Discriminative responses to auditory representations revealed by means of EEG frequency tagging of synthetic sounds

Martina Berto[1], Emiliano Ricciardi[1], Pietro Pietrini[1] and Davide Bottari[1]
[1]*Molecular Mind Lab, IMT School for Advanced Studies Lucca, Lucca, Italy*

The auditory system relies on different mechanisms to process and differentiate sound-objects. Local feature encoding allows to discriminate sounds based on their fine-grained temporal details; when temporal details exceed the system capacity, averages over time are computed and summarized into a set of statistics. Whether these local feature encoding and statistical averaging operate automatically, and to which extent they represent alternative or cumulative processes is unclear.
To answer these questions, we used an auditory EEG frequency-tagging approach to investigate the neural correlates of discriminative responses associated to these two modes of auditory representation (features encoding vs. statistical averaging). Stimuli were synthesized with a computational model to control which auditory statistics were embedded in each sound. As statistical similarity varies as a function of sound duration, stimuli of three different lengths were employed. The EEG was recorded to sound triplets presented with a base frequency of 2Hz and with oddball stimuli at 0.667Hz.
Two versions of the experiment were designed: (i) in Exemplar Discrimination, statistical properties of all three sounds tended to progressively converge when sound duration increased, as they all originated from the same sound source, the two standards were exactly the same sound, and the oddball significantly deviated only for its local features; (ii) in Texture Discrimination, the oddball was originated from a different sound source and, for all durations, it differed in both its local features and statistical properties as compared to the standards, which were identical.
Fourteen normal-hearing participants were tested (mean age = 26.64; std = 2.37) and were asked to detect an infrequent target sound occurring at a random rate within the auditory stimulation.
Significant discriminative responses were found for both experiments and systematically varied across conditions and durations.
Despite in the Exemplar Discrimination only local features were markedly different between the oddball and the standards, and in Texture both local features and statistical averaging varied, the oddball response was greater for Exemplar as compared to Texture Discrimination.
Namely, once differences between averaged statistics were available the response was dampened.
These findings revealed that discriminative responses associated to auditory local feature encoding and time-average statistics processing can be objectively measured by Frequency tagging and occur at an automatic level. Moreover, the two modes appear to be alternative to each other. The presence of statistical differences among sounds (e.g. different sound sources) determines whether the system will automatically engage in one mode, at the expense of the other.