

# Experience with the cochlear implant modulates the neural tracking of the beat

Celma-Miralles, Alexandre<sup>1</sup>; Seeberg, Alberte B.<sup>1</sup>; Haumann, Niels T.<sup>1</sup>; Vuust, Peter<sup>1</sup>; Petersen, Bjørn<sup>1</sup>

<sup>1</sup>Center for Music in the Brain, dpt. of Clinical Medicine, Aarhus University & The Royal Academy of Music Aarhus/Aalborg, Denmark

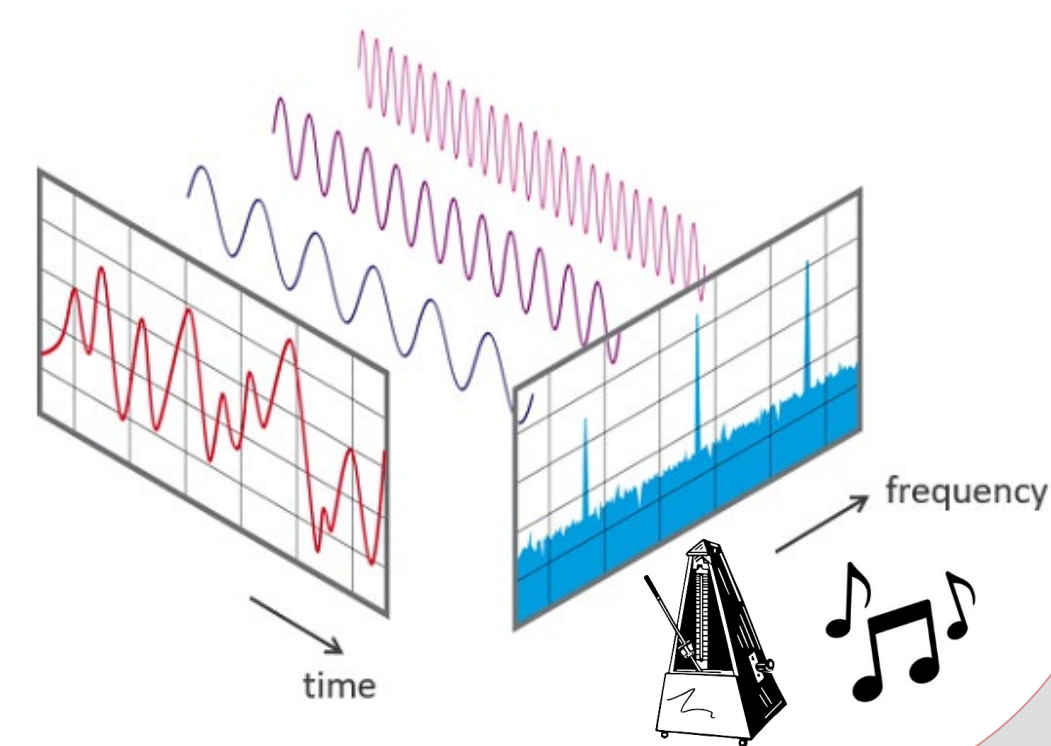
## Rhythm perception in CI-users

The processing of musical features is not trivial in cochlear implant (CI) users.

While multifeature paradigms eliciting mismatch negativities allowed to objectively study the **discrimination of musical features** (i.e. pitch, intensity or timbre; Petersen et al. 2020; Seeberg et al., in rev.), the same paradigms struggled to capture the rhythmic deviations of the musical stimuli.

Here, we approach previous electroencephalography (EEG) recordings of CI-users and NH controls with a frequency-tagging method, allowing us to study the **neural synchronization to the beat** of the Alberti bass: an arpeggiated 4-tone pattern.

The **frequency-tagging method** (Nozaradan, 2014) uses a fast Fourier transform to decompose the oscillating EEG activity into its underlying frequencies. With this method, we can measure the **frequency amplitudes related to the periodicities of the stimuli**, such as the **beat and its metrical groupings**.



## Recording periodic stimuli with EEG

Participants:

- **Recently implanted CI-users (Clre)**, N=8, mdn age=61, 2♀ recorded twice: first 6 weeks (T1) and after 3 months (T2)
- **Experienced CI-users (Clex)**, N=13, mdn age=56, 9♀ CI-experience: mdn = ~7 years
- **Normal hearing controls (NH)**, N=14, mdn age= 62, 7♀

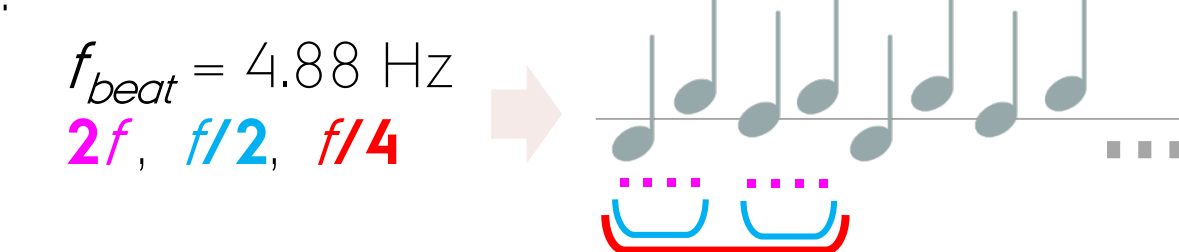


Task: "watch a muted movie while hearing the auditory stimuli"



Stimuli:

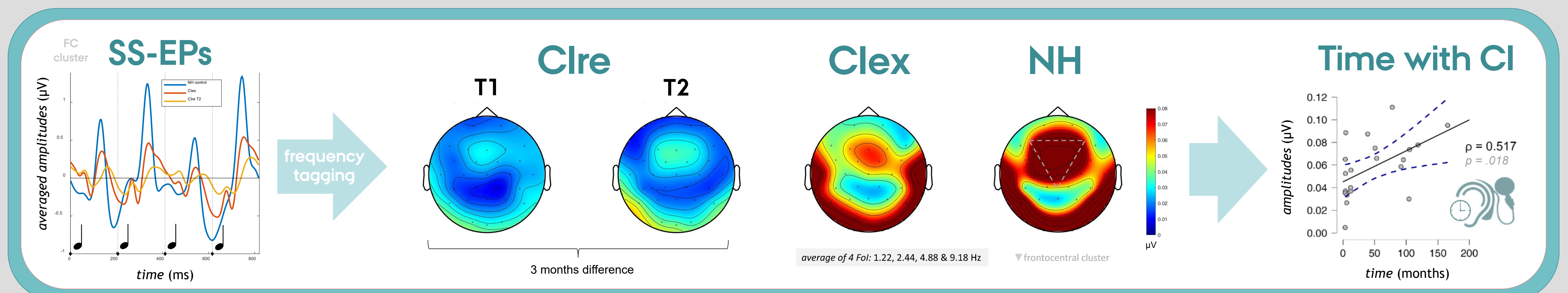
- Musical MultiFeature paradigm playing the Alberti bass at 4 different keys
- 48 trials lasting 39.36s with 192 (200 ms-)tones presented at 146 BPM
- Frequencies of Interest:



EEG:

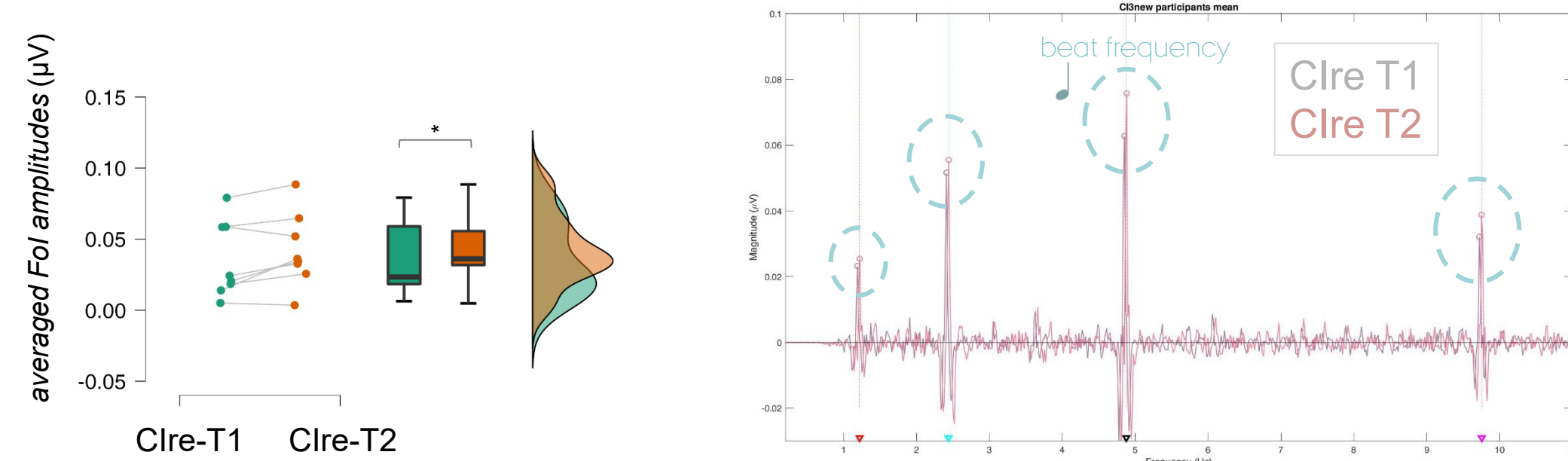
- 32 electrodes 10/20 system, actiCap (BrainProducts), Reference = FCz
- Band-pass filtered 1-25 Hz, ICA artifact removal, downsampled to 250Hz

The more experience a CI-user has with the implant, the stronger the neural tracking of the beat becomes.



## Higher peaks in Clre after 3 months

After approximately three months of experience with the CI, the **neural synchronization to the beat** has already increased.

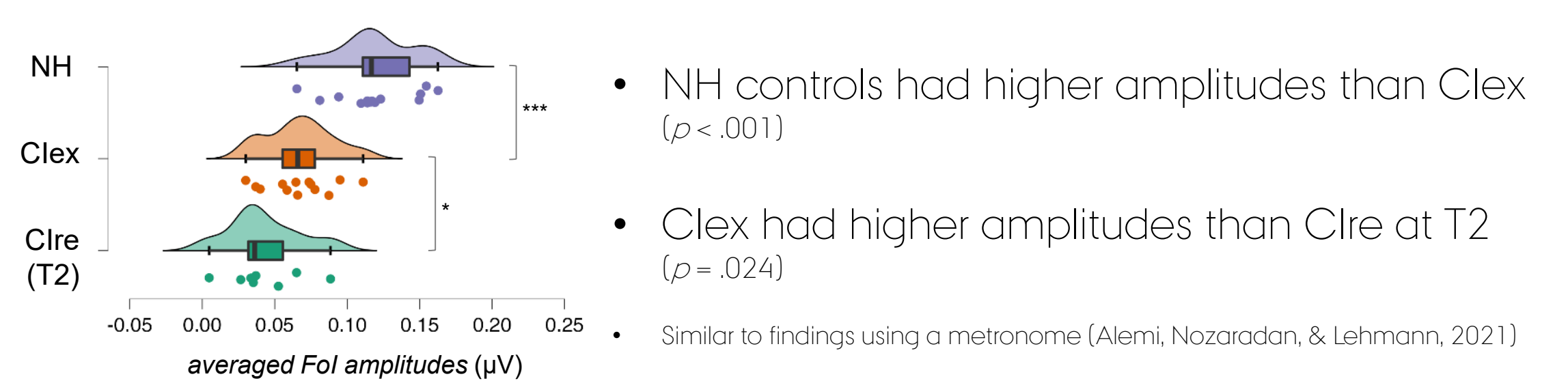


- Peaks at beat-related frequencies → amplitudes greater than zero (all  $p < .005$ )
- The averaged peak amplitudes increased after 3 months of CI experience ( $p = .025$ )

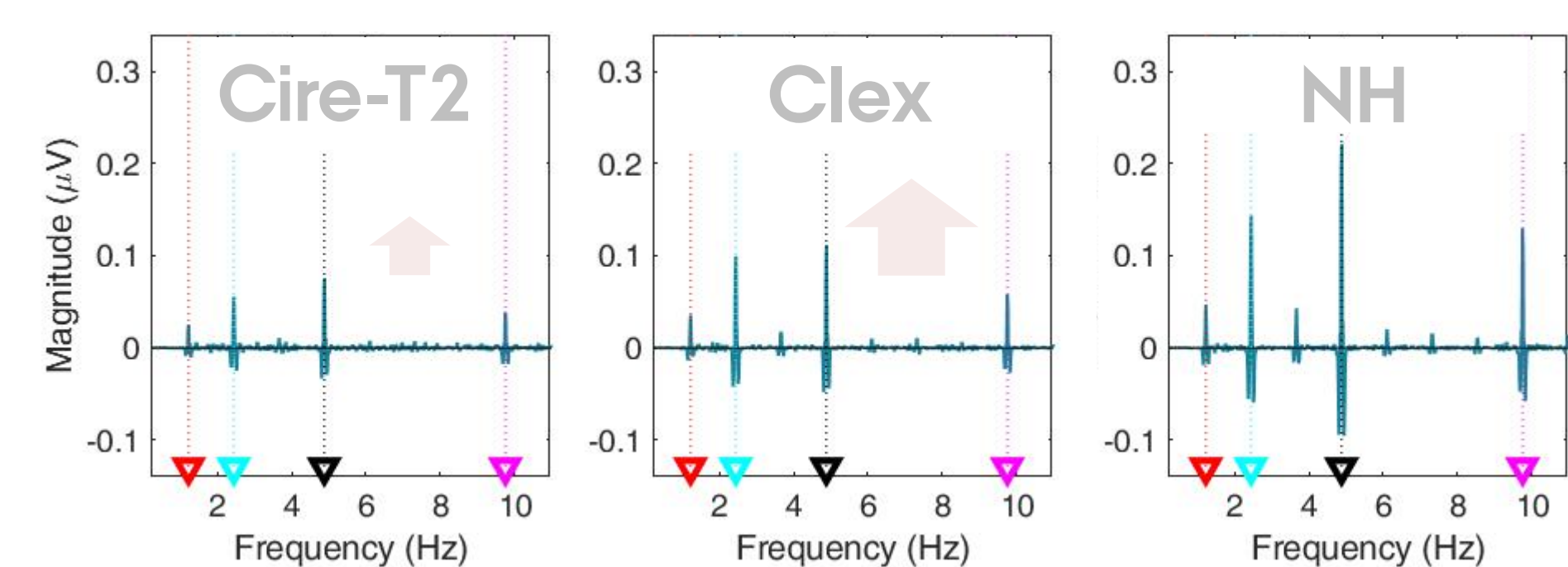
Frequency-tagging the beat of "musical stimuli" could become a **supplementary tool to assess the early brain adaptation to the CI.**

## With time, Clre & Clex approach NH

The auditory **SSEPs of CI-users increase** and become closer to those of NH adults, after several months of experience with the CI.



- NH controls had higher amplitudes than Clex ( $p < .001$ )
- Clex had higher amplitudes than Clre at T2 ( $p = .024$ )
- Similar to findings using a metronome (Alemi, Nozaradan, & Lehmann, 2021)



### REFERENCES

Alemi, R., Nozaradan, S., & Lehmann, A. (2021). Free-Field Cortical Steady-State Evoked Potentials in Cochlear Implant Users. *Brain Topography*, 34(5), 664-680. JASP Team (2022). JASP (Version 0.16.3). Nozaradan, S. (2014). Exploring how musical rhythm entrains brain activity with electroencephalogram frequency-tagging. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 369(1658), 20130393. Petersen, B., Andersen, A. S. F., Haumann, N. T., Højlund, A., Dietz, M. J., Michel, F., ... & Vuust, P. (2020). The CI MuMuFe—a new MMN paradigm for measuring music discrimination in electric hearing. *Frontiers in neuroscience*, 2. Seeberg A. B., Trusbak Haumann, N., Højlund, A., Andersen, A. S. F., Faulkner, K. F., Brattico, E., Vuust, P., Petersen, B. (in review). Adapting to the sound of music - development of music discrimination skills in recently implanted CI users. *Trends in Hearing*.

