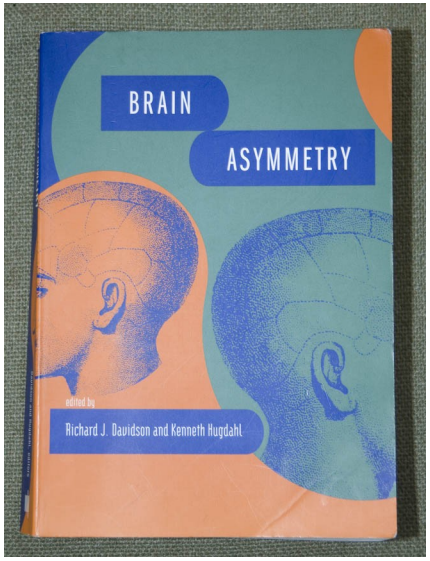
Lecturer in Neurophysiology applied to Anaesthesia

Research School of Clinical & Laboratory Sciences

The University of Manchester

http://www.medicine.manchester.ac.uk/staff/ChrisPomfrett

Davidson R.J., Hugdahl K. eds (1999) *Brain Asymmetry* MIT Press



Selected chapters:

Hemispheric asymmetry, autonomic asymmetry, and the problem of sudden cardiac death Lane, R.D., & Jennings, J.R.

Brain asymmetry in the control of autonomic-physiologic activity Wittling, W.

Anatomic basis of cerebral dominance Galaburda, A.M.

Hemispheric asymmetry for components of visual image processing Brown, H.D. & Kosslyn, S.M.

Handedness and its relation to other indices of cerebral lateralization Peters, M.

Cerebral asymmetry, emotion, and affective style Davidson, R.J.

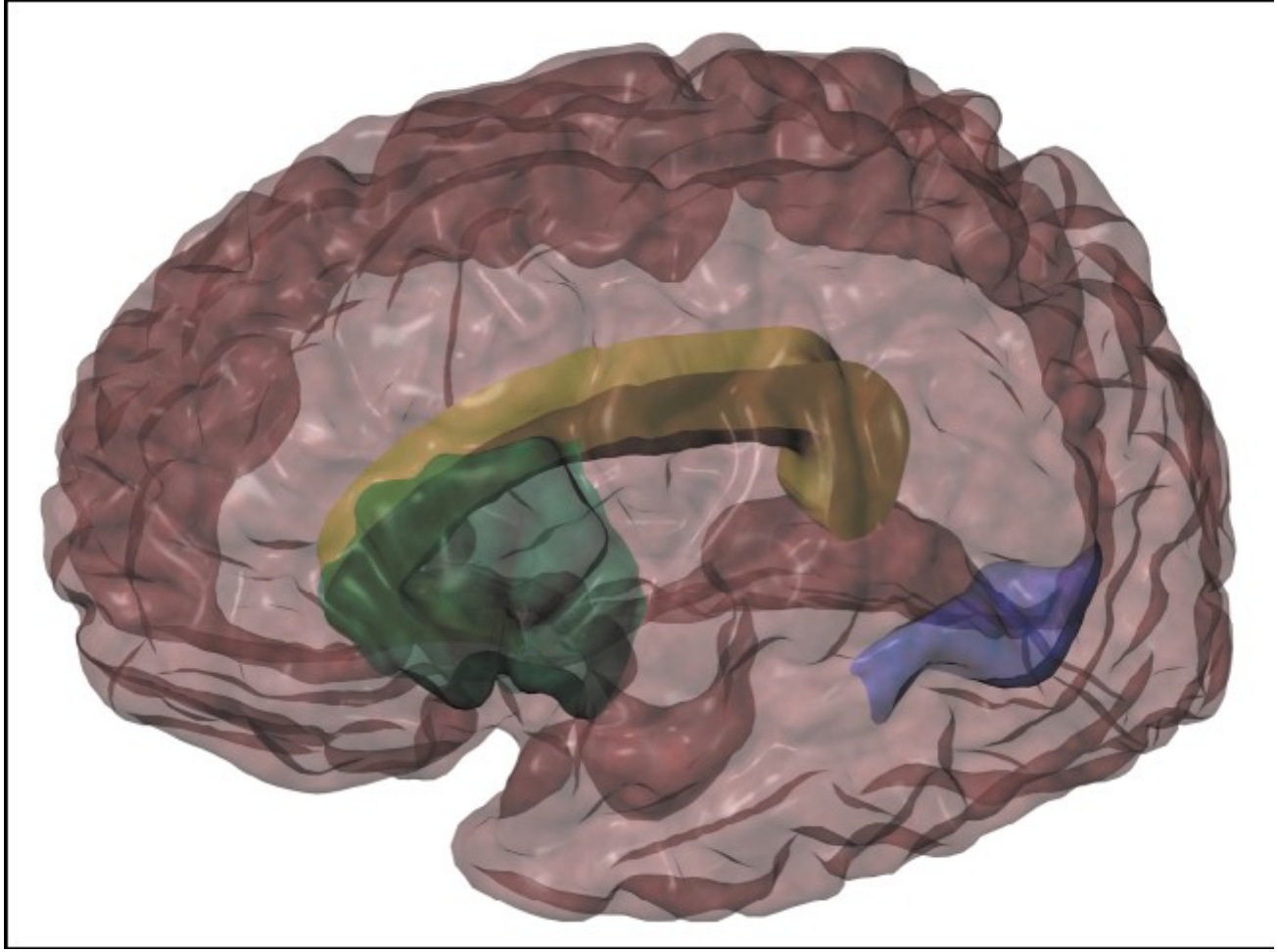


Figure 1 Language areas with anatomical and functional asymmetries. Broca's speech area (green) and Wernicke's language-comprehension area (blue) are identified on a transparent surface model of the human cerebral cortex. All cortical regions are heavily interconnected with corresponding systems in the opposite brain hemisphere, through the corpus callosum (yellow). The language areas show profound asymmetries, both structurally and functionally, the left hemisphere being dominant for language in most right-handed individuals.

From: Toga AW & Thompson PM (2003) "Mapping Brain Asymmetry"
Nature Reviews Neuroscience 4: 37-48

Bilateral Brain Structure, Function & Neurochemistry

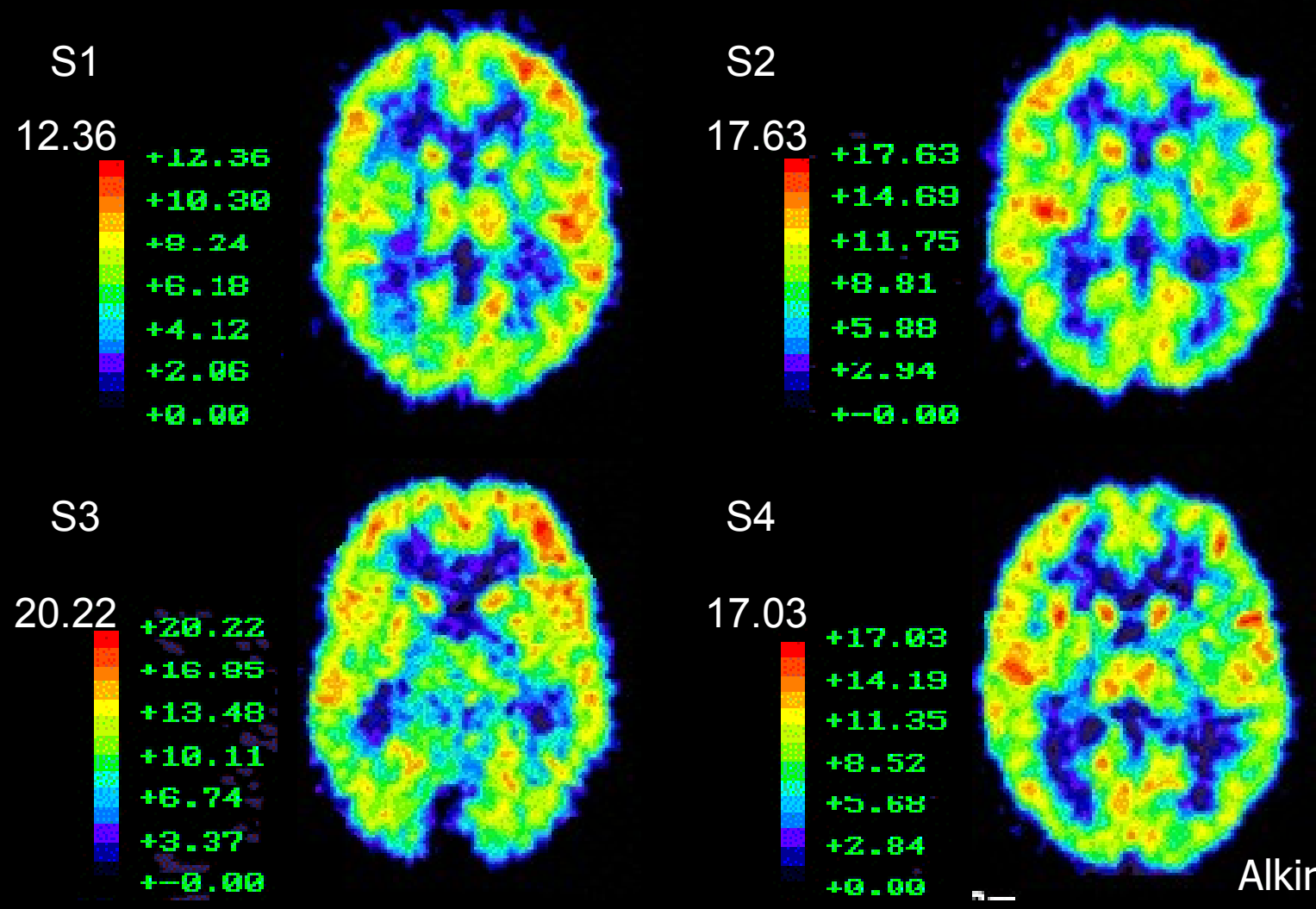
(as seen in the majority of right-handed subjects)

Left Wada test transiently impairs speech	Right Wada test transiently makes singing monotone
Dopaminergic (globus pallidus & basal ganglia)	Noradrenergic (ventro-lateral thalamus)
Language comprehension (Wernicke's area)	Central sulcus larger (primary motor cortex)
Language production (Broca's area)	90% of dyslexics right hemisphere language-dominant
Handedness (planum temporale)	Regulation of cardiac autonomic function (Lane & Jennings, 1995) Brain-heart laterality hypothesis
Semantic dementia & Alzheimer's show increased damage to left side	

From: Toga AW & Thompson PM (2003) "Mapping Brain Asymmetry"
Nature Reviews Neuroscience 4: 37-48

Baseline brain function differs between awake individuals

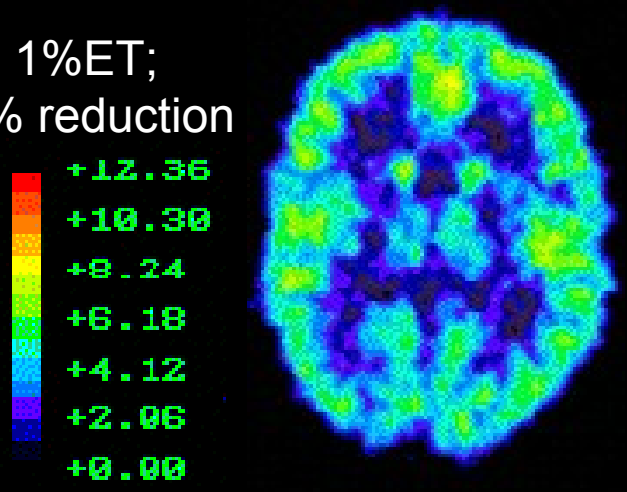
18FDG PET measures absolute brain metabolism (µmoles glucose/100ml/min)



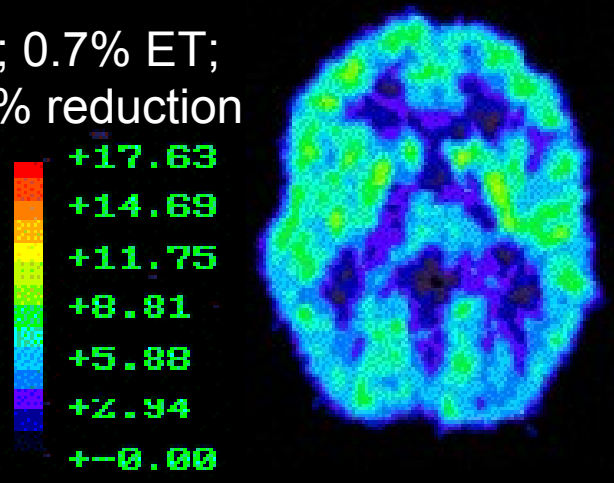
Alkire et al, 1999

Halothane
Loss of response to verbal command

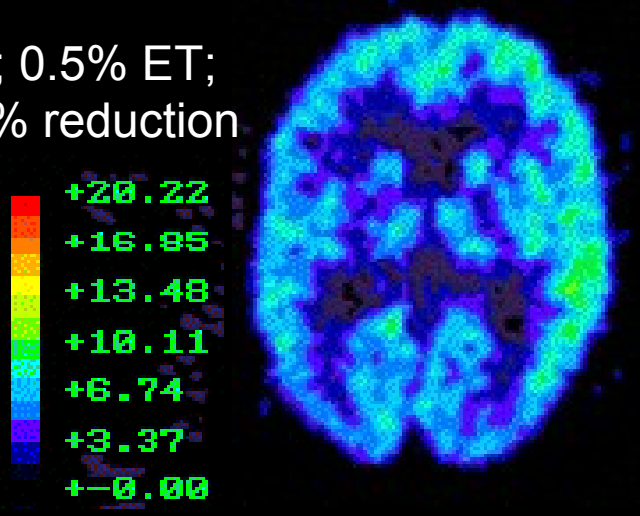
S1; 1%ET;
28% reduction



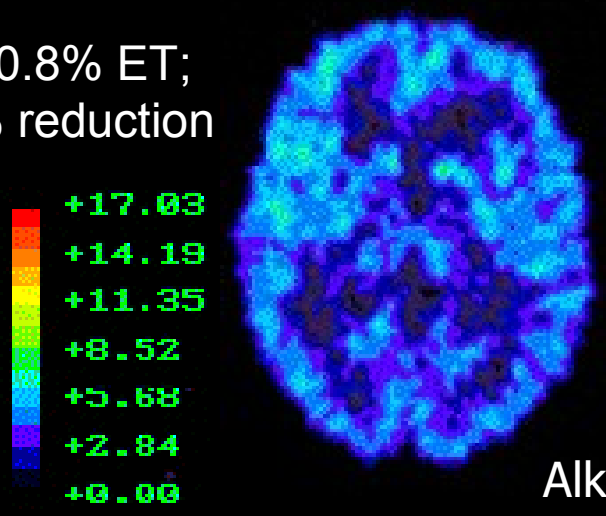
S2; 0.7% ET;
41% reduction



S3; 0.5% ET;
44% reduction



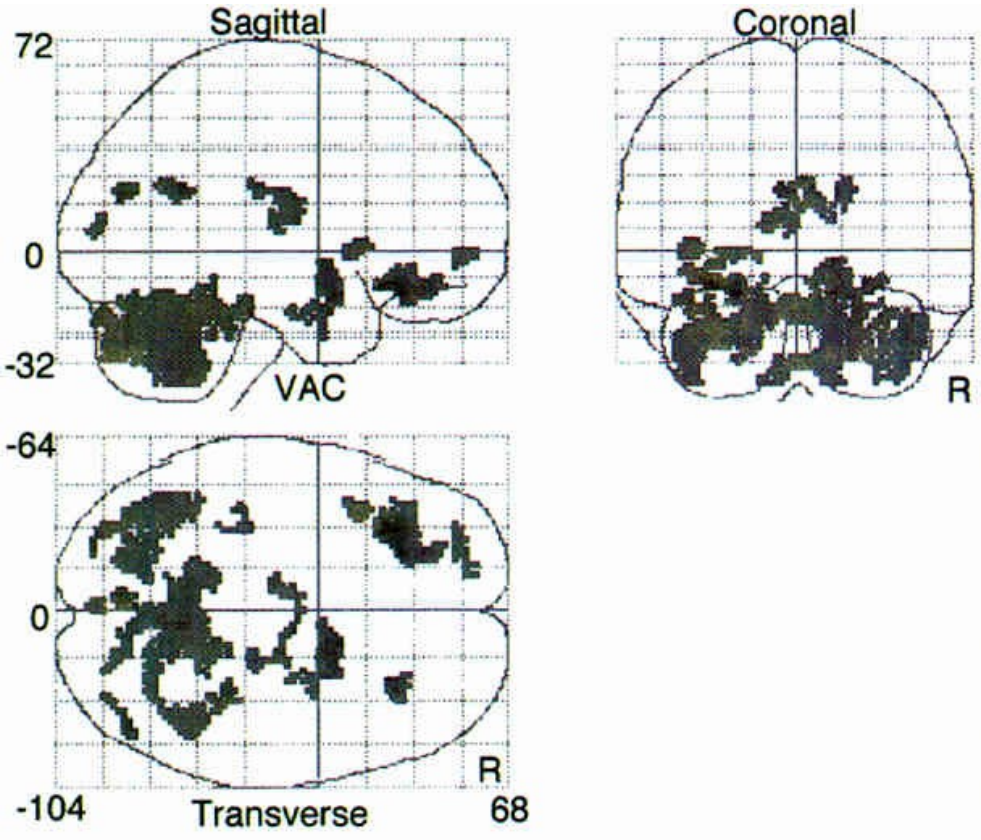
S4; 0.8% ET;
53% reduction

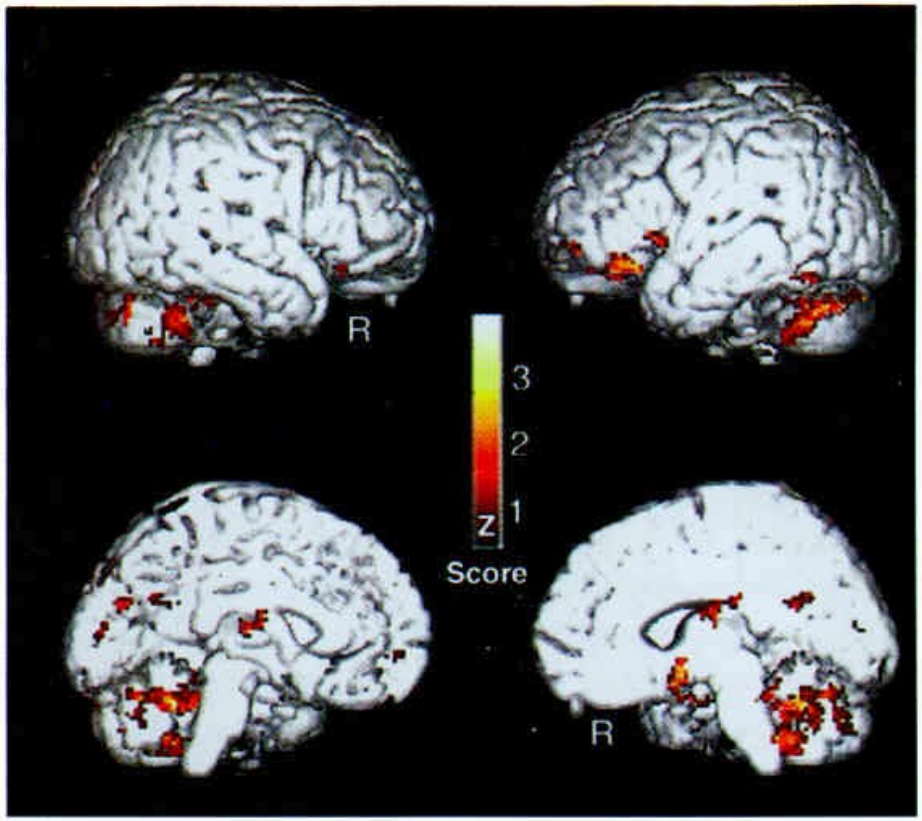


Alkire et al, 1999

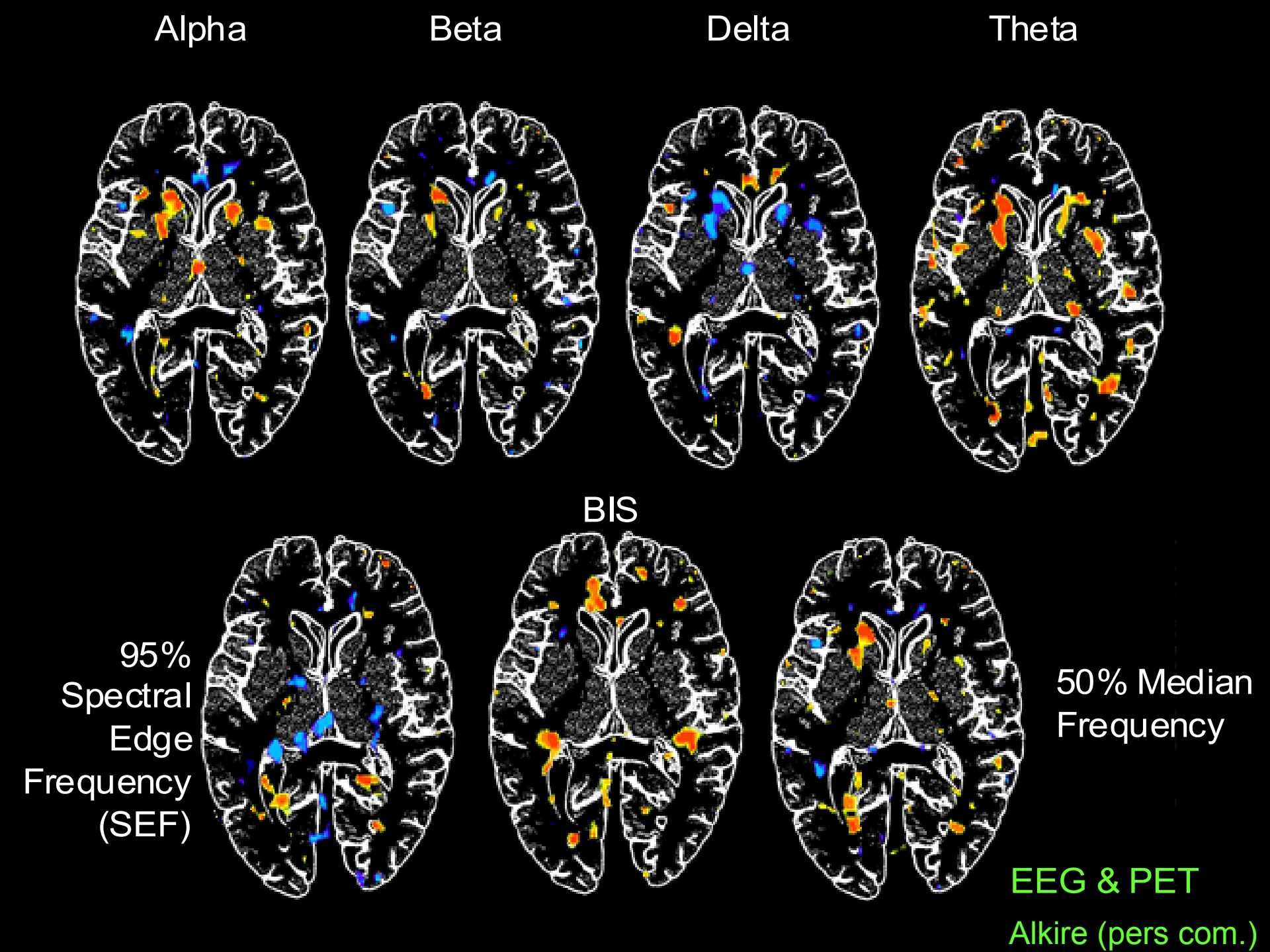
PET functional imaging reveals asymmetry in cerebral metabolic rate

18FDG; SPM p<0.01; significant reductions in glucose metabolism with halothane





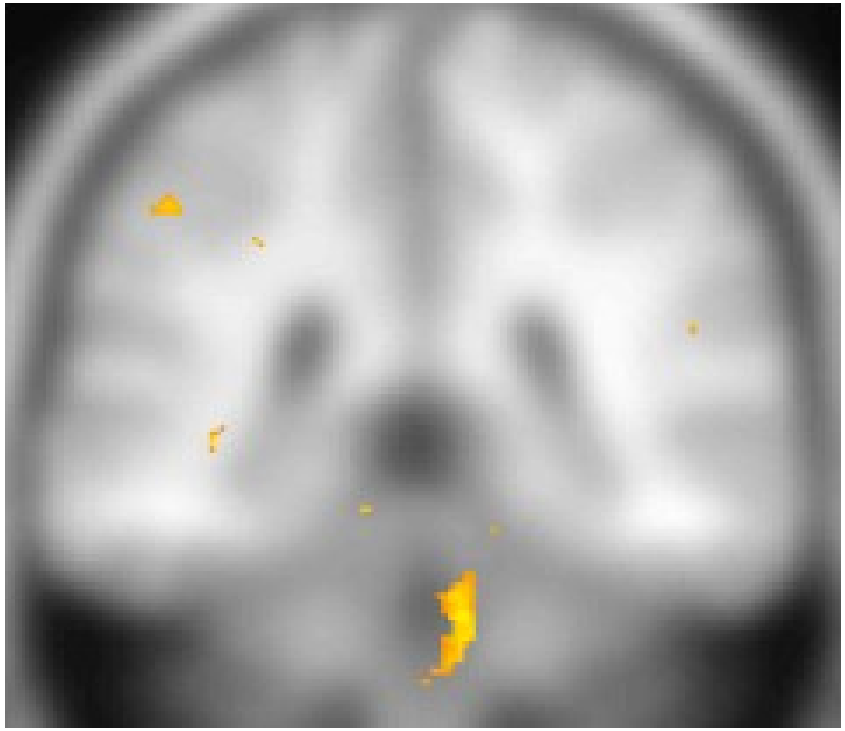
Alkire MT, Pomfrett CJD, Haier RJ, Gianzero MV, Chan CM, Jacobsen BP, Fallon JH. Functional Brain Imaging during Anesthesia in Humans: Effects of Halothane on Global and Regional Cerebral Glucose Metabolism. *Anesthesiology* (1999) **90**(3): 701-709


Alpha
Beta
Delta
Theta
BIS
95% Spectral Edge Frequency (SEF)
50% Median Frequency
EEG & PET
Alkire (pers com.)

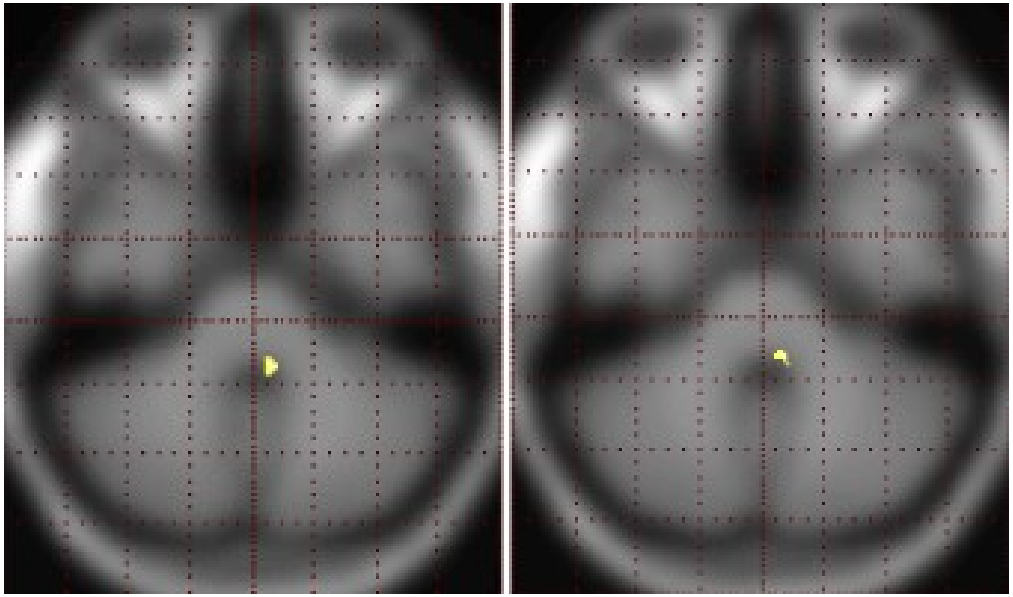
Asymmetry of vagal autonomic function during hypnotic anaesthesia

SPM96 PET Correlation

GMR:Respiratory sinus arrhythmia: ET Isoflurane $p<0.01$



n=6: Coronal



n=6: Transverse

Pomfrett C.J.D., Alkire M.T. (1999) Respiratory sinus arrhythmia as an index of anaesthetic depth in man: evidence from functional imaging studies. *Journal of Physiology* **518**P: 180.

A421

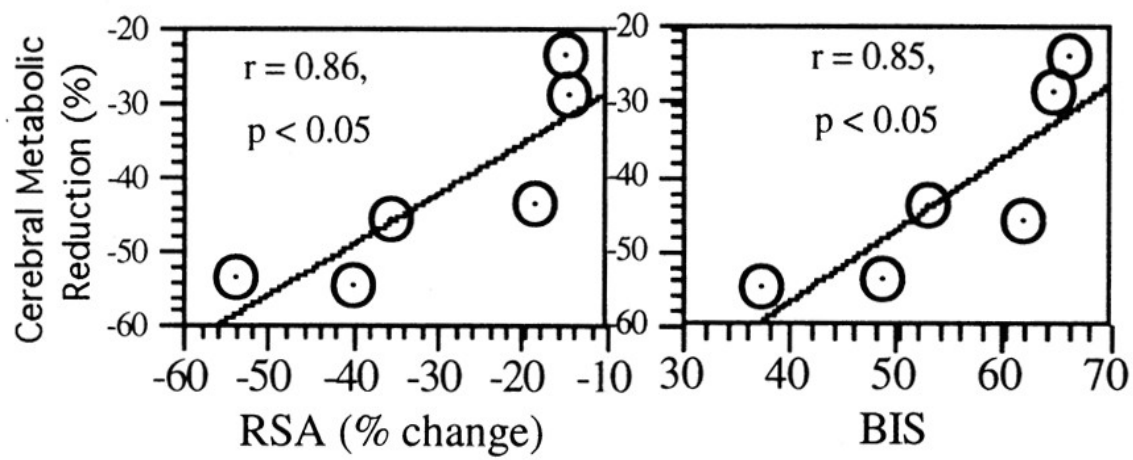
TOWARD A MONITOR OF DEPTH: BISPECTRAL INDEX (BIS) AND RESPIRATORY SINUS ARRHYTHMIA (RSA) BOTH MONITOR CEREBRAL METABOLIC REDUCTION DURING ISOFLURANE ANESTHESIA

M.T. Alkire, M.D., and C.J.D. Pomfrett*, Ph.D.
Department of Anesthesiology, University of California-Irvine, Medical Center, Orange CA. 92668,
* Department of Anaesthesia, University of Manchester, UK.

Introduction: Recent
Tomography (PET) has rev
cerebral metabolic reductic
propofol anesthesia can be c

technique. BIS and RSA data were subsequently correlated with PAMR using Pearson's r coefficient with Fisher's r to z.

Results: Whole-brain PAMR correlated significantly with BIS ($r = -0.85$, $p < 0.05$) and also with the RSA percent change from baseline ($r = -0.86$, $p < 0.05$), as shown below.



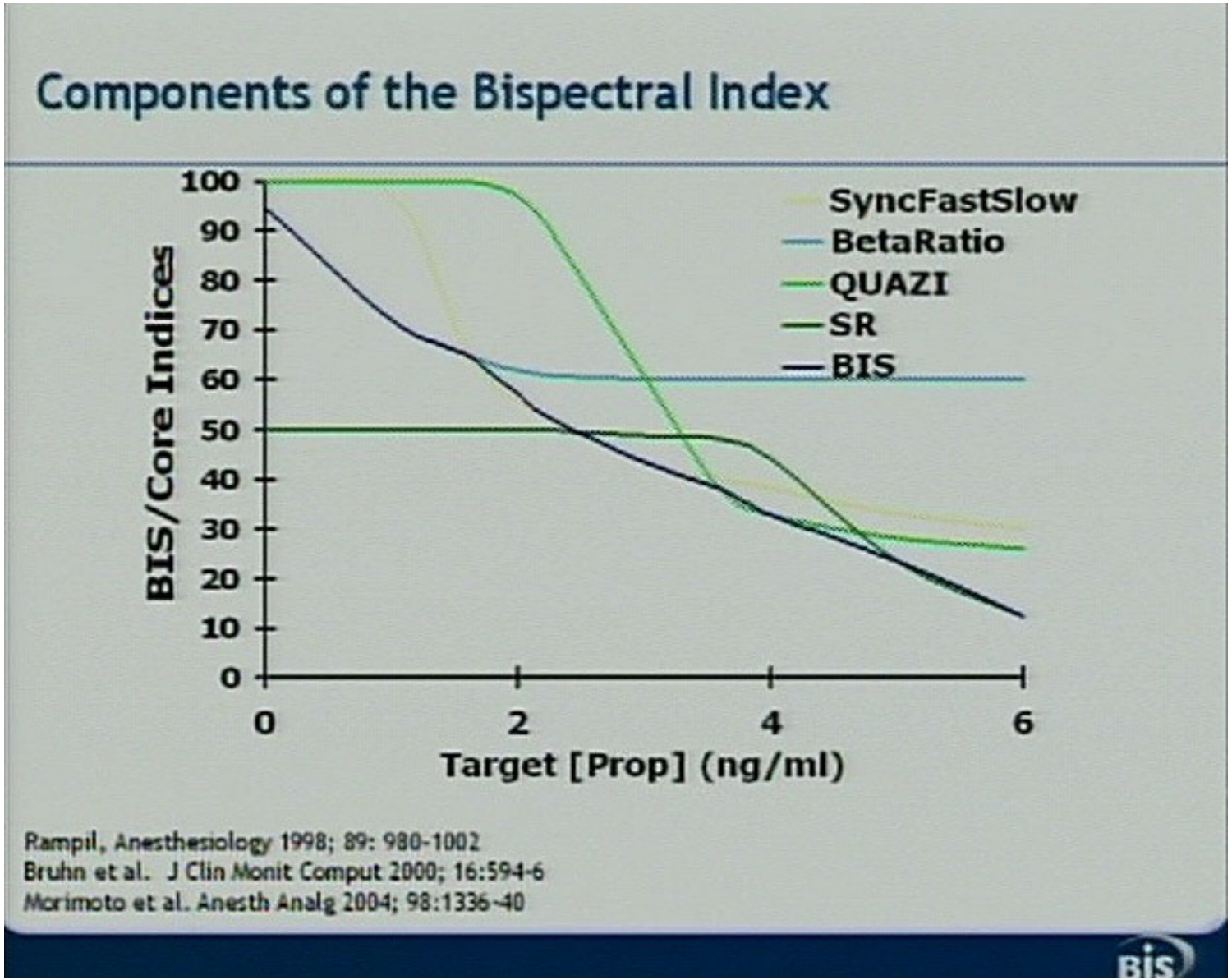
Discussion: These data show that BIS (a construct derived from cortical EEG activity) and RSA (a directly monitored brain-stem physiologic response to anesthesia) are both

Alkire M.T., Pomfrett C.J.D. (1997) *Anesthesiology* **87**(3A):A421


Datex

Nassib Chamoun, inventor of BIS

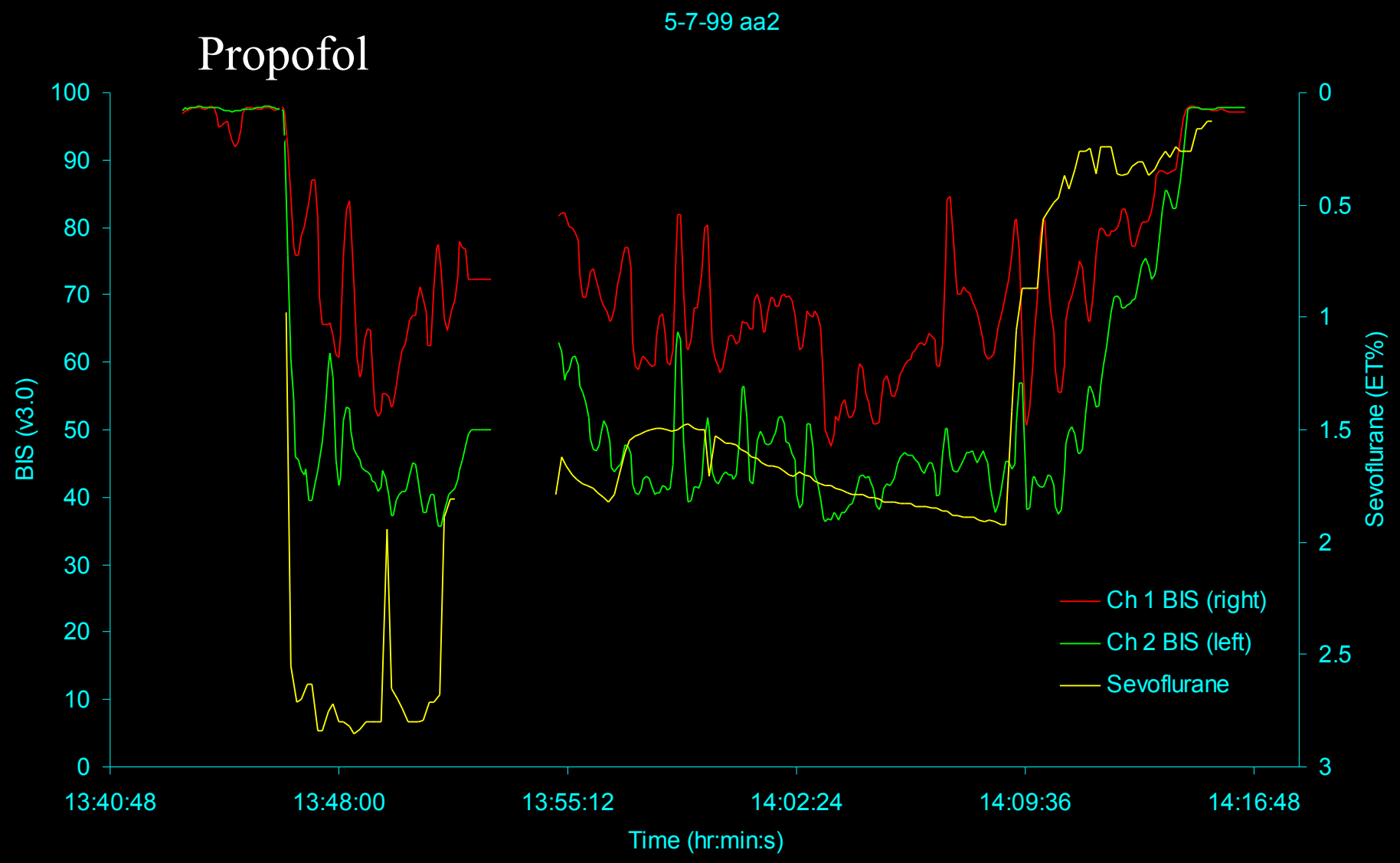
RSM Consciousness & Anaesthesia 12 May 2006



A-1000 headstage

- 2 channel referential montage
- F7(ground) - FP1(left)
- F8(ref) - FP2(right)

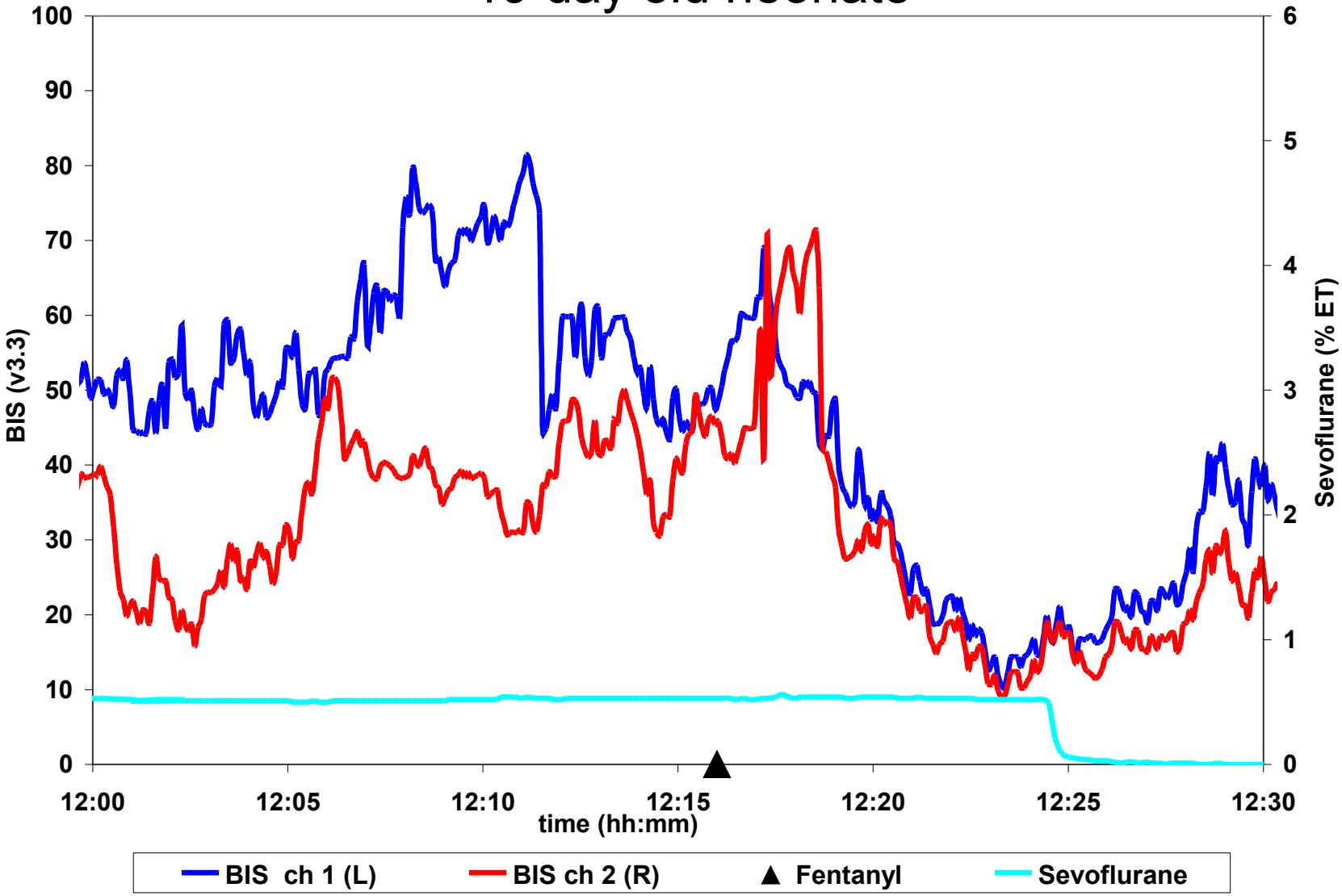
BIS asymmetry after induction (n=3/19)



(Pomfrett/Pollard/Longmuir/Kapila, MAA, NYC 2001)

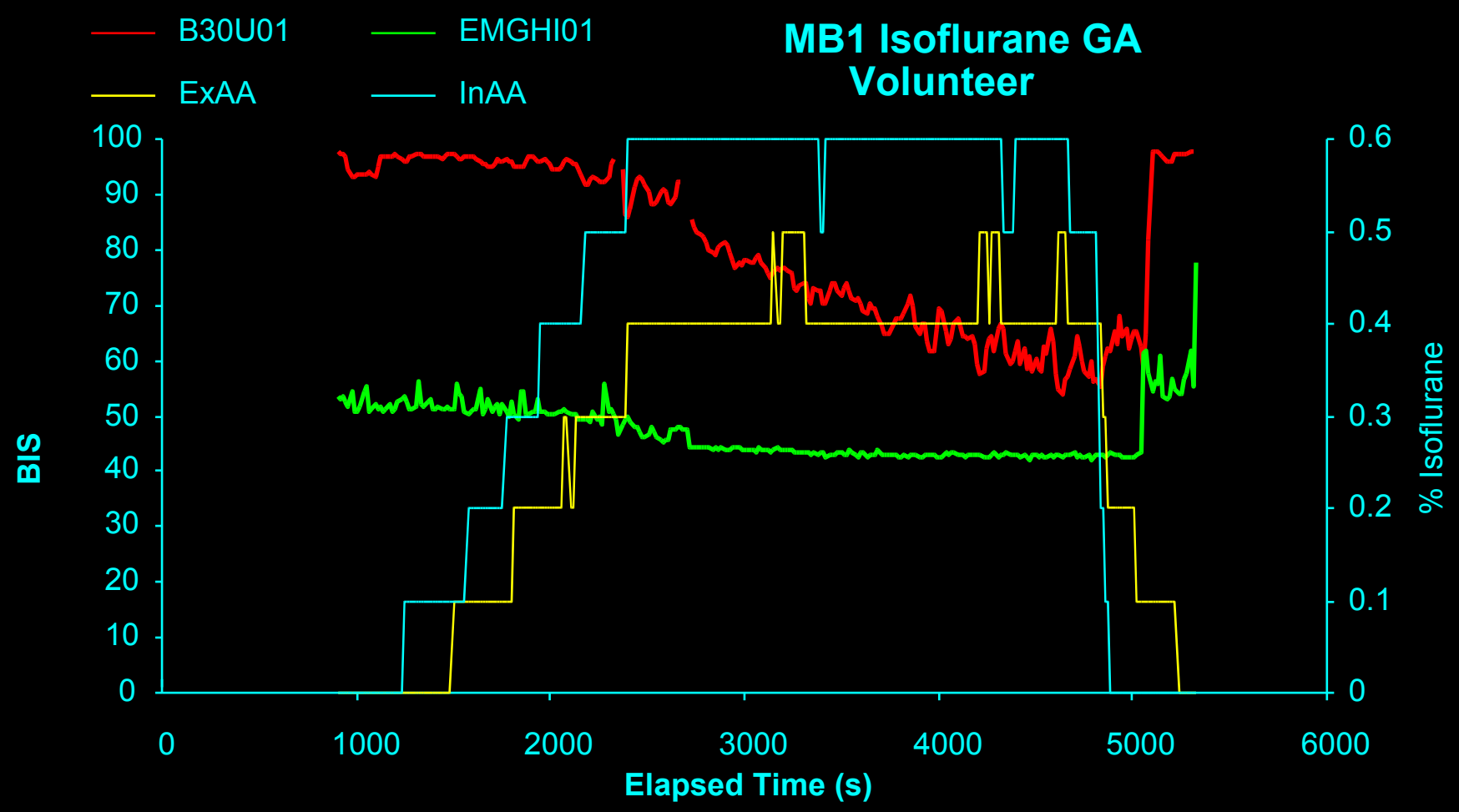
BIS asymmetry

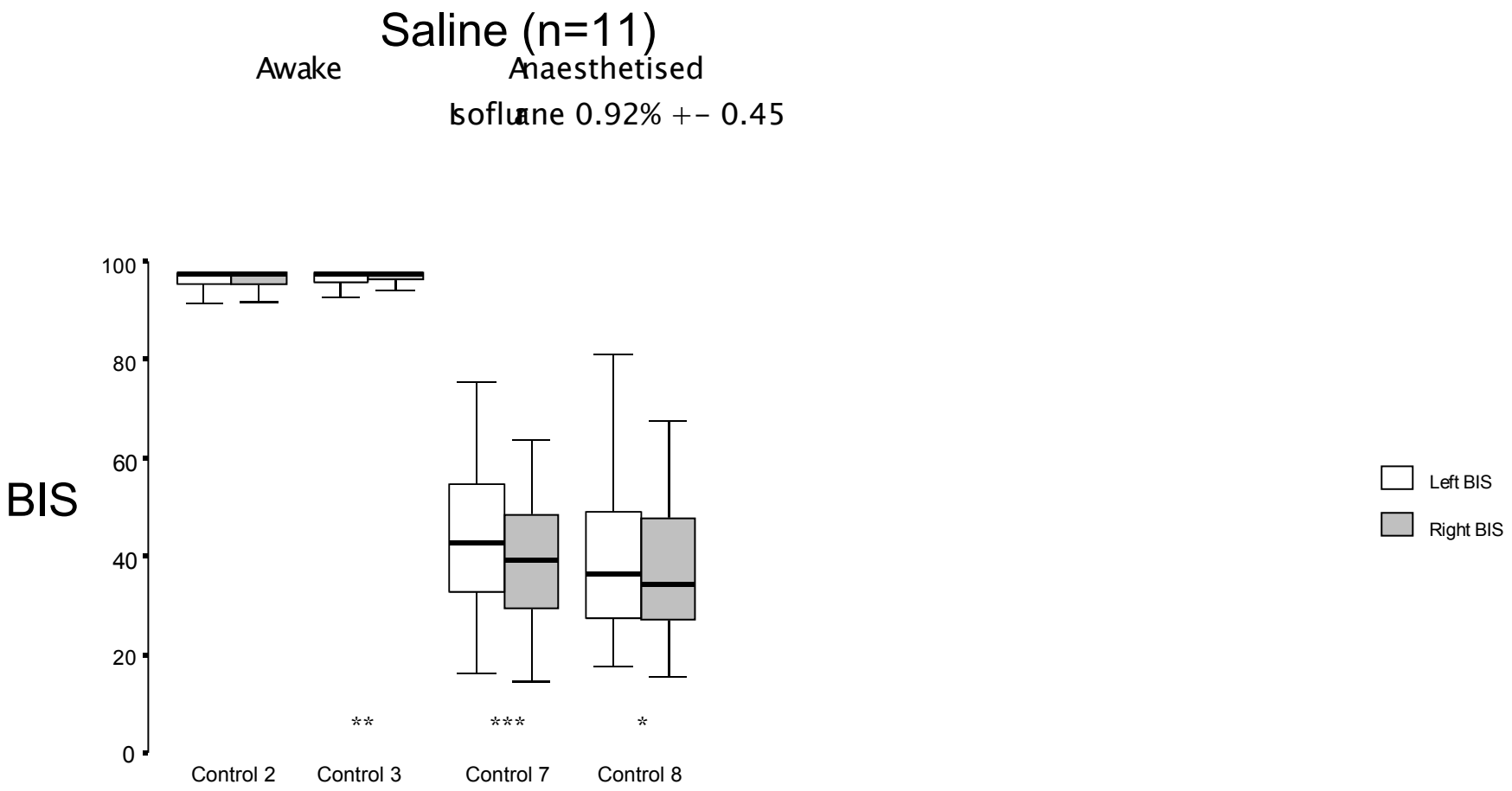
19 day old neonate

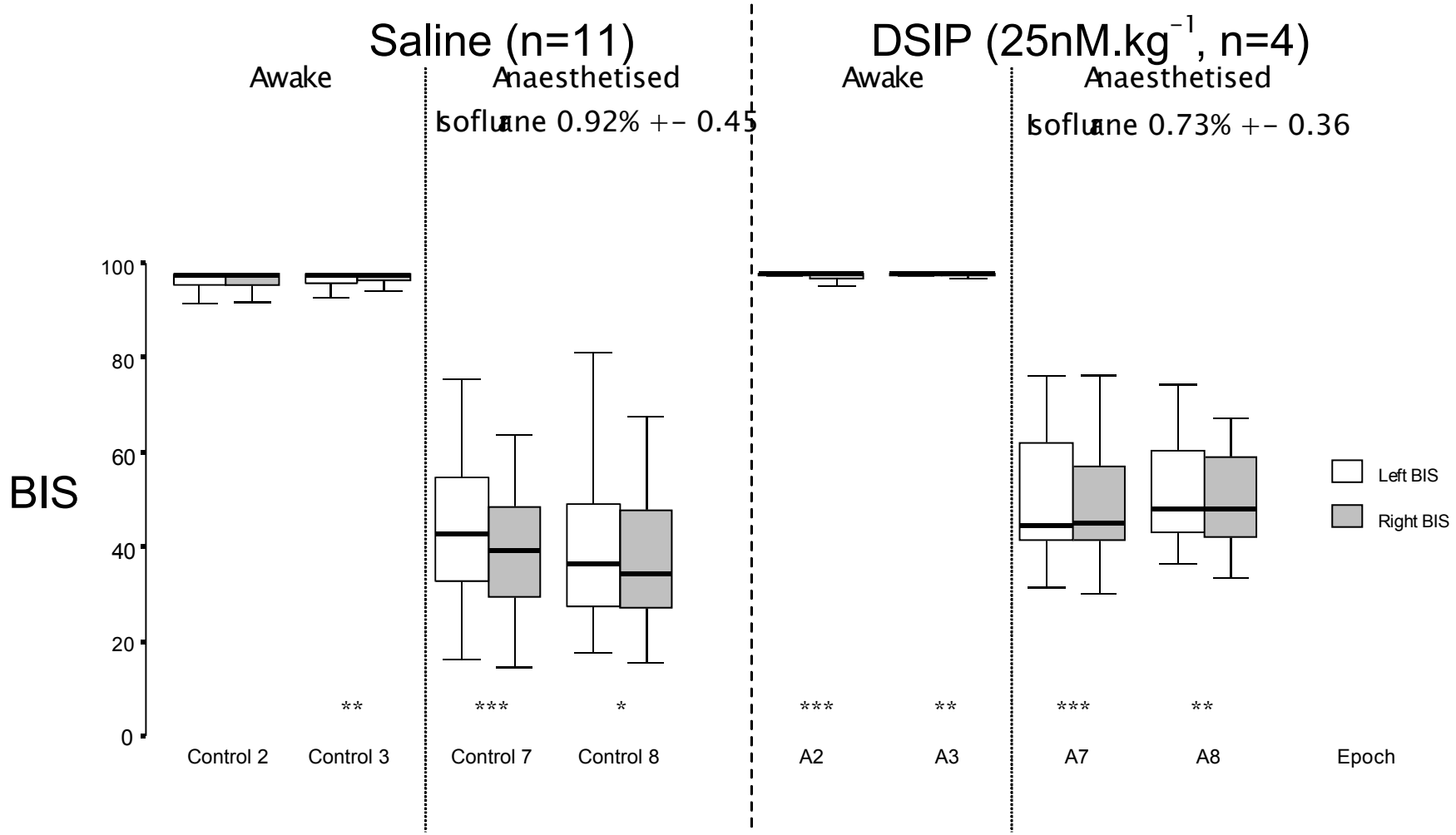


Bryan et al pers.com.

Effect of fEMG on BIS




Saline (n=11)
Awake
Anaesthetised
Isoflurane 0.92% +- 0.45
BIS
100
80
60
40
20
0
**
***
*
Control 2
Control 3
Control 7
Control 8
Left BIS
Right BIS


Saline (n=11)
DSIP (25nM.kg^{-1}, n=4)
Awake
Anaesthetised
Isoflurane 0.92% +- 0.45
Awake
Anaesthetised
Isoflurane 0.73% +- 0.36
BIS
100
80
60
40
20
0
**
***
*
***
**
***
**
Control 2
Control 3
Control 7
Control 8
A2
A3
A7
A8
Epoch
Left BIS
Right BIS

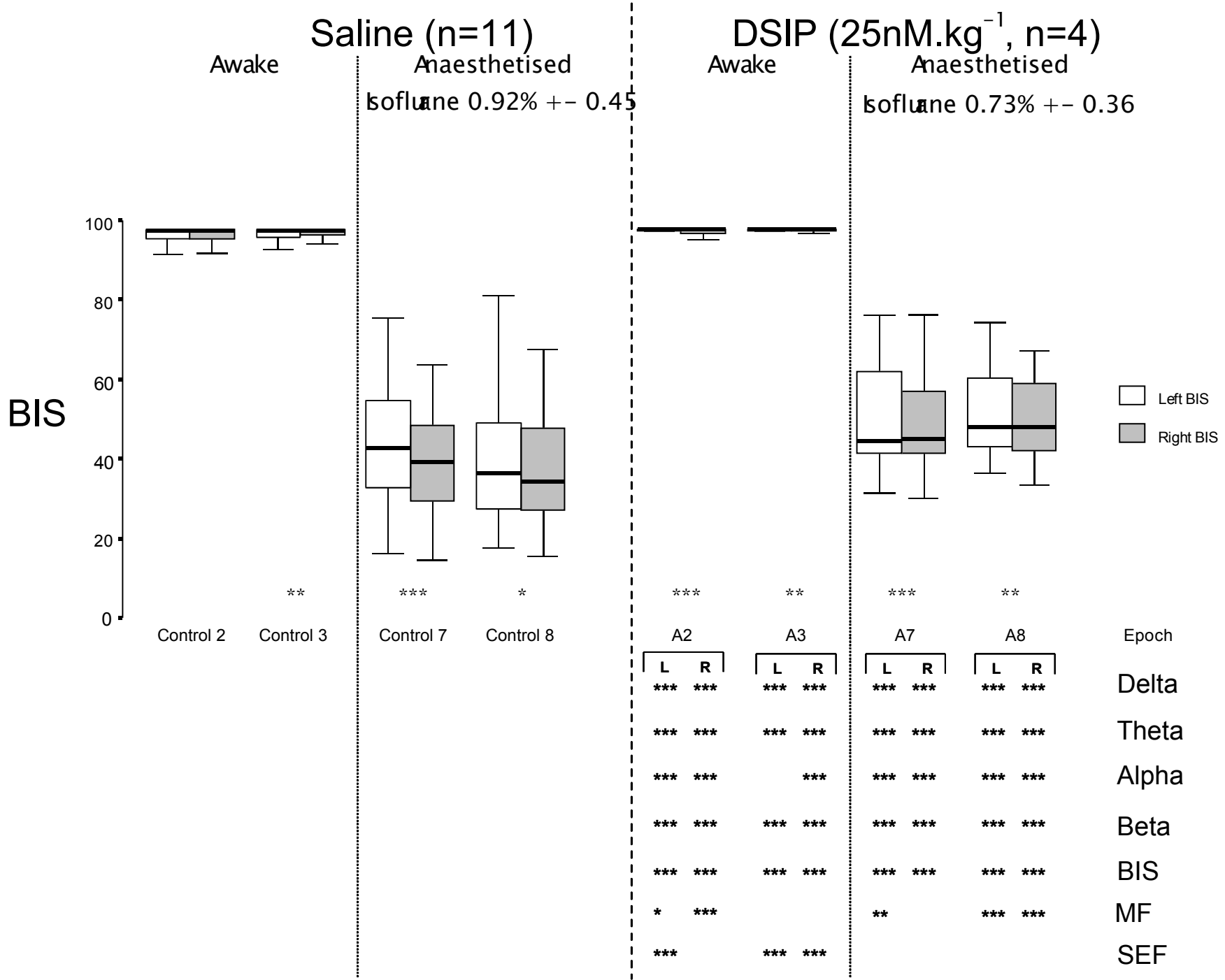

Saline (n=11)
DSIP (25nM.kg^{-1}, n=4)
Awake
Anaesthetised
Isoflurane 0.92% +- 0.45
Awake
Anaesthetised
Isoflurane 0.73% +- 0.36
BIS
100
80
60
40
20
0
Left BIS
Right BIS
Control 2
Control 3
Control 7
Control 8
A2
A3
A7
A8
Epoch
L
R
Delta
Theta
Alpha
Beta
BIS
MF
SEF

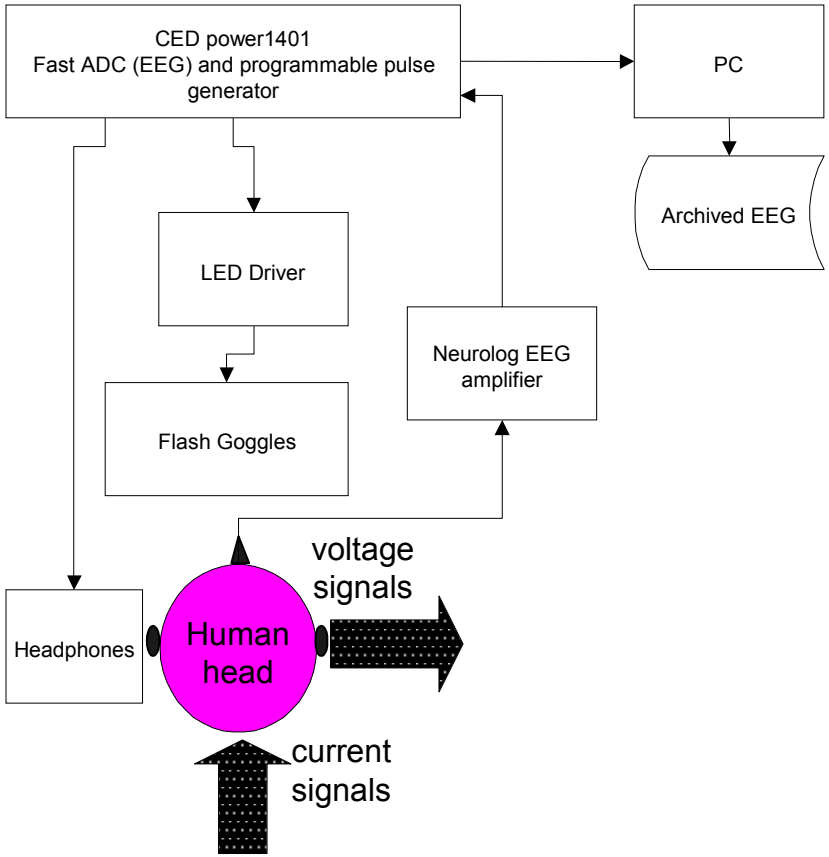
Figure 1. Aspect's VISTA Monitor™ and bilateral sensor (under development). The analysis herein used data collected using individual electrodes placed to collect bilateral single-channel EEG for BIS 3.4 processing.

Paul Manberg, Ph.D. , Hongmei Cai, Ph.D., and Scott Greenwald, Ph.D. pers comm.

Electrical Impedance Tomography (EIT)

- Array of voltage measurements
- Detects conductance changes as current flows through tissue
- Pairs of current injection and recording electrodes
- Portable
- Relatively inexpensive
- High temporal resolution
- Poor spatial resolution

fEITER
functional EIT from evoked response

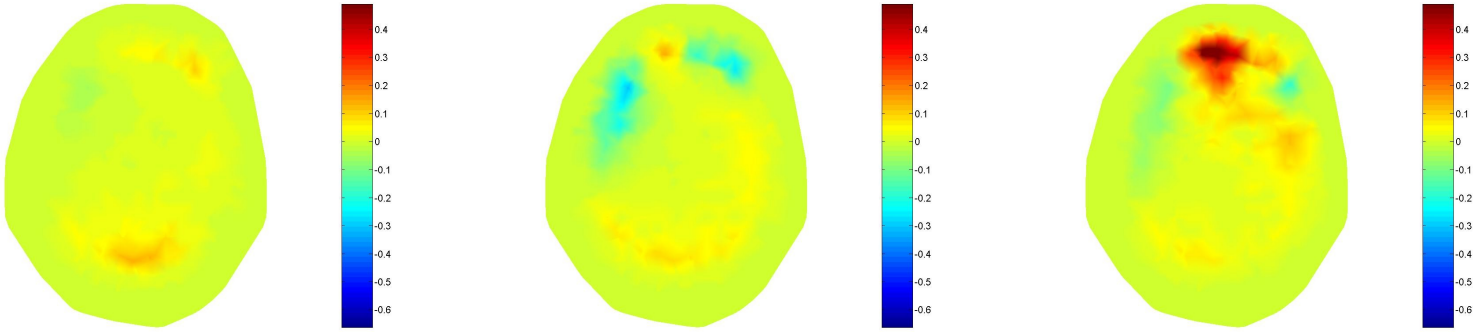


fEITER sub-second response to flash visual stimuli

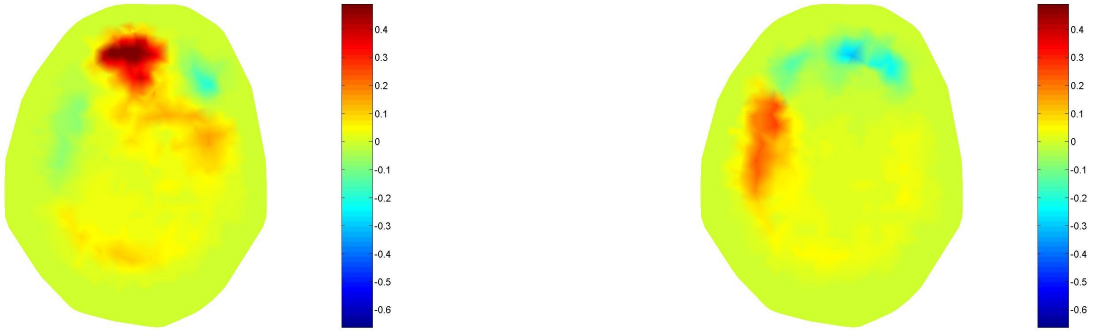
n = 1 relative to no-flash control

Team:

H McCann, N Polydorides, J C Murrieta-Lee, PCW Beatty, R Waterfall, C Mussel, CJD Pomfrett



A 71 ms **B** 126 ms **C** 193 ms



D 240 ms **E** 334 ms

Conclusions

- The brain has asymmetry of some basic function e.g.
  - Handedness
  - Speech & language
  - Autonomic control
- Bilateral function changes dynamically during some clinical interventions e.g.
  - Anaesthesia
  - Analgesia
  - Administration of one endogenous regulatory peptide
- Monitoring bilateral brain function is of interest for future study

MHRA

- All commercial monitors of anaesthetic depth to be placed on the market in the UK since 2003 need MHRA approval (competent body for the EU Medical Device Directive and CE marking)
- Portfolio of evidence for safety and efficacy
- Similar to US FDA 510k approval process
- Restricts usage to approved consumables and instructions
- Restricts development of commercial products by clinical researchers