

# Increase of High-Frequency (>150 Hz) Intracranial EEG Activity during Face Perception in Humans

Jean-Philippe Lachaux<sup>1</sup>, Nathalie George<sup>1</sup>, Bernard Renault<sup>1</sup>, Jacques Martinerie<sup>1</sup>, Philippe Kahane<sup>2</sup>

<sup>1</sup> Laboratoire de Neurosciences Cognitives et d'Imagerie Cerebrale. LENA – CNRS. UPR 640, Paris, France

<sup>2</sup> Neurophysiopathology of the Epilepsy, Grenoble University Hospital, Grenoble, France

**Abstract-** We have analyzed high-frequency components of the intracranial EEG activity in response to visual stimuli in the occipital and temporal cortex of epileptic patients. Face perception in particular elicited modulations in the gamma band at frequency ranges up to 250 Hz. This study suggests that the response to complex visual stimuli extends well beyond the common frequency components usually studied in evoked potentials.

**Keywords -** gamma, face perception, depth EEG, epilepsy

## I. INTRODUCTION

In humans, the early response (within a couple of hundreds of milliseconds) of the visual cortex to the presentation of complex visual stimuli has been studied predominantly by analyzing the potentials phase-locked to the presentations of such stimuli, present in the well-known evoked potentials. This approach is limited by the fact that short high-frequency (above 30 Hz, roughly) response components are usually not phase-locked to the stimulus onset and thus cannot be detected using this methodology. Following a recent stream of research, we used time-frequency analysis to extract such non-phase locked components of the response to face stimuli, and found that the activity of several visual areas in the occipital and temporal lobes were modulated at frequencies up to 250 Hz by the processing of the stimuli.

## II. METHODOLOGY

Three epileptic patients with intractable epilepsy were implanted with depth electrodes in the left and right posterior lobes for therapeutic purposes. They gave their fully informed consent to participate in a simple visual discrimination protocol described in [1], where they were presented with mooney faces, upside up or upside down, on screen for 200 ms. The task was to respond with their right index finger (resp. right middle finger) if they did (resp. did not) immediately perceive a face in the picture. 80 % of the faces presented upside up were recognized (those will be referred to as condition 'UFY'), while 80 % of the faces presented upside down were not recognized (those will be referred to as condition 'DFN'). After careful rejection of all recording sites and trials showing epileptiform activity, we gathered around 100 trials for each condition and subject. We computed the time-frequency transform of each trial (using either a short-term Fourier transform, a pseudo-smoothed Wigner transform, or a Morlet Wavelet Transform, for purpose of comparison) and averaged them within each condition and subject. The resulting averaged time-frequency

maps revealed for each recording site, the components of the response to the stimulus that are either phase-locked or non-phase-locked to the stimulus onset.

## III. RESULTS

In all three subjects, we found clear and significant increases of energy in the gamma range (30 Hz and above). Those increases occurred between 200 ms and 700 ms after the stimulus onset, their latency and dominant frequency varied with the recording site. For some sites, this gamma induced response was significantly greater when the face was perceived ('UFY') than when it was not ('DFN'). In several of those sites, where the gamma was modulated differently in the two conditions, the evoked potential was in contrast not different between the two conditions. In some sites, the modulation in the gamma band extended well above the frequency range usually documented, above 200 Hz. In one patient, we found a modulation of the energy above 200 Hz that occurred at 40 ms post-stimulus onset in early occipital areas.

## IV. DISCUSSION

This study provides further evidence that the processing of complex stimuli involves neural activity in the gamma range. In contrast with the gamma induced responses recorded from the scalp using standard non-invasive scalp EEG, that are mostly uniform in latency, and rarely extend above 60 Hz, we found the intra-cranial gamma induced responses to constitute a mosaic of heterogeneous responses, as already shown in response to kanisza triangles [2]. This preliminary study will constitute the basis for more refined analysis studying the network structure of this mosaic.

## REFERENCES

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