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Critiques

Studies of specific movements and their stabilization do not allow general inferences on motor learning, even at the neurophysiological level - comment on Lage et al (2021)

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This commentary refers to the minireview of Lage et al [1]. Writing reviews has recently enjoyed such growing popularity on the part of readers as well as on authors and publishers that critical voices that stimulate reflection are increasingly perceptible. Reviews are attractive and helpful in an environment of exponentially growing publications and the accompanying time crunch in the competitive environment of a publish-perish mentality. At the same time, they place the consumer in a dependency by trusting the reviews and place a high degree of responsibility on the author, as reviews are often associated with the power to form opinions for research directions. With the intention of "redirecting" research in the field of motor learning, Lage et al [1] set out to do so. Such a high and general claim related to motor learning makes one wonder, especially against the background of the current replication crisis in the life sciences. Increasing the generality of scientific claims reduces the probability of successful replications and suggests certainties about the predictability of interventions in the context of motor learning processes that are not tenable on closer inspection.

In the article in question, future potential for a deeper understanding of motor learning processes is seen in an extension of findings in memory and perception research, especially in connection with neurophysiological processes in the brain. As much as further gains in knowledge can be expected with brain research, which has dominated the last two decades, one must keep in mind that brain images in majority only reflect the tasks set from the outside and their experimental designs associated with them.

A closer analysis of the references listed reveals that they refer to a very narrow field of motor learning research, which shows systematic bias, especially in the addressed areas of perception and memory. Unfortunately, this is done without explicitly stating these boundaries, which opens the door to inadmissible generalization that frequently raises false hopes and limits the necessary diversity of research that would be helpful for the healthy development of science. Specifically, the studies discussed are limited to two specific models of variable motor learning, the Variability of Practice Model (VP) and the Contextual interference Model (CI) [2]. Both models have been systematically confirmed

only for the stabilization of movements with a small number of degrees of freedom (sDGF) in conjunction with a dominant influence of the visual perceptual apparatus in adults [2]. Studies on gross motor movements that could be interpreted as supporting the CI paradigm were dominated by visual content as well. It has not yet been possible to systematically generalize the initial findings to those with many Degrees of Freedom, nor to children's and adolescent's learning[2]. Analogously, the scope of the VP model is similar to CI limited to movements without the influence of gravity and inertial forces, thus excluding the majority of everyday and sports movements. Interestingly, both models refer to memory models as part of their explanatory attempts, which also have been studied exclusively on activities with visual, linguistic, sequential, and spatial character [2]. This tendency to study such activities is currently supported to a large extent by the orientation of the questions to the applied measurement methodology in the field of brain research. To avoid spurious signals in EEG measurements, movements are selected for experiments that do not allow head movements. Movement studies in conjunction with MRI brain scan also allow only a few degrees of freedom due to the spatially confined conditions.

Movements where kinesthetic, tactile, and proprioceptive perception are the main focus, such as cycling, running, walking, balancing on a slackline, playing soccer, etc., are excluded from these types of investigations. If one could still assume possible analogies on a proprioceptive-phenomenological level, neuroanatomical/physiological findings show sensor-specific pathways and networks that suggest different information processing. This deficit has recently been admonished in relation to memory research by Baddeley, who was instrumental in the development of the classical memory model[2].

It is also against this background that the minireview most likely compares the divergence of results in the EEG study of Henz et al [3]. This specific study differed from the other studies listed in two keyways. First, it did not examine brain activity during exercise, but in the subsequent resting state mode. Second, the badminton serve was a whole-body movement with many DGF and numerous kinesthetic demands that was studied. Thereby, these findings were not an isolated case or exception but confirmed findings from previous studies where a broader understanding of variable training was suggested, specifically the differential learning model [4]. The model interprets variable motor learning as a resonance phenomenon of variable internal and external noise levels, where VP and CI are understood as two specific levels of external noise. The differential learning model is derived from artificial neural network training and assumes that learning with added fluctuations can positively affect acquisition, stabilization, and improvement dependent on an individual's situation. Evidence for an altered influence of parallel complexity, as it occurs during whole body movements, on brain activities that are associated with working memory performance is provided by studies on solving cognitive tasks while sitting on unstable chairs [5]. Contrary to expectations that an additional coordinative task would overload working memory and be associated with a decline in performance, sitting on the unstable chair resulted in an increase in performance. Even if these are only initial indications of altered neurophysiological mechanisms, they are already too numerous to ignore.

In summary, the recommendation to investigate motor learning processes in connection with perception and memory processes by means of neurophysiological imaging methods in the future is essentially agreed with, but only with the extension to a stronger shift of the focus to kinesthetic, tactile, and proprioceptive perception processes in connection with more contemporary memory models, which additionally consider individual

specifics. Both would result in a fundamental rethinking of the common experimental paradigms.

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