A2CPS
Acute to Chronic Pain Signatures

Imaging MRIQC Summary

Use of the MRIQC MRI Quality Package
(and other tools)

Image Quality Measures (IQMs)

- MRIQC and other tools generate “image quality measures” (IQMs)
  - Signal and noise: signal to noise ratios (multiple versions), contrast of gray and white matter vs. noise
  - Motion-related effects: framewise displacement, motion “spike” counts
  - Measures intended to capture predictable artifacts like ghosting
- Variations in scanners and other factors make comparison of IQMs between sites imperfect
  - Comparisons can still be useful to understand sources of differences
  - The primary aim is comparisons within each site’s scans (outlier detection), which will become better as scans accumulate

Quality Checking Process

- Manual review of every image is not realistic, but manual review is still essential
  - We have followed UK Biobank's hybrid approach: automated IQM-based flagging of possible concerns (outliers), with manual followup
  - False positives in IQM flagging are expected, and acceptable (we want maximum sensitivity, but don't need specificity to be as high)

- IQMs are generated by multiple tools, primarily MRIQC
  - MRIQC: specialized package incorporating measures from the literature for anatomic and functional MRI scans
  - QSIPrep: DWI specific measures
  - FreeSurfer, CAT12 (in process): additional anatomic MRI measures

Parameter Checking

- In addition to checking image **contents**, need to assess **parameters**
  - An additional set of checks verifies scan parameters (TE, TR, etc.)
  - These are again comparisons made within each site

- Some degree of variation is expected
  - For example, when slice thickness is set to 2.4 mm, we may see
    2.4000000122906
    2.3999999424197
    2.4000000143951
    as well as 2.4 – this may depend on the scanner
  - We look for 3 s.d. differences, imposing an additional tolerance level (typically 0.01 or 0.001) based on experience

Notable Issues

- This group had noted several discrepancies in IQMs across sites
  - Very high anatomic MRIQC SNRd at Univ. Chicago site
  - Low MRIQC SNRd for anatomic scans at other sites
  - Systematically higher ghosting measure (MRIQC GSR) on NorthShore fMRI scans
- Between site differences do not interfere with our monitoring approach but are worth understanding

High SNRd at UChicago

- MRIQC SNRd [Dietrich et al. 2008] compares brain signal to background (air) noise

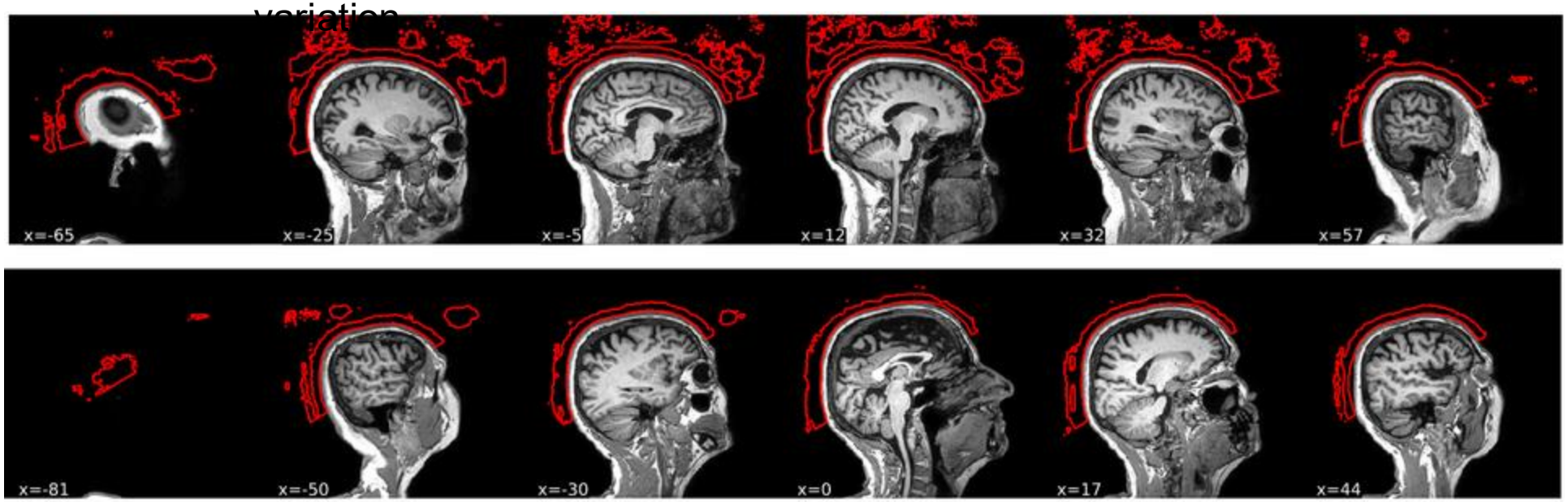
- Two factors are at work in UChicago scans:
  - When using SENSE, the background region is thresholded out as much as possible from coil sensitivity maps, leading to negligible signal
  - In MRIQC, the air region is sampled using a complement to the head mask, omitting slices below a certain level and omitting all zero voxels

High SNRd at UChicago

- The result is variable air masks that tend to sample from the “noise corona” around the head

- If zeros were included, the noise sample would be even lower (and the SNRd even higher)!

MRIQC air masks for two UChicago scans, showing variation

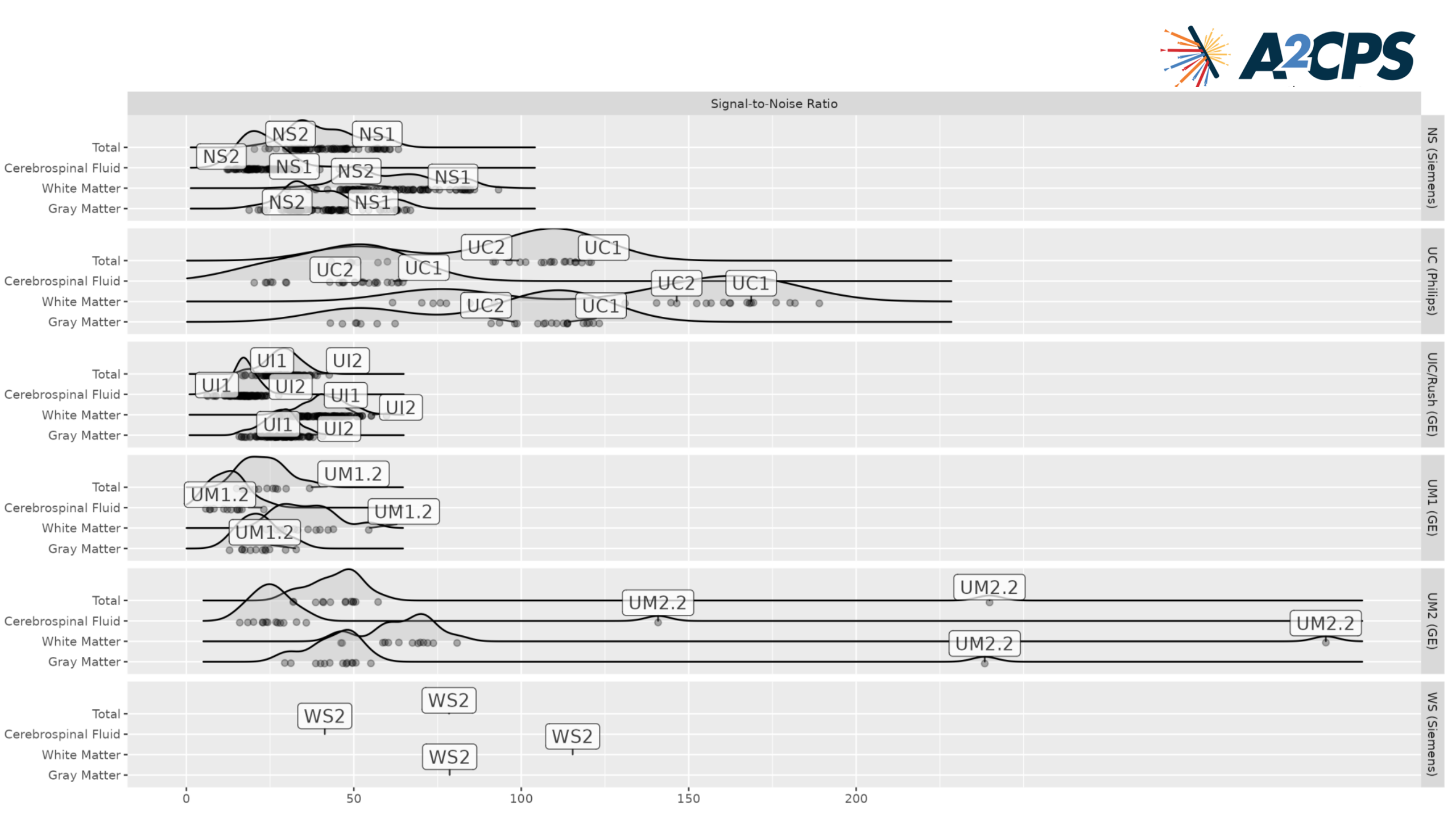


Low SNRd in General

- As shown with UChicago data, SNRd estimate is generally *not* an accurate estimate of true SNR
  - The background air region can be variable
  - The brain mask is also imperfect
  - The effects of parallel imaging and scanner processing can't be properly accounted for
- It **is**, however, still an effective IQM when compared only within site

Comparison to Traveling Human Scans

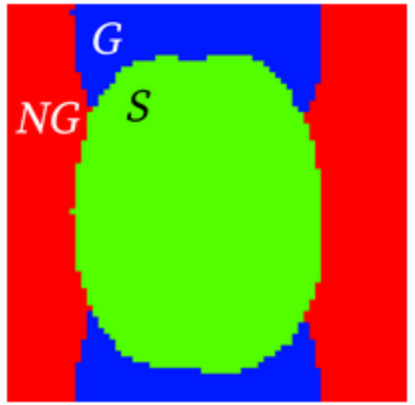
- The original MCC1 “traveling human 1” scans were judged visually to have good SNR
- We can compare “traveling human 1” and “traveling human 2” values to study subjects to confirm quality is equivalent
  - *Note*: *On MCC2/UM scanner 2 scan of traveling human 2 (UM2.2), we do not have a raw T1w image, only one with scanner denoising*


A2CPS
Signal-to-Noise Ratio
Total
Cerebrospinal Fluid
White Matter
Gray Matter
NS2
NS1
NS (Siemens)
UC2
UC1
UC (Philips)
UI1
UI2
UIC/Rush (GE)
UM1.2
UM1 (GE)
UM2.2
UM2 (GE)
WS2
WS (Siemens)
0
50
100
150
200

High GSR in NorthShore fMRI Scans

- The Ghost-Signal Ratio (GSR) is intended to be sensitive to ghosting
  - Checks for signal in a “ghost prone region” (G) and compares to a comparison region (NG), normalized by brain signal (S)
  - Not necessarily specific to ghosting
- NorthShore fMRI scans may have higher “G” signal for at least two reasons:
  - Coil sensitivity (since this is a 64 channel Siemens headcoil, and we do not use Prescan Normalization)
  - Phase wrapping effects due to tight FOV

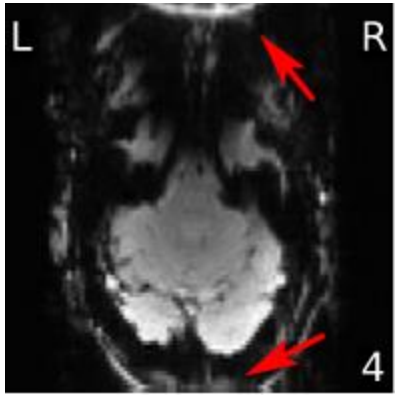
$$\mathrm{GSR} = \frac{\mu_G - \mu_{NG}}{\mu_S}$$



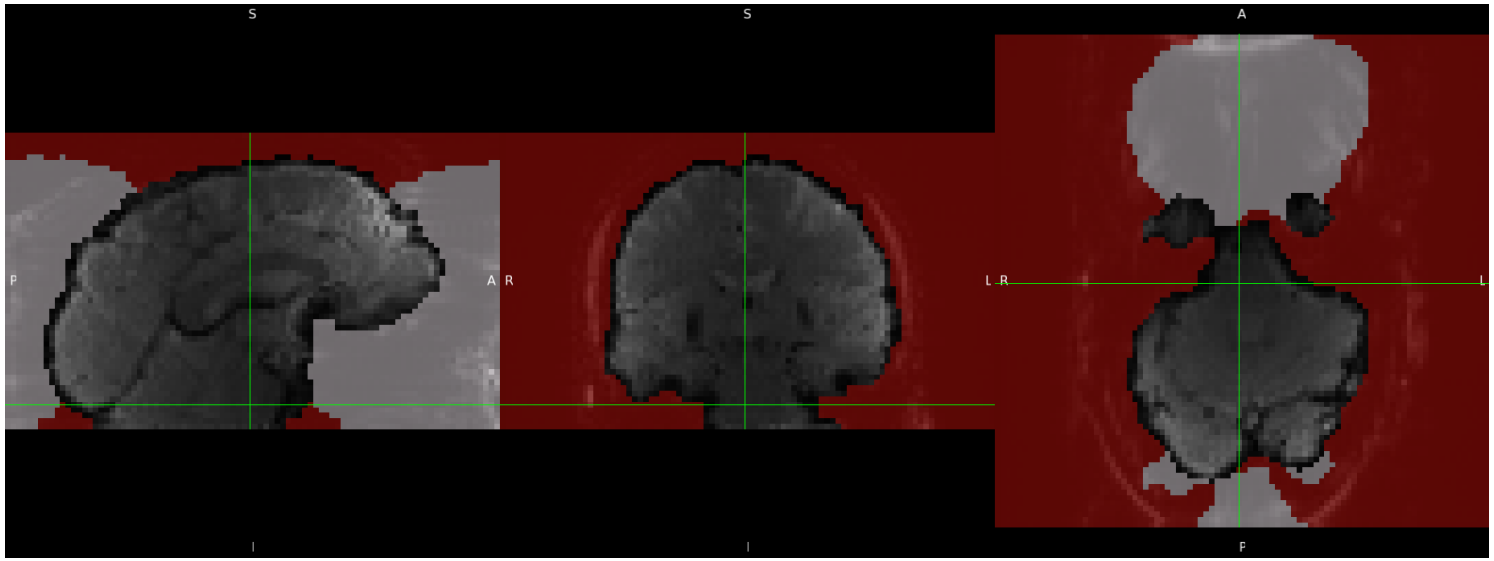
Source: MRIQC documentation

High GSR in NorthShore fMRI Scans

- Calculation of G mask:
  - 1) shift brain region ½ A-P with wraparound
  - 2) subtract from brain mask
- This may include non-brain, non-ghost signal (which should not vary by site)
- Site specific factors due to headcoil:
  - Wrapping
  - Coil sensitivity



NS sample resting state fMRI (NS10157V1) showing wrapping



“G” ghost region mask for scan above (axial view with same slice as above)

High GSR in NorthShore fMRI Scans

- To assess coil sensitivity effect, NorthShore ran a sample fMRI scan with and without Prescan Normalization
- With Prescan Normalization turned on, the calculated GSR for this test case dropped by 37% (7.6% to 4.8%), reaching the fringe of the 0-5% range of other sites