# Effects of SENSE1 Image Reconstruction on tSNR and Explainable Variance from Multichannel fMRI

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## Introduction

- The method used to combine signals from different coil elements in multi-channel MRI can impact the properties of reconstructed images[1].
- The SENSE1 method has been shown to improve the dynamic range of voxel intensities and model fits under low SNR conditions in diffusion MRI[2].
- SENSE1 has been recommended for proper reconstruction of phase images for fMRI[3] but the effect of SENSE1 on magnitude image based fMRI has not been evaluated.
- Although SENSE1 could benefit fMRI studies targeting regions low in signal due to susceptibility dropout, it could also introduce undesirable signal void artifacts[1].

## Methods

Two healthy participants (~30 yo, males; one per scanner) performed a short resting-state task (50 volumes) to quantify tSNR, and one participant also performed a movie-watching task (466 volumes) to quantify functional SNR (fSNR). In the movie task, the same movie was repeated four times each.

Imaging: We acquired fMRI data using the gradient-echo BOLD, CMRR multiband sequence R016a[4-6] on a 3T Siemens Trio (32 ch coil) as well as on a 3T Siemens Prisma (64ch coil). Scan parameters were: 2.6 mm iso, TR 2 s, MB 2, slices 50, FOV 220 x 220 mm$^2$, TE 30.8 ms, FA 71 deg, RF duration 6 ms. Data were reconstructed using vendor default Maxwell correction (MC), which corrects for distortions caused by concomitant fields. For comparison, the data were retro-reconstructed with MC off[3] and with either SENSE1 or root-sum-of-squares (rSoS) as the coil combination method.

Analysis: tSNR and fSNR quantify complementary properties that fMRI sequences should maximize. tSNR quantifies signal stability and was computed as the temporal mean divided by the temporal standard deviation. Because high tSNR[7] does not guarantee high BOLD contrast, reconstruction methods were also evaluated with a measure of fSNR: explainable variance (EV)[8,9]. EV quantifies the noise ceiling for encoding models. EV was computed on a per-voxel basis as the mean $R^2$ score between voxel responses to each repetition of the movie and the average response across repetitions. Movie task fMRI data were minimally preprocessed (i.e. motion-corrected, distortion-corrected, and linearly detrended in time). Spatial smoothing and slice-timing correction were not performed.

## Results

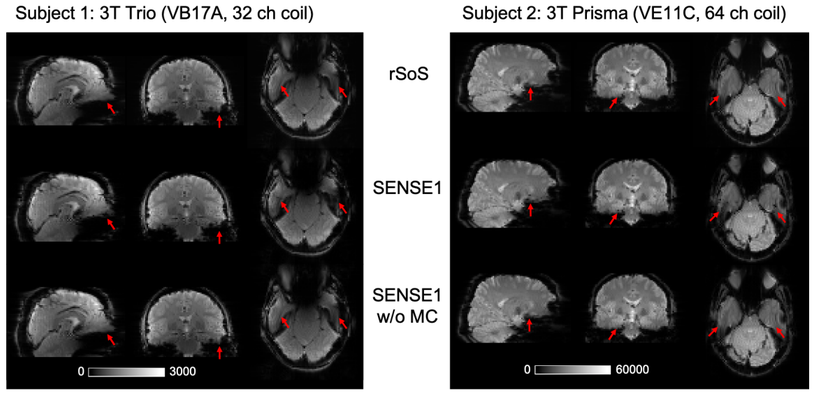


Figure 1. Cross-sections showing image quality for various reconstruction methods. Left) Subject 1 (3T Trio VB17, 32 ch). Right) Subject 2 (3T Prisma VE11C, 64 ch). For both subjects, SENSE1 results in signal void artifacts in regions of high susceptibility (red arrows) but not when Maxwell correction (MC) is turned off.

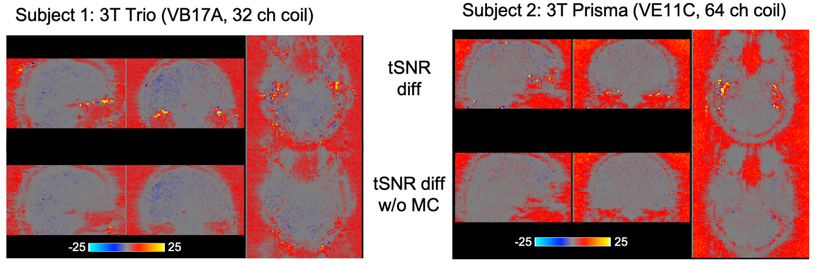


Figure 2. Cross-sections showing rSoS-SENSE1 tSNR difference. Left) Subject 1 (3T Trio VB17, 32 ch). Right) Subject 2 (3T Prisma VE11C, 64 ch). As expected when using SENSE1, the tSNR is lower outside the brain as well as in regions of the signal void artifacts. Although there is slightly lower tSNR within the brain using rSoS for Subject 1, this difference is not seen in Subject 2.

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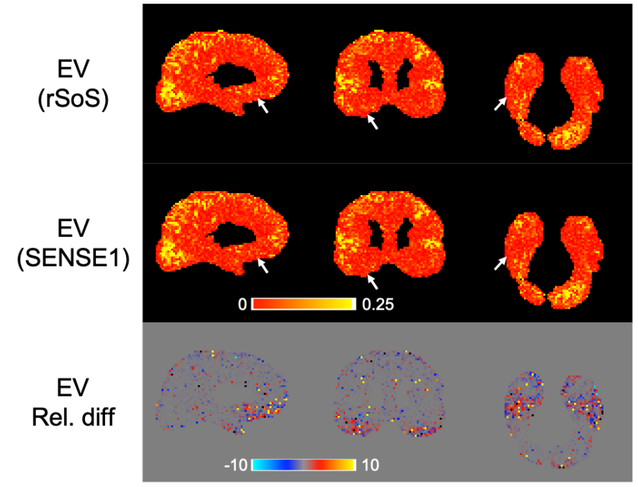


Figure 3. Effect of reconstruction method on explainable variance (EV). EV map using rSoS (top) and SENSE1 (middle). White arrows indicate regions of lower EV in SENSE1 due to the signal void artifacts. The relative EV difference ($EV_{rSoS}$-$EV_{SENSE1}$)/$EV_{SENSE1}$ (bottom) shows a multi-fold reduction in EV in high-susceptibility regions (e.g. ventral temporal and orbital frontal cortex).

## Conclusion

We evaluated SENSE1 reconstruction of gradient-echo fMRI data from two different 3T scanners. At both scanners, using SENSE1 with vendor default MC settings resulted in signal void artifacts in regions of high susceptibility but not when MC was off. Although there was a modest tSNR advantage with SENSE1 in the brain on the Trio 3T, rSoS and SENSE1 performed similarly on the Prisma 3T. Further investigation is needed to determine the reason for this. These results highlight the importance of evaluating new reconstruction options prior to finalizing an fMRI scan protocol.

## References

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