Left prefrontal cortex stimulation enhances free recall of unemotional and emotional content

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Memory generation first requires encoding of new information. The depth of encoding influences later retrieval performance; that is, deeper encoding is more beneficial than shallow encoding [1] and the encoding of emotionally valenced material even further facilitates retrieval [2]. For the encoding [3] of both unemotional and emotional material [4], the dorsolateral prefrontal cortex (DLPFC) is functionally relevant, with more activity leading to better retrieval. In the current study, we modulated the excitability of the DLPFC via anodal transcranial direct current stimulation (tDCS) during three depths of encoding (i.e., shallow, deep, and emotional; Fig. 1). We stimulated either the left or the right DLPFC, since in healthy young adults, the left DLPFC may be particularly involved during encoding, while the right DLPFC is more important during retrieval of information.

In this double blind, placebo-controlled, and parallel group study, we randomly assigned participants to one of three encoding conditions (Fig. 1). During encoding, they categorized 40 words based on two different criteria while we simultaneously applied either sham or 20 minutes of 1mA anodal tDCS. We placed the anode over the left (n=127, age 23.6 ± 2.6, 64 male) or right DLPFC (n=132, age 23.1 ± 3.0, 56 male) and the cathode over the contralateral supraorbital region. We tested retrieval performance with a surprising free recall test and we focused on total remembered words but also on remembered emotionally valenced content.

Hypotheses:

1. **Anodal stimulation of the left DLPFC increases free recall performance, while anodal stimulation of the right DLPFC will not.**
2. **Anodal stimulation of the left or right DPLFC differently increases free recall performance of positive vs. negative content.**

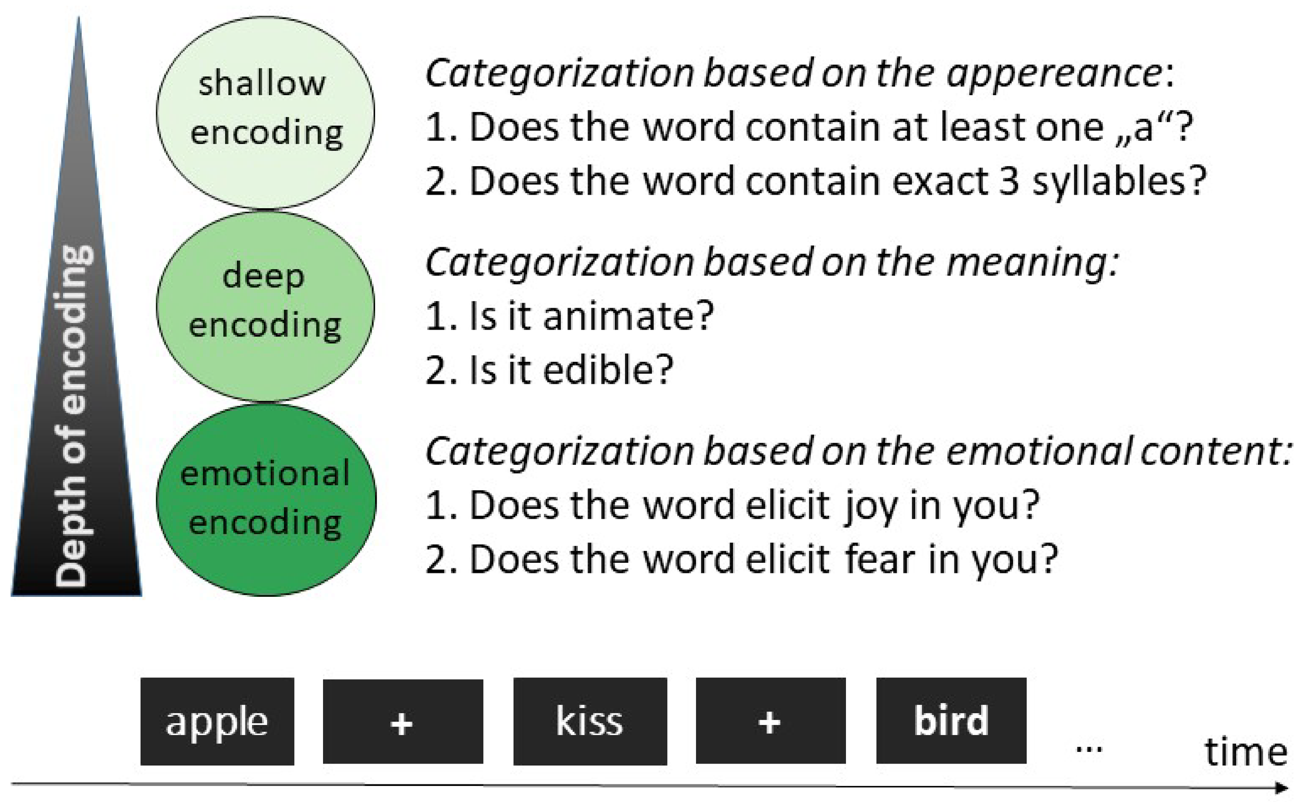

Figure 1. Illustration of the memory task with corresponding criteria for each encoding group.

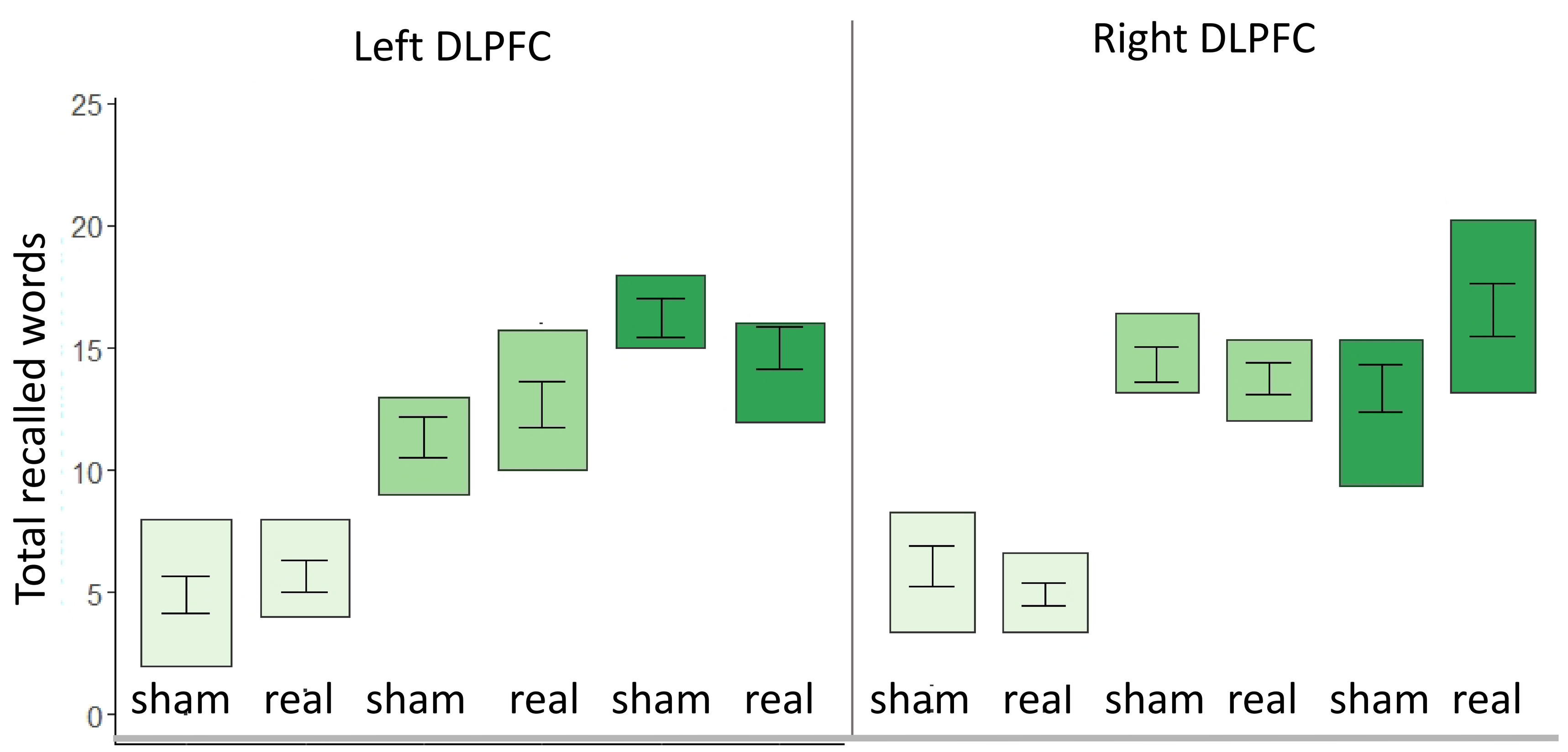

Figure 2. Total number of recalled words after left or right DLPFC stimulation for all encoding groups. Note: Error bars represent the standard error of the mean.

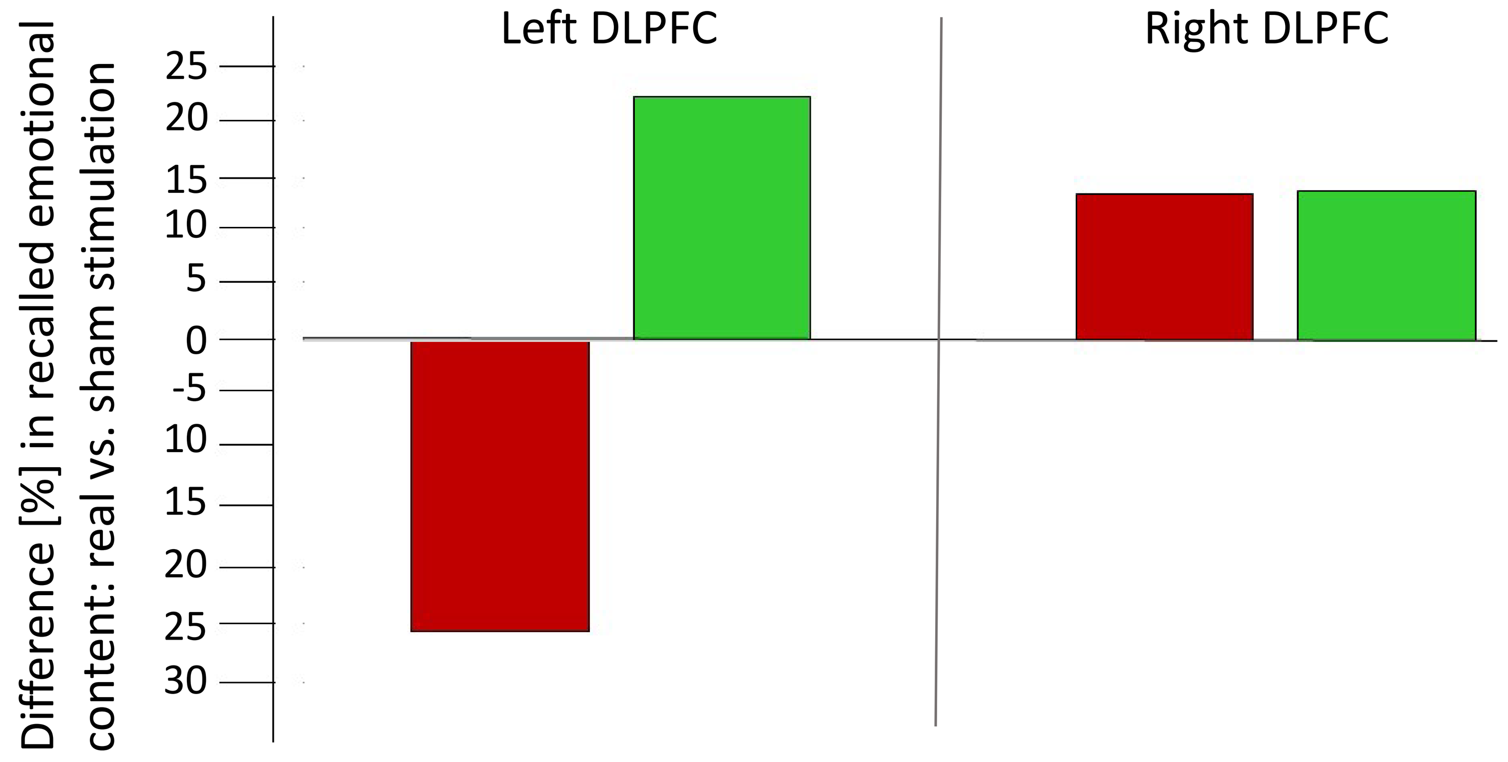

Figure 3. Difference [%] in recalled negative (red) or positive content for real stimulation (real/sham stimulation*100)

For free recall, we found a significant interaction between stimulation (sham/real), hemisphere (left/right), and group (shallow, deep and emotional) [$F_{(2,247)}$= 4.96, p= 0.008]. Stimulation of the left DLPFC led to better memory performance except for the emotional encoding group, whereas stimulation of the right DLPFC led to the opposite effect (Fig. 2). Positive content was better retrieved after real stimulation of both the left and right DLPFC [$F_{(1,81)}$= 4.85, p= 0.030]. On the contrary, right stimulation increased while left stimulation decreased retrieval of negative content [$F_{(1,81)}$= 4.89, p= 0.030].

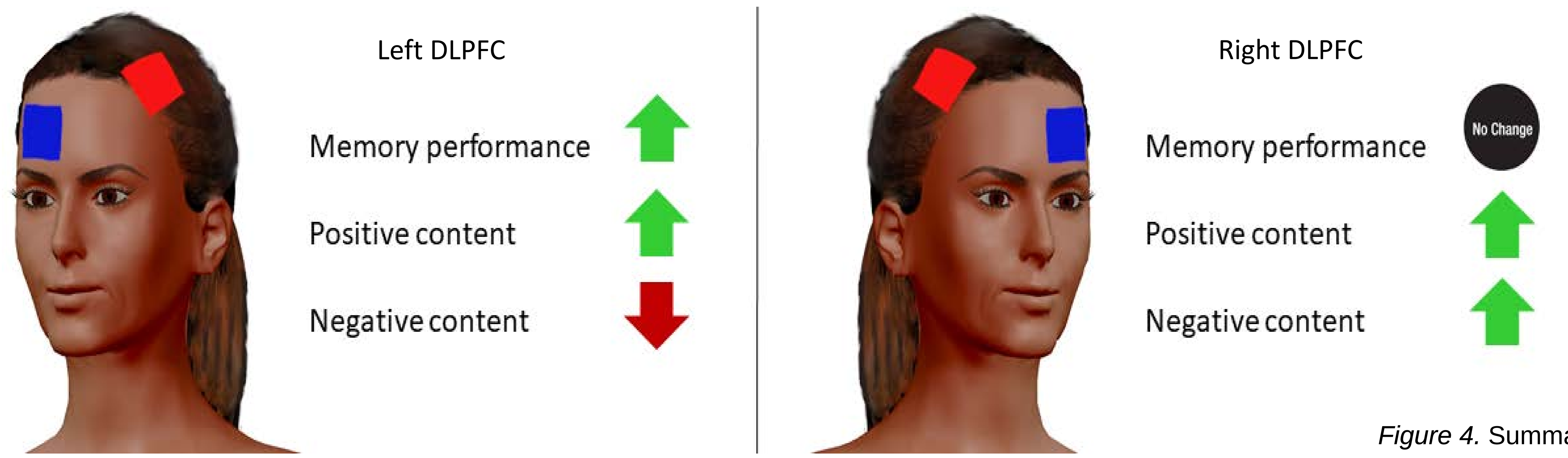

Figure 4. Summary of our results.

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