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Concept cells in the temporal pole: Preliminary results

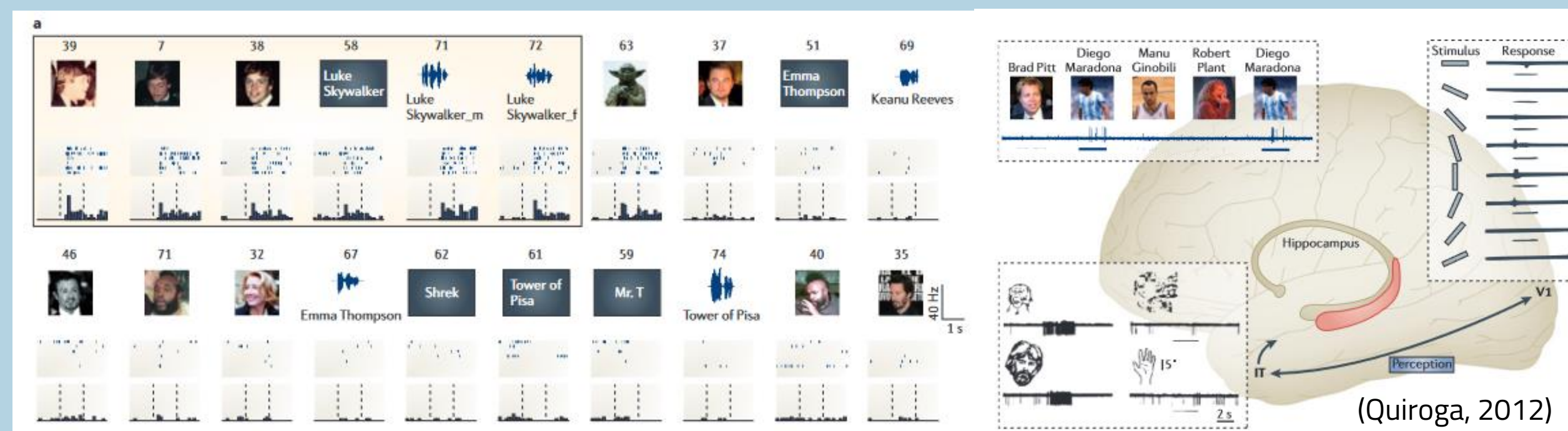
Vincent Dornier¹, Aube Darves-Bornoz¹, Leila Reddy¹, Luc Valton^{1,2}, Marie Denuelle^{1,2}, Jean-Albert Lotterie^{3,4}, Amaury de Barros^{3,5}, Annabelle Goujon⁶, Jonathan Curot^{1,2} & Emmanuel J. Barbeau¹

1: Centre de Recherche Cerveau et Cognition (Cerco), UMR5549, Université de Toulouse – CNRS; 2: Électrophysiologie cérébrale, épilepsie, sommeil, CHU Toulouse; 3: INSERM, U1214, TONIC; 4: Radiochirurgie Stéréotaxique, CHU Toulouse; 5: Neurochirurgie, CHU Toulouse; 6: Laboratoire de Recherches Intégratives en Neurosciences et Psychologie Cognitive UR 481, Université de Franche-Comté, Besançon, France

Introduction

Intracranial recordings have revealed that the first responses to faces are located in the fusiform gyrus, with a evoked response at 110 ms. Along the ventral visual pathway, latencies increase progressively, with the slowest responses in the medial temporal lobes. These latter regions are the only ones to respond differently to familiar and unfamiliar faces (Barbeau et al., 2008). Even within these late-responding regions, the hippocampus and temporal pole respond later than other MTL regions such as the perirhinal cortex (Despouy et al., 2020). This implies that the hippocampus and temporal pole could be involved in high-level processes, such as memory, while the other regions of the ventral visual pathway could be involved in perceptual processes.

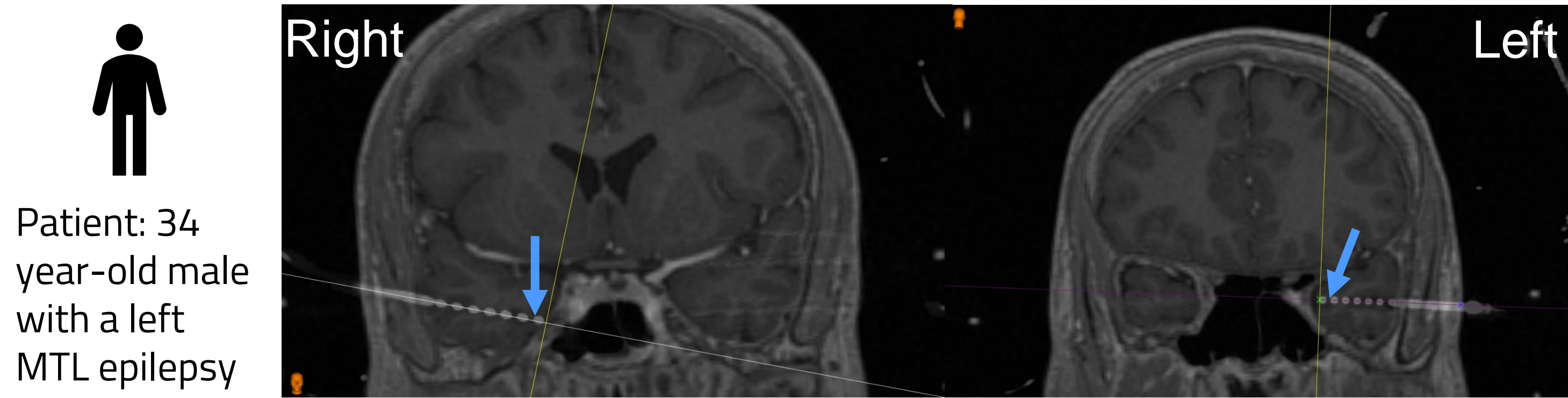
In line with these findings, highly selective neurons have been observed in the hippocampus, with neurons responding only to images corresponding to a particular concept and to no other images (Quiroga et al., 2005). These concept cells have many properties, for example they are multimodal, with responses to faces but also to written or spoken names (see figure below, for a review see Quiroga, 2016).



Concept cells have mainly been recorded in the hippocampus. However, they appear to underly semantic knowledge, whereas it is the temporal poles which are usually associated with semantic memory, as shown for example in semantic dementia. In addition, patients with developmental amnesia show severe bilateral hippocampal atrophy associated to hypoxia at birth. They consequently have severe amnesia. Notwithstanding, some of these patients have excellent performance in semantic memory tasks associated with significantly thicker temporal pole (Jonin et al., 2018). These findings are consistent with the idea that the temporal pole is the hub of semantic memory (Ralph et al., 2017). If anything, concept cells should thus be found in the temporal poles.

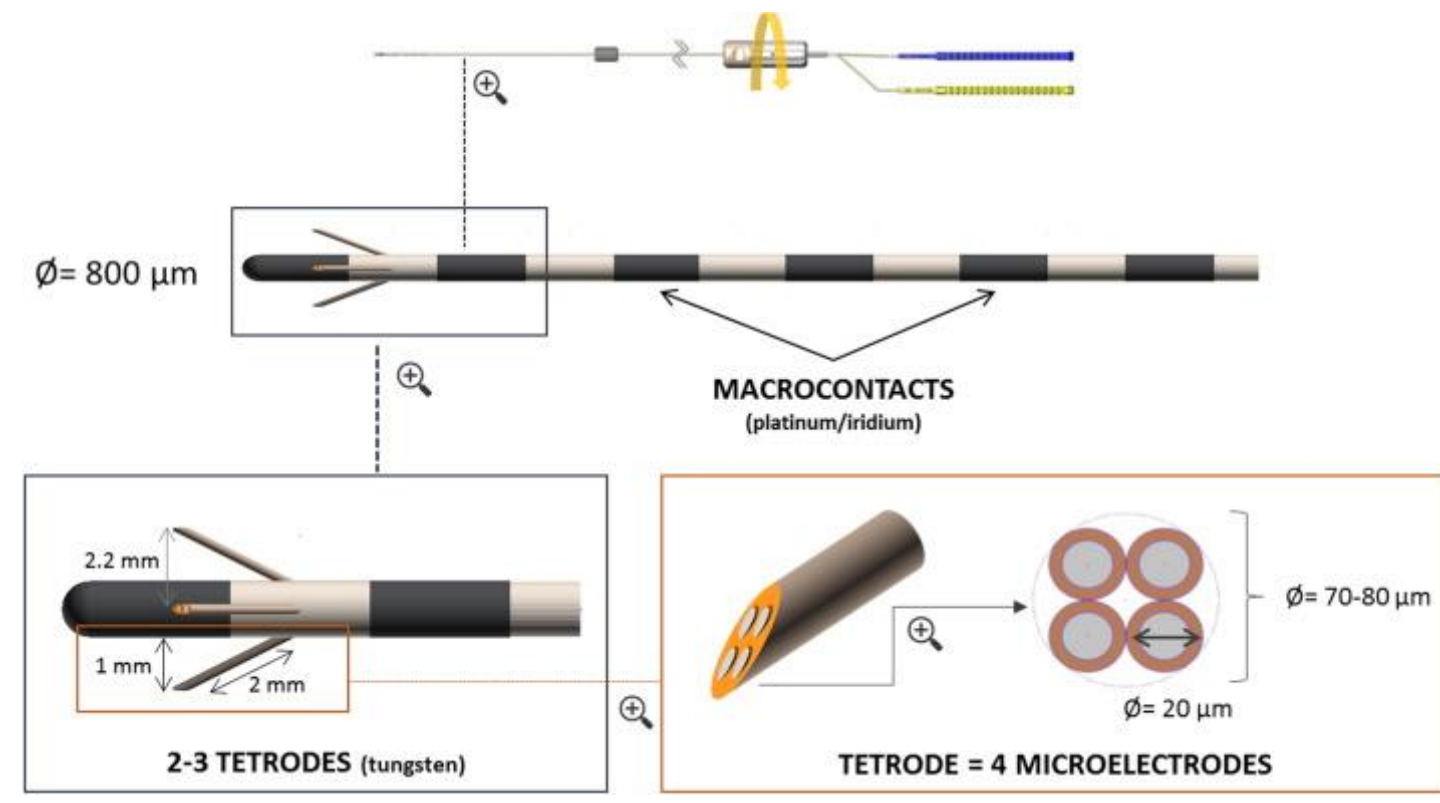
Do concept cells also exist in the temporal pole?

Methods

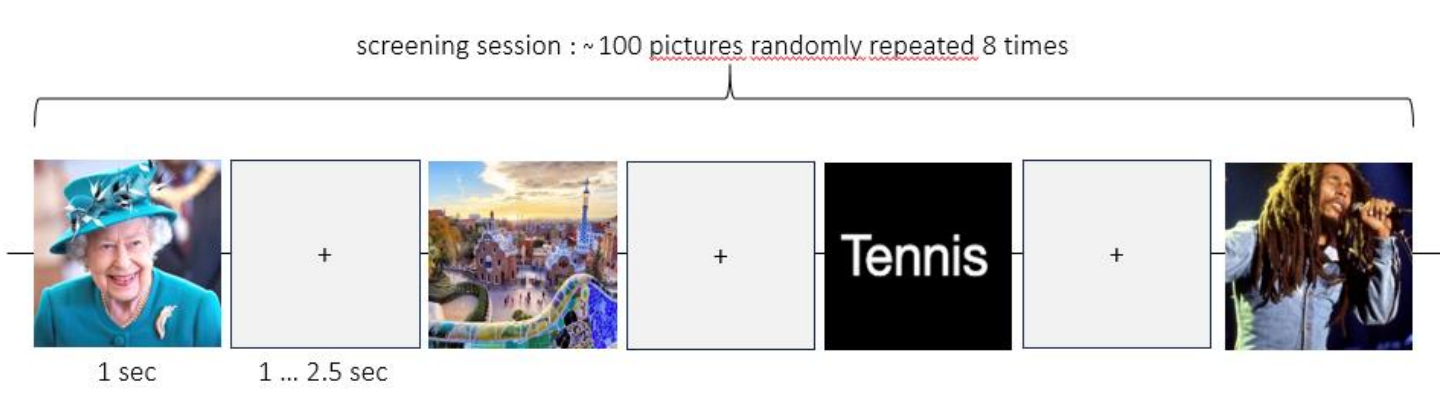


Patient: 34 year-old male with a left MTL epilepsy

Electrodes. 9 semi-rigid multi-contact electrodes and 4 hybrid electrodes were implanted in this patient. The macroelectrodes (Dixi Medical, France) had a diameter of 0.8 mm and contained 5 to 18 contacts (platinum/iridium). The contacts were 2 mm long and evenly spaced at 1.5 mm intervals. Hybrid electrodes (Dixi Medical, France) consisted of a standard macroelectrode but fitted with two tetrodes extending from the shaft between the 2 deepest contacts (blue arrows).



Experimental sessions. The patient was in his room and was presented with a large number of images of famous people, landmarks, familiar objects, some of them related to the interest of the patient. iEEG signal were acquired with a 256 channel Atlas System (Neuralynx).



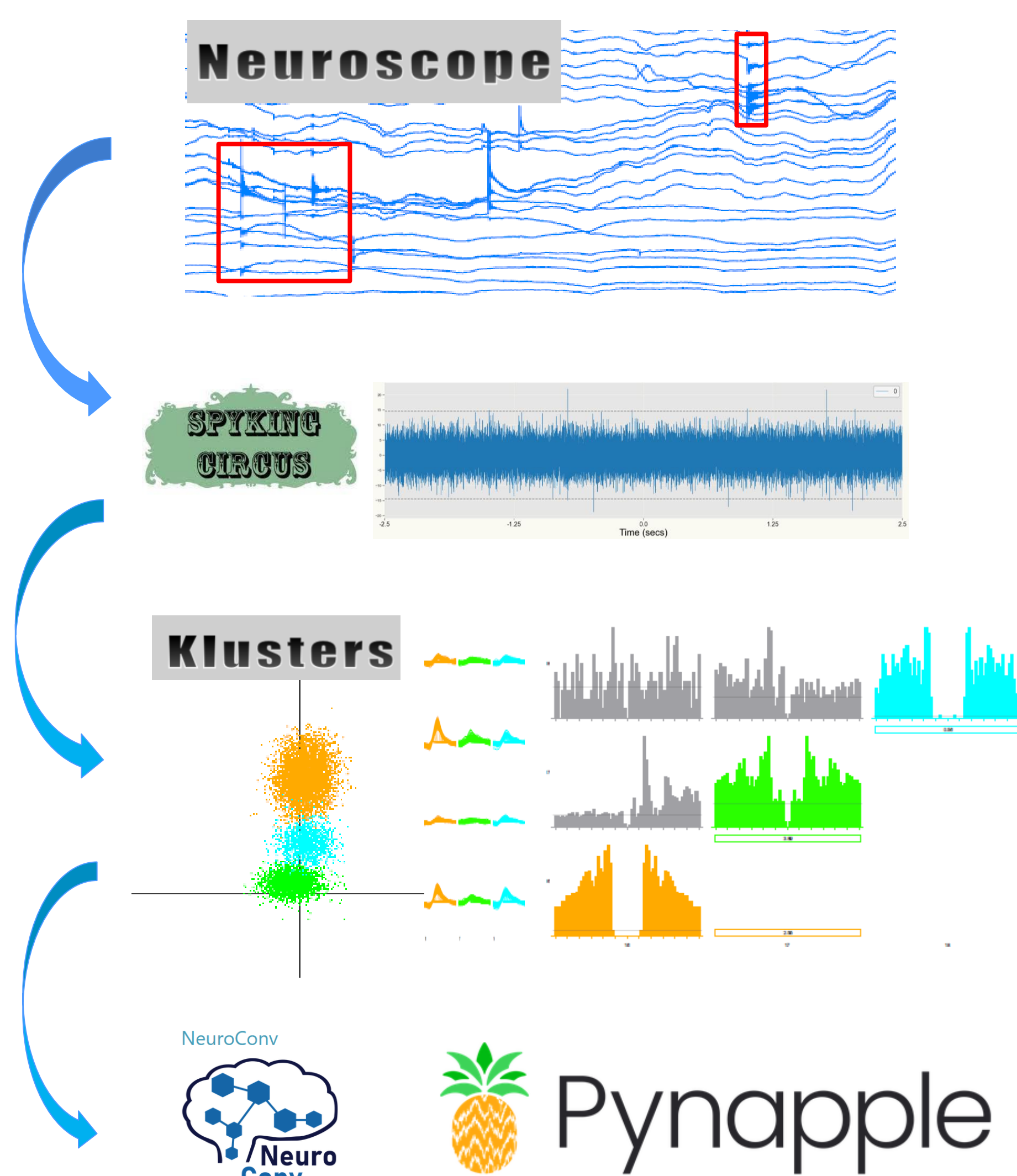
Data analysis.

1) iEEG raw data were loaded in Neuroscope (Hazan et al., 2006) to note in a dead file the periods (in ms) with artefacts

2) Band-pass filtered between 300 and 3000 Hz
3) Processed with the Spyking-circus algorithm (Yger et al., 2018)

4) Manually cleaned with Klusters (Hazan et al., 2006)

5) Klusters files (.clu) were transformed into NWB files (.nwb) with NeuroConv (Baker et al., 2023)
6) They were then analyzed with Pynapple (Viejo et al., 2023)

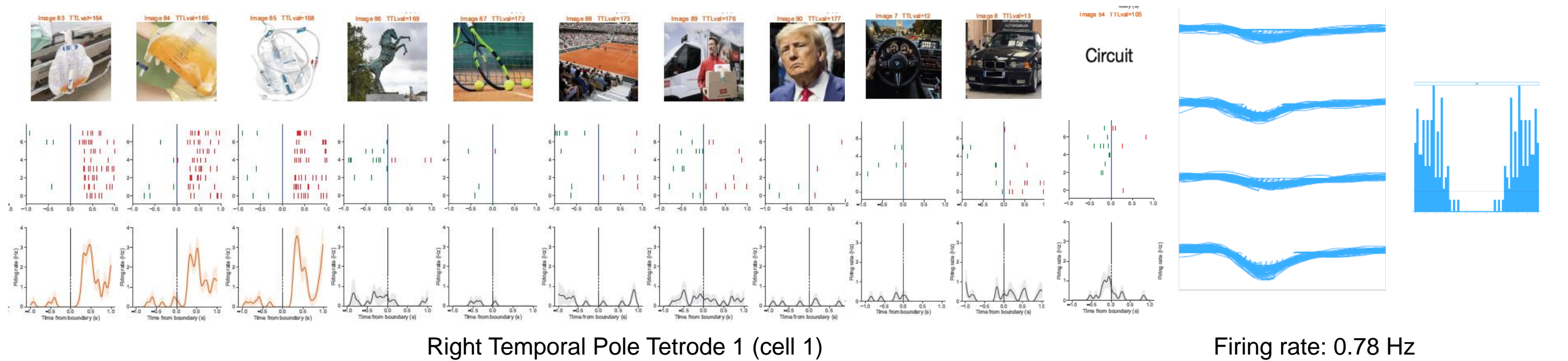


Results

Across five different sessions, we identified 46 different single units with an average of 9.2 single-units per session, mostly in the right temporal pole (73.91 %) and in the left temporal pole (23.91 %). Across the 5 sessions, 28 single-units were responsive to at least one image (60.87 %).

Région	Session1 (Week 1: Tuesday)	Session2 (Week 1: Wednesday)	Session3 (Week 1: Thursday)	Session4 (Week 1: Friday)	Session5 (Week 2: Tuesday)	Total Single-Unit
Rhinal cortex (R)	0	0	1	0	0	1
Temporal pole (R)	11	9	9	4	1	34
Hippocampus (L)	0	0	0	0	0	0
Temporal pole (L)	4	2	0	1	0	7
Total per session	15	11	10	5	1	42

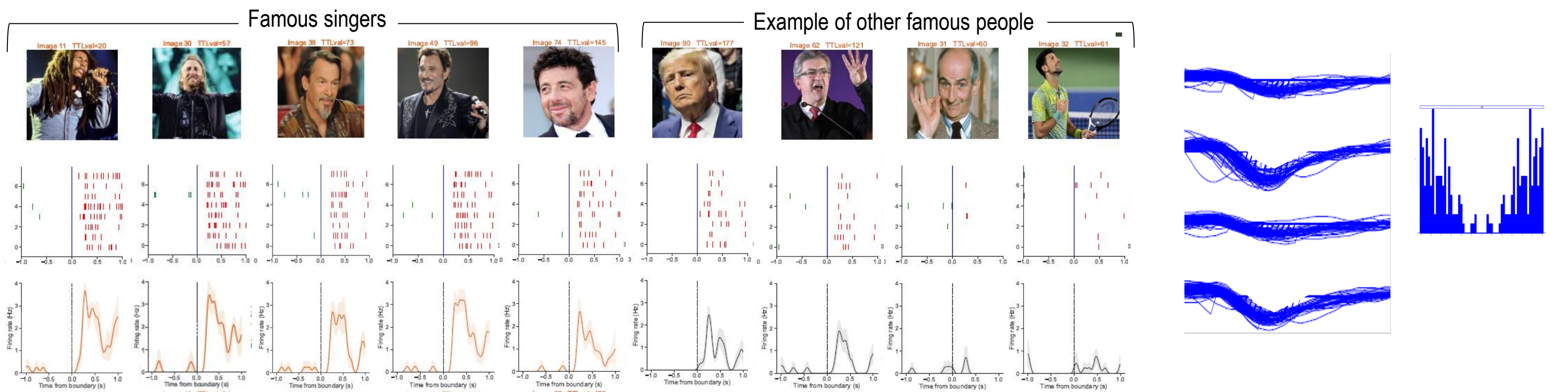
Do concept cells exist in the temporal pole? Yes.



Right Temporal Pole Tetrode 1 (cell 1)

Firing rate: 0.78 Hz

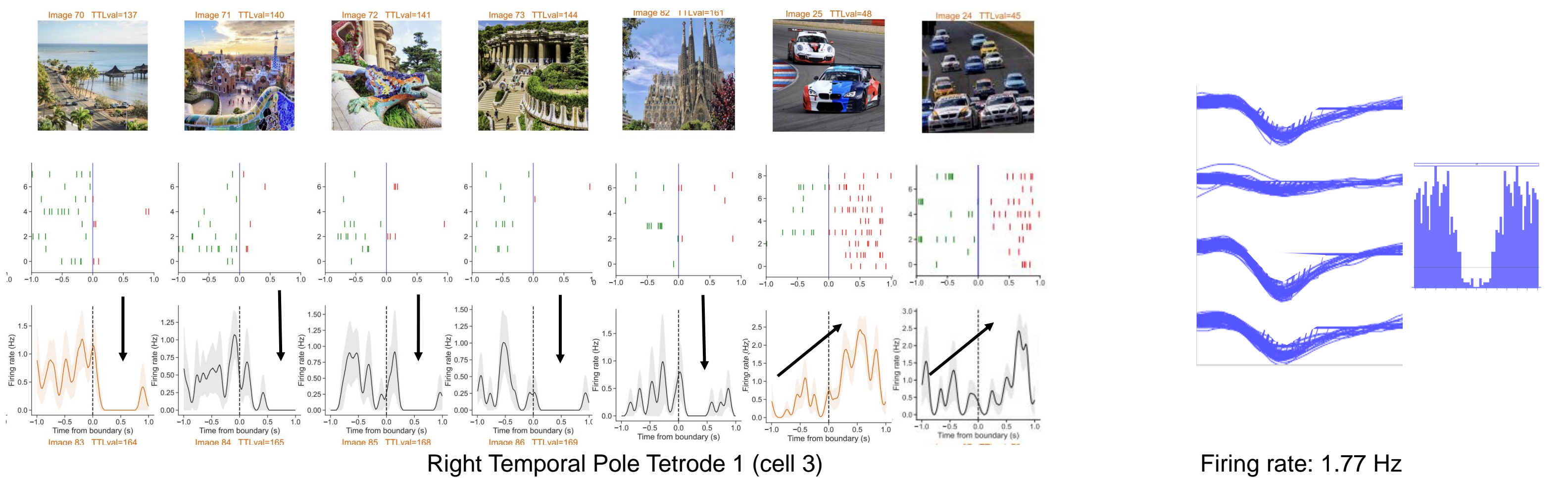
Are some of these cells responding to semantically related concepts? Yes.



Right Temporal Pole Tetrode 1 (cell 2)

Firing rate: 0.66 Hz

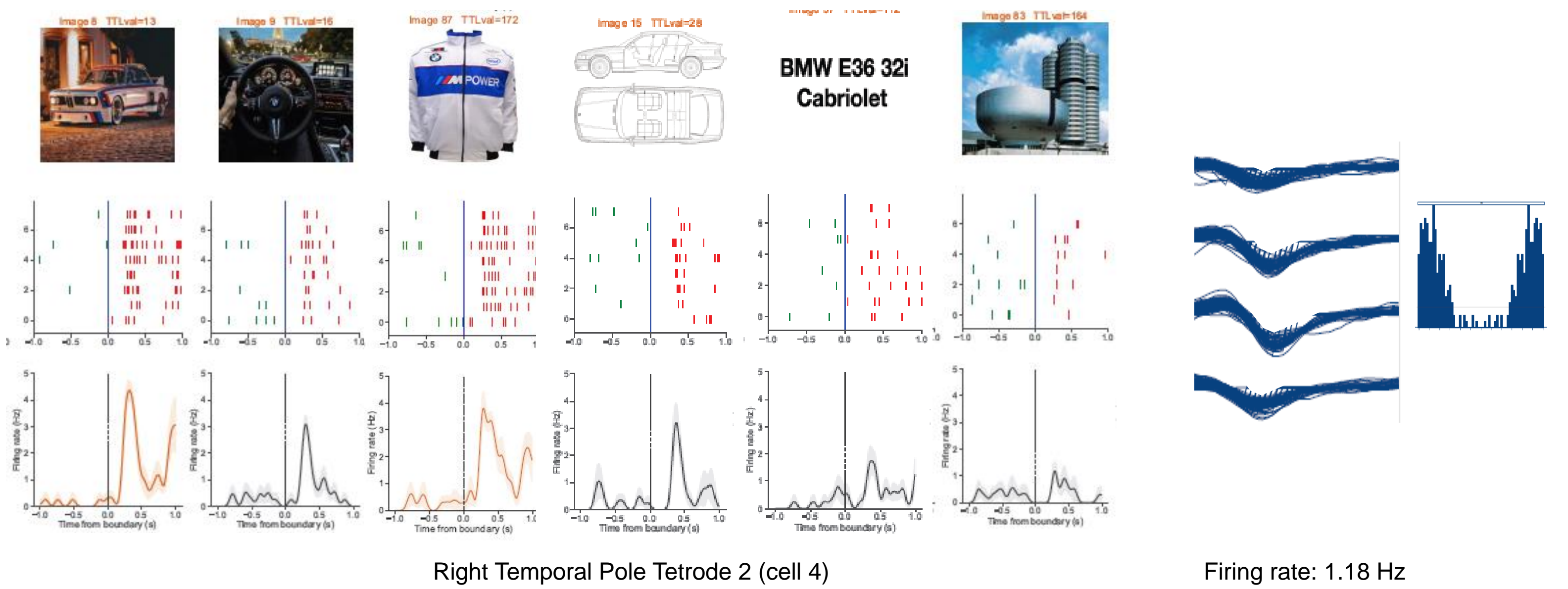
Different forms of coding? Some neurons cease firing for some pictures but show increased firing rate for others.



Right Temporal Pole Tetrode 1 (cell 3)

Firing rate: 1.77 Hz

Response to personal semantic concepts? Is there a multimodal coding? BMW cell



Right Temporal Pole Tetrode 2 (cell 4)

Firing rate: 1.18 Hz

Preliminary conclusion

Concept cells in the temporal pole? Yes, we observe a lot of activities in the temporal poles for related semantic concepts but with multiple coding modalities. Data have already been acquired for 14 more patients. More concept cells to come across different patients and brain structures to better characterize their properties!

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Contact: vincent.dornier@cnrs.fr

