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

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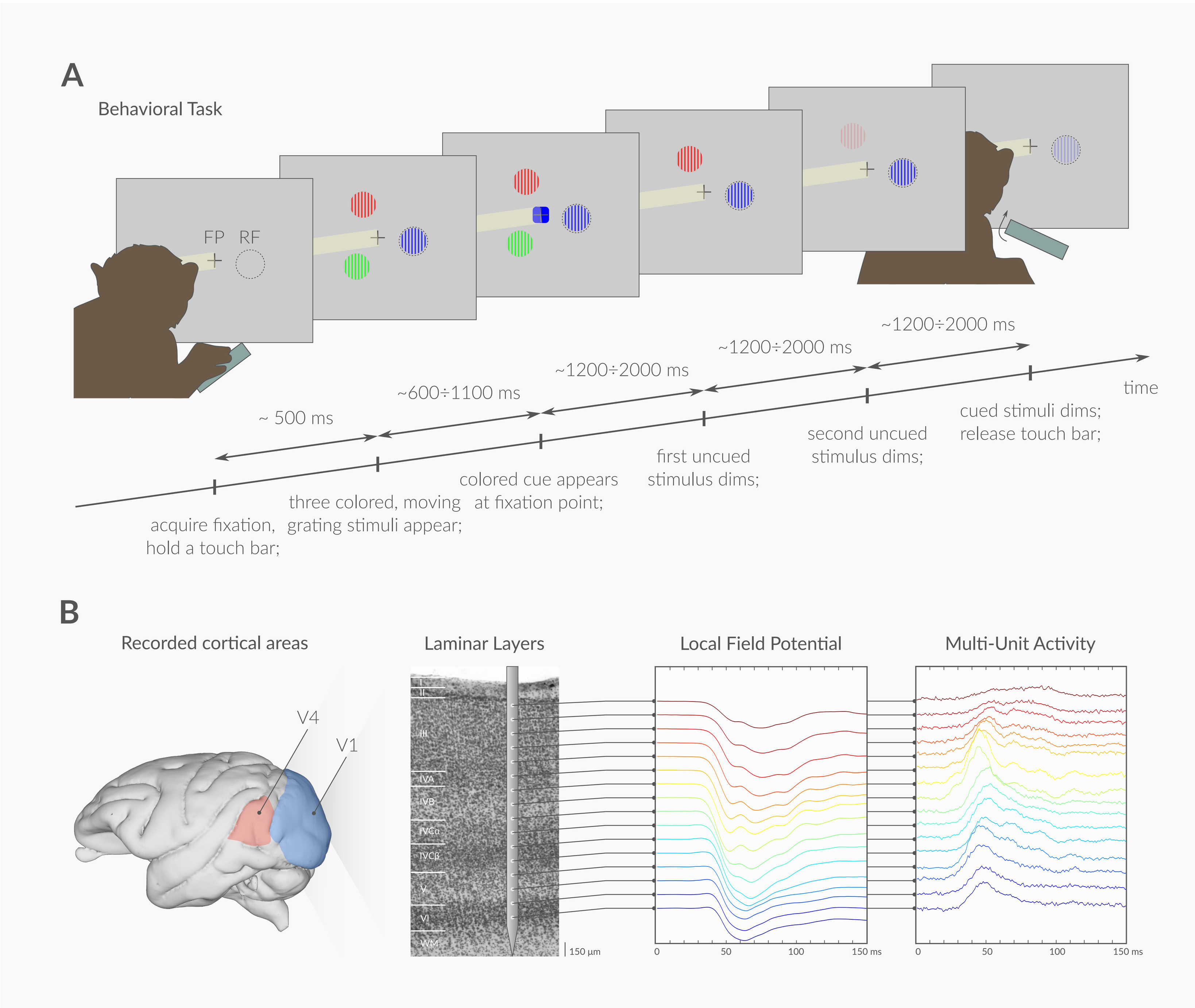
INTRODUCTION

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 and different cell types is only just emerging [2,3].

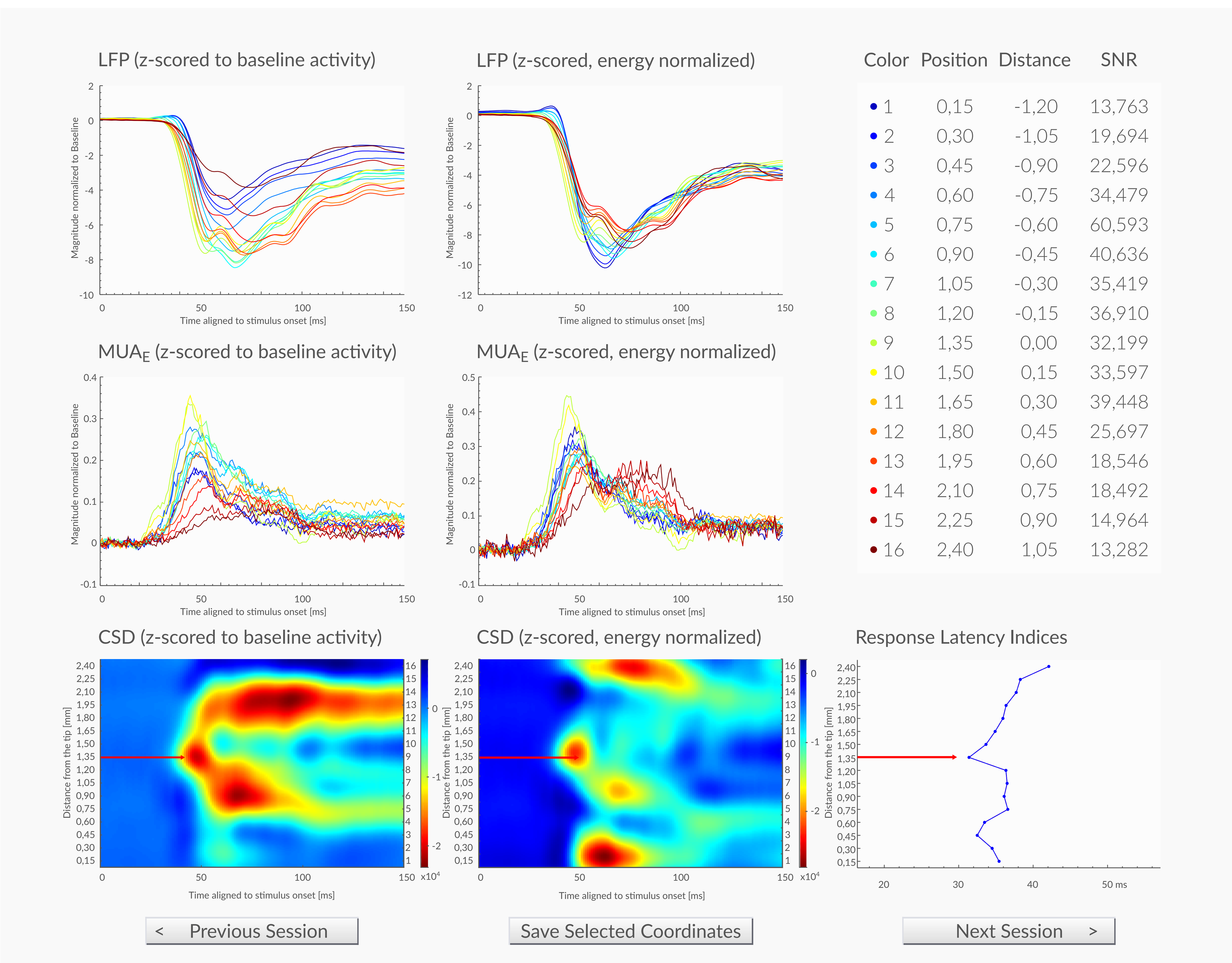
To address this, we analyse the neuronal activity of two macaque monkeys from cortical areas V1 and V4, while performing top-down cued spatial attention task. Experiments and data recordings were performed at the University of Newcastle.

Figure 1 – Behavioral Task and Data Acquisition



A. Behavioral Task timeline. Fixation point (FP) cue color and stimuli colors may vary within red, blue and green. Attended stimuli location may fall either inside or outside the Receptive Field (RF) of recorded cells. Cue onset time and stimulus dimming time are random. B. Schematic view of the recording tools. Electrode probe spanning through laminar layers. Local Field Potential and Multi-Unit Activity plots from Monkey 1, V1.

Figure 2 – Computational Tools for Laminar Alignment



Color	Position	Distance	SNR
• 1	0,15	-1,20	13,763
• 2	0,30	-1,05	19,694
• 3	0,45	-0,90	22,596
• 4	0,60	-0,75	34,479
• 5	0,75	-0,60	60,593
• 6	0,90	-0,45	40,636
• 7	1,05	-0,30	35,419
• 8	1,20	-0,15	36,910
• 9	1,35	0,00	32,199
• 10	1,50	0,15	33,597
• 11	1,65	0,30	39,448
• 12	1,80	0,45	25,697
• 13	1,95	0,60	18,546
• 14	2,10	0,75	18,492
• 15	2,25	0,90	14,964
• 16	2,40	1,05	13,282

Matlab® GUI designed for Laminar Alignment filled with sample data from Monkey 1, V1. Laminar depth selection is interactive. Clicking on one of the plots with red arrow allows the identification of the alignment point. Buttons allow to save the selection, and to navigate through experimental sessions.

CURRENT WORK

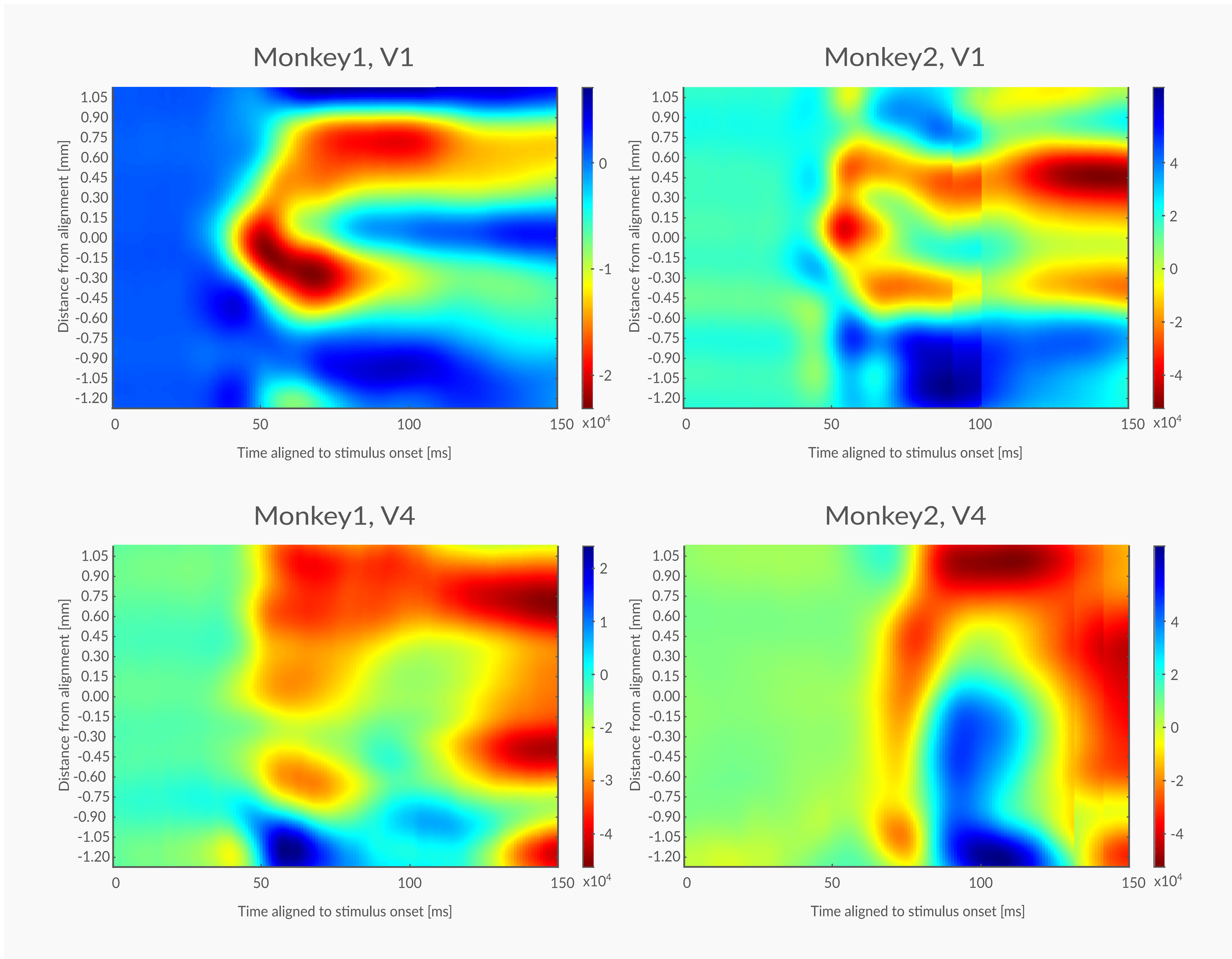
After the extraction of Local Field Potentials (LFPs) and Multi-Unit Activity Envelopes (MUAEs), the analysis moved towards the computation of Current Source Densities (CSD) [4] and Response Latency Indices [5] across the laminar layers at locations of recordings.

The main issue addressed by now is the alignment of the recorded signal in terms of laminar depth. Across experimental sessions, electrode ccontacts may not be aligned to the same cortical levels, so they need to be aligned.

Common reference point is set to the location of earliest current sink, i.e. laminar layer IVCα, to be identified from CSD plots and Latency Indices. The identification of such location was performed manually for each experimental session, with the support of a Matlab® Graphical User Interface developed for the specific purpose.

Once all of the laminar alignment points were identified, it was possible to compute average CSDs across experimental sessions for both monkeys and for both V1 and V4. Results were trimmed to the lengh of the electrode probe and centered to alignment point.

Figure 3 – Average Laminar CSD Profiles



Average Laminar Current Source Density profiles for both monkeys and for both V1 and V4 obtained from laminar alignment. It is possible to note that there always is a current sink at alignment point.

FUTURE WORK

Next stages include the isolation of single units to extract the spiking activiy of recorded cells. From this, we intend to analyse the properties of single unit signals and infer the effects of attention by considering its effects when attending towards versus outside the RF of recorded cells.

Among possible future work, it is possible to formulate and test hypotheses about the task-relevant information propagating within different laminar layers and different cortical areas such as V1 and V4.

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