Review of: "Study of EEG characteristics while solving scientific problems with different mental effort"

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The study of Zhu, Wang and Zhang's has the merit of tackling the complex problem of mental effort by relying on the recording of electroencephalographic activity during the solving of scientific problems. These scientific problems were visually presented on the computer screen under the form of symbolic diagrams mimicking the forces acting on targeted objects including writing indications of the velocity of the object and the friction of contacting surfaces. Low or high complexity of these scientific problems were compared. In the first part of the Introduction, the authors recognized the inherent complexity of the 'mental effort' concept and the difficulty to manage an experimental setup capable to decipher the involvement of the related neural mechanisms.

There are a number of concerns with this study which include the following:

At this stage of the manuscript, it is no clear how the graphical representation used in this study can help to better identify mental effort during the solving of scientific problems.

Moreover, the presentation of different graphical abstracts of low or high complexity implies different scanpaths of the eyes that occur continuously during the activation period. These basic ocular explorative movements linked to the recognition of the graphical picture related to the scientific problem are not taken into account in the present study.

This methodological weakness is not trivial because it is well recognized that explorative saccades rhythmically sample the environment in theta cycles supporting the fluctuation of spatial attention and perceptual sensitivity (Fiebelkorn & Kastner, 2019). These theta signal may also predicted individual differences in oculomotor switch costs, associated to reactive reconfiguration of target selection (van Driel *et al.*, 2019) when the object of attention is imposed like in the present case. This could also mean that it is not possible to differentiate the real contribution of the explorative saccades and the related theta ERS from the other mental effort processing in the present study.

Another weakness concerns the absence of a dynamical analysis of the EEG data. The power of the theta and alpha oscillations were analyzed during the 500 ms of the activation periods and reported as single entities during which the dynamic variations of the EEG signal were not analyzed. It is well recognized that the brain processing follows a temporal template inside of the different network which may continuously switch at about 30 ms (Abeles, 2014; Tal & Abeles, 2018). Classical event related spectral perturbation (ERSP) analysis and inter-trials coherency analysis (ITC) (available in the EEGlab software used by authors)

would had allowed to follow the dynamic of the mental effort in every subject. During this period of 500 ms the different processing including visual processing, working memory, decision making and outcome reporting and prediction may differently influence the global power increase or decrease of the theta and alpha oscillation. It would have been important to determine temporal elements during the activation period in order to be able to demonstrate the presence of a phase-locking of specific EEG rhythms, whether or not accompanied by a concomitant variation in power. This would have allowed to respond in the case of the presence of a pure phase-locking (Cebolla *et al.*, 2009) that the ongoing rhythms undergo a phase adjustment in line with the intensity of the effort.

Another pitfall concerns the limitation of the EEG analysis at the scalp level which involve a mixing of multiple cortical process by volume conduction and the absence of direct anatomical recognition of the true EEG generators by means of the scalp surface localization (see Fig. 1 of (Loo & Makeig, 2012).

By failing to resolve these problems, the authors tend to exaggerate their conclusions and take comfort in stating generalities already supported by other publications. Fortunately, further data analysis should be certainly possible and likely to provide us with more information closer to the neural oscillatory mechanisms involved in mental effort.

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