Distinct patterns of intrinsic spectral-power associations on the sub-second and seconds timescales

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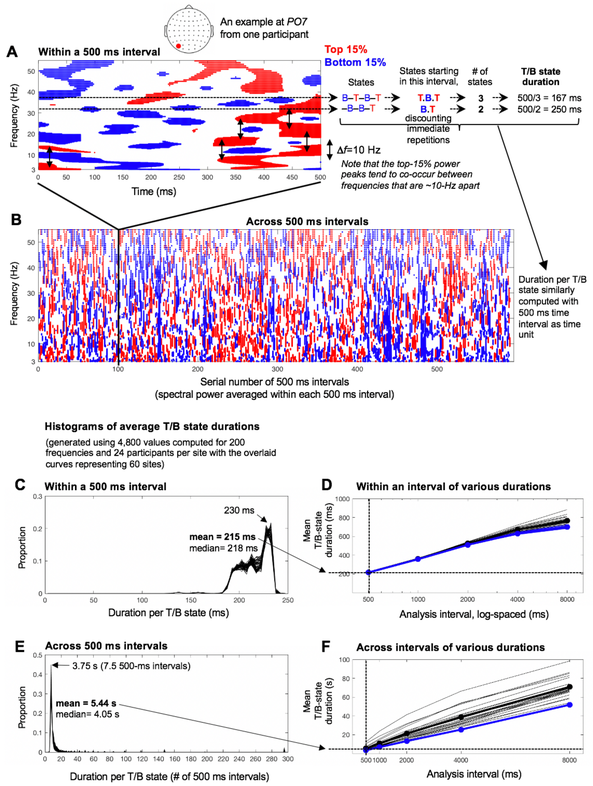
Introduction & Methods

We investigated the global structure of intrinsic cross-frequency dynamics by systematically examining power-based temporal associations among a broad range of oscillation frequencies both within and across EEG-based current sources (sites). We focused on power-based associations that could reveal unique timescale dependence independently of interacting frequencies. Large spectral-power fluctuations across all sites occurred at two characteristic timescales, sub-second and seconds, yielding distinct patterns of cross- frequency associations.

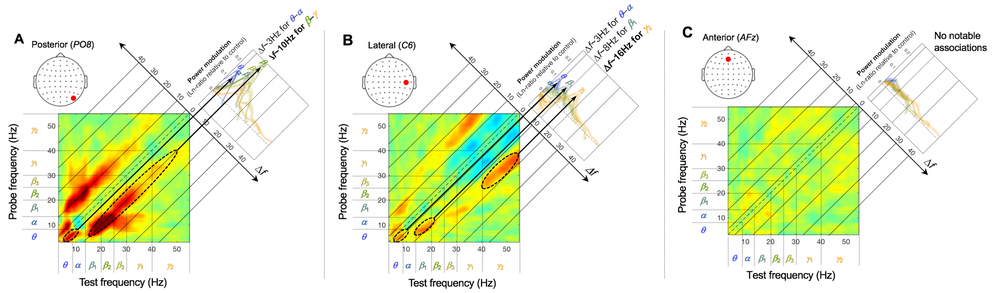
Intrinsic spectral-power variations on the characteristic sub-second and seconds timescales



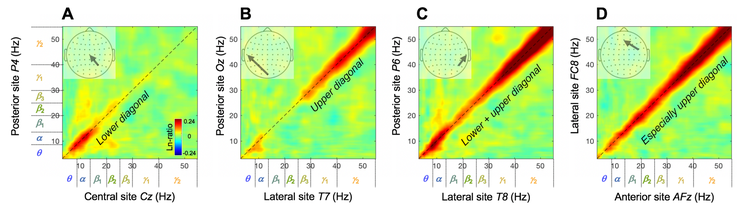
Results

On the (fast) **sub-second timescale** (within a 500 ms interval), within-site (local) associations were consistently between pairs of **β-γ** frequencies differing by a constant ***Δf*** (particularly ***Δf*** ~10 Hz at posterior sites and ***Δf*** ~16 Hz at lateral sites) suggesting that higher-frequency oscillations are organized into ***Δf*** amplitude-modulated packets, whereas cross-site (long-distance) associations were all within-frequency (particularly in the >30 Hz and 6-12 Hz ranges suggestive of feedforward and feedback interactions).

*Representative **within-site** spectral-power associations*

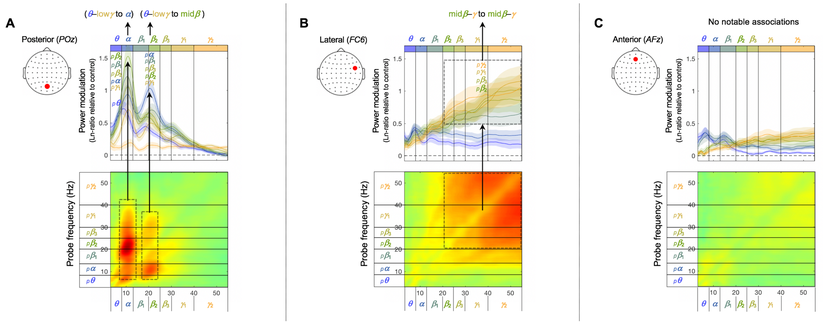


*Representative **cross-site** spectral-power associations*

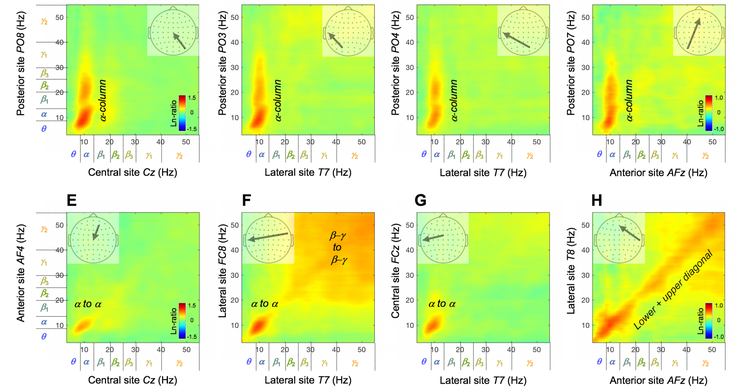


On the (slower) **seconds timescale** (across 500 ms intervals), within-site (local) associations were characterized by a broad range of frequencies selectively associated with ~10 Hz at posterior sites and associations among higher (>20 Hz) frequencies at lateral sites, whereas cross- site (long-distance) associations were characterized by a broad range of frequencies at posterior sites selectively associated with ~10 Hz at other sites, associations among higher (>20 Hz) frequencies among lateral and anterior sites and prevalent associations at ~10 Hz. Regardless of timescale, within-site (local) cross-frequency associations were weak at anterior sites indicative of frequency-specific operations.

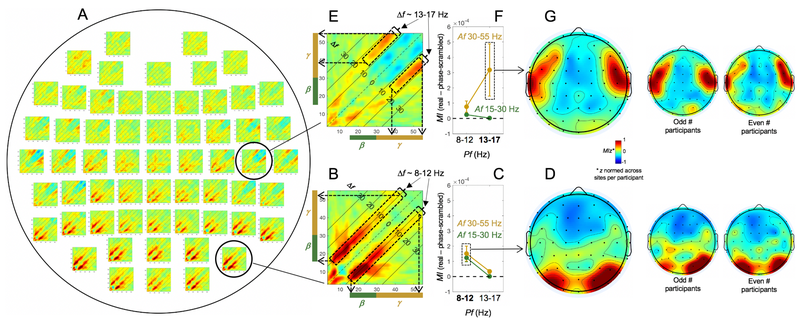
*Representative **within-site** spectral-power associations*



*Representative **cross-site** spectral-power associations*



*Relationship between spectral-power associations and **phase-amplitude coupling***



We examined the relationship between the posterior ***Δ***f ~10 Hz and lateral ***Δ***f ~16 Hz spectral-power associations on the sub-second timescale and phase-amplitude coupling assessed as the Modulation Index (MI; Tort et al., 2010; Hülsemann et al., 2019). The results suggest that at least the spectral-power associations at ***Δ***f ~10 Hz and ***Δ***f ~16 Hz on the sub-second timescale are related to amplitude-modulation of higher-frequency oscillations by the phase of ***Δ***f oscillations. However, the current results do not provide a coherent interpretation for the lateral ***Δ***f ~16 Hz associations that imply low **β**-phase-to-**γ** -amplitude coupling.

Conclusions

Our results suggest that the (fast) sub-second-timescale coordination of spectral power is limited to local amplitude modulation and insulated within-frequency long-distance interactions (likely feedforward and feedback interactions), while characteristic patterns of cross-frequency interactions emerge on the (slower) seconds timescale.

Our results also suggest that the occipital **α** oscillations play a role in organizing higher-frequency oscillations into ~10 Hz amplitude-modulated packets to communicate with other regions. Functional implications of these timescale-dependent cross-frequency associations await future investigations.

Menceloglu, M., Grabowecky, M., & Suzuki, S. (in press). Spectral-power associations reflect amplitude modulation and within-frequency interactions on the sub-second timescale and cross-frequency interactions on the seconds timescale. *PloS one*.

See preprint at bioRxiv.