Individual differences in cortical GABA concentrations and motor excitability

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Introduction

Magnetic resonance spectroscopy (MRS) can provide estimates of γ-aminobutyric acid (GABA) content in vivo.

GABA content within brain areas is reliable across hours, days, and weeks (Evans et al., 2010; Bogner et al., 2010; O’Gorman et al., 2011; Geramita et al., 2011; Near et al., 2014).

Q1: Do individual differences in GABA content in one brain area predict differences in another brain area? Transcranial magnetic stimulation (TMS) offers a tool to assess motor excitability. Resting motor threshold (RMT) is defined as the stimulation intensity required to elicit motor evoked potentials (MEPs) on 50% of trials. This individualized measure is highly reliable; hypothecized to reflect a combination of anatomical and physiological factors.

One study has reported a relationship between individual differences in resting motor excitability and GABA content in motor cortex (Stagg et al., 2011).

Q2: Is the relationship between GABA content and motor excitability specific to motor cortex? We tested 28 participants (21.8 ± 4 years old, all male) at four separate visits. GABA MRS measurements were acquired at two visits from four cortical voxels, and RMT was assessed at two separate visits.

Methods

MRS Methods
• 3T Siemens TIM/Triac 32-channel coil
• Two visits (16 ± 3 days apart)
• Cortical MEGA-PRESS voxels prescribed in T1-weighted images:
  1. Lateral prefrontal cortex (LPF)
  2. Primary sensorimotor cortex (M1)
  3. Dorsal premotor cortex (PMd)
  4. Occipital cortex (V1)
• Two scans of 160 measures
• Preprocessing:
  1. Zero-filled
  2. Apodized (4 Hz gaussian)
  3. Phase corrected & freq. aligned
• Peak integration for GABA+ & Cretaive

LPF M1 PMd V1

Transcranial Magnetic Stimulation (TMS) Methods
• Same participants: two visits (13.7 ± 2.5 days apart)
• Single-pulse TMS (7 cm figure-eight coil) targeted at right M1.
• Electromyography was recorded from the left first dorsal interosseous (FDI) muscle
• RMT: TMS intensity that elicited MEPs on 5 of 10 attempts.

Results

GABA:Cr is Reliable Across Sessions

- Good reliability in all four brain areas. The unity line is shown as a diagonal dotted line, with blue dashed lines indicating 95% C.I.
- V1 data was only acquired at both visits for a subset of participants due to time constraints.

RMT was Highly Reliable Across Sessions

- Negative correlation between RMT and GABA:Cr in M1.
- Countervailingly, higher concentrations of total GABA in M1 is associated with greater corticospinal excitability (lower threshold).
- Individuals with more excitable corticospinal pathways may require a larger reserve of M1 GABA to counteract a lower threshold for triggering corticospinal volleys.

Conclusions

Individual differences in local GABA concentrations are reliable, but not uniform across the cortex. This may reflect intrinsic (e.g., genetic) or environmental (e.g., use-dependent) factors.

Individual differences in resting motor threshold are related to physiological factors (e.g., local GABA concentrations), and are not only due to anatomical factors (e.g., skull thickness).

References & Acknowledgements


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