The role of cerebellum in sub-second timing processing: a Contingent Negative Variation study.

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Background: Time management is an important aspect of human behaviour and cognition. In recent years, functional imaging studies have tried to identify the neural correlates of several timing functions, ranging from simple motor tapping to higher cognitive time estimation functions. Several brain regions, such as dorsolateral prefrontal cortex, anterior cingulate gyrus, the supplementary motor area and the inferior parietal lobes, are thought to be involved in tasks of motor timing and time estimation. However, also subcortical regions such as the basal ganglia and the cerebellum seem to play a role in timing control.

Aim: to better explore the role of the cerebellum in the timing control, we transitorily inhibited cerebellar activity by means of cathodal tDCS and studied the effects on ERP components elicited during a S1-S2 motor task in healthy subjects.

Methods: Sixteen healthy subjects underwent a S1-S2 motor task prior and after cathodal and sham cerebellar tDCS in separate sessions. During the S1-S2 task, which was a duration discrimination task with a matching-to-sample procedure, subjects were asked to judge whether the duration of a probe interval trial was shorter (Short ISI trial: 800ms), longer (Long ISI trail: 1600ms), or equal to the Target interval of 1200ms represented into the base trial. Total-CNV and W2-CNV areas were measured for each interval trial, pre and post tDCS, separately for cathodal and sham sessions. Performance measures were obtained by calculating the mean reaction times (RTs) of correct responses and the accuracy of the responses (absolute number of errors) for each interval probe trial.

Results: A reduction in total-CNV and W2-CNV amplitude emerged only after cathodal tDCS for Short (total-CNV: $p<0.001$; W2-CNV: $p=0.003$) and Target interval trial (total-CNV: $p<0.001$; W2-CNV: $p=0.003$). No difference was detected after sham stimulation. Errors were significantly higher after cathodal tDCS than basal evaluation for Short ($p=0.06$) and Target interval ($p=0.05$). RTs were prolonged after cathodal tDCS selectively for Short ($p=0.004$) and Target interval ($p=0.06$). No differences in performance emerged after sham stimulation.

Discussion: These data indicate that cerebellar inhibition following cathodal stimulation selectively reduced the available attentional resources to make adequate time estimations for second or sub-second interval timing, while the supra-second timing control was not altered. We argue that the cerebellum is specifically involved in the management of short time intervals mostly related to

automatic or involuntary cognitive processes, while the timing control of longer intervals mainly requires the activation of associative cortical brain areas.