Attention improves object representation in monkey area V4

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Attention is thought to improve processing of selected stimuli. It has been demonstrated that firing rates can be modulated by attention and that their enhancement can improve the signal-to-noise ratio for discriminating stimulus features.

Here we investigate effects of selective attention on object representation using recordings of epidural local field potentials (eLFPs). We trained two monkeys to an extended version of the delayed match to sample paradigm. The animals were required to attend to one of two object sequences presented simultaneously in both hemifields. They had to identify the re-occurrence of the initially presented sample object in the attended object sequence. eLFPs were recorded with an array of 36 epidural electrodes covering parts of area V4 and V1, while the monkeys performed the task.

Analysis of object encoding was done with standard support vector machines trained on eLFP wavelet power coefficients, allowing to estimate the probability of correct classification of object identity. Using all electrodes, we found a classification performance of up to 94% correct (1200 ms window, chance level: 17%) on a trial by trial basis, i.e. the eLFP-data enabled nearly perfect object identification. Almost all stimulus-specific information was concentrated in the gamma frequency range from 40 to 160 Hz.

Classification on data from 4 electrodes covering V4 resulted in 56% performance for non-attended stimuli, and 64% for attended stimuli (chance level: 17%). Classification of attention direction on eLFP-signals from the 4 electrodes located above V4 gave 81% performance (chance level: 50%).

We further investigated if encoding improvement is specifically linked to shifts in spectral content, or could be explained solely by increased signal-to-noise ratios (SNRs). We found, that SNR improvements due to attention were small and when removed from the data the classification performance increases were largely conserved.

Our results show that neuronal activity in the gamma band contains a high amount of information on stimulus shape and direction of attention. They indicate that attention improves the distinctiveness of cortical states associated with the processing of different visual stimuli. The high classification performance on objects and direction of attention suggests that eLFP signals from visual cortex could be useful for brain machine interfaces.

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