Separation of VLF fluctuations from periodic cardiorespiratory noise with critically sampled magnetic resonance encephalography.

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Target audience: neuroscientists, radiologists, sequence developers

Purpose. Very low frequency osciallations (VLFO) have been shown to migrate over brain cortex in BOLD fMRI data. Under-sampled classical BOLD signal may mix aliased physiological noise into VLFO since it does not critically sample cardiac and respiratory pulse effects in tissue. In this study we explicitly separate cardiorespiratory pulsations from VLFO with critically sampled magnetic resonance encephalography (MREG) and monitor each effect in tissue by separate time windows.

Methods. We scanned 9 subjects after informed consent and ethical approval using 3T Siemens SKYRA with 32-channel head coil. Imaging was performed with a single shot MREG sequence, which under-samples k-space with alternating in/out stacks of spirals, TR 100 ms, FA 23°[1]. Anatomical T1 MPRAGE 0.9 mm cubic was used to align data with. HEPTA-scan multimodal acquisition was used for electrocardiogram (ECG) to identify R-peaks and scanner bellows for respiratory cycles[2]. Onset for VLFO (0.01-0.027 Hz) were derived from DMN_{vmpf} using FSL dual regressed groupPICA time domain signal. After normal FSL preprocessin, the MREG data was bandpassed for respective physiological frequencies. QPP algorithm was used in Matlab to obtain group average cardiorespiratory and VLFO effects in 2 mm MNI152 space[3]. FSL H-O Atlas ROI's were used for averaged pulse effects from the brain.

Results. Periodic cardiac impulses, respiratory cycle effects were spatially and temporally markedly different from VLFO's in the critically sampled MREG data, c.f. Fig 1 on left.

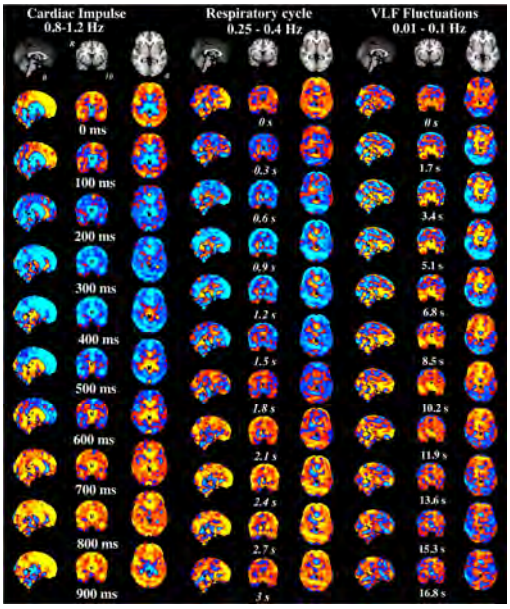

Fig1. Z-score maps in MNI 152 space averaged QPP plots with time marked in (s) below respective image.

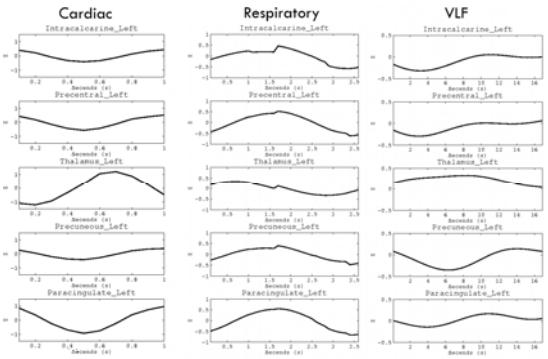

Figure 2 above shows H-O atlas ROI data. Each physiological signal effect has a unique temporal pattern depending on anatomical site. Notably these pulses are not identical to the cardiac or respiratory waveforms derived from external measures. Note the different time scales of each measure.

Discussion and Conclusion. Critically sampled MREG enables separation of periodic cardiorespiratory pulsations from VLFO without aliasing. Since the physiological noise effects have both varying in spatiotemporal patterns and they do not resemble externally measured signals temporally, their removal needs to be performed 1) at voxel level 2) with adaptive techniques. The removal needs to be based on critically sampled effect maps rather than averaged external waveform measures. More accurate noise removal with critically sampled data may enhance the detection of underlying neurophysiological signals.

References

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