Title: Looping Star – a novel silent approach to imaging brain function in health and disease
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Background: The auditory noise in conventional functional MRI (fMRI), of comparable levels to a power drill, can lead to confounds in the interpretation of brain activity in cognitive paradigms[1,2]. It also contributes to a negative participant experience[3], and prevents studies of infants, sleep and patient groups with hypersensitivity to sound. Recently, a novel silent multi-echo fMRI pulse sequence known as "Looping Star" has been developed[4,5], which also reduces geometric distortion and the effect of large draining veins on the haemodynamic response. However, little validation of image quality and sensitivity has been conducted.

Aims: To validate Looping Star with task-based and resting state paradigms in a healthy population, by comparing the imaging outcomes with those of conventional gradient-recalled echo echo-planar imaging (GE-EPI) fMRI.

Methods: We scanned eight healthy participants, who performed a periodic, visual block design task (8Hz checkerboard alternating with a dark screen) and a resting state paradigm. For the task we scanned with two-echo Looping Star ($N_{spokesperecho}$ = 32; FA = 1°; TR = 2410ms; TE = 0ms, 30.4ms; 225 volumes; matrix size = 64 x 64 x 64) and four-echo Looping Star ($N_{spokesperecho}$= 16; FA = 1°; TR = 3130ms; TE = 0, 8.7ms, 17.4ms, 26.2ms; 150 volumes; matrix size = 64 x 64 x 64), as well as single-echo GE-EPI (FA = 75°; TR = 2000ms; TE = 30ms; 180 volumes; slice thickness = 3mm; slice gap = 3.3mm; matrix size = 64 x 64 x 38). For resting state we acquired a four-echo GE-EPI scan (FA = 80°; TR = 2500ms; TE = 12ms, 28ms, 44ms, 60ms; 192 volumes; slice thickness = 3mm; slice gap = 4mm, matrix size = 64 x 64 x 32) and the aforementioned four-echo Looping Star sequence.

Results: For the task paradigm, we conducted a group-level whole-brain fixed effects analysis. We found that Looping Star can produce activity maps not only of comparable sensitivity to GE-EPI but also of good image quality and improved functional localisation (Figure 1). For resting-state at single-subject level, we found highly differing BOLD and non-BOLD components, as formalised by Kundu et al[6], between GE-EPI and Looping Star, which we are studying further.

Conclusions: These task-based results suggest that the sensitivity of Looping Star is of comparable quality to GE-EPI, but there is certainly room for improvement. This includes studying the noise characteristics of resting state studies for use with connectivity analysis. Optimisation of Looping Star would revolutionise the study of neural activity in both health and disease; facilitating research in more populations, improving participant experience, and reducing confounds from both acoustic noise and image quality.

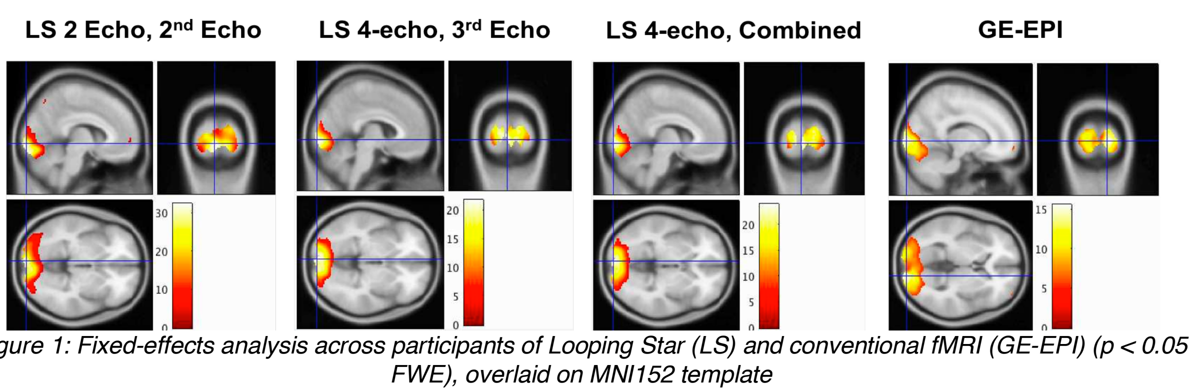

Figure 1: Fixed-effects analysis across participants of Looping Star (LS) and conventional fMRI (GE-EPI) ($p < 0.05$ FWE), overlaid on MNI152 template

[1] Bandettini, P.A., et al. 1998. Magnetic resonance in medicine, 39(3), pp.410-416., [2] Tomasi, D., et al. 2005. Neuroimage, 27(2), pp.377-386. [3] Quirk, M.E., et al. 1989. Radiology, 170(2), pp.463-466., [4] Solana-Sánchez, A. 2017. ISMRM
[5] Wiesinger, F. et al. in press. Magnetic resonance in medicine., [6] Kundu, P. et al. 2012. Neuroimage, 60(3), pp.1759-1770.