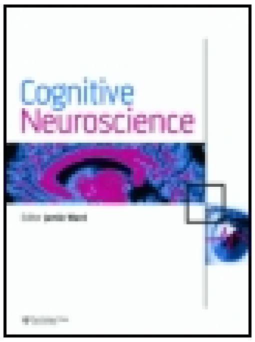

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Cognitive Neuroscience

ISSN: 1758-8928 (Print) 1758-8936 (Online) Journal homepage: http://www.tandfonline.com/loi/pcns20

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To cite this article: Olga Kepinska & Niels O. Schiller (2016): Possible neural oscillatory mechanisms underlying learning, Cognitive Neuroscience, DOI: 10.1080/17588928.2016.1205578

To link to this article: http://dx.doi.org/10.1080/17588928.2016.1205578

COGNITIVE NEUROSCIENCE, 2016
http://dx.doi.org/10.1080/17588928.2016.1205578

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COMMENTARY

Possible neural oscillatory mechanisms underlying learning

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ABSTRACT
In response to Voelker et al. (this issue), we argue for a wide array of neural oscillatory mechanisms underlying learning and practice. While the authors propose frontal theta power as the basis for learning-induced neuroplasticity, we believe that the temporal dynamics of other frequency bands, together with their synchronization properties can offer a fuller account of the neurophysiological changes occurring in the brain during cognitive tasks.

ARTICLE HISTORY
Received 9 May 2016
Published online 22 July 2016

KEYWORDS
Learning; neural oscillation; neuroplasticity

Voelker et al. (this issue) offer a fascinating view on the molecular basis of learning, a line of study that clearly merits investigation.

While we agree with the premise that changes in white matter can underlie behavioral manifestations of learning, we believe that learning and practice might be based on a much wider array of different neural mechanisms.

We would like to mention a possible extension of the working hypothesis that considers the frontal theta rhythm as the basis for neuroplasticity mechanisms coupled with learning, as the authors suggest.

We believe that apart from local oscillatory mechanisms, such as frontal theta power, global mechanisms, such as long-range coherence, should be taken into account. For example, information about functional cooperation between cortical regions during learning can be obtained by analyzing the synchronization properties of the electroencephalogram (EEG) signal within certain frequency bands.

In the language-learning domain, for instance, increased long-range gamma band phase coherence has been shown to accompany successful rule learning (De Diego-Balaguer, Fuentemilla, & Rodriguez-Fornells, 2011). These results are in line with the view that an increase in coherence in the gamma band ‘could fulfil the criteria required for the formation of Hebbian cell assemblies, binding together parts of the brain that must communicate with one another in order for associative learning to take place’ (Miltner, Braun, Arnold, Witte, & Taub, 1999, p. 434).

Also, our data (Kepinska, Pereda, Caspers, & Schiller, in prep.) provide evidence for the role of gamma band coherence in the process of learning. Employing a bivariate, frequency-specific index of phase synchronization termed Phase Locking Value (PLV, Mormann, Lehnertz, David, & Elger, 2000), we evaluated the contribution of four frequency bands (alpha, beta, gamma, and theta) to online learning of novel grammar. We observed a negative correlation between global PLV values of the slow frequency bands (theta and alpha) and scores on the learning task, and a positive correlation between the high frequency bands (gamma and beta) and the scores. However, only the gamma band global PLV values proved predictive of the performance according to a stepwise linear regression analysis.

In the context of investigations into neuroplasticity mechanisms, it therefore seems vital to us not to limit the observations of the EEG signal to theta band power, but to expand the approach and include the temporal dynamics of other frequency bands, together with their synchronization properties as well. Such an approach can offer a fuller account of the neurophysiological changes occurring in the brain during cognitive tasks.

Disclosure statement

No potential conflict of interest was reported by the authors.

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Funding

This work was supported by the Leiden University Centre for Linguistics and the NWO Graduate Programme.

References

De Diego-Balaguer, R., Fuentemilla, L., & Rodriguez-Fornells, A. (2011). Brain dynamics sustaining rapid rule extraction from speech. *Journal of Cognitive Neuroscience*, *23*, 3105–3120.

Kepinska, O., Pereda, E., Caspers, J., & Schiller, N. O. (in prep.). *Neural oscillatory mechanisms during novel grammar learning*.

Miltner, W. H., Braun, C., Arnold, M., Witte, H., & Taub, E. (1999). Coherence of gamma-band EEG activity as a basis for associative learning. *Nature*, *397*, 434–436.

Mormann, F., Lehnertz, K., David, P., & Elger, C. E. (2000). Mean phase coherence as a measure for phase synchronization and its application to the EEG of epilepsy patients. *Physica D: Nonlinear Phenomena*, *144*, 358–369.

Voelker, P., Piscopo, D., Weible, A. P., Lynch, G., Rothbart, M. K., Posner, M. I., & Niell, C. M. (2016). How changes in white matter might underlie improved reaction time due to practice. *Cognitive Neuroscience*, 1–7. doi:10.1080/17588928.2016.1173664