

**Creativity and neuroscience:
What neural oscillations tell us
about generating and processing of creative ideas**

In electrophysiological research on creativity, participants are invited to laboratories and asked to be creative at will. Analyses of neural oscillations in these studies have revealed changes in the alpha band (8 – 12 Hz), with increases in the alpha band activity when participants perform tasks requiring generating novel as compared to common ideas. Although such changes in alpha power have been replicated in several studies so far (Benedek et al., 2011; Jauk et al., 2012), the identification of specific cognitive processes underlying creative thinking remains a challenging task (Abraham, 2013). For example, the long time windows within which these changes are observed increase the difficulty of dissecting the process of idea generation into specific steps. A recent study (Rominger et al., 2018) found that when such time windows are divided into smaller ones, the increases in the upper alpha band are observed only in the late time windows, preceding the response. This brings up a question of whether the effects in the alpha power band observed in previous studies were related to creative idea generation, or rather elaboration on or evaluation of the generated ideas preceding response selection. Also, most conclusions regarding the relationship between neural oscillations and creativity have been formulated based on research employing the alternate uses task, in which participants generate alternate uses of common objects. At the same time, other tasks potentially related to creative thinking have rarely been used. In order to zoom into the specific cognitive processes underlying creative thinking, we investigated the changes in neural oscillations related to the processing of creative ideas in two electrophysiological studies, in which different materials and tasks were employed. In these studies, participants were presented with creative ideas, i.e., novel metaphors, e.g., *He was amazed by another moldy theory* (Study 1), and alternate uses of objects, e.g., *use a nest as a crown* (Study 2) (Rataj et al., 2018). In study 1, participants read the sentences for comprehension, while in Study 2, they evaluated whether it was usable or not (question 1), and common or not (question 2) to use one object as another in the alternate use evaluation task (AUeT). Except for the creative items, participants also read literal and anomalous sentences in Study 1, and evaluated common and impossible uses of objects in Study 2. Different oscillatory patterns were observed in the two studies, with increased activity in the theta band related to the processing of novel metaphoric as compared to literal sentences, and increased activity in the upper alpha band related to evaluating alternate as compared to common uses of objects. These results can be interpreted as reflecting increased semantic processing demands in the novel metaphor reading task (Study 1), and common use inhibition in the AUeT (Study 2), suggesting potential differences in the oscillatory patterns depending on stimulus and task type. The results will be discussed in reference to current theories of creativity and functional roles of the alpha and theta oscillations.

Word count: 489

Key words: creativity, neural oscillations, alternate uses task, novel metaphor

References

- Abraham, A. (2013). The promises and perils of the neuroscience of creativity. *Frontiers in human neuroscience*, 7, 246.
- Benedek, M., Bergner, S., Könen, T., Fink, A., & Neubauer, A. C. (2011). EEG alpha synchronization is related to top-down processing in convergent and divergent thinking. *Neuropsychologia*, 49(12), 3505-3511.
- Jauk, E., Benedek, M., & Neubauer, A. C. (2012). Tackling creativity at its roots: Evidence for different patterns of EEG alpha activity related to convergent and divergent modes of task processing. *International Journal of Psychophysiology*, 84(2), 219-225.
- Rataj, K., Nazareth, D. S., & Van Der Velde, F. (2018). Use a spoon as a spade?: Changes in the upper and lower alpha bands in evaluating alternate object use. *Frontiers in Psychology*, 9, 1941.
- Rominger, C., Papousek, I., Perchtold, C. M., Weber, B., Weiss, E. M., & Fink, A. (2018). The creative brain in the figural domain: distinct patterns of EEG alpha power during idea generation and idea elaboration. *Neuropsychologia*, 118, 13-19.