Auditory pattern formation is an important higher level function of auditory perception. The ability to detect repeating pitch patterns, i.e., to form groups from a short sequence of sounds, underlies skills that are crucial for making sense of complex auditory scenes as well as to learn speech and music. In the framework of the EmCAP project (Emergent Cognition through Active Perception, http://emcap.iua.upf.es), we investigated whether newborn babies can detect repeating pitch patterns similarly to adults by recording EEG from sleeping newborns.

One of the ontogenetically earliest event related brain potential (ERP) responses, the mismatch negativity (MMN), is elicited by deviants embedded in a regular sound sequence [1]. In adults, when a repeating tone (standard, S) is randomly exchanged for a different tone (deviant, D) 20% of the time, deviant tones elicit the MMN component [2, 3]. In contrast, when the same tones with the same probability are presented in a fully regular order (SSSSDSSSSDSSSSD...) at short stimulus onset asynchronies, no MMN is elicited by the D tones [3]. This result suggests that the five-tone SSSSD cycle is extracted by the adult brain as the repeating unit of the sequence and the D tones become part of the regular sequence. In the current study we tested automatic grouping of the SSSSD pattern in sleeping neonates by comparing the responses to D tones between regular and random-order sequences. In addition to the ERP responses, oscillatory gamma-band EEG activity was also analyzed, because gamma-band activity related to cognitive processing of auditory stimuli has been previously reported in adults [4].

In two stimulus conditions, standard (S) and deviant (D) tones were delivered with a SOA of 100 ms, the D tone appearing less frequently (20%) than S tones (80%). In the random condition, tones were delivered in a pseudorandomized order with at least two standards separating successive deviants. In the grouped condition, the SSSSD pattern was repeated regularly.

The recordings were carried out in the hospital ward of the First Department of Obstetrics and Gynecology, Semmelweis University, Budapest, Hungary. The mother of the infant was present at the measurements. EEG was recorded with 24-bit resolution and a sampling rate of 250 Hz by a direct-coupled amplifier (V-Amp, Brain Products, Gilching, Germany). Our portable EEG workstation consisted of two notebooks with the V-amp attached to one of them and the other producing the auditory stimuli. The small weight and size of the V amp made the transport and setup of the workstation relatively easy in the very limited space of the hospital's environment and its low voltage consumption allowed us to run the experiment safely on battery power. The results showed that the newborn brain extracted the repeating pitch pattern from the sound input. Group-averaged ERPs elicited by deviant tones in the random condition displayed a fronto-centrally negative waveform between 150 and 250 ms from stimulus onset. This response was not elicited either by standard tones or by deviant tones in grouped condition. This result suggests that the repetition of the SSSSD pattern was detected in the grouped condition and, similarly to adults [3], the S and D tones were processed as part of the same regularity in neonates. In contrast, in the random condition, deviants were detected as violating the frequent repetition of the standard tone.

We also found for the first time in newborn infants an oscillatory gamma band response that was sensitive to sequential sound probability. In the random condition, prominent gamma-band oscillations were triggered by deviants whereas standards were followed by an amplitude decrease in the same frequency band. In summary, these results show that the neonate auditory system can extract repeating pitch patterns from the auditory input thus being able to detect various local and large-scale regularities of the sound environment.