Ultra High Field, High-Resolution Neuroimaging in Adolescents

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There is a gap in the literature regarding ultra high-field (> 3 Tesla), high-resolution (< 2mm voxel resolution) functional neuroimaging in adolescents. Ultra high-field, high-resolution imaging can greatly improve sensitivity (through increases in signal-to-noise-ratio) and image quality, but it is not yet certain how traditional pre-processing steps may alter activation outcomes in this newer method of neuroimaging. This study begins to address the variability in pre-processing pipelines for 7T functional magnetic resonance imaging (fMRI) data collected from adolescents. Common preprocessing pipelines include smoothing, motion correction and slice time correction. Smoothing reduces the effect of noise and/or artifacts and improves signal to noise ratio (Darki & Oghabain, 2013). Motion correction uses algorithms to limit the effect of movement during scanning sessions (Johnstone et al., 2006). Slice time correction shifts the collected image slices by a given amount to temporally align the data (Sladky et al.,
2011).

Data were collected from 19 adolescent participants during an inhibitory Go/No-Go task in Auburn University's Siemens 7T MAGNETOM scanner (sequences had the following parameters: 37 slices acquired parallel to the AC-PC line, 0.85mm x 0.85mm x 1.5 mm voxels, TR/TE: 3000/28 ms, 70° flip angle, base/phase resolution 234/100, A > P phase-encode direction, iPAT GRAPPA acceleration factor 3, interleaved acquisition). The inhibitory Go/No-Go task presented the participants with either an X or Y stimulus. The X cued the participants to perform a motor response (go) by hitting a button on a response box, and the Y cued the participants to inhibit a response (no-go) by refraining from pressing the response button. All data were processed in FMRIB Software Library.

To establish the effects of smoothing, the Gaussian smoothing kernel size was adjusted (0 mm, 1 mm, 3 mm, and 5 mm) while all other components were held constant. Then, the effects of motion correction and motion correction with slice time correction were tested while smoothing was kept at 5 mm. Data analysis showed a pattern of growing activation connected to the increase of the smoothing kernel size, with 0 mm smoothing showing the least activation and 5 mm showing the most activation. Similarly, adding motion correction and/or slice time correction to smoothing at 5 mm further increased the size and location of activation patterns.

The adolescent population is rarely investigated using ultra high field, high- resolution neuroimaging. Working with adolescents as participants added a layer of complexity due their propensity to move more than adults during scanning sessions. Small movements during the scans, such as eye movements or breathing, can have an effect on image outcomes when using submillimeter means. While motion correction is intended to account for such small movements, the movement produced in adolescent scanning sessions could be much bigger, contributing to the growing of activation patterns produced in the various pipelines addressed above. The results demonstrate how traditional processing pipelines used on submillimeter neuroimaging can easily effect the size, extent, and even location of activation across all slices collected. Interestingly, the effects of pre-processing pipelines appear to be more pronounced using high-resolution data compared to lower resolution data. This study suggests that although using ultra high field, high-resolution imaging increases the magnetic field strength and allows for improvements in sensitivity and spatial resolution, there is an underlying uncertainty concerning the accuracy of the continued use of traditional smoothing, motion correction, and slice time correction on such data. Future research is needed in order to address the implications of pre-processing pipelines on ultra high-field, high-resolution data along with potential standardization of processing steps across neuroimaging research.

Statement of Research Advisor:

Anna has been a true pleasure, and exemplifies an undergraduate research fellow. Her research has addressed a critical gap in the literature and we look forward to publishing the results in the coming weeks.

–Jennifer Robinson, Psychology

References:

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