



## Commentary

## The value of subsequent memory paradigms in uncovering neural mechanisms of early social learning

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de Klerk and Kampis (2021) discuss our finding that 7–10 Hz power over the motor cortex was increased for the observation of others' actions in 10- and 20-month-olds and, in addition, predicted the subsequent imitation of these actions in 20-month-olds (Köster et al., 2020). Activation of the motor cortex is commonly associated with a decrease in power in this frequency range (for a review, see Fox et al., 2016). Based on this, de Klerk and Kampis ask whether our findings may be explained by potential confounds in the baseline.

We applied a subsequent memory paradigm to investigate neural mechanisms of action learning: Contrasting neural activity for successfully versus unsuccessfully encoded items during the learning phase is the gold standard for isolating learning processes in human neuroimaging (Paller and Wagner, 2002), and is also commonly applied in neural oscillation studies (e.g., Frieze et al., 2013; Köster et al., 2018, 2019; Osipova et al., 2006). Thus, our characterization of the 7–10 Hz activity does not solely depend on the neural activity during the action observation phase, but also on identifying neural mechanisms underlying the successfully encoding of others' actions. de Klerk and Kampis speculate that our findings can be explained by baseline artifacts, due to infant movement or differences in interest levels. We consider this unlikely: de Klerk and Kampis rightfully remark that we did not exclude infants based on potential body movements in the baseline. However, we did not observe frequent movements, and these would have had to be highly consistent during baseline (-0.5 to -0.2 s) and introduction of the object (0–2 s). This is because the 7–10 Hz activity was relatively low when the object was introduced (0–2 s) and then increased succinctly during the action demonstration phase (2–6 s; see Köster et al., 2020, Fig. 2A). Moreover, this would not explain our main finding, the subsequent memory effect, which peaked in the same frequency (7–10 Hz) and at the same electrodes (C3, C4; see Fig. 3B). For the subsequent memory effect, we set the baseline to the object introduction phase (-1 to -0.2 s, prior to the action; i.e., 1 – 1.8 s with regard to the stimulus onset), which

we regard as a highly suitable baseline. It rules out major confounds because the experimenter shows an object, and all elements of action demonstration are already in place. Thus, this baseline should not differ between subsequently remembered and not remembered actions. This includes the level of interest in the object (as speculated by de Klerk and Kampis, 2021), because the object is presented during both the baseline and the action demonstration.<sup>1</sup>

In fact, several former studies have pointed towards an increase in 6–12 Hz activity in the developing motor cortex, specifically for the observation of others' actions (de Klerk et al., 2015 [see, pre-training phase]; Marshall et al., 2013 [for watching live object-directed actions]; Meyer et al., 2020; Ruyschaert et al., 2013; Upshaw et al., 2016; van Elk et al., 2008 [interpreting the findings in terms of walking-crawling, instead of crawling-walking]). So, how may an increase in neural synchronization in the alpha range (6–12 Hz) contribute to observation learning? Potentially, the 6–12 Hz rhythm may act as a gating mechanism in the developing motor cortex, analogous to the alpha rhythm in perceptual and mnemonic processes (e.g., Jensen and Mazaheri, 2010). By this token, an increase in the 6–12 Hz rhythm may inhibit motor cortex processes during action observation and learning (e.g., to prevent direct imitation).

<sup>1</sup> de Klerk and Kampis further note that we missed to report what was presented prior to the stimuli. We presented a duck with a sound (1 s) as an attention grabber, followed by a black screen with a variable duration of 0.5 to 0.7 s. Furthermore, de Klerk and Kampis asked whether there was a difference in 7–10 Hz activity during the baseline period of the subsequent memory contrast (-1 to -0.2 s, prior to the action), with regard to the baseline of the grand mean effect (-0.5 to -0.2 s, prior to the object presentation). This was not the case ( $t[32] = 0.54, p = .596$ ). Finally, de Klerk and Kampis highlighted that analyses of differences in other frequencies/processes may be of interest. We also analyzed the second frequency band which popped out (3–6 Hz at parietal electrodes) and did not find any interesting effects (see manuscript).

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We hope that future research considers the value of subsequent memory designs and the possibility that both an increase and a decrease in 6–12 Hz activity may play a critical role in action observation and learning in the developing motor cortex.

#### Data availability

N/A, because it is the reply to a commentary.

#### Declaration of Competing Interest

There are no conflicts of interest.

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