Effects of Attention on Visual Processing between Cortical Layers and Cortical Areas

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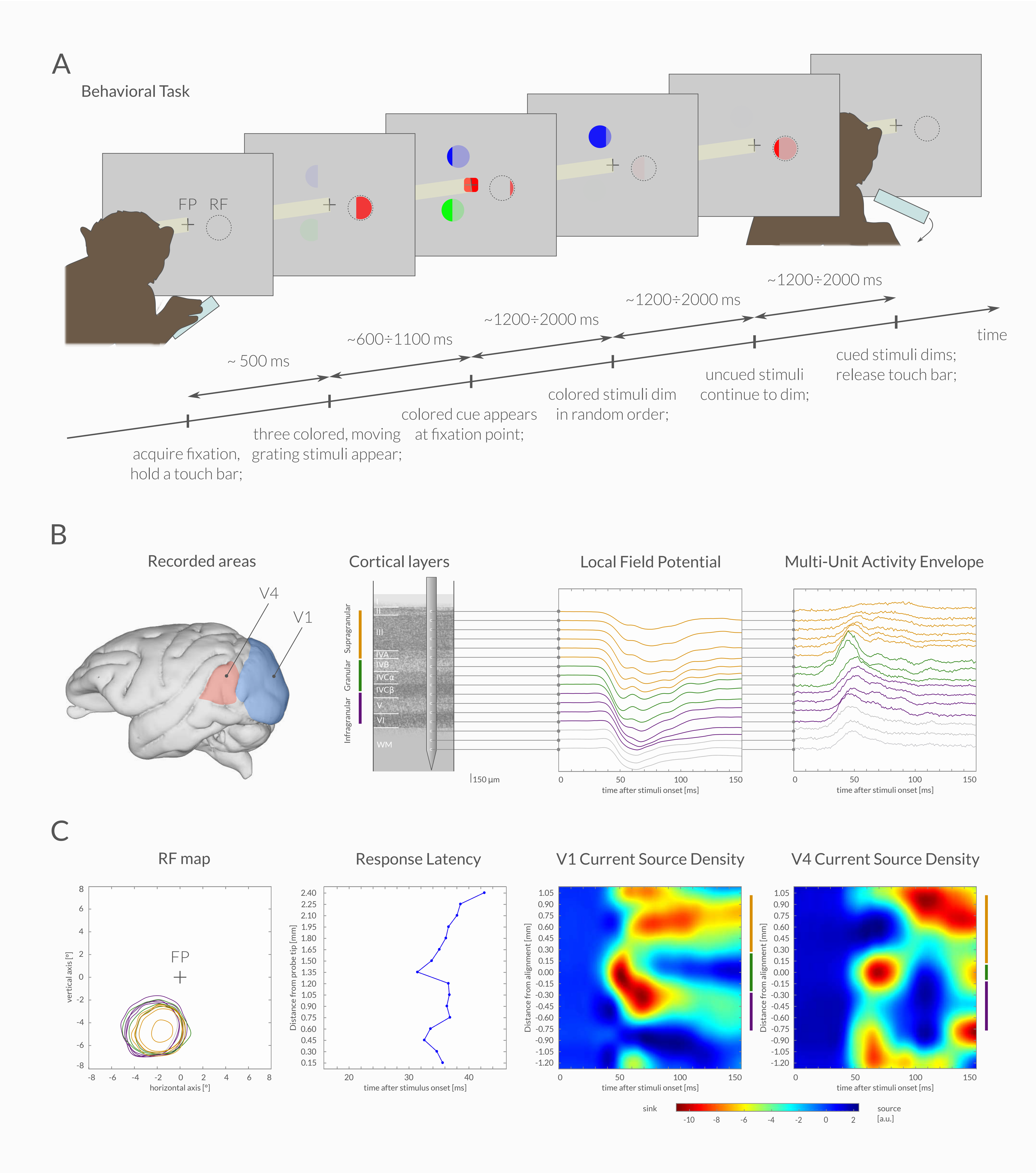
INTRODUCTION

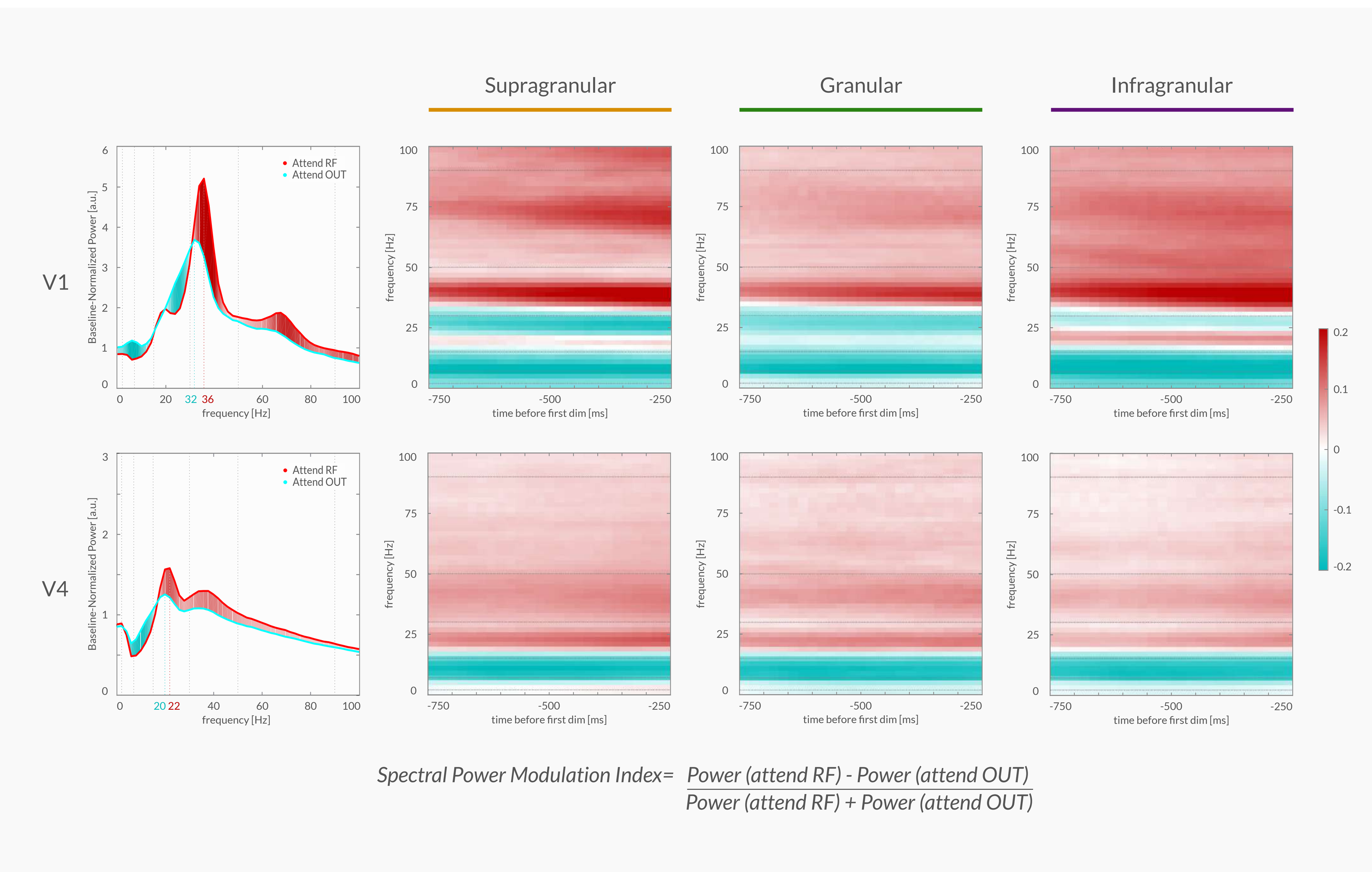
Attention is critical to high level cognition, and it improves perceptual abilities. Many studies have delineated how attention affects neuronal firing rates, rate variability, and neuronal correlations [1]. However, a detailed understanding of how this differs between cortical layers is only just emerging [2,3]. To address this, we analysed the neuronal activity recorded from cortical areas V1 and V4 in 3 macaque monkeys, while performing top-down cued spatial attention task. Experiments and data recordings were performed at the University of Newcastle.

Figure 1 - Experimental setup and laminar alignment



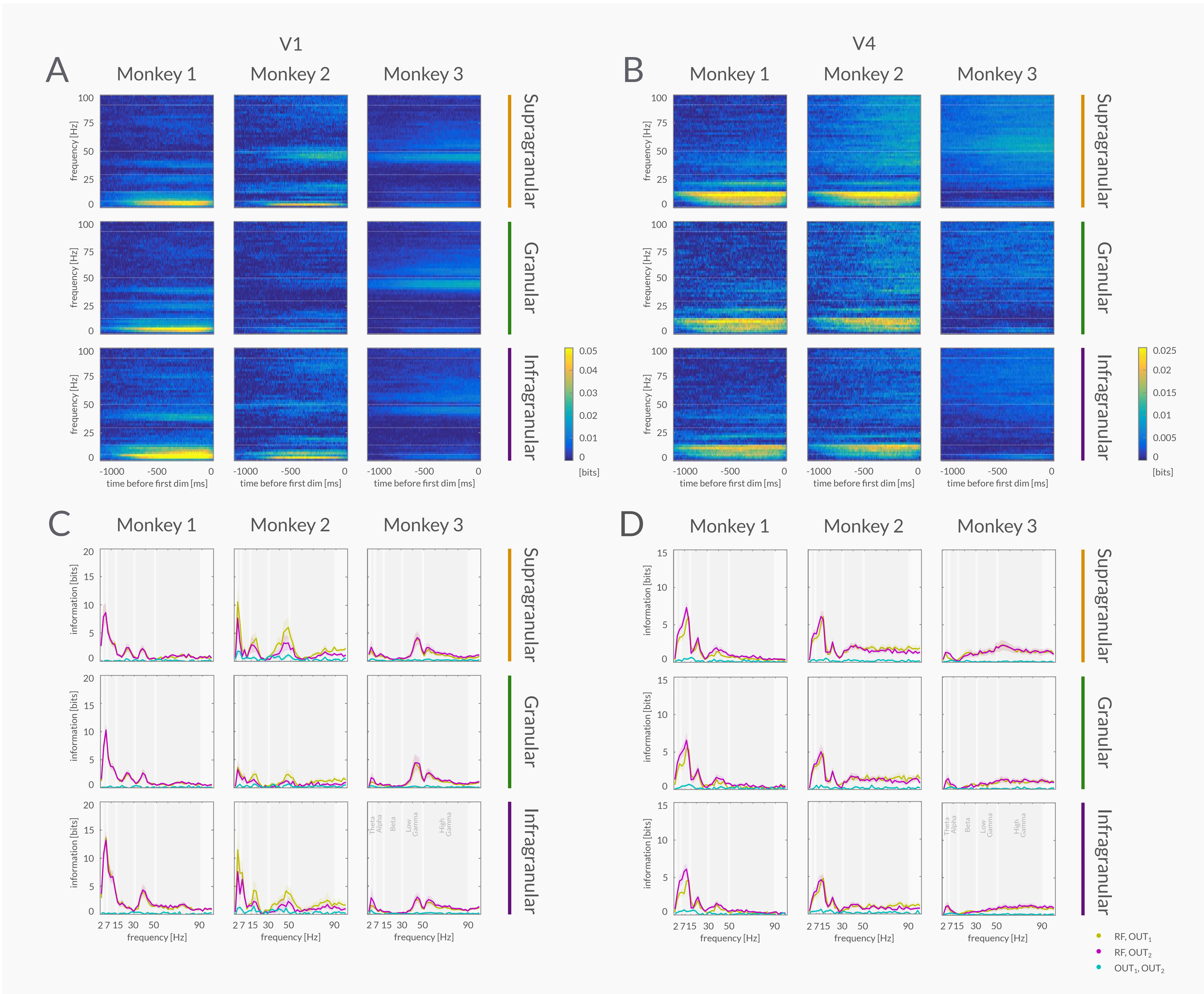
A. Behavioral task timeline. Stimulus and cue onset times, as well as stimuli dimming times are random. Fixation Point (FP) and Receptive Field (RF) locations are not shown during the experiment. **B.** Brain areas and multi-contact electrode probe. Local field Potential (LFP) and Multi-Unit Activity Envelope (MUA_E) signals labelled by cortical layers. **C.** RF mapped on visual space. Response Latency and Current Source Density (CSD) plots used for the identification of cortical layers. CSD plots for V1 and V4 are averaged across sessions performed by Monkey 1 and 3 respectively, all other plots refer to a sample session for Monkey 1.

Figure 2 - Spectral Power Modulation



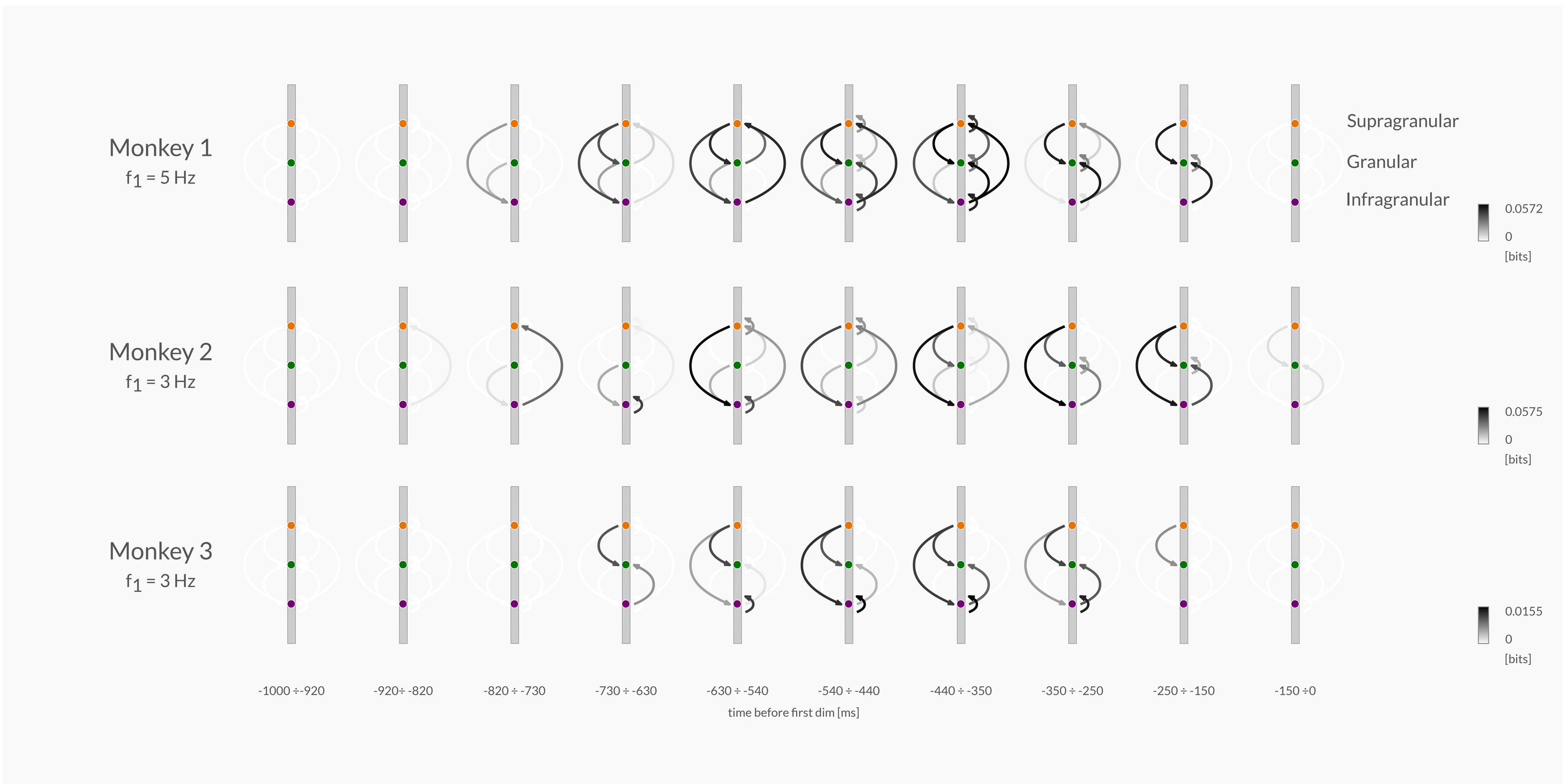
LFP Spectral Power Modulation in time/frequency domain averaged across session performed by Monkey 1. Plots for Monkey 2 and 3 showed similar attentional modulatory effects even though stimulus-induced peaks in spectral power did not match across subjects.

Figure 3 - Attentiotial information conveyed by LFP signals



A. Mutual Information about attended spatial location conveyed by V1 LFP signals in time/frequency domain. **B.** Same as in A but for V4 LFPs. **C.** Mutual information about attended spatial location carried by V1 LFP signals as in A, but cumulated over times preceding the first dim. **D.** Same as in C but for V4 LFPs.

Figure 4 - Attentional information transfer



Directed flows of information about attended spatial location (RF, OUT) across V1 LFP signals sorted by laminar depths. Signals are filtered around f_1, matching the first peak in frequency in Figure 3C. Information quantities are cumulated in time windows preceding the first dim time.

CONCLUSIONS

Attentional modulations of the spectral features that we considered did not show major differences across layers. We found that the main effect of attention on V1 LFPs consisted of a shift in spectral power peak in the low gamma frequency range (~40÷60 Hz) towards higher frequencies. In V4 we found an overall decrease in power for frequencies below 20 Hz and an increas above 20 Hz. We were particularly interested in quantifying the information about attended spatial location carried by LFP signals and its directed flows across different layers, for specific frequencies. For all subjects we found very robust patterns of theta-band (4÷8 Hz) visuo-spatial information [4] that preferentially flowed from supragranular and infragranular layers towards granular layer in V1. Future analyses will focus on information flows within V4 layers and between V1-V4 layers.

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Funded by Autonomous Province of Trento
ATTEND Project -*"Grandi Progetti 2012"*
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