The time-course of visual rule learning in preverbal infants: evidence from neural entrainment

Bettoni R.[1,2], Bulf H. [1,2], Silvestri V.[1,2], Tursi B. [1], Peykarjou S.[3], & Macchi Cassia V. [1,2]

[1] Dept. of Psychology, University of Milano-Bicocca, Italy,
[2] Milan Center for Neurosciences (NeuroMI), Italy
[3]Dept. of Developmental and Biological Psychology, University of Heidelberg, Germany

Detecting and generalizing repetition-based, abstract patterns (e.g., ABB, ABA) in continuous streams of information (i.e., Rule Learning, RL) is an important cognitive ability available from earlier on in development. Most studies investigating RL in infants focused on the outcome of learning by having participants passively exposed to structured item sequences, and then tested for their ability to discriminate between sequences of new items instantiating the familiar or a novel rule-based structure (e.g., Marcus et al., 1999). Nonetheless, the neural correlates of such learning process can be investigated by exploiting neural entrainment, the phenomenon by which brain activity naturally synchronizes to the rhythm of periodic external stimuli (Norcia et al., 2015). Electrophysiological studies have shown that, when applied to speech streams, neural entrainment gradually aligns neural excitability from syllable frequency to words and embedded structures frequencies, thus supporting the learning of high-level rules (Ding et al., 2017).

Here, for the first time, we exploited the neural entrainment EEG procedure to investigate the time-course of RL from sequences of visual shapes in 9-month-olds infants (N = 17) and adults (N = 10, preliminary samples). Both adults and infants were exposed for 2 minutes to a continuous stream of shapes organized into ABA triplets. Each shape was presented at the frequency of 6Hz, while the triplet frequency was 2 Hz. Adults were also tested in a second condition where the stream of shapes contained a more complex hierarchical structure in which ABB and ABA triplets were organized into a hierarchical ABA structure (i.e., *aba-abb-aba*), so that the shape frequency was 6 Hz, the triplet frequency was 2 Hz, and the frequency of the hierarchical structure was 0.66 Hz.

Data collection is still in progress; preliminary data showed a clear EEG response time-locked to the item frequency (6 Hz) and the embedded triplet frequency (2 Hz) in all infants during the first 20 seconds of exposure. A similar response was found in the adult preliminary sample, who showed a significant response to both the item frequency (6 Hz) and the triplet frequency (2 Hz). No response at the frequency of the embedded hierarchical structure (0.66 Hz) was evident so far. Although exploratory, these preliminary results suggest that the infant brain is capable to track probability information among visual shapes through neural mechanisms which emerge early in life and are maintained throughout the lifespan (Choi et al., 2020).